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Hydrologic Properties of Mangrove and Sawgrass Peat in Shark River Slough, Everglades, Florida

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FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

HYDROLOGIC PROPERTIES OF MANGROVE AND SAWGRASS PEAT IN SHARK RIVER SLOUGH, EVERGLADES, FLORIDA

A thesis submitted in partial fulfillment of

the requirements for the degree of

MASTER OF SCIENCE

in

GEOSCIENCES

by

Nicole Cordoba

2022

To: Dean Michael R. Heithaus
College of Arts, Sciences and Education

This thesis, written by Nicole Cordoba, and entitled Hydrologic Properties of Mangrove and Sawgrass Peat in Shark River Slough, Everglades, Florida, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this thesis and recommend that it be approved.

William Anderson

Leonard Scinto

René M. Price, Major Professor

Date of Defense: May 17, 2022

The thesis of Nicole Cordoba is approved.

Dean Michael R. Heithaus
College of Arts, Sciences and Education

Andrés G. Gil
Vice President for Research and Economic Development
and Dean of the University Graduate School

Florida International University, 2022

DEDICATION

Para mi mami y papi, las personas mas bellas, cariñosas, y fuertes que conozco, quienes siempre me han demonstrado lo que puedes lograr cuando tienes el apoyo te los que te quieren y cuando te dedicas a trabajar duro.

For my beautiful, caring, and strong parents who have always shown me what hard work and a loving support system can accomplish.

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This research was conducted on land traditionally and currently cared for and inhabited by the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida. I'd like to acknowledge the Calusa and Tequesta tribes who were removed from these lands by Spanish colonization.

ABSTRACT OF THE THESIS

HYDROLOGIC PROPERTIES OF MANGROVE AND SAWGRASS PEAT IN SHARK RIVER SLOUGH, EVERGLADES, FLORIDA

by

Nicole Cordoba

Florida International University, 2022

Miami, Florida

Professor René M. Price, Major Professor

Peat sediments are the foundation of most wetlands, acting as a medium for water to flow through, governed by hydraulic conductivity, and as a potential source of nutrients. Shark River Slough is a known, main fresh waterway for Everglades National Park, distributing essential nutrients and freshwater into the wetland. Hydraulic conductivity was calculated through experimental (both *in situ* water and higher salinity water) falling head tests performed on mangrove and sawgrass peat cores. Nutrient concentrations, Total Nitrogen (TN), Total Phosphorous (TP), Total Carbon (TC), Total Organic Carbon (TOC), Total Inorganic Carbon (TIC), were analyzed for the pore water released during hydrologic testing. Hydraulic conductivity values were higher in the sawgrass peat than the mangrove peat. No significant difference was found in hydraulic conductivity between *in situ* and higher salinity water. Total dissolved phosphorous concentrations were higher in mangrove peat porewater than in sawgrass peat porewater. Higher hydraulic conductivity in sawgrass peat allows water and nutrients to be transported more easily between surface water and groundwater.

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CHAPTER 1

INTRODUCTION

Peat sediments are the foundation of most coastal wetlands, providing a medium for water to flow through, stimulating critical biogeochemical cycling, and overall water transport in wetlands (Harvey et al., 2005). The ongoing threat of climate change makes coastal wetlands extremely susceptible to the negative effects of sea level rise, specifically saltwater intrusion (Chambers et al., 2013; White and Kaplan, 2017). Given the critical roles peat sediments play in maintaining the overall health of wetlands, furthering the understanding of hydrologic properties of peat sediments under *in situ* and sea level rise conditions is critical to understanding the exchange of water and nutrients with its surface water or underlying aquifer in coastal peats globally (Ward et al., 2020).

Coastal peat sediments of Everglades National Park are threatened and threatened by sea level rise and its subsequent saltwater intrusion, which will be defined as stated in Wilson et al. (2019), referring to saltwater intrusion as any marine origin water composed of salt-forming ions, intruding into a freshwater area. Saltwater intrusion can occur through various means, but principally saltwater intrudes beneath the land surface into a coastal aquifer forming a wedge shape of varying salinity with more saline groundwater occurring further inland at the bottom of the aquifer (Bear et al., 1999). Coastal areas affected by tides can experience saltwater intrusion above the land surface due to storm surges, high tides, and large waves (Heiss and Michael, 2014). When the saltier water covers a freshwater marsh, it will ultimately sink due to its high density and immediately invade the peat sediments at the floor of the marsh. The infiltration of the salty water through the peat can lead to changes in its hydrologic properties (Harvey et al. 2005).

Hydraulic conductivity (k), defined as the ability of a fluid to flow through a porous medium, is an important hydrologic parameter to measure for determining the transport of water and constituents. The investigation of hydraulic conductivity of peat sediments in subtropical/tropical regions has not been as extensively researched as in northern peatland sediments (Sirianni et al. 2020). However, peatlands in Sumatra and Kalimantra Indonesia have been known to become degraded due to human activities. The effects of their degradation have shown an increase in fire vulnerability, causing high carbon emissions. (Liew and Miettinen, 2010).

Provided that surface waters in the Everglades must first flow through a layer of peat before reaching the underlying bedrock and aquifer, measuring, and understanding the hydraulic conductivity of these peat sediments will aid researchers in determining the fate and transport of constituents from those surface waters. Exposing peat sediment cores to higher salinity waters through experimental falling head tests and calculating hydraulic conductivity can give insight to how these sediments would react under saltwater intrusion conditions. Previous studies have found that the hydraulic properties of peat sediments are highly dependent on the type of vegetation existing in the peatland and the degree of decomposition of the organic remains in the peat matrix, which is dependent on a variety of factors including soil depth and age (Rezanezhad et al., 2016).

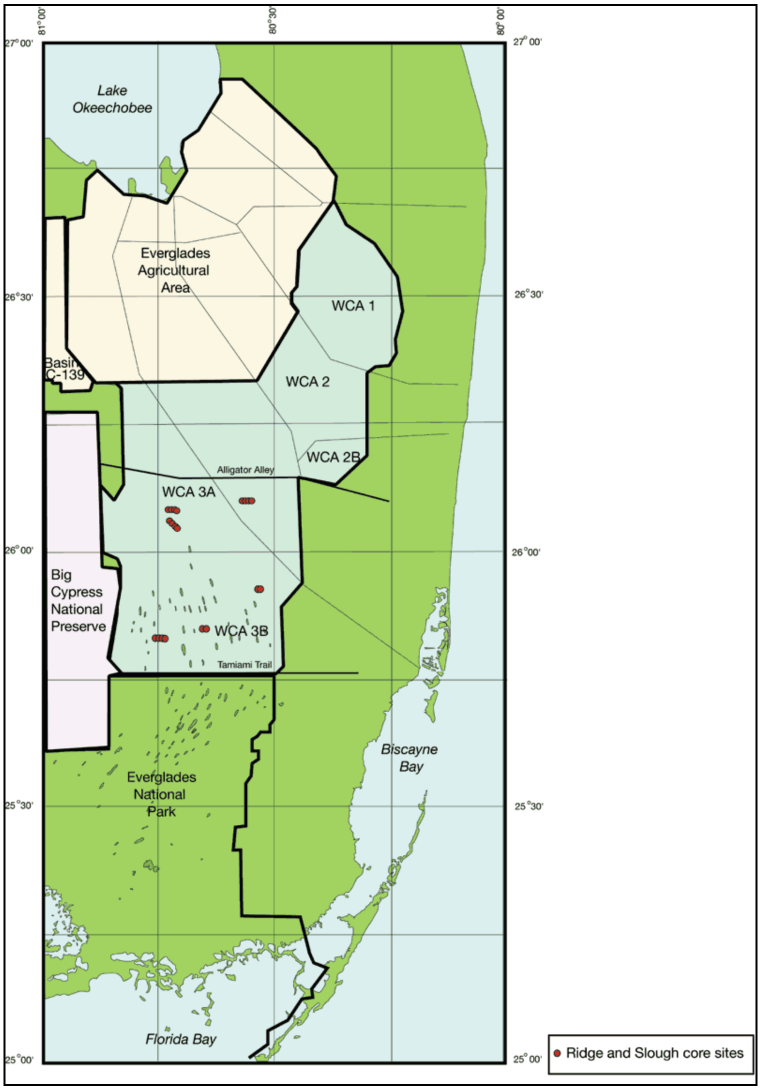
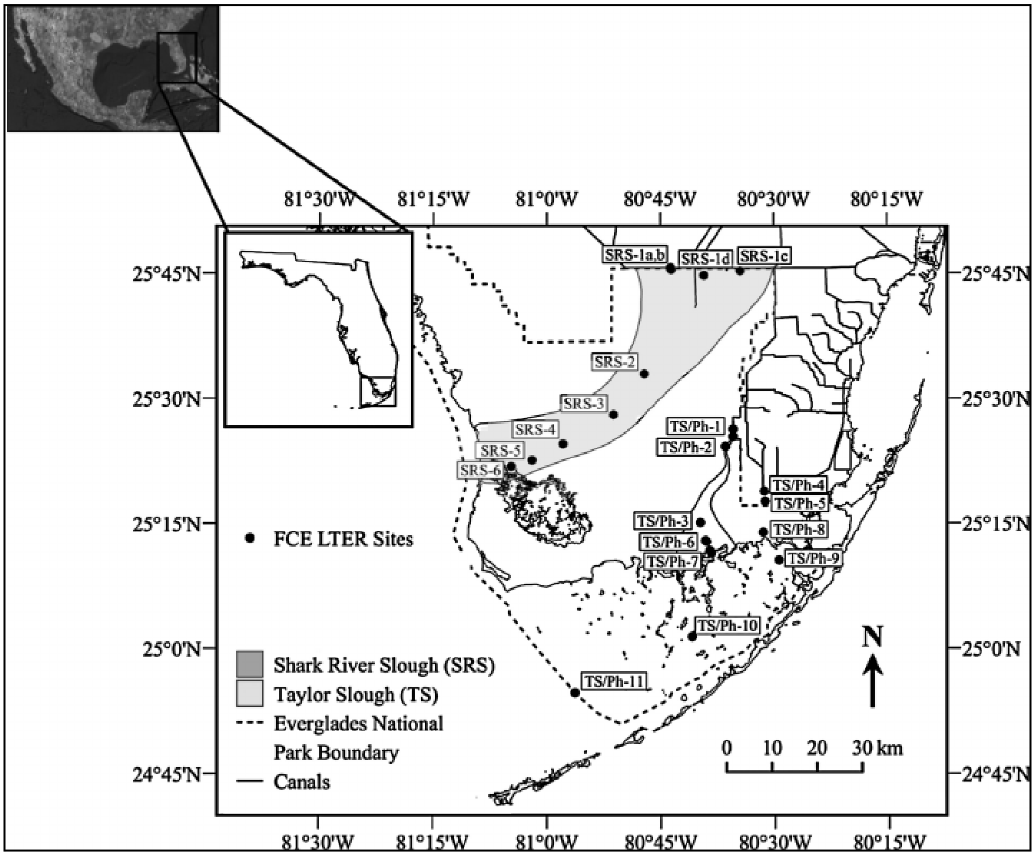


Figure SEQ Figure * ARABIC 1. Map showing Water Conservation Areas 1-3B and extent of Everglades National Park in Miami-Dade County, Broward, and Palm Beach County. (Source: USGS)

Sirianni and Comas, 2016, found that the hydraulic conductivity of peat monoliths collected from Water Conservation Area 3a (located in the northwestern region of Miami-Dade County and southwestern region of Broward County) (Figure 1) was dependent on the salinity of water to which it was exposed. The hydrologic properties of peat sediments in Shark River Slough, located in the southern portion of Everglades

National Park (Figure 2) have not been previously investigated. Previous research in this region has focused on sedimentation rates (Breithaupt, 2014, 2017, 2019a, 2020; Smoak, 2013) and deposition of storm surge deposits (Breithaupt, 2019b). This study provides estimates of the hydraulic properties of peat sediments in two regions of Shark River Slough, one dominated by mangroves and the other by sawgrass (*Cladium jamaicense)*, under varying salinity conditions. This research also investigates the release of constituents and nutrients from the peats under varying salinity conditions and compares them to chemical conditions in adjacent groundwater and surface waters and will help to



identify hydrologic connectivity between the surface and groundwater in the region from water samples and analysis of constituents. Given that Shark River Slough is the principal waterway within Everglades National Park (Dessu et al., 2018), understanding how peat sediments in this region function, how peat collapse affects an ecosystem, and consequences of sea level rise is important for the understanding hydrologic connectivity of the region and the potential for restoration of the Everglades as a whole (Dessu et al., 2021).

RESEARCH OBJECTIVES

The goal of this research is to advance the understanding of hydrologic properties of Everglades' peat sediments under varying salinity conditions. Although this research will occur in the Everglades, peatlands dominate 50-70% of wetlands globally, covering 3% of the total land and freshwater surface on the planet (Joosten and Clarke, 2002). Quantifying the hydraulic conductivity and the release of nutrients from Everglades' peat sediments under lower salinity/freshwater and saltwater intrusion conditions will aid in understanding of the response of these sediments to sea level rise. Specific research objectives were to:

- Determine hydrologic properties (hydraulic conductivity or K, specific yield, bulk density) of sediments collected from different regions in Shark River Slough, specifically between mangrove and sawgrass peats;
- Determine if the hydrologic properties of peats from Shark River Slough change under exposure to water of higher salinity; and

- Determine the release of constituents, including nutrients from peats in Shark River Slough under varying salinity conditions.

HYPOTHESIS

The following hypotheses will be investigated in this research:

a) Hydraulic conductivity of peat will decrease with a higher salinity;

b) Peat cores from mangroves will have a lower hydraulic conductivity as compared to that of sawgrass cores; and

c) The nutrient and ion concentrations from the water leached from the peat is expected to increase with lower hydraulic conductivity

STUDY AREA

Everglades National Park (ENP) is a vastly diverse, subtropical, coastal wetland, located in South Florida, United States, spanning an area of about 8,000 km^2. It is categorized as a low-lying, subtropical, freshwater peatland, or wetland known for its systems of accumulated peat, threatened by sea level rise (Mitsch and Gosselink, 2015). Published sea level rise projections put the Everglades at risk of becoming inundated with marine water, exposing previously unexposed freshwater areas to saltwater, and potentially altering the hydrologic properties of the peat. (Sirianni and Comas, 2020; Zhang et al. 2011) Underlying the Everglades' peat is limestone bedrock, home to the Biscayne Aquifer, the principal source of potable water for most of South Florida. Throughout the decades, the freshwater flow of the Everglades has been altered to make room for agricultural and residential practices. The restoration of the Everglades is one of the largest wetland restoration efforts, named the Comprehensive Everglades Restoration

Plan, and implemented in 2000 (Perry, 2004). Maintaining the Everglades inundated with freshwater ensures the hydration of the Biscayne Aquifer, providing South Florida residents with a secure water source, as well as providing a home to native vegetation and fauna (Price and Swartz, 2019).

Site Description

Shark River Slough is and was, historically, the principal fresh waterway for the Everglades, often dubbed the "River of Grass", characterized as a mostly low-lying region comprised of mangrove tree islands and sawgrass prairies and a distinctive wet and dry season, June through November, and December through May, respectively. Beginning just South of the Tamiami Trail at over 20 miles wide, it is the largest freshwater flow system in ENP, with an area estimated to be 991 km^2 (Flora & Rosendahl, 1982). West where it discharges into the Gulf of Mexico. The Florida Coastal Everglades Long-Term Ecological Research (FCE/LTER), a National Science Foundation (NSF) funded program, has monitoring and research sites in Shark River Slough (SRS), designated with the prefix SRS before a site number. Three of these sites were sampled and monitored during this research- SRS2, SRS4, and SRS6. Near FCE/LTER site SRS4, the Slough transitions from freshwater to an estuarine region (Figure 3). The average annual hydroperiod is about eleven months, with flooding lasting several years. Given the prolonged hydroperiod of this region, peat soils underlie this region.

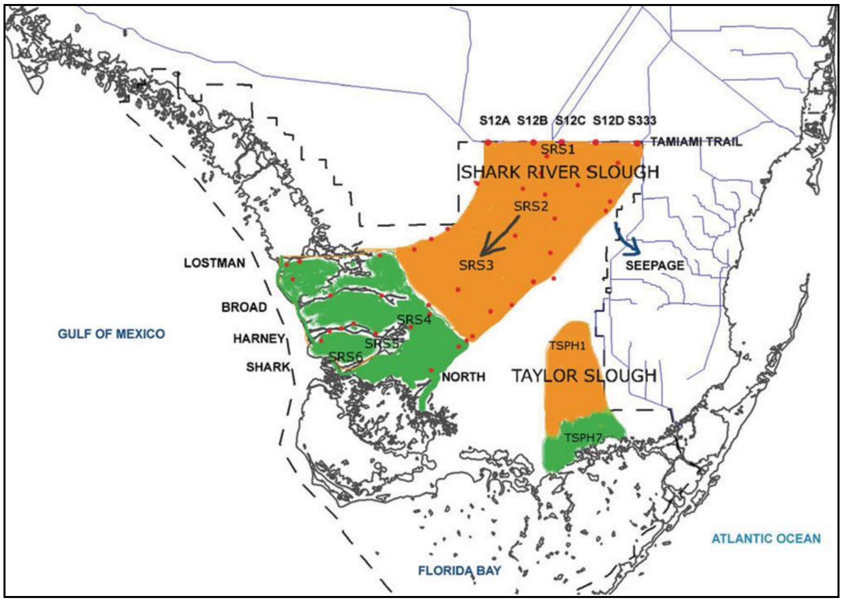


Figure SEQ Figure * ARABIC 3. Map showing extent of Shark River Slough, FCE/LTER site locations, and transition from freshwater (orange) to estuarine conditions (green). (Source: USGS)

The northernmost site, SRS2, is categorized as a freshwater, sawgrass dominated marsh with some Eleocharis/Panicum slough. It is primarily hydrated via overland, freshwater, sheet flow. The peat sediment layer of this site is estimated to be close to one meter thick. Southeast from SRS2, entering the transition zone of freshwater to brackish conditions, is SRS4. This site is characterized by brackish water, and a dwarf mangrove wetland with sawgrass present as well. Its hydrology involves overland, freshwater, sheet flow as well as inputs from tidal ocean currents. The peat sediment layer is thicker than one meter. The southernmost site, closest to the Gulf of Mexico, is SRS6, characterized as a mangrove wetland with larger stature mangroves present. Like SRS4, this site is hydrologically driven by tidal oceanic inputs and freshwater sheet flow, with its peat sediment layer thicker than one meter as well.

CHAPTER 2

METHODOLOGY

This research was conducted at three Florida Coastal Everglades-Long Term Ecological Research (FCE-LTER) stations: SRS2, SRS4, SRS6A and B in Shark River Slough, (Figure 2). Site SRS2 (*25° 32.9837′ N, 80° 47.1124′ W*) is located furthest north and inland from the coastline and is a freshwater wetland, dominated by sawgrasses. Site SRS4 (*25° 24.5858′ N, 80° 57.8586′ W*) is located at the boundary of freshwater and oceanic inputs and surrounded by low, dwarf mangroves and sawgrasses. SRS6A (*25° 21.85′ N, 81° 4.7167′ W*) and SRS6B (*25° 21.8777′ N, 81° 4.6768′ W*) are both located furthest south, closest to the coastline in a mangrove dominated wetland (mangroves found here are larger in stature than those in SRS4). SRS6A is closest to USGS wells, while site SRS6B is located at the base of the FCE Eddy Flux tower.

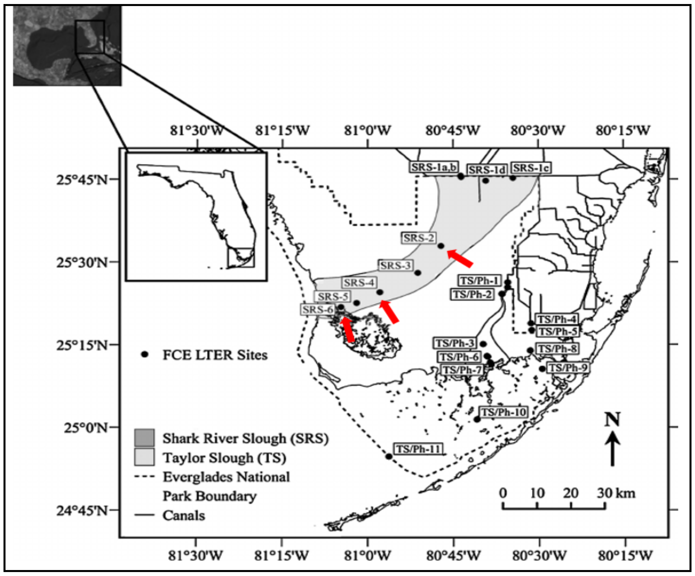


Figure 4. Map of South Florida, showing Everglades National Park boundary and location of Shark River Slough within the park. Red arrows point to the sites sampled in this research. (Source: Modified from Monroy et al., 2010)

HYDROLOGIC TESTING

Groundwater Wells

Both SRS4 and SRS6A sites have shallow and deep groundwater wells- previously installed by United States Geological Survey (USGS). The wells consist of 7.62cm PVC pipes. The shallow wells are set in the peat sediment layer, while the deep wells are set in the underlying limestone bedrock. At SRS4, the shallow well measures 1.3 m in depth and the deep well measures 4.91 m in depth. At SRS6A, the shallow well measures 1.45 m in depth and the deep well measures 7.72 m in depth. There are no wells located at SRS2.

Slug Tests

Horizontal hydraulic conductivity of the peat at SRS6A was determined using slug tests performed in the shallow well. Slug tests were not able to be performed at SRS4 because the shallow well was fully screened, therefore slug test data would not be representative of the peat but rather the well itself, which would lead to unusable results. The slug test at SRS6A was conducted with a Solinst 3001 Barologger 5 placed in the well, programmed to collect data points (water level measurements) every 0.1 seconds. The slug had a volume of 492.7 cm^3, constructed using a PVC pipe of diameter of 3.17 cm and length of 62.23 cm, filled with sand, and sealed on both ends. A string tied to an eyehook placed at one end of the slug was used for placement into and retrieval of the slug from the well. The depth to water level was measured in the well using a Solinst Water Level Meter model 1001 before the slug was inserted to the well. The displacement of water following the insertion of the slug was measured again using the water level meter. Water depth measurements were repeated every three minutes until the water level returned to its starting, stable state. Once water level stabilized, the slug was pulled from the well and the water level was once again measured and repeatedly monitored every three minutes until stable. A slug test was completed whenever the slug was inserted and whenever the slug was removed, resulting in a total of four slug tests. Using an online slug test calculator from Environmental Software Online (https://www.groundwatersoftware.com/calculator_11_slugtest.htm), which bases their calculations according to the Bouwer and Rice (1976) method, the hydraulic conductivity was determined from slug test data.

Core collection and Testing

Cores from the upper 1 m of the peat sediment layer were collected at each of the three research sites (Figure 2). The cores were collected using 1 m long, 10 cm diameter, clear, thin walled, polycarbonate tubes. The tubes were inserted into the peat sediment using a piston core device to minimize compaction during collection. The length of sediment collected in each core tube was compared to the total depth of each core bore hole, to calculate percent loss from compaction. In total, 20 cores were collected among the three sites, resulting in eight sawgrass cores and twelve mangrove cores. Additional mangrove cores were collected from further in site SRS6A, designated as SRS6B. Surface water present *in-situ* above the peat was also collected in the core tubes, which from here on out in this document is referred to as lower salinity water.

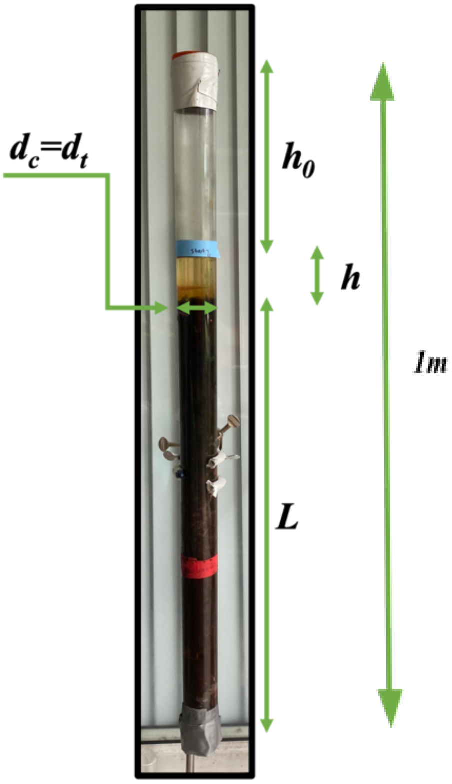


Figure 5. Falling head test set up for peat cores with labeled components used in Equation 1.

Hydrologic testing of the peat cores was conducted to determine vertical hydraulic conductivity and specific yield. Vertical hydraulic conductivity was determined from falling head tests. The falling head tests were conducted first using lower salinity water and second with a higher salinity water (Figure 4). After three consecutive falling head tests were performed on all cores with the lower salinity water, select cores (one for SRS2, two for SRS6A and B, two for SRS4) were then exposed to a higher salinity water (30 ppt) collected from surface water at SRS6A. This second set of falling head tests using the higher salinity water consisted of ten falling head tests per core, calculated thus to allow the lower salinity water to adequately drain from the cores and have the higher salinity water successfully flow through the entire peat matrix and pore spaces. Figure 5 illustrates the general set up for the falling head tests experiments. Hydraulic conductivity (K) was determined in units of cm s-1 for each core using the following equation from Fetter (2003):

$$K = \frac{d_t^2 L}{d_c^2 t} \ln ln \left(\frac{h_0}{h} \right) \qquad \text{(Eq. 1)}$$

where L is core length (cm), h_0 is initial head (cm), h is final head (cm), t is time (s) for the head to fall from h_0 to h, d_t is the inside diameter of the tube and d_c is the diameter (cm) of the core sample. For this study, d_t and d_c were assumed to be equal given the negligible thickness of the tube.

Specific yield tests were conducted on four cores, one from each site and two from SRS4 (mangrove and sawgrass). First, the lower salinity water collected *in-situ* overlying the peat core was decanted and then the cores were allowed to drain for 24 hours. The volume of water released from each core was measured. Specific yield (Sy) was calculated according to Equation 2 from Fetter (2003):

$$S_y = \frac{V_d}{V_T} \qquad \text{(Eq. 2)}$$

where V_d (cm^3) is the volume of water drained and V_T (cm^3) is the total volume of the peat sediment in the core tube.

PEAT SEDIMENT ANALYSIS

Physical Properties of Peat

A set of 4 cores were collected from SRS4 (one from mangrove peat, one from sawgrass peat), SRS6A (mangrove peat), and SRS2 (sawgrass peat) for sediment analysis (Figure 6). These cores were not exposed to the higher salinity water to retain their *in-situ* properties. The cores were allowed to drain by gravity drainage. Each core tube was then split open using a Dremel rotary tool to expose the peat sediment. (Figure 5)

Figure 6. Four representative cores, SRS4 C9, SRS4 C8, SRS6A C4, and SRS2 C1 used for sediment analysis.

The peat sediment in each core was divided into three sections, determined by any distinguishing, visible features in the core. The length of each section was measured (a range of 12-28cm) and the volume for each section was calculated (a range of 250-560cm^3). Sections were labeled A, B, C, with A representing the uppermost part of the core, B representing the middle of the core, and C representing the lowermost part of the core. Each one of these sections was cut in half to form duplicates, labeled 1 and 2.

Laboratory Analysis of Peat

Each peat sediment section was dried in a Fisher Scientific Isotemp Oven at 75 °C using aluminum foil trays. The trays were weighed without sample and later with sample twice daily until the weight didn't fluctuate more than 0.02g (9 days). Dry bulk density was then determined using dry weight over total volume. The dried peat sediment samples were analyzed for Total Nitrogen (TN), Total Phosphorous (TP), Total Carbon (TC), Total Organic Carbon (TOC), Total Inorganic Carbon (TIC), and Loss on Ignition (LOI) in FIU's Seagrass laboratory. Samples were dried to a constant weight in an oven at 60 °C, then ground to a fine powder using a motorized ball mill. A small, known amount of each sample was weighed into a tin capsule and analyzed for Carbon and Nitrogen content using a Thermo Flash 1112 elemental analyzer. Organic carbon content was determined as described in Fourqurean et al. 2012 using loss-on-ignition and carbon-nitrogen analysis of the ashed material. Samples were analyzed for phosphorus content using dry oxidation followed by acid hydrolysis and measured with a spectrophotometer (Shimadzu 2450) using a colorimetric procedure.

WATER SAMPLING AND ANALYSIS

Using a MasterFlex L/S peristaltic pump, the groundwater wells at SRS4 and SRS6A were sampled in August, September, and November 2020 and in July and October 2021. Wells were purged of at least 3 well volumes using the pump. Field parameters of salinity, conductivity, and temperature were monitored until stable using a

YSI Model 85 SCT meter. Surface water samples from Shark Slough adjacent to each well were also collected and salinity, conductivity, and temperature were measured at the time of sample collection.

Both groundwater and surface water samples were analyzed for nutrients. In addition, the water discharged from the peat cores during each lower salinity falling head test was collected and analyzed for nutrients. Total dissolved phosphorous (TDP) and nitrogen (TDN), and dissolved organic carbon (DOC) were determined in FIU's InWE laboratory, which is NELAC certified (E76930) for SERC SOPs based on methods: EPA 365, ASTM D5176, NU-062-1.8, respectively.

CHAPTER 3

DATA & RESULTS

HYDROLOGIC TESTING

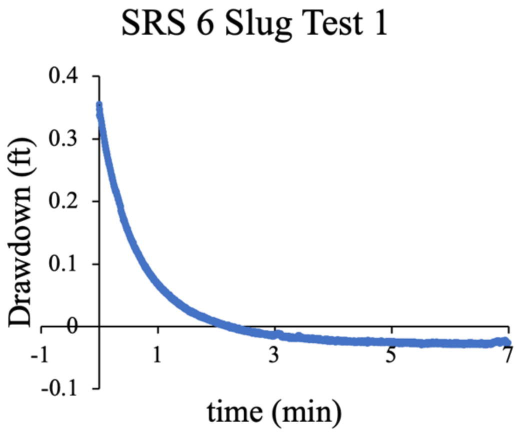
Horizontal Hydraulic Conductivity

Slug tests 1 and 3 were a result of removing the slug from the well and recording the drop of the water level, both had similar head changes, with test 1 having a head change of about 0.3ft and test 3, although atypical, having a head change of about 0.2ft (Figures 7a and 7b). Slug tests 2 and 4 were a result of dropping the slug into the well and recording the water level displacement, both tests had similar head changes, with test 2 having a head change of about 0.70ft, and test 4, having a head change of about 0.72ft (Figures 7c and 7d).

Horizontal hydraulic conductivity (K_H) values from the SRS6A slug test range from 451 cm/day to 2817 cm/day. Slug test 1 had the highest K_H value, at 2817 cm/day, and slug test 3 had the lowest, at 451 cm/day. Given these values vary on 1 order of magnitude, the geometric mean was calculated (Table 1). A geometric mean K_H value of 1272 cm/day was calculated from these 4 slug tests. Slug test 3 was an atypical result (Figure 7b), the geometric mean calculated without this value was 1797 cm/day.

Slug Test	K_H (ft/min)	K_H (cm/day)
1	0.064	2817
2	0.017	777
3	0.010*	451*
4	0.060	2649
Geometric Mean:	0.02/0.04*	1272/1797*
*Geometric Mean calculated without slug test 3		

Table 1. Horizontal hydraulic conductivity (K_H) results of slug tests performed on the shallow, peat penetrating well located at SRS6A.



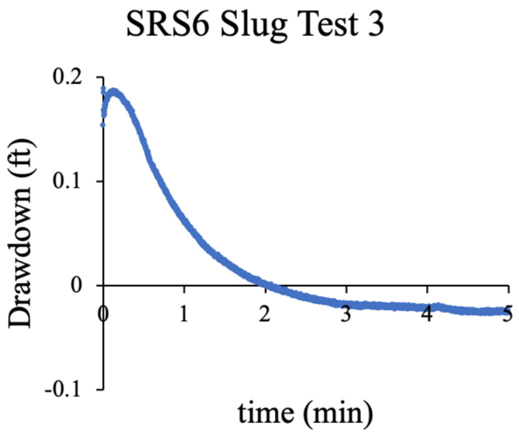


Figure 7a and 7b. Slug test graphs for tests 1 and 3, showing water level response after slug was removed.

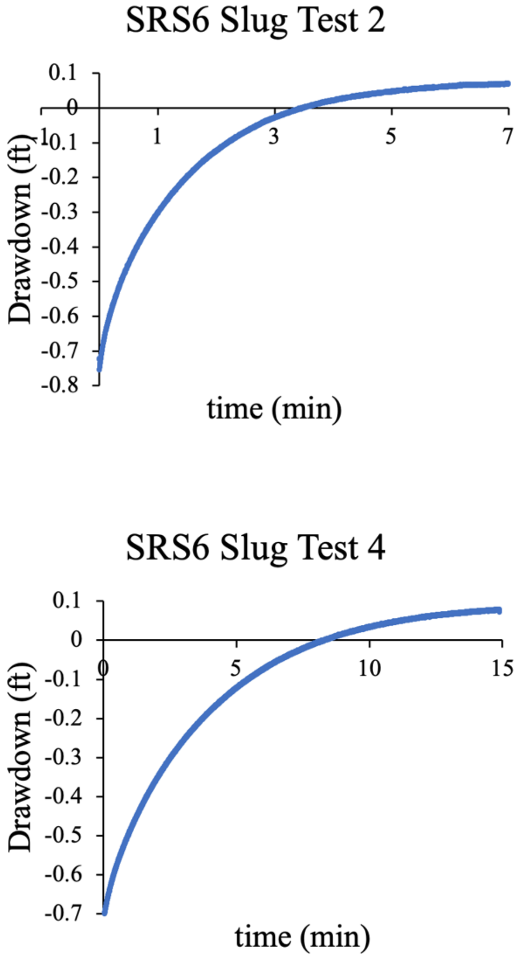


Figure 8a and 8b. Slug test graphs for tests 2 and 4, showing water level response after slug was dropped.

Vertical Hydraulic Conductivity and Specific Yield

The recovery from core collection of each core ranged from 55% to 100% (table 2). Cores collected from SRS6B had the lowest recovery of all other sites, with a range of 55-75%. The SRS6A site had the highest recovery, with a range of 94-100%. Average vertical hydraulic conductivity (K_v) from lower salinity falling head test experiments ranged from 1.2 $x10^{-3} \pm 2.9x10^{-4}$ cm s-1 to 2.6 $x10^{-4} \pm 1.7x10^{-4}$cm s-1. Freshwater, sawgrass-dominated site SRS2 had the highest average K_v at 1.2 $x10^{-3} \pm 2.9x10^{-4}$ cm s-1. Mangrove-dominated, saline sites SRS6A and SRS6B had the lowest average K_v, with a value of 2.6 $x10^{-4} \pm 1.6x10^{-4}$. The average K_v value for the brackish, transition site SRS4 was lower in the sawgrass peat, at 1.5 $x10^{-3} \pm 8.4x10^{-4}$ cm s-1, with the mangrove peat having an average K_v of 2.2 $x10^{-4} \pm 1.2x10^{-4}$ (table 3).

A statistically significant difference in K_v between the lower salinity and elevated salinity falling head tests was not observed. Between the two vegetation types, mangrove and sawgrass, the sawgrass peat cores had higher K_v values, by an order of magnitude, than the mangrove peat cores (ANOVA=$F_{72.31}$ >$Fcrit_{4.11}$), (figure 9). Resulting from the elevated salinity (30 falling head tests, the SRS4 mangrove peat K_v decreased from 2.2 $x10^{-4} \pm 1.2x10^{-4}$ to 7.2 $x10^{-5} \pm 1.7x10^{-5}$, a difference of one magnitude. Other mangrove peat cores from SRS6A did not see this decrease, neither did the sawgrass peat cores from SRS4 and SRS2 (table 3). Specific yield values ranged from 5.7-17.12%. The sawgrass core collected from SRS2 had the highest specific yield value, at 17.12% while the SRS4 mangrove core had the lowest specific yield value, at 5.7% (table 4).

Site	Vegetation Type	Core #	Core Length (cm)	Borehole Depth (cm)	Recovery (%)
SRS4	Sawgrass	C1	58	62	94
SRS4	Sawgrass	C2	55	58	95
SRS4	Sawgrass	C3	54	58	93
SRS4	Mangrove	C4	63.5	68	93
SRS4	Mangrove	C5	58	66	88
SRS4	Mangrove	C6	62	67	93

SRS6A	Mangrove	C1	47	50	94
SRS6A	Mangrove	C2	55	56	98
SRS6A	Mangrove	C3	63	63	100
SRS6B	Mangrove	C1	41	75	55
SRS6B	Mangrove	C2	53	71	75
SRS6B	Mangrove	C3	34	46	74
SRS6B	Mangrove	C4	60	82	73
SRS4	Sawgrass	C7	51	61	84
SRS4	Sawgrass	C8	54	59	92
SRS4	Mangrove	C9	67	69	97
SRS6A	Mangrove	C4	64	66	97
SRS2	Sawgrass	C1	80	87	92
SRS2	Sawgrass	C2	68	83	82
SRS2	Sawgrass	C3	67	77	87

Table 2. Inventory of all cores collected matched to collection site, vegetation type, core length, borehole depth, and recovery percentage from extraction.

		In Situ	
		Mangrove	**Sawgrass**
Sites	**In Situ Salinity (ppt)**	**K_v (cm s-1) ± SD**	**K_v (cm s-1) ± SD**
SRS2	0.1		1.2 x10^{-3} ± 2.9x10^{-4}
SRS4	0.7	2.2 x10^{-4} ± 1.2x10^{-4}	1.5 x10^{-3} ± 8.4x10^{-4}
SRS6A	24.7	2.6 x10^{-4} ± 1.8x10^{-4}	

SRS6B	17	$3.3x10^{-4} \pm 1.7x10^{-4}$	
		Elevated Salinity (30 ppt)	
		Mangrove	**Sawgrass**
Sites	**Salinity Range (ppt)**	**K_v (cm s-1) ± SD**	**K_v (cm s-1) ± SD**
SRS2	0-19		$1.2\ x10^{-3} \pm 1.4x10^{-4}$
SRS4	2.5-24	$7.2\ x10^{-5} \pm 1.7x10^{-5}$	$1.4\ x10^{-3} \pm 1.2x10^{-4}$
SRS6A	27-37	$1.0\ x10^{-4} \pm 1.4x10^{-5}$	
SRS6B	15-25	$2.0\ x10^{-4} \pm 4.0x10^{-5}$	

Table 3. Average hydraulic conductivity (K) and standard deviation (Std. Dev.) in cm s-1 in mangrove and sawgrass peat cores based upon in situ water (with a salinity range of 0.1ppt to 24.7ppt) from collection at Shark River Slough sites and later exposed to salinity of 30ppt for 10 pore volumes.

Table 4. Specific yield values for each site and vegetation type, in %.

Site	Core #	Vegetation Type	Specific Yield (%)
SRS2	C1	Sawgrass	17.12
SRS4	C8	Sawgrass	9.30
SRS4	C9	Mangrove	5.70
SRS6A	C4	Mangrove	7.60

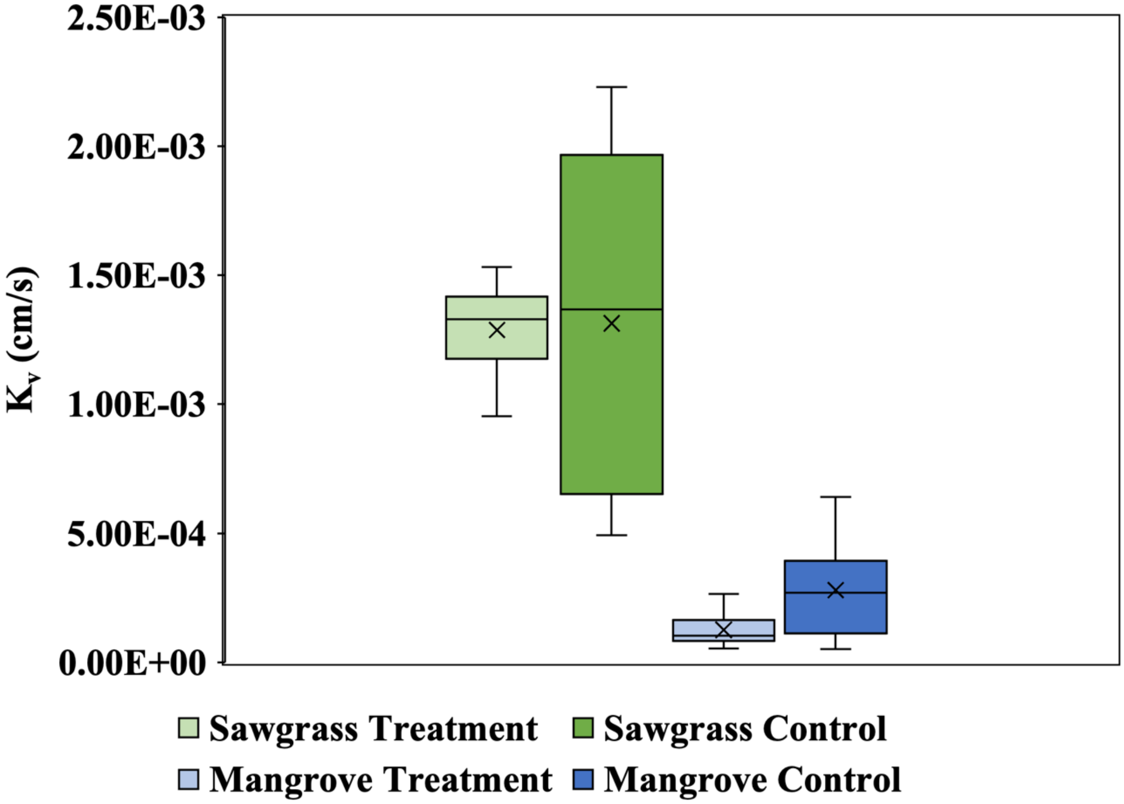


Figure 9. Box and whisker plots differentiating the vertical hydraulic conductivity (K_v) (cm s-1) measurements for mangrove and sawgrass cores (blue and green, respectively) and control vs. treatment cores (lighter shades and darker shades, respectively).

Bulk Density

Bulk density values for peat sediment samples ranged from 0.06 g/cm^3 to 0.4 g/cm^3, between both sawgrass and mangrove peat sediment cores (Tables 5a-5d). Overall, the sawgrass peat sediment had lower bulk density values as compared to the mangrove peat sediment cores, with the bulk density values for the sawgrass samples falling within a range of 0.06 to 0.16 g/cm^3 and the mangrove samples falling within a range of 0.09 to 0.40 g/cm^3. The mangrove sample with the lowest bulk density was collected from SRS4, with a value of 0.09 g/cm^3, while the mangrove sample with the highest bulk density was collected from SRS6A, with a value of 0.6 g/cm^3. The sawgrass sample with the lowest bulk density was collected from SRS4, with a value of 0.06 g/cm^3, while the sawgrass sample with the highest bulk density was collected from SRS4 with a value of 0.16 g/cm^3.

Mangrove peat sediment samples collected from SRS6A showed a higher range of bulk density values as compared to those from SRS4, with a range of 0.15 g/cm^3 to 0.40 g/cm^3 and 0.09 g/cm^3 to 0.13 g/cm^3 respectively. Sawgrass peat sediment samples collected from SRS4 showed a higher range of bulk density values as compared to those from SRS2, with a range of 0.06 g/cm^3 to 0.16 g/cm^3 and 0.07 g/cm^3 to 0.11 g/cm^3, respectively.

SRS2 Sawgrass C1				
Section	Length (cm)	Dry Weight (g)	Total Volume (cm^3)	Bulk Density (g/cm^3)
A1	22.86	25.217	231.665	0.11

A2	22.86	19.525	231.665	0.08
B1	25.40	17.027	257.410	0.07
B2	25.40	25.025	257.410	0.10
C1	27.94	23.855	283.150	0.08
C2	27.94	24.15	283.150	0.09

Table 5. Bulk density values for each section of the SRS2 Sawgrass core.

SRS4 Sawgrass C8				
Section	Length (cm)	Dry Weight (g)	Total Volume (cm^3)	Bulk Density (g/cm^3)
A1	22.86	21.29	231.67	0.09
A2	22.86	13.99	231.67	0.06
B1	12.70	19.39	128.71	0.15
B2	12.70	20.25	128.71	0.16
C1	16.51	19.87	167.32	0.12
C2	16.51	16.84	167.32	0.10

Table 6. Bulk density values for each section of the SRS4 Sawgrass core.

SRS4 Mangrove C9				
Section	Length (cm)	Dry Weight (g)	Total Volume (cm^3)	Bulk Density (g/cm^3)
A1	22.86	21.29	231.66	0.09
A2	22.86	26.12	231.67	0.11
B1	24.13	28.38	244.54	0.12
B2	24.13	25.60	244.54	0.10
C1	18.40	18.95	186.47	0.10
C2	18.40	25.11	186.47	0.13

Table 7. Bulk density values for each section of the SRS4 Mangrove core.

Table 8. Bulk density values for each section of the SRS6A Mangrove core.

SRS6A Mangrove C4				
Section	Length (cm)	Dry Weight (g)	Total Volume (cm^3)	Bulk Density (g/cm^3)
A1	21.59	72.42	218.80	0.33
A2	21.59	87.35	218.80	0.40
B1	20.95	41.76	212.31	0.20
B2	20.95	52.38	212.31	0.25
C1	20.95	34.84	212.31	0.16
C2	20.95	32.60	212.31	0.15

SEDIMENT CHEMISTRY

The mangrove peat core collected from SRS6A had the highest bulk density values as compared to the rest of the cores, with a range of 0.16 g/cm^3 to 0.33 g/cm^3 (Figure 10). The mangrove peat core from SRS4 had a bulk density range of 0.09 g/cm^3 to 0.12 g/cm^3. The sawgrass peat core from SRS4 had a higher bulk density range as compared to the sawgrass peat core from SRS2, showing a range of 0.09 g/cm^3 to 0.15 g/cm^3 and 0.07 g/cm^3 to 0.11 g/cm^3, respectively (Figure 10).

Total phosphorous concentrations, in %, were highest in the SRS4 mangrove core, with values ranging from 0.02 % to 0.8 % (Figure 11). The mangrove peat core from SRS6A had the highest phosphorous concentrations, ranging from 0.07 % to 0.09 %. The sawgrass cores form SRS2 and SRS4 had phosphorous concentrations of 0.01 % to 0.04 % and 0.02 % to 0.04 %, respectively (Figure 11).

The sawgrass peat core from SRS2 had the highest total nitrogen concentration range, in %, as compared to the rest of the cores, with values from 2.5 % to 4 % (Figure 12). The sawgrass peat core from SRS4 had the second highest total nitrogen concentration range, with values from 1.8 % to 2.3 %. The mangrove peat core from SRS4 showed a small range of values for total nitrogen concentrations, with values of 2.2 % to 2.3 %. The mangrove peat core collected from SRS6A showed the lowest total nitrogen concentration range, with values of 0.7 % to 1.0 %.

Both sawgrass peat cores from SRS2 and SRS4 had similar total carbon concentrations, in %, with values ranging from 43.6 % to 54.5 % and 37 % to 48.9 %, respectively (Figure 12). The mangrove peat core from SRS4 had total carbon concentrations ranging from 43.8 % to 45.3 %. The mangrove peat core from SRS6A had the lowest total carbon concentrations, with values ranging from 20.4 % to 26.2 % (Figure 12).

The SRS6A mangrove peat core showed the largest range in total inorganic carbon concentrations, with values ranging from 0.07 % to 6.6 % (Figure 13). In contrast, the mangrove peat core from SRS4 showed a small range in total inorganic carbon concentrations, with values ranging from 2.1 % to 2.5 %. Sawgrass cores from SRS2 and SRS4 showed total inorganic carbon concentrations with values ranging from 1.9 % to 3.5 % and 1.0 % to 2.0 %, respectively (Figure 13).

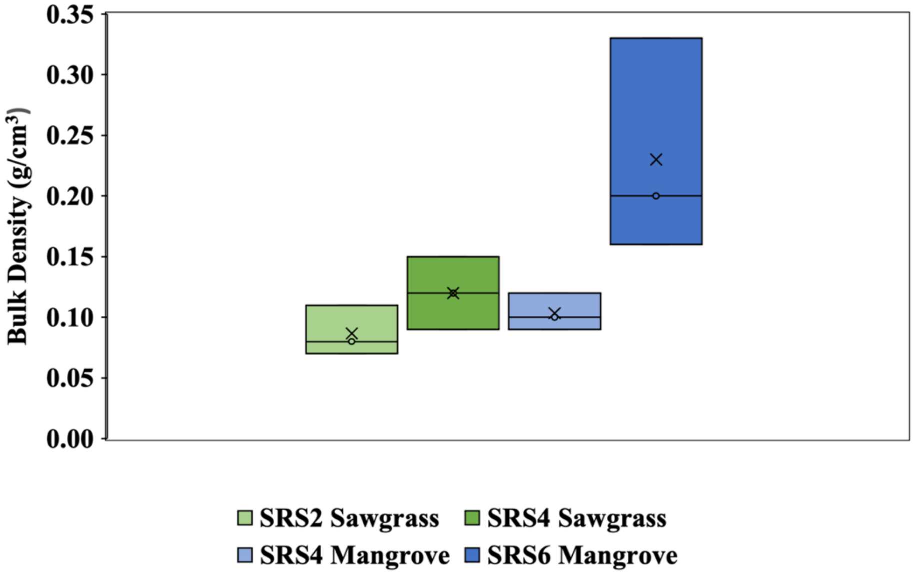


Figure 10. Box and whisker plots differentiating bulk density measurements (g/cm^3) for peat sediment cores from SRS2 Sawgrass (light green), SRS4 Sawgrass (dark green), SRS4 Mangrove (light blue), SRS6 Mangrove (dark blue).

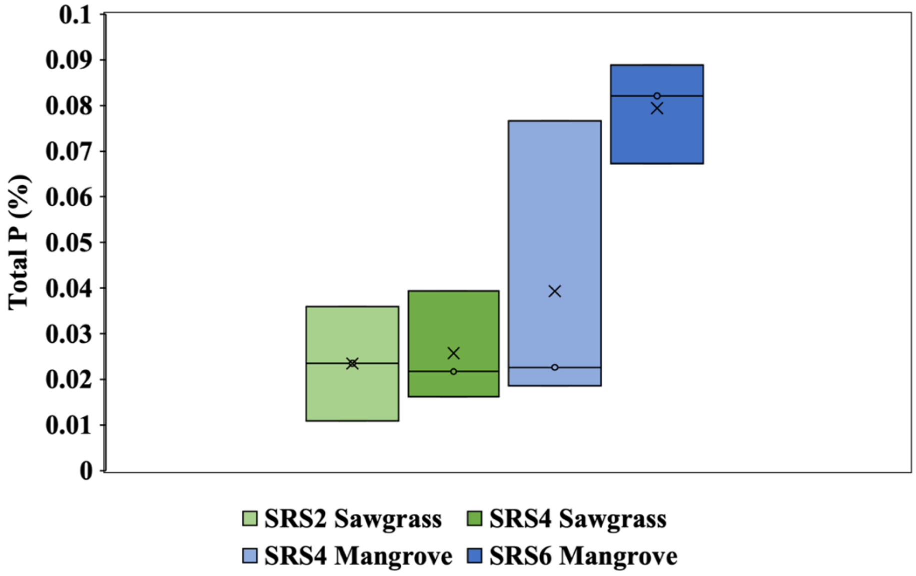


Figure 11. Box and whisker plots differentiating total phosphorous (P) measurements (%) for peat sediment cores from SRS2 Sawgrass (light green), SRS4 Sawgrass (dark green), SRS4 Mangrove (light blue), SRS6 Mangrove (dark blue).

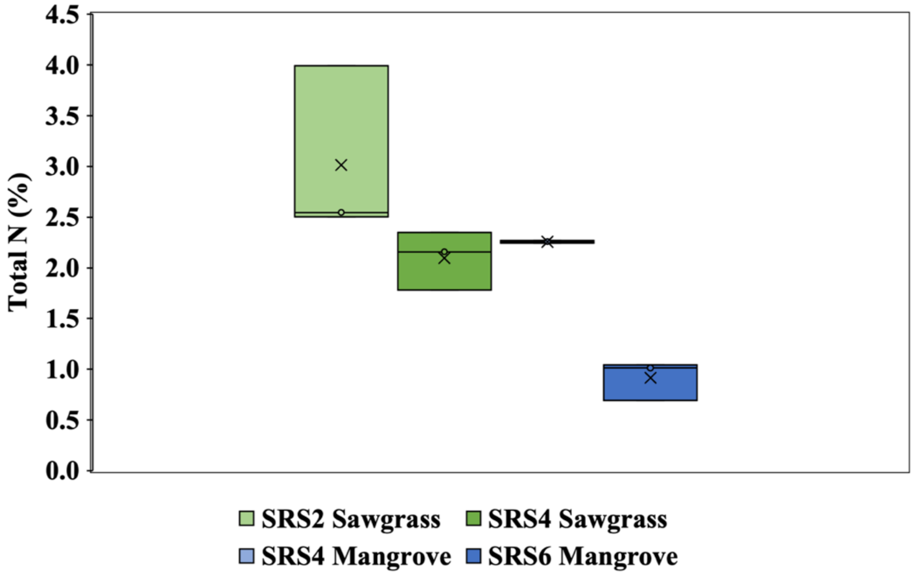


Figure 12. Box and whisker plots differentiating total nitrogen (N) measurements (%) for peat sediment cores from SRS2 Sawgrass (light green), SRS4 Sawgrass (dark green), SRS4 Mangrove (light blue), SRS6 Mangrove (dark blue).

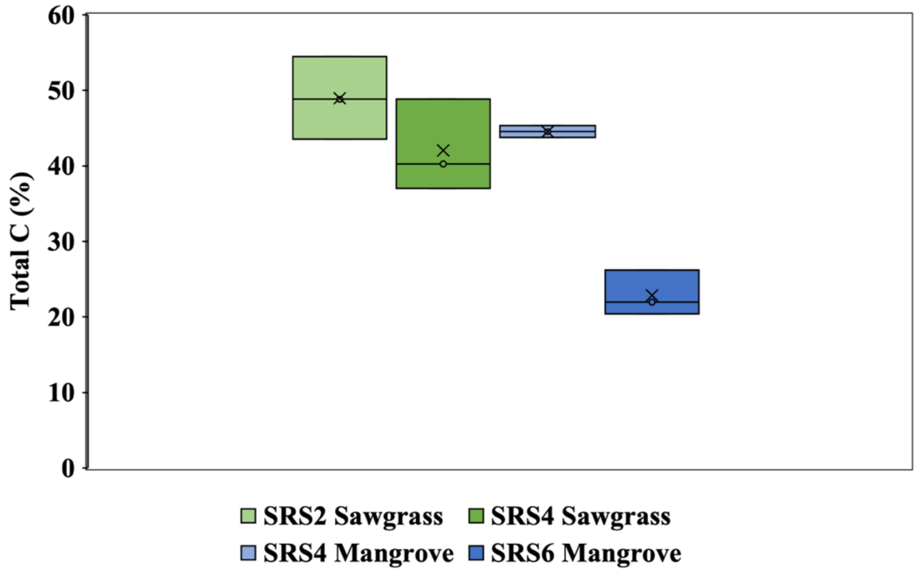


Figure 13. Box and whisker plots differentiating total carbon (C) measurements (%) for peat sediment cores from SRS2 Sawgrass (light green), SRS4 Sawgrass (dark green), SRS4 Mangrove (light blue), SRS6 Mangrove (dark blue).

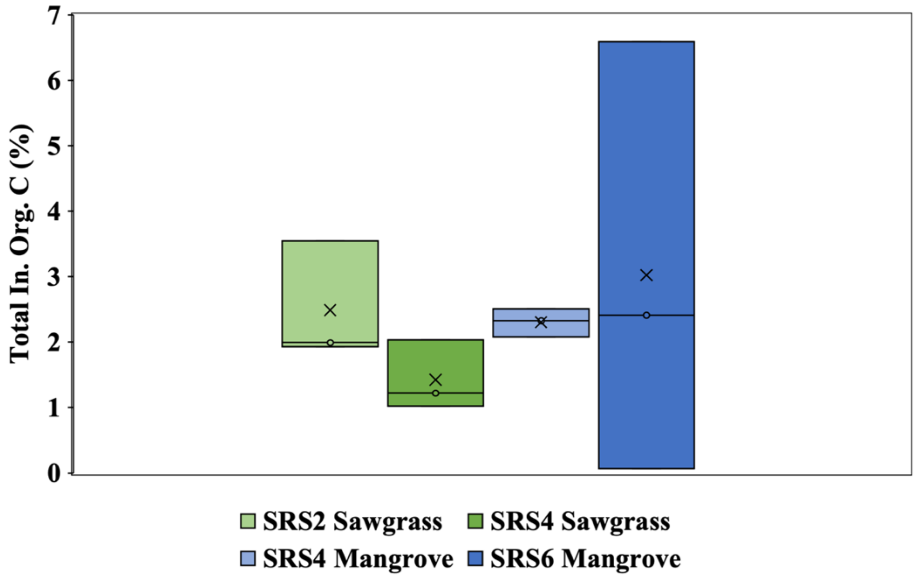


Figure 14. Box and whisker plots differentiating total inorganic carbon (In. Org. C) measurements (%) for peat sediment cores from SRS2 Sawgrass (light green), SRS4 Sawgrass (dark green), SRS4 Mangrove (light blue), SRS6 Mangrove (dark blue).

WATER CHEMISTRY

The peat core lower salinity test porewater samples from both SRS4 and SRS6 showed higher concentrations of all nutrients tested than the surface water and groundwater samples collected in July 2019 from those sites (Figures 15 & 16). Furthermore, the mangrove peat core's porewater from SRS4 had higher concentrations overall than the sawgrass peat core's porewater. Total dissolved nitrogen concentrations, in µmol/L, were about the same between SRS4 and SRS6A mangrove peat core porewaters with averages of 226.2 µmol/L and 238.4 µmol/L, respectively. The total dissolved phosphorous concentrations, in µmol/L, were lower in SRS4 mangrove peat core porewater as compared to the SRS6A mangrove peat core porewater, with averages of 1.84 µmol/L and 4.74 µmol/L, respectively. The dissolved organic carbon concentrations, in µmol/L, for the mangrove porewater from SRS4 was higher than that from SRS6A, with average values of 5270.4 µmol/L and 2179.6 µmol/L, respectively. There is no figure for SRS2 as there are no wells to compare data to in this site.

The peat core porewater for cores exposed to higher salinity water (30) showed an increase in salinity after each pore volume (Figures 17-19). For the SRS4 sawgrass core, the porewater salinity increased from about 3 to 23 after being exposed to the higher salinity water over 10 pore volumes (Figure 17). The SRS6B mangrove core had varying porewater salinity, starting at about 20 and reaching 25ppt after being exposed to the higher salinity water over 15 pore volumes (Figure 18). The SRS2 sawgrass core porewater salinity had an initial value of 0 and after 4 pore volumes, increased to 19 (Figure 19). An inverse correlation between the salinity and nutrient values was noted overall for all cores: as salinity increased, nutrient values decreased.

Total nitrogen concentrations for groundwater and surface water samples collected from SRS4 in November of 2020 were higher than those water samples from SRS6 (Figure 20). Surface water samples from both sites had higher total nitrogen concentrations than the samples collected from shallow and deep wells. Total phosphorous concentrations were relatively the same throughout both sites, falling within a range of 0.8 to 1 µmol/L, except for the deep well water sample from SRS6, which had a value of about 0.4 µmol/L. Total organic carbon concentrations were highest in both SRS4 and SRS6 deep wells, with values of 7,212 µmol/L and 9019 µmol/L, respectively (Figure 20). Water samples from the shallow well and surface waters from both SRS4 and SRS6 had total organic carbon concentrations within the range of 3000 µmol/L to 3400 µmol/L.

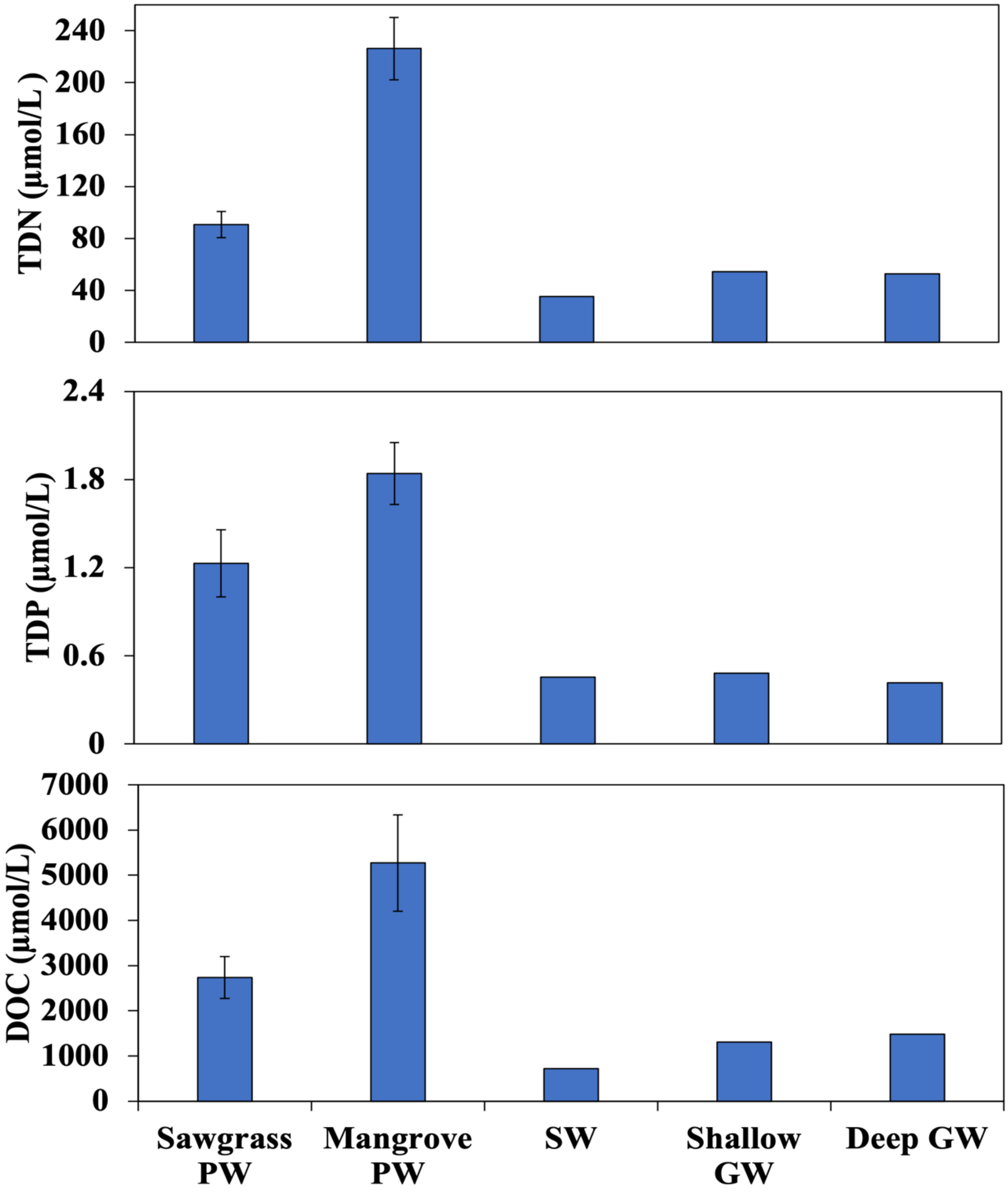


Figure 15. Nutrient data for core porewater (PW), surface water (SW), and shallow/deep groundwater (GW) from SRS4.

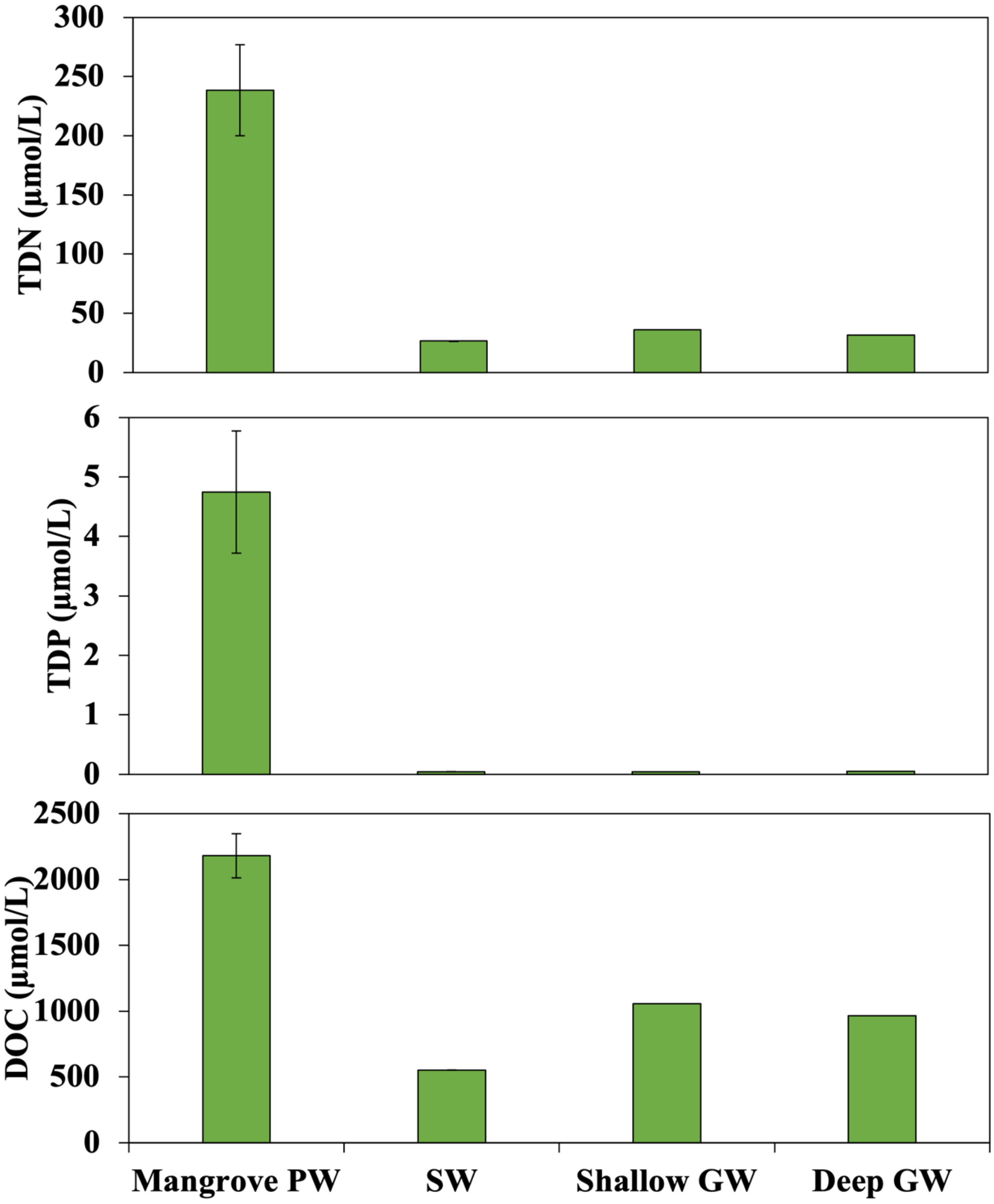


Figure 16. Nutrient data for core porewater (PW), surface water (SW), and shallow/deep groundwater (GW) from SRS6A.

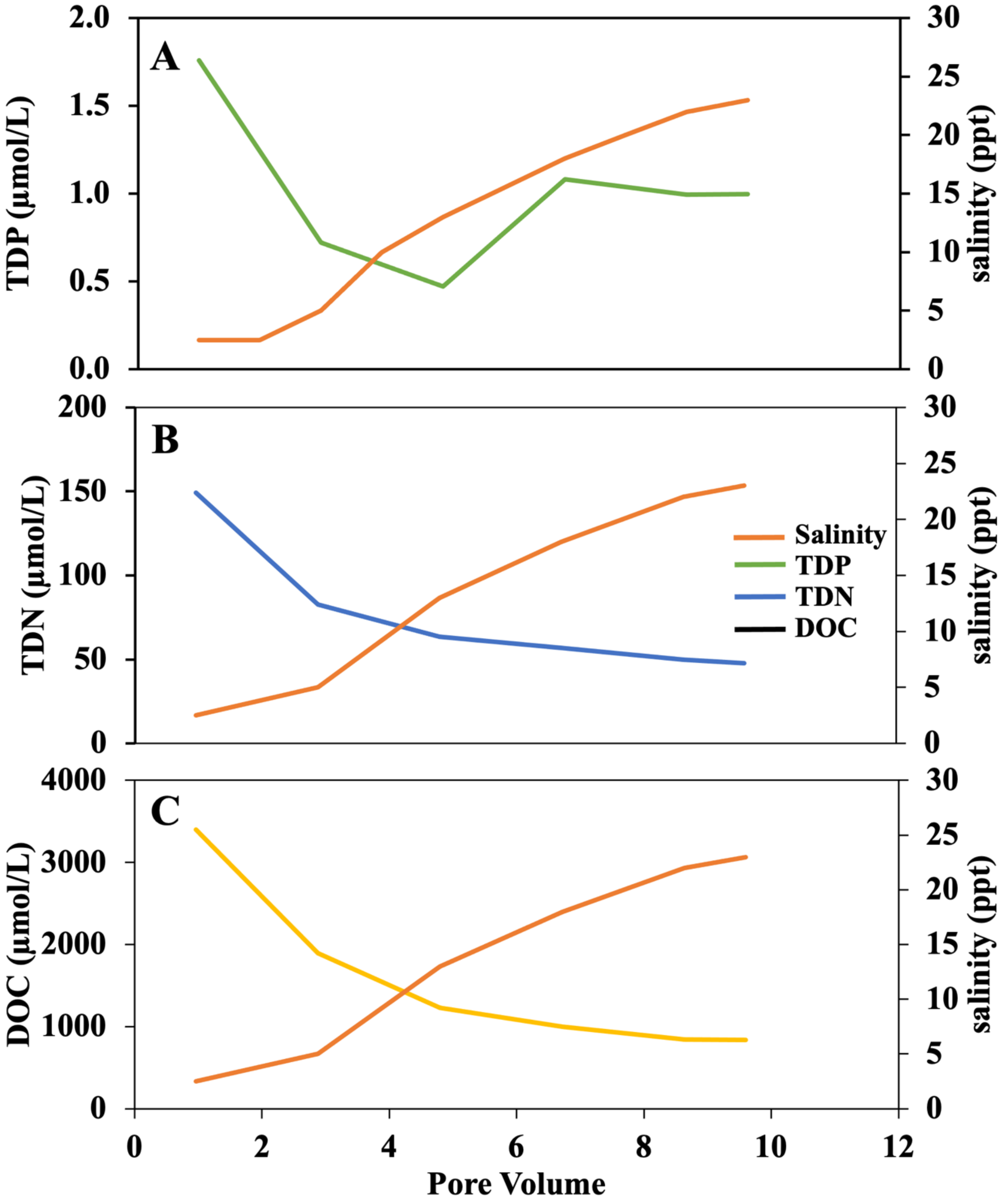


Figure 17. The change in A (TDP), B (TDN), and C (DOC) with salinity per pore volume for SRS4 C3 sawgrass core upon exposure to higher salinity water, 30 ppt.

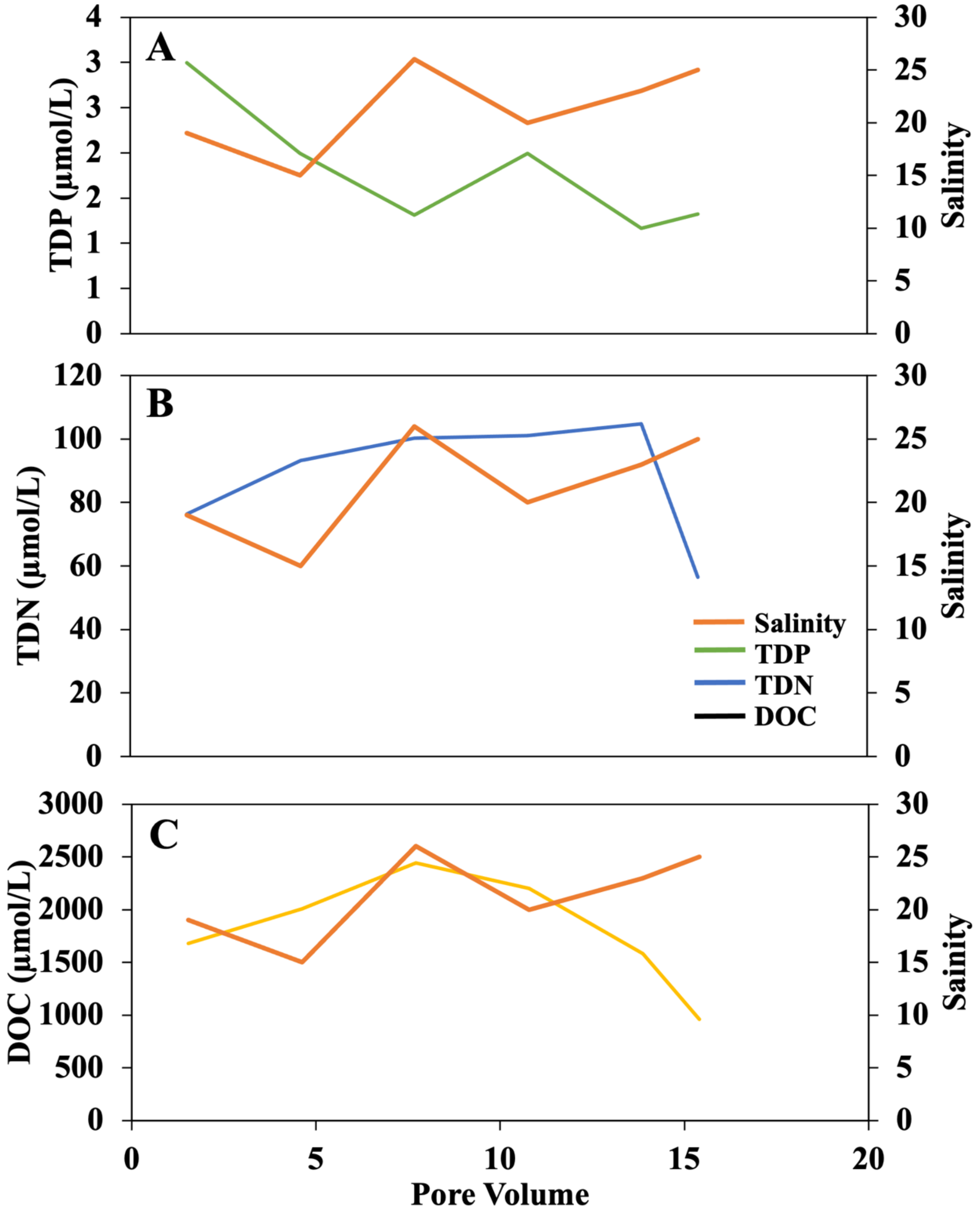


Figure 18. Nutrient data and salinity values for SRS6B C1 mangrove core porewater per pore volume as it was exposed to higher salinity water during falling head tests

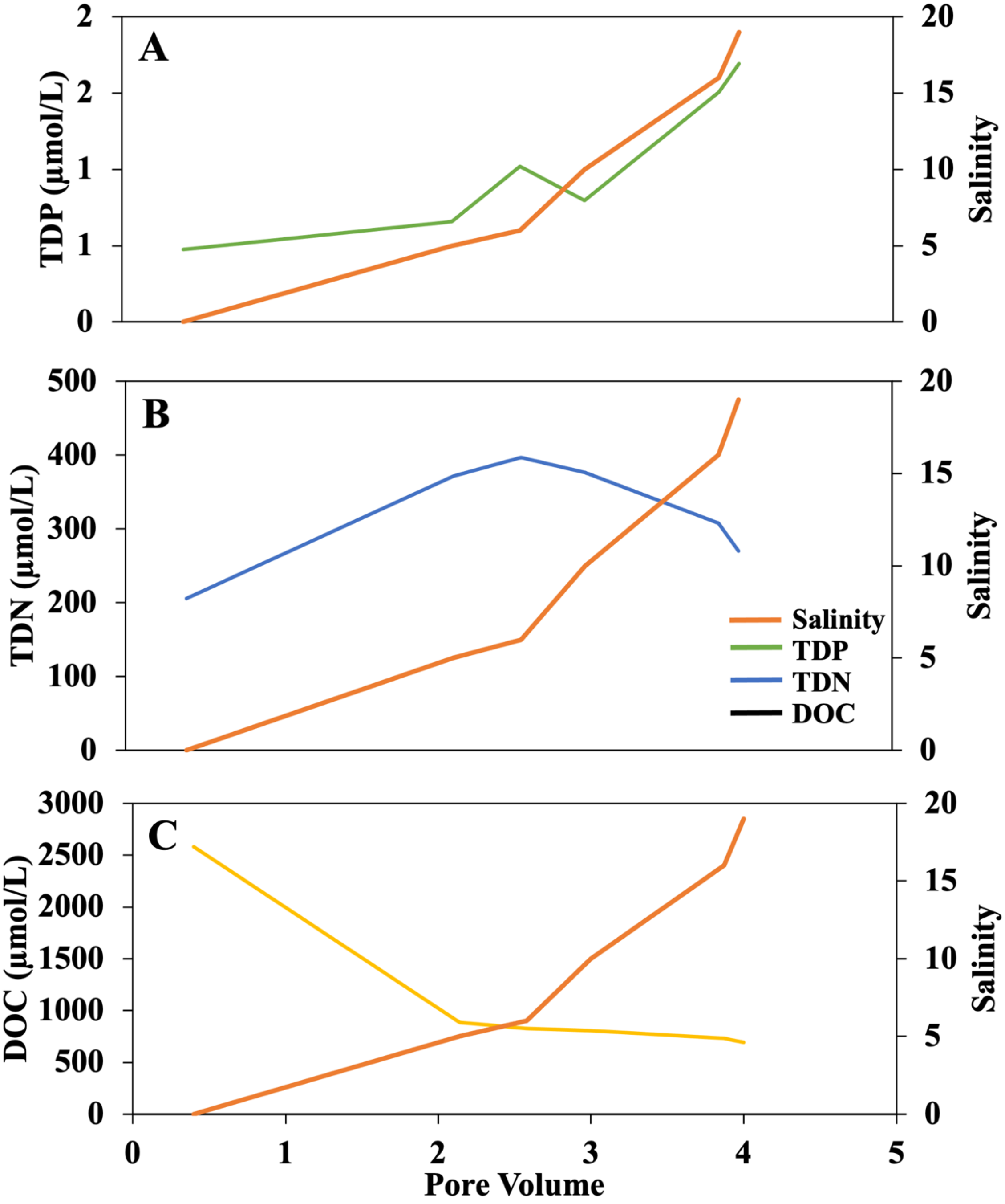


Figure 19. Nutrient data and salinity values for SRS2 C2 sawgrass core porewater per pore volume as it was exposed to higher salinity water during falling head tests.

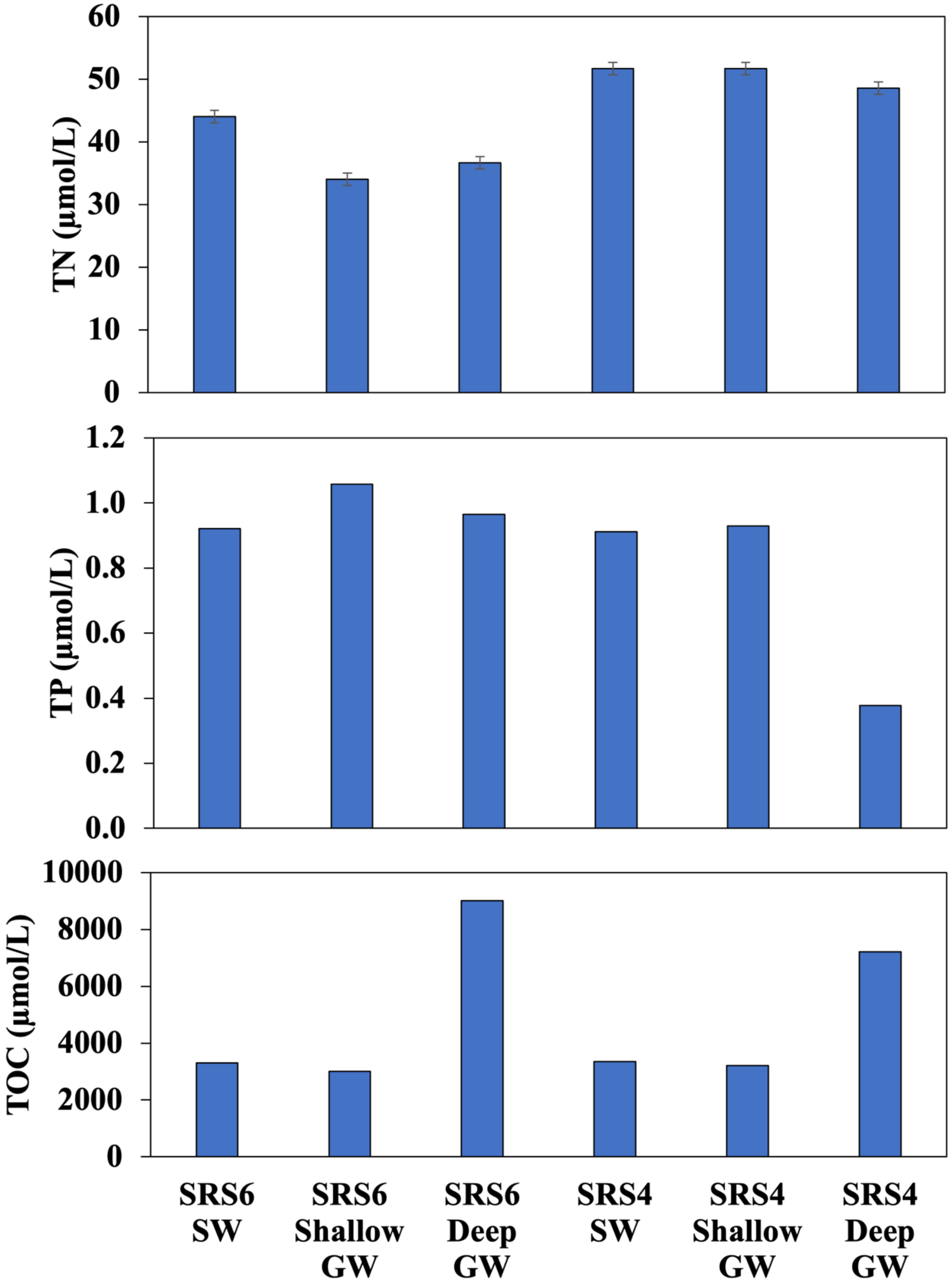


Figure 20. Total nutrient data values for groundwater and surface water field samples, collected in September through November of 2020.

CHAPTER 4

DISCUSSION

Wetland sediments store excess amounts of carbon, nutrients, metals, and contaminants, which can become mobilized to the surface waters lying above and groundwaters below (Reddy et al., 2007). The exchange of both water and constituents between the peat and the surrounding groundwater/surface waters is important to understand the main mechanisms which drive biogeochemical cycling, nutrient cycling, and the overall water quality of wetlands (Harvey et al., 2005). Peat soils are a definitive characteristic of the Everglades (Lodge, 2010). Peat soils are categorized according to the principal plant material derived from- mosses (*Sphagnum)*, grasses/sedges, woody materials. In the Everglades, there exists two widely occurring peat types: Everglades peat which is formed almost entirely from sawgrass remains and Mangrove peat, formed along coastline from mangrove remains and other sediments (Lodge, 2010; Rezanezhad et al., 2016).

Peat soils have idiosyncratic properties, resulting in distinctive hydrologic conditions. Total porosity can range from 71% to 96% while effective porosity is lower, ranging from 10% to 40% (Comas, 2016; Rezanezhad et al., 2016). Peat soils also exhibit dual porosity (Hoag and Price, 1997), characterized by a “mobile region” of interconnected pore spaces allowing fluids and colloids to easily be transmitted and an “immobile region” comprised of smaller, closed off, dead-end pore spaces, usually formed by intact plant remains (Hayward and Clymo, 1982; Hoag and Price, 1997; Kremer et al., 2004). For shallow peat soils, the degree of decomposition increases with depth, decreasing pore diameter and total porosity. Given that interparticle pore space and larger pores are reduced, hydraulic conductivity of peat soils is expected to lower with depth, due to compaction, and as peat decomposes (Rezanezhad et al., 2016).

HYDROLOGIC TESTING

Slug Tests and Horizontal Hydraulic Conductivity

Hydraulic conductivity can be measured in the horizontal and vertical direction. A slug test measures the *in-situ* horizontal hydraulic conductivity, as it involves allowing water to flow in a well horizontally through a geologic unit, timing and measuring the water level after a known volume of water has been displaced. The hydraulic conductivity values acquired from slug tests can be used for a variety of reasons, but for the purpose of this project, these values were used to determine the horizontal hydraulic conductivity of the peat sediment. (Butler Jr., 2019)

Slug tests to measure the hydraulic conductivity of peat in Shark River Slough have not been performed previously, so there is no accurate comparison point for these values. In Taylor Slough, Zapata et al. (2012) published an average horizontal hydraulic conductivity of .70 m day^{-1} with a standard deviation of .25 m day^{-1} for mangrove peat. Zapata et al.'s values were two orders of magnitude lower than the geometric mean from the slug tests conducted at SRS6, which was 22.46 m day^{-1} (Table 1). Other studies have conducted experiments using peat soils collected from different sites located in the Everglades wetland, north of Everglades National Park. Sirianni and Comas (2020) calculated an average value of 51.84 m day^{-1} for horizontal hydraulic conductivity of peat monoliths collected from Water Conservation Area 3A (WCA-3A) (Figure 1), which was higher than this study, but within the same order of magnitude. Sullivan et al. (2012) performed slug tests on man-made tree islands at the Loxahatchee Impoundment Landscape Assessment (LILA) and obtained an average value of 1.09 m day^{-1} with a standard deviation of 0.82, which is lower by a degree of magnitude than the peat located in the natural Everglades landscape, from SRS6 and WCA-3A.

Vertical Hydraulic Conductivity

Falling head tests are commonly performed in laboratories to determine the vertical hydraulic conductivity of a soil or sediment- the sediment sample is saturated, and the water is kept at a known head (Fetter, 2003). A fluid tends to flow closer to the vertical direction in a medium of lower vertical hydraulic conductivity, and closer to the horizontal direction in a medium of higher vertical hydraulic conductivity (Figure 21). In the case of Shark River, the limestone bedrock underlying peat sediments in the Everglades has a published average vertical hydraulic conductivity of 2,490 m day^{-1} (Wacker et al. 2014) and the peat sediments of the Everglades have a published vertical hydraulic conductivity range of 0.02 to 14 m day^{-1} (Harvey et al., 2004). Vertical hydraulic conductivity values of the mangrove and sawgrass peat sediments from Shark River Slough ranged from 0.28 to 1.0 m day^{-1} (Table 3), which fall within the published range for Everglades peat sediments (Harvey et al., 2004). ANOVA tests showed a statistically significant difference in peat sediment cores collected from freshwater, sawgrass-dominated sites, having a higher hydraulic conductivity, by an order of magnitude, than peat cores from brackish, mangrove-dominated sites (Figure 9).

A lower hydraulic conductivity in mangrove peat could be due to the salinity difference between sawgrass and mangrove sites, where mangrove sites have higher salinity/brackish waters and sawgrass sites have very low salinity or freshwater. Mangrove peat cores exist in a site of higher salinity and therefore have been exposed to higher salinity waters for prolonged periods of time. Sirianni and Comas (2020) and Wilson et al. (2019) noted a decrease in vertical hydraulic conductivity after having exposed their cores to higher salinity waters for a longer period.

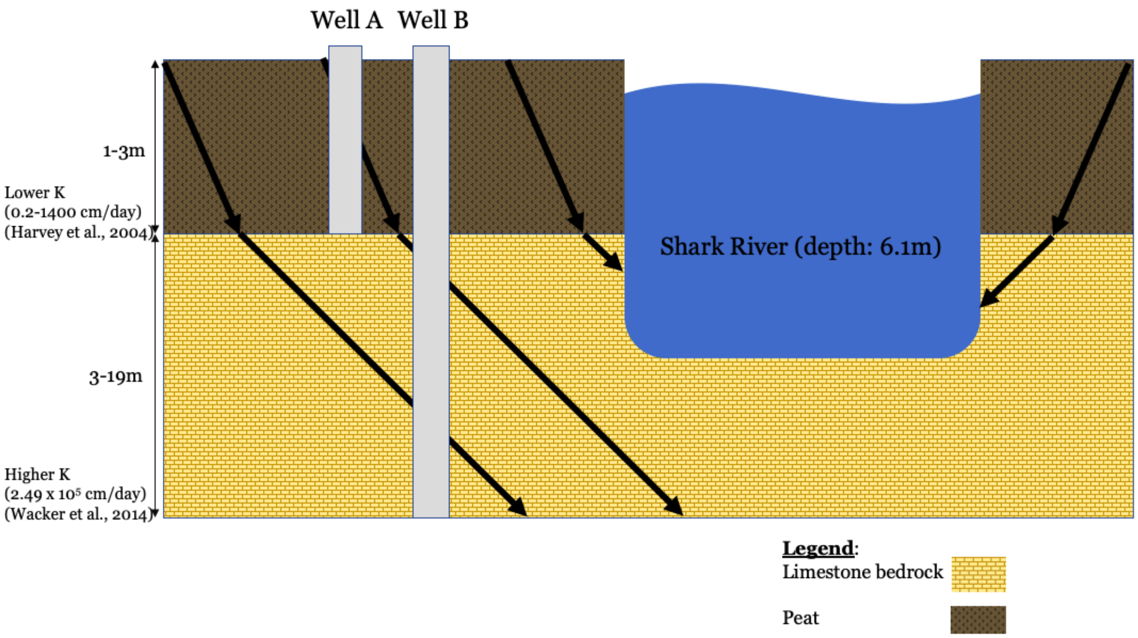


Figure 21. Schematic of direction of water flow (black arrows) through peat sediment layer and underlying limestone bedrock in Shark River Slough. Published hydraulic conductivity (K) values of peat sediments in the Everglades and the Biscayne Aquifer range from 0.2-1400 cm day^{-1} and 2.49 x 10^{5} cm day^{-1}, respectively. (Harvey et al., 2004; Wacker et al., 2014)

After exposing the peat cores to a higher salinity water (30 ppt) collected from SRS6 and completing falling head tests, ANOVA testing showed no significant difference in the hydraulic conductivity between the cores exposed only to the lower salinity waters collected *in-situ* and those exposed to the higher salinity water. Exposure to the higher salinity water for the cores in this study was at most 2 weeks. Sirianni and Comas (2020), progressively exposed peat monoliths from WCA-3A to higher salinity waters over a couple of years. Wilson et al. (2019) concluded a minimum two-year period of exposure to higher salinity waters was needed for observable changes in sawgrass peat to occur. Hydrologic properties of peat sediments are heavily influenced by a variety of factors as well, like micro and macro pore spaces, percentage of root biomass, amount of nutrients present, vegetation present at time of accumulation, accumulation rate, etc. (Servais et al., 2018; Wilson et al., 2018b) Therefore, the lack of change to the vertical hydraulic conductivity of the peat sediment in this study could be a result of having exposed the peat cores to a higher salinity water for only a couple of weeks (Figure 9). This short-term exposure period can mimic a pulse event, like storm surge from a hurricane. Given that the peat core sediments did not show a difference when being exposed to the higher salinity waters, it can be assumed that a pulse event would not affect peat sediments as heavily as long-term, press event, like sea level rise.

Specific yield is defined as the amount of water a porous medium will release due to gravity and is often equated with porosity (Fetter, 2003). Previous studies have determined the specific yield of peat sediments is highly dependent on the depth of the sediment, with lower specific yield at greater depths (Chambers et al., 2013; Heliotis, 1989; Ivanov, 1981). In this study, the peat cores were collected from the upper 1 m, where peat thickness was known to range from 1.5 to 3 m (Anderson et al., 2014). Rezanezhad et al., 2016 published specific yield values for peat sediments from Michigan ranging from 4.8 to 45%. Sullivan et al., 2012 published specific yield values for

Everglades peat sediments ranging from 10 to 32%. In this investigation, specific yield values ranged from 5.7 to 17.12% within the range of previously published values (Rezanezhad et al., 2016; Sullivan et al., 2021). In Shark Slough, sawgrass peat had a higher specific yield (17.1%) than the mangrove peat (5.7%) (Table 4), which can lead to the conclusion that these sawgrass peat sediments are more easily drained than the mangrove peat sediments.

PEAT SEDIMENT ANALYSIS

Bulk Density

Similar to specific yield, bulk density can be a proxy for a medium's porosity. Peat soils are known to have a bulk density ranging from 0.10 to 0.20 g cm^{-3} (Clymo, 1983) and can exceed this range with more decomposition. Peat sediments from man-made mangrove tree islands from LILA have an average bulk density of 0.06 ± 0.01 g cm^{-3}, while in the Water Conservation Areas and ENP the average bulk density of peat sediments was greater, at 0.10 ± 0.01 and 0.17 ± 0.06, respectively (Craft C.B and Richardson C.J., 2008). Bulk density measurements form this study fall within this published range, with mangrove peat sediments from SRS4 having a bulk density range of 0.09 to 0.13 g cm^{-3} and from SRS6A, 0.15 to 0.40 g cm^{-3} (Tables 7 & 8). Sawgrass peat sediment cores collected from SRS4 and SRS2 had lesser bulk density ranges, with values of 0.07 to 0.11 g cm^{-3} and 0.06 to 0.16 g cm^{-3}, respectively (Tables 5 & 6).

WATER CHEMISTRY

Dissolved nutrients are the primary form of nutrients that can be mobilize in water bodies and are absorbed by roots and microorganisms. In this study, pore water released from mangrove peat cores had higher total dissolved nitrogen, phosphorous, and organic carbon when compared to the sawgrass peat cores (Figures 15 & 16). These results can suggest that the nutrients from the sawgrass peat cores are being mobilized to the surrounding waters, whereas in the mangrove peat cores, these nutrients are remaining in the sediment. In the case that these nutrients are being deposited at an appropriate interval, for example allowing the ecosystem to adequately absorb the nutrients and successfully become fertilized, these excess nutrients in the mangrove regions could promote a healthy ecosystem.

Hurricanes are a known threat to wetland ecosystems, as they are known to disrupt nutrient cycling, plant root systems, and flood regions with ocean-derived saltwater. Negative effects are often emphasized but in a study from Castañeda and Moya (2020), mineral inputs from hurricane events were found to have a positive effect on soil fertility. Specifically, an increase in phosphorous concentration in soils was noted, which increases the uptake of phosphorous by plants. Mangroves existing in the Everglades region (a karstic setting) are known to be deprived of terrestrial sediment and nutrients, notably phosphorous (Woodroffe, 1992).

Castañeda and Moya (2020) found the highest amount of mineral sediment deposition occurred in the near-coast mangroves, as compared to the upstream mangrove regions. This study found higher concentration of Total Dissolved Phosphorous in the near-coast mangrove peat cores, from SRS6A (Figure 15 & 16), compared to the mangrove peat cores collected further upstream at SRS4. These values differ by a factor of more than 2, supporting the idea that near-coast mangroves receive a higher concentration of nutrients and sediment.

CHAPTER 5

CONCLUSION

To conclude, this study calculated vertical hydraulic conductivity values for sawgrass and mangrove peat sediment located in Shark River Slough, a principal, fresh waterway for the Everglades. ANOVA tests showed a statistically significant difference in the lower salinity vertical hydraulic conductivity values between the sawgrass and mangrove peat sediment- the sawgrass peat having higher hydraulic conductivity ranges than the mangrove peat. A higher specific yield and lower bulk density was also observed for the sawgrass peat as compared to the mangrove peat. The results of this study suggest that the peat located in sawgrass regions have a higher hydrologic connectivity, as demonstrated by the higher hydraulic conductivity and specific yield and lower bulk density. Nutrient values were also lower in the sawgrass peat sediment as compared to the mangrove peat sediment, which could signify a greater ability for nutrients to mobilize from sawgrass regions compared to mangrove regions. If the pulse events bringing nutrients to the mangrove regions were spaced out enough, it's possible that it would help in fertilizing the mangroves, instead of depriving them from essential nutrients. This study also found that the hydrologic properties of sawgrass and mangrove peat sediments are not altered by a short term (pulse) exposure to saltwater intrusion. The results of this study can be applied to coastal wetlands worldwide, vulnerable to pulse events like storm surges.

REFERENCES

Anderson, G.H., Smith, T.J., III, and Balentine, K.M., 2014, Land-margin ecosystem hydrologic data for the coastal Everglades, Florida, water years 1996–2012: U.S. Geological Survey Data Series 853, 38 p.

Bear, J., Cheng, A.H.D., Sorek, S., Ouazar, D. and Herrera, I. eds., 1999. *Seawater intrusion in coastal aquifers: concepts, methods and practices* (Vol. 14). Springer Science & Business Media.

Butler, James Johnson. The design, performance, and analysis of slug tests. Crc Press, 2019.

Castañeda-Moya, E., Twilley, R.R., Rivera-Monroy, V.H. et al. Sediment and Nutrient Deposition Associated with Hurricane Wilma in Mangroves of the Florida Coastal Everglades. Estuaries and Coasts 33, 45–58 (2010).

Chambers, L.G., Davis, S.E., Troxler, T., Boyer, J.N., Downey-Wall, A. and Scinto, L.J., 2014. Biogeochemical effects of simulated sea level rise on carbon loss in an Everglades mangrove peat soil. Hydrobiologia, 726(1), pp.195-211.

Clymo, R. S., and P. M. Hayward. "The ecology of Sphagnum." Bryophyte ecology. Springer, Dordrecht, 1982. 229-289.

Craft, Christopher B., and Curtis J. Richardson. "Soil characteristics of the Everglades peatland." Everglades experiments. Springer, New York, NY, 2008. 59-72.

DiFrenna, Vincent J., René M. Price, and M. Reza Savabi. "Identification of a hydrodynamic threshold in karst rocks from the Biscayne Aquifer, south Florida, USA." Hydrogeology Journal 16.1 (2008): 31-42.

Fetter, C. W. (2001). Applied hydrogeology. Upper Saddle River, N.J., Prentice Hall.

Flora, M.D., Rosendahl, P.C. Historical changes in the conductivity and ionic charateristics of the source water for the Shark River Slough, Everglades National Park, Florida, U.S.A.. Hydrobiologia 97, 249–254 (1982).

Harvey, J.W., Krupa, S.L. and Krest, J.M., 2004. Ground water recharge and discharge in the central Everglades. Groundwater, 42(7), pp.1090-1102.

Harvey, J.W., Saiers, J.E. and Newlin, J.T., 2005. Solute transport and storage mechanisms in wetlands of the Everglades, south Florida. Water Resources Research, 41(5).

Heliotis, Francis D. "Water storage capacity of wetland used for wastewater treatment." Journal of Environmental Engineering 115.4 (1989): 822-834.

Hoag, R. S., and J. S. Price. "A field-scale, natural gradient solute transport experiment in peat at a Newfoundland blanket bog." Journal of Hydrology 172.1-4 (1995): 171-184.

Hoag, Rob S., and Jonathan S. Price. "The effects of matrix diffusion on solute transport and retardation in undisturbed peat in laboratory columns." Journal of Contaminant Hydrology 28.3 (1997): 193-205.

Ivanov, K.E. 1981. Water Movement in Mirelands. London, Academic Press Inc., 276 pp.

Joosten, H. and Clarke, D., 2002. Wise use of mires and peatlands. International Mire Conservation Group and International Peat Society, 304.

Kelly, Thomas J., et al. "The high hydraulic conductivity of three wooded tropical peat swamps in northeast Peru: measurements and implications for hydrological function." *Hydrological processes* 28.9 (2014): 3373-3387.

Lodge, Thomas E. The Everglades handbook: understanding the ecosystem. Crc Press, 2016.

Miettinen, J., Liew, S.C. Status of Peatland Degradation and Development in Sumatra and Kalimantan. AMBIO 39, 394–401 (2010).

Perry, W. Elements of South Florida's Comprehensive Everglades Restoration Plan. Ecotoxicology 13, 185–193 (2004).

Price, Rene M., Peter K. Swart, and James W. Fourqurean. "Coastal groundwater discharge–an additional source of phosphorus for the oligotrophic wetlands of the Everglades." Hydrobiologia 569.1 (2006): 23-36.

Reddy, M.M., Reddy, M.B., Kipp, K.L., Burman, A., Schuster, P. and Rawlik Jr, P.S., 2008. Peat porewater chloride concentration profiles in the Everglades during wet/dry cycles from January 1996 to June 1998: field measurements and theoretical analysis. Hydrological Processes: An International Journal, 22(11), pp.1713-1724.

Regier, Peter, and Rudolf Jaffé. "Short-term dissolved organic carbon dynamics reflect tidal, water management, and precipitation patterns in a subtropical estuary." *Frontiers in Marine Science* 3 (2016): 250.

Rezanezhad, Fereidoun, et al. "Structure of peat soils and implications for water storage, flow and solute transport: A review update for geochemists." Chemical Geology 429 (2016): 75-84.

Rivera-Monroy, V.H., Twilley, R.R., Davis III, S.E., Childers, D.L., Simard, M., Chambers, R., Jaffe, R., Boyer, J.N., Rudnick, D.T., Zhang, K. and Castañeda-Moya, E., 2011. The role of the Everglades Mangrove Ecotone Region (EMER) in regulating nutrient cycling and wetland productivity in south Florida. Critical Reviews in Environmental Science and Technology, 41(S1), pp.633-669.

Servais, Shelby, et al. "Saltwater intrusion and soil carbon loss: Testing effects of salinity and phosphorus loading on microbial functions in experimental freshwater wetlands." Geoderma 337 (2019): 1291-1300.

Sirianni, Matthew J., and Xavier Comas. "Changes in physical properties of Everglades peat soils induced by increased salinity at the laboratory scale: Implications for changes in biogenic gas dynamics." *Water Resources Research* 56.6 (2020): e2019WR026144.

Smoak, Joseph M., et al. "Sediment accretion and organic carbon burial relative to sea-level rise and storm events in two mangrove forests in Everglades National Park." Catena 104 (2013): 58-66.

Sullivan, Pamela L., et al. "The role of recharge and evapotranspiration as hydraulic drivers of ion concentrations in shallow groundwater on Everglades tree islands, Florida (USA)." Hydrological Processes 28.2 (2014): 293-304.

Wacker, M.A., Cunningham, K.J., and Williams, J.H., 2014, Geologic and hydrogeologic frameworks of the Biscayne aquifer in central Miami-Dade County, Florida: U.S. Geological Survey Scientific Investigations Report 2014–5138, 66 p.

Wilson, B.J., Servais, S., Charles, S.P., Mazzei, V., Gaiser, E.E., Kominoski, J.S., Richards, J.H. and Troxler, T.G., 2019. Phosphorus alleviation of salinity stress: Effects of saltwater intrusion on an Everglades freshwater peat marsh. Ecology, 100(5), p.e02672.

Woodroffe, C., “Mangrove sediments and geomorphology” in Tropical Mangrove Ecosystems, A. I. Robertson, D. M. Alongi, Eds. (American Geophysical Union, Washington, DC, 1992), pp. 7–41.

Woods, Jeff. "Surface water discharge and salinity monitoring of coastal estuaries in Everglades National Park, USA, in support of the Comprehensive Everglades Restoration Plan." Proceedings of the 3rd International Perspective on Current & Future State of Water Resources & the Environment, Chennai, India (2010).

Xiaochen Zhao, Victor H. Rivera-Monroy, Hongqing Wang, Z George Xue, Cheng-Feng Tsai, Clinton S. Willson, Edward Castañeda-Moya, Robert R. Twilley, Modeling soil porewater salinity in mangrove forests (Everglades, Florida, USA) impacted by hydrological restoration and a warming climate, Ecological Modelling, Volume 436, 2020

Zapata-Rios, Xavier, and René M. Price. "Estimates of groundwater discharge to a coastal wetland using multiple techniques: Taylor Slough, Everglades National Park, USA." *Hydrogeology Journal* 20.8 (2012): 1651-1668.