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USING SEDIMENT ORGANIC GEOCHEMISTRY TO INTERPRET LATE HOLOCENE BARRIER ISLAND AND ESTUARINE EVOLUTION, NORTH CAROLINA, USA
(Under the direction of Dr. Siddhartha Mitra)
East Carolina University, Department of Geological Sciences, June, 2014

Deconvolving the relationship between meteorological and oceanographic phenomena and associated impacts to coastal systems is critical to understanding the future of coastal systems worldwide. North Carolina’s barrier islands, commonly known as the Outer Banks, and the associated Albemarle-Pamlico estuarine system is an example of a coastal ecosystem that will be affected in the future by such phenomena. Based on sedimentological and micropaleontological proxies, past research suggests that intense storm activity may have caused extensive segmentation of the Outer Banks during the Holocene. To gain a better understanding of meteorological and oceanographic factors affecting the evolution of North Carolina’s coastal system, organic geochemical techniques were applied to sediments from two cores collected within Pamlico Sound. Specifically, down-core trends in total organic carbon (TOC), refractory black carbon (BC), refractory soot carbon, labile organic carbon (OC), total nitrogen (TN), and their stable isotopic signatures ($\delta^{13}C$ and $\delta^{15}N$) were analyzed in order to assess the varying inputs of marine and terrestrial organic matter into Pamlico Sound.

In Chapter 1, TOC, BC/TOC, soot/TOC, TOC/TN, and $\delta^{13}C_{TOC}$ were compared to a paleoclimatological proxy of El Niño Southern Oscillation (ENSO) and interpretations of stages of the North Atlantic Oscillation (NAO) throughout the mid-to-late Holocene. These phenomena have been suggested to influence southeast U.S. temperature, precipitation, and Atlantic hurricanes, all of which ultimately affect barrier island and estuarine evolution, as recorded in Pamlico Sound sediments.

In general, there has been little consideration of carbon sequestered in coastal systems throughout the Holocene, a period that shows anthropogenic changes in the carbon cycle. This is an important omission, as most of the sediments exported by the world's major rivers are currently deposited on continental shelves (e.g., deltas and estuaries). Chapter 2 examines how the degree of barrier island segmentation affects abundance and source of carbon sequestered in Pamlico Sound throughout the mid-to-late Holocene. Total organic carbon sequestered in Pamlico Sound was calculated over the past 3500 years. Since the ultimate fate of TOC depends on its composition (e.g., whether it is labile or refractory), both OC and BC in sediments were quantified down-core. Results show that greater continuity of a barrier island chain significantly increased the amount of carbon sequestered in sediments. To our knowledge, this chapter provides the first quantitative estimate of the amount of carbon sequestered as a function of its composition since the mid-Holocene in any coastal system. The results of both chapters suggest that ENSO, NAO, eastern North Carolina temperature and precipitation, Atlantic storm activity, Outer Banks barrier island evolution, and coastal carbon sequestration were linked throughout the mid-to-late Holocene.

Using sediment organic geochemistry to interpret late Holocene barrier island and estuarine evolution, North Carolina, USA

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Dedication

I would like to dedicate this thesis to my family. They have always supported me throughout my college career. Most importantly I dedicate this thesis to my wife. She has always thought the most of me and encouraged me to do the best I can. Thank you.

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I would first like to thank my advisor Dr. Siddhartha Mitra for his guidance throughout this project. He, along with many others, has made sure that I have received a great education during my time at East Carolina University. I would also like to thank my other committee members on this project. Dr. David Mallinson, Dr. Eduardo Leorri, and Dr. Rosana Ferreira have also given me scientific guidance throughout this project. Also, thank you Dr. Stephen Culver, who was not on my committee, but took time out of his busy schedule to give me scientific and editorial input throughout my time researching and writing.

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CHAPTER 1. A 7000 YEAR LINK BETWEEN MID-ATLANTIC REGIONAL FIRES, CLIMATIC PHENOMENA, AND BARRIER ISLAND EVOLUTION, NORTH CAROLINA, USA

Abstract

Atlantic hurricane genesis is a major concern for coastal regions of eastern North America. The frequency and path of Atlantic hurricanes throughout the Holocene, which has been linked to El Niño Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO), have been documented previously in the sedimentary record using a variety of proxies including sediment grain size, foraminiferal abundance, and bulk organic carbon geochemistry. Along with Atlantic hurricane frequency, ENSO has been linked to temperature and precipitation conditions in the southeast U.S. Although periods of inactive El Niño have been shown to cause warm and dry conditions in the southeast U.S., which can lead to an increase in the frequency of regional fires, the link between ENSO and regional fires is equivocal. Using down-core relative abundances of black carbon and soot carbon, two tracers for organic matter pyrolysis, in sediment cores from Pamlico Sound, North Carolina, we report a link between regional fires, ENSO, NAO, Atlantic storm frequency, and barrier island evolution throughout the mid-to-late Holocene. High relative abundance of aeolian soot (soot/TOC) in the sedimentary record during periods of inactive El Niño suggests that these periods were coincident with dry conditions in the southeast U.S. and greater fire susceptibility in vegetation. In contrast, periods of active El Niño are coincident with more moist conditions in the southeast U.S, as recorded by higher relative abundance of erosion-derived black carbon (BC/TOC) in the Pamlico Sound sedimentary record. Other studies have indicated that hurricanes are more frequent in the Atlantic during times of inactive El Niño and less frequent during times of active El Niño. Other studies have also indicated that during times of positive NAO, Atlantic hurricanes tend to track northward along

the U.S. east coast, and during times of negative NAO, Atlantic hurricanes tend to track into the Gulf of Mexico. During times of inactive El Niño conditions in the Pacific Ocean and suggested times of positive NAO conditions in the Atlantic Ocean, proxies of marine influence are observed in sediment cores collected from Pamlico Sound. One explanation for these results is intense storm activity, most likely hurricanes, causing extensive segmentation of the barrier islands, which resulted in advection of Gulf Stream waters into the Sound. These results suggest that Pacific and Atlantic Ocean meteorological and oceanographic phenomena may have had an influence on regional wild fires, transportation of sediments from wild fires, and barrier island evolution of coastal North Carolina during the mid-to-late Holocene.

Introduction:

North Carolina's coastline is located on a passive continental margin of the southeast U.S., and consists of the second largest estuarine/lagoonal system in the contiguous U.S. (Fig. 1-1). This estuarine system has characteristics of a drowned river-valley estuary and a bar-built estuary, and is currently wave-dominated and micro-tidal (Wells and Kim, 1989). Residence time of water in the system is approximately 11 months (Mallinson et al., 2008), which is primarily controlled by four rivers discharging fresh water into the lagoonal system and the connection to the ocean through five widely spaced inlets (Fig 1-1). Holocene deposits are transgressive in response to sea-level rise since the Last Glacial Maximum and overlie a coastal plain of Pleistocene deposits. Paleo-geomorphology was formed from incision of rivers during the Last Glacial Maximum (Riggs and Ames, 2003; Mallinson et al., 2010), and is now the main control on current depositional settings of the environment. A majority of this lagoonal/estuarine

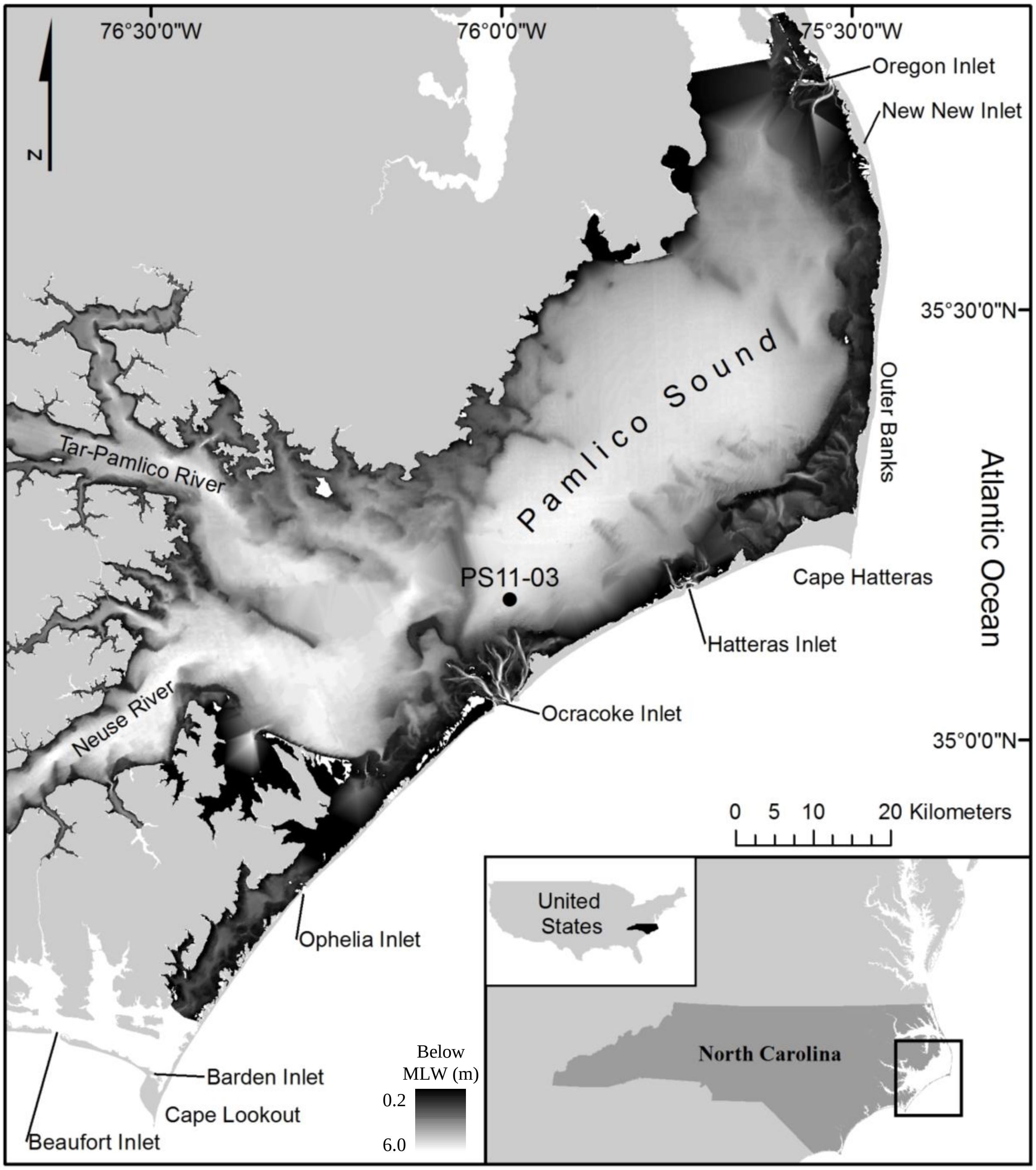

Figure 1-1. Map of North Carolina's northeast coast with Pamlico Sound, Outer Banks, inlets, and location of sediment core PS11-03 (same location as core PS-03) (Culver et al., 2007; Grand Pre et al., 2011).

system consists of Pamlico Sound, with an area of ~4350 km^2 (Pietrafesa et al., 1986), and the Outer Banks barrier islands, with a length of ~270 km (Mallinson et al., 2011) (Fig. 1-1).

Geophysical data, as well as micropaleontological, sedimentological, and chronological data from over 100 sediment cores collected throughout Pamlico Sound and the Outer Banks suggest that considerable geomorphological changes have occurred throughout the system during the Holocene (Culver et al., 2007; Grand Pre et al., 2011; Mallinson et al., 2011). Down-core sedimentary lithofacies and relative abundance/diversity of marine foraminiferal assemblages suggest that the Sound was exposed to open marine conditions ca. 4000 to 3500 cal. yBP and ca. 1000 to 500 cal. yBP as a result of extensive barrier island segmentation, probably caused by increased intensity and frequency of Atlantic storms (most likely hurricanes) (Culver et al., 2007; Grand Pre et al., 2011; Mallinson et al., 2011).

Hurricane path and frequency in the Atlantic Ocean have been shown to be related to the position of the Bermuda High, which is associated with the North Atlantic Oscillation (NAO) (Elsner et al., 2000; Liu and Fearn, 2000; Elsner et al., 2001; Scott et al., 2003), and El Niño Southern Oscillation (ENSO) conditions in the Pacific Ocean, respectively (Gray 1984; Elsner et al., 2001; Donnelly and Woodruff, 2007; Smith et al., 2007). The NAO refers to the atmospheric pressure gradient between the Bermuda High and Icelandic Low. During times of positive NAO (negative NAO) there is a high (low) atmospheric pressure gradient. This research considers the position of the Bermuda High during different stages of the NAO. During times of positive NAO, the Bermuda High is in a northeast position, which tends to cause hurricanes to track northward along the U.S. east coast. Conversely, during times of negative NAO, the Bermuda High is in a southwest position, which has been shown to result in hurricanes tracking intot he Gulf of Mexico to a greater extent than period of positive NAO (Elsner et al., 2000; Elsner et al., 2001). Variability in ENSO has been shown to affect hurricane frequency in the Atlantic. During periods of active El Niño conditions in the Pacific, increased vertical wind shear is observed in the Atlantic, which inhibits the formation of hurricanes. Conversely, during inactive El Niño conditions in the Pacific, a decrease in vertical wind shear is observed in the Atlantic resulting in an increase in frequency of hurricanes (Gray 1984; Elsner et al., 2001; Donnelly and Woodruff, 2007; Smith et al., 2007). Hurricanes, and not other Atlantic storms, are discussed in the context of this research because of their production of high storm tides, which is a major factor in evolution of coastal systems (Riggs and Ames, 2003). Regional temperature and precipitation in the southeast U.S. are also affected by variability in ENSO. During times of active El Niño the southeast U.S. experiences relatively cold and wet conditions, while during times of inactive El Niño the southeast U.S experiences warm and dry conditions (Ropelewski and Halpert, 1986; Kurtzman and Scanlon, 2007). The warm and dry conditions during times of inactive El Niño cause vegetation to be more vulnerable to combustion, which can lead to an increase in fire occurence (Balling et al., 1992). Increased fires result in the formation of pyrogenic residues known as black carbon (BC) (Goldberg, 1985).

Total BC is generally defined as highly condensed and refractory carbonaceous products resulting from organic matter combustion and ranging along a continuum from slightly charred biomass to soot (Goldberg, 1985, Masiello, 2004). Soot, which is also pyrogenic, specifically originates from condensation of gases formed during pyrolysis. This renders soot to be relatively smaller than other types of BC (e.g., slightly charred biomass, char), and thus useful as a tracer of combustion aerosols that can be transported atmospherically (up to 1000s of km). In contrast, other larger portions of total BC are primarily located more proximal to the source of combustion (m to km) (Masiello, 2004). Various sub compartments of the total BC combustion continuum have been used to reconstruct sedimentary cycles of watershed-wide wildfires in relation to regional climate (e.g., Millspaugh et al., 2000; Liu and Fearn, 2008; Mitra et al., 2009).

Other geochemical variables (total organic carbon/total nitrogen (TOC/TN) and $\delta^{13}C$) in sediments have been used to determine changes in source of organic matter deposited in coastal systems. For example, marine organic matter is known to have a lower TOC/TN molar ratio (<10) and more enriched $\delta^{13}C_{TOC}$ (-18.0‰ to -21.0‰) in comparison to TOC/TN (>12) and $\delta^{13}C_{TOC}$ (-25.0‰ to -33.0‰) of terrestrial organic matter (Peters et al., 1978; Peterson and Fry, 1987; Matson and Brinson, 1990; Lamb et al., 2006).

The objective of Chapter 1 is to determine if there is a link between down-core organic geochemical proxies (TOC, BC, soot, TN, and $\delta^{13}C_{TOC}$) in Pamlico Sound, regional fires, Atlantic storm frequency, barrier island evolution, and ENSO and NAO phenomena.

Materials and Methods:

A sediment core was collected from Pamlico Sound, North Carolina (Fig. 1-1). Core PS11-03 (7.8 m length, Pleistocene not reached), was collected from south-central Pamlico Sound within a paleo-river valley (paleo-Pamlico Creek) at latitude 35° 11’ 2.3” N and longitude 76° 0’ 48.1” W in a water depth of 6.5 m (Fig. 1-1), and was analyzed for TOC, relative abundance of black carbon in total organic carbon (BC/TOC), relative abundance of soot carbon in total organic carbon (soot/TOC), $\delta^{13}C_{TOC}$, and molar ratio of TOC/TN (Fig. 1-2). PS11-03 is a replicate core of PS-03 studied by Culver et al., (2007) and Grand Pre et al., (2011) (Fig. 1-2A).

Hydrochloric acid was used to dissolve carbonates within samples in order to isolate TOC. In this study, BC is operationally defined as the residue remaining after a robust hydrochloric acid and hydrofluoric acid demineralization followed by a 400 hour chemical oxidation in potassium dichromate-sulfuric acid (additional methodological details in Chapter 2) (Masiello et al., 2002). Loss of hydrophobic soot often occurs in this procedure due to extensive handling required. The loss of soot in this procedure can result in the preferential isolation of larger BC particles (char) (Elmquist et al., 2004). Thus, a separate thermal oxidation procedure requiring minimal manipulation was used to isolate the soot portion of the total BC continuum (Elmquist et al., 2006).

Results and Discussion:

In core PS11-03, ca. 7000 to 4000 cal. yBP (7.8 m to 5.5 m), sediments contain an average of 37.5 ± 12.5% and 10 ± 6% of BC/TOC and soot/TOC, respectively (Fig. 1-2D and E). Molar ratio of TOC/TN and $\delta^{13}C_{TOC}$ are 14 ± 2 and -23.0 ± 0.8‰, respectively for this portion of the core (Fig. 1-2F and G). During this time period the barrier island and Sound system have been suggested to be developed, which would have resulted in prominent estuarine conditions (Grand Pre et al., 2011). However, the high variability of TOC/TN and $\delta^{13}C_{TOC}$ (Fig. 1-2F and G) suggest a more dynamic depositional environment (Peters et al., 1978; Peterson and Fry, 1987; Lamb et al., 2006) during this time period. One explanation for such an observation is that the estuarine system had very shallow water depths with variable input from rapidly eroding wetland areas, such as marshes, during this time period. Presently, North Carolina marshes vastly consist of *Juncus roemerianus* and *Spartina alterniflora*, which are C_3 and C_4 plants, respectively (Matson and Brinson, 1990). Different amounts of C_3 and C_4 inputs associated with these two marsh plants (O'Leary, 1988) is a possible explanation for the variation in $\delta^{13}C_{TOC}$ as observed in Fig. 1-2G. Also, the estuary was a much shallower system, and the periodic influence from seasonal fluvial discharge would have been more of a factor in organic matter cycling throughout this time period, which may explain high variability observed in TOC/TN and $\delta^{13}C_{TOC}$.

Organic matter cycling in coastal systems can be affected by climatic phenomena. Rodbell et al., (1999) established a relationship (referred to as the gray scale index) between ENSO and sediment deposited in a lagoon located in southern Ecuador (Fig. 1-2H). Variability in ENSO was low until ca. 5000 cal. yBP (Fig 1-2H), which has been attributed to changes in solar insolation (Rodbell et al., 1999; Clement et al., 2000). This would make discrete changes in temperature and precipitation in the southeast U.S. less likely to be correlated with the variability in ENSO during this time period (Table 1-1). The early Holocene (~7000 cal. yBP) has been shown to be a time of drier conditions in this region, which has been suggested to be caused by predominate stages of negative NAO (Cronin et al., 2005)

Beginning ca. 4000 cal. yBP and continuing to 3500 cal. yBP (5.5 m to 3.5 m), relative abundance of BC/TOC and soot/TOC abruptly changes to an average of 25.0 ± 4.0% and 60 ± 20%, respectively (Fig. 1-2D and E). During this time the ENSO gray scale index indicates a period of inactive El Niño (Fig. 1-2H). Conditions of inactive El Niño in the Pacific may have caused warm and dry conditions in the southeast U.S. (Ropelewski and Halpert, 1986; Kurtzman and Scanlon, 2007). Warm and dry conditions in the southeast U.S. would presumably result in vegetation being more vulnerable to combustion, which may have caused more fires regionally (Balling et al., 1992). However, a lack of precipitation during such warm and dry conditions would result in minimal erosion and fluvial runoff of larger BC particles originating from these fires. The period of 4000 to 3500 cal. yBP is represented by low BC/TOC but high soot/TOC concentrations (Fig. 1-2D and E), suggesting overall drier conditions in eastern North Carolina,

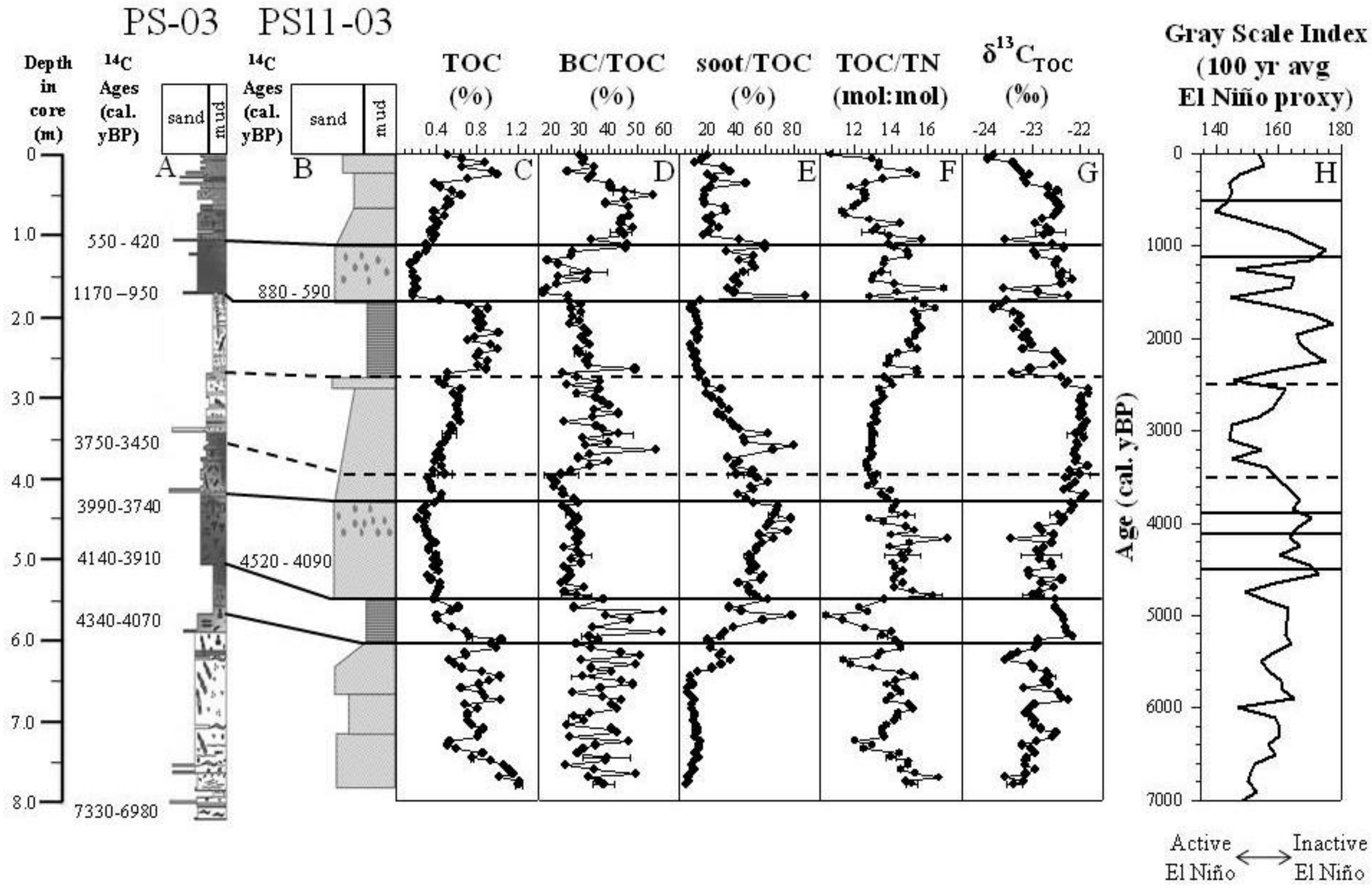

Figure 1-2. On the left, depth applies to PS-03 and PS11-03. Solid lines correlate known radiocarbon age estimates and lithologic units in cores PS-03 and PS11-03. Dotted lines correlate inferred radiocarbon dates and lithologic units. (A) Core log for PS-03 with radiocarbon age estimates to the left (Culver et al., 2007). (B) Core log for PS11-03 with radiocarbon age estimates to the left. (C) Percentage TOC. (D) Percentage BC/TOC. (E) Percentage Soot/TOC. (F) TOC/TN molar ratio. (G) $\delta^{13}C_{TOC}$. (H) Gray scale index indicating variability in ENSO (modified from Rodbell et al., 1999).

which would have promoted regional fires and aeolian transport of soot from these fires (Table 1-1). Also, beginning ca. 4000 cal. yBP and continuing until ca. 3800 cal. yBP (5.6 m to 3.7 m), TOC/TN and $\delta^{13}C_{TOC}$ show little variation with an average of -22.8 ± 0.4‰ and 14.5 ± 0.5, respectively (Fig. 1-2F and G). From ca. 3800 to 3500 cal. yBP (3.7 m to 3.5 m) TOC/TN decreases to 13.0 ± 0.5 and $\delta^{13}C_{TOC}$ gradually enriches to -22.0 ± 0.4‰ (Fig. 1-2F and G). The sedimentologic and micropaleontologic record from ca. 4000 to 3500 cal. yBP shows the presence of sand deposits and foraminiferal assemblages suggesting a strong marine influence in Pamlico Sound during this period (Fig. 1-2A, B, F, and G) (Grand Pre et al., 2011). The inactive El Niño conditions during this time (Fig. 1-2H) would reduce vertical wind shear in the Atlantic, which would lead to an increase in frequency of hurricanes (Gray 1984; Elsner et al., 2001; Smith et al., 2007). A period of more frequent Atlantic hurricanes and the relatively low TOC/TN and enriched $\delta^{13}C_{TOC}$, taken together, are consistent with the idea of a greater marine influence in Pamlico Sound resulting from wide-spread barrier island segmentation caused by intense storm activity, as suggested by Grand Pre et al., (2011) (Table 1-1).

At ca. 3500 cal. yBP (3.7 m) there is an abrupt increase in BC/TOC from 25% to 42% and a decrease in soot/TOC from 60% to 40% (Fig. 1-2D and E). Also, TOC/TN begins to gradually increase (Fig. 1-2E). These trends in organic geochemistry can be explained by a change from a period of inactive El Niño to active El Niño (Fig. 1-2H) (Rodbell et al., 1999). The shift in ENSO may have resulted in a change from warm and dry to cool and wet conditions in the southeast U.S. (Ropelewski and Halpert, 1986; Kurtzman and Scanlon, 2007) and increased vertical wind shear in the Atlantic causing a decrease in frequency of hurricanes (Gray 1984; Elsner et al., 2001; Smith et al., 2007). Wet conditions may have caused a decrease in fires and resulted in the decrease in soot/TOC, but larger BC particles stored in soils from fires during the previous inactive El Niño period would be transported to Pamlico Sound by erosion and fluvial drainage resulting in the increase in BC/TOC (Fig. 1-2D and E). The decrease in hurricane activity during the active El Niño conditions would allow the barrier islands to develop without major disturbance, resulting in an overall increase of carbon rich terrestrial organic matter deposited in the Sound causing TOC/TN to increase (Fig. 1-2F) (Table 1-1).

There is a gradual decrease from ca. 3500 to 1100 cal. yBP (3.7 m to 1.8 m) in both BC/TOC and soot/TOC from 42% to 28% and 40% to 10%, respectively (Fig. 1-2D and E). Also during this time period, TOC/TN increases substantially from 13 to 16 while $\delta^{13}C_{TOC}$ concomitantly becomes depleted from -22.0‰ to -23.8‰ (Fig. 1-2F and G). These trends in sediment geochemistry are coincident with a period of active El Niño conditions until ca. 2500 cal. yBP (Fig. 1-2H). The active El Niño conditions would likely inhibit the formation of hurricanes, which would then presumably allow the barrier islands to continue developing without major disturbance (Table 1-1). At ca. 2500 cal. yBP the ENSO record switches to the beginning of a period of inactive El Niño (Fig. 1-2H), which ideally would be coincident with more Atlantic hurricanes (Gray, 1984; Smith et al., 2007). However, ca. 3000 to 1000 cal. yBP, it has been suggested that negative NAO conditions were prevalent (Scott et al., 2003). Negative NAO conditions imply the Bermuda High was in a southerly position, which would inhibit U.S. east coast hurricane landfall (Elsner et al., 2000; Elsner et al., 2001). During this time period, the suggested negative NAO anomalies have been shown to be coeval with intense and more frequent storm activity in the Gulf of Mexico and the northeast Atlantic states (Liu and Fearn, 1993; Liu and Fearn, 2000; Noren et al., 2002; Scileppi and Donnelly, 2007), and with less frequent storm activity in the mid-Atlantic states as evidenced by sediment lithology (Scott et al.,

Table 1-1. Summary of results and discussion of link between sediment geochemistry in Pamlico Sound, climatic phenomena, and barrier island evolution during the Holocene.

Time	**Predominant Climate**		**Hurricane**			
(cal. yBP)	**ENSO**	**NAO**	**Frequency**	**Trajectory**	**Geochemistry**	**Barrier Islands**
500 to present	Active El Niño	Positive	low	U.S. east coast	increasing TOC, high BC/TOC followed by a decrease, low soot/TOC, $\delta^{13}C_{TOC}$ depletion	Redeveloping/Continous
1100 to 500	Inactive El Niño	Positive	high	U.S. east coast	low BC/TOC, high soot/TOC, lowTOC/TN, $\delta^{13}C_{TOC}$ enrichment	Segmented
2500 to 1100	Inactive El Niño	Negative	high	Gulf of Mexico	high TOC, decreasing BC/TOC and soot/TOC, high TOC/TN, $\delta^{13}C_{TOC}$ depleted	Continuous
3500 to 2500	Active El Niño	Negative	low	Gulf of Mexico	high BC/TOC, decreasing soot/TOC, increasing TOC/TN	Redeveloping
4000 to 3500	Inactive El Niño	N/A	high	N/A	low BC/TOC, High soot/TOC, decreasing TOC/TN, $\delta^{13}C_{TOC}$ enrichment	Segmented
7000 to 4000	No Variability	N/A	N/A	N/A	highly variable BC/TOC, TOC, TN, and $\delta^{13}C_{TOC}$	Present

2003; Mann et al., 2009a). The observed absence of intense storm activity on the U.S. east coast is also evidenced in the deposition of fine-grained estuarine sediments throughout Pamlico Sound during this time period (Fig 1-2A and B) (Culver et al., 2007; Grand Pre et al., 2011). The presence of a barrier island chain would minimize the physical export of phytoplankton and terrestrial particulate organic matter from the Sound, as evidenced by an increase of TOC buried in the Sound, depletion in $\delta^{13}C_{TOC}$, and an increase in TOC/TN (Fig. 1-2C, F, and G). The increase of TOC consequently leads to the decreases in relative abundances of BC/TOC and soot/TOC during this time period (Fig. 1-2C, D, and E) (Table 1-1).

At ca. 1100 cal. yBP and continuing until ca. 500 cal. yBP (1.8 m to 1.1 m), the relative abundances of BC/TOC abruptly decreases from 28% to 18%, while soot/TOC abruptly increases from 10% to 50% (Fig. 1-2D and E). Also during this time period, TOC/TN decreases abruptly and $\delta^{13}C_{TOC}$ enriches abruptly from 16 to 13 and -23.8‰ to -22.2‰, respectively (Fig. 1-2F and G). At ca. 1100 cal. yBP the ENSO gray scale index indicates a period of inactive El Niño (Fig., 1-2H). This is during the time known as the Medieval Climate Anomaly (MCA), with several paleo-reconstructions of ENSO during the MCA indicating a period of inactive El Niño conditions (Cobb et al., 2003; Rein et al., 2004; Mann et al., 2009a; Mann et al., 2009b; Burgman et al. 2010). The MCA has also been shown to be a period of increased storm activity in the Atlantic (Mann et al., 2009b). It has been suggested that positive NAO conditions were prevalent during this time period (Scott et al., 2003), which would cause Atlantic hurricanes to make landfall on the east U.S. coast more frequently (Elsner et al., 2000; Liu and Fearn, 2000; Elsner et al., 2001). At ca. 1100 cal. yBP there is a sand layer in the sedimentary record interpreted as a high energy marine environment resulting from intense storm activity causing extensive segmentation of the Outer Banks, which allowed advection of Gulf Stream waters into

Pamlico Sound (Fig. 1-2A and B) (Culver et al., 2007; Grand Pre et al., 2011). This initial interpretation has been further confirmed based on geophysical, sedimentological, and micropaleontological studies by other researchers (Mallinson et al., 2011; Peek et al., 2013). Hurricane activity at this time exhibits an increase in frequency on the U.S. east coast (Scott et al., 2003; Mann et al., 2009). Conversely, hurricane activity in the Caribbean and Gulf of Mexico is shown to be quiescent between ca. 1100 to 500 cal. yBP (Liu and Fearn, 2000; Donnelly and Woodruff, 2007). Collectively, the geochemical record in core PS11-03, in combination with the suggested northerly position of the Bermuda High and the period of inactive El Niño conditions during the MCA, are in congruence with the increase in hurricane activity on North Carolina’s coast, as well as warm and dry conditions in the southeast U.S. (Ropelewski and Halpert, 1986; Kurtzman and Scanlon, 2007). Specifically, at a regional level, the MCA has been shown to be a time of extreme drought on the U.S. east coast (Burgman et al., 2010, Cronin, et al., 2010), including North Carolina (Stahle et al., 2013). The warm, dry, and drought conditions presumably caused more regional fires, which explains the increase in soot/TOC (Fig. 1-2D and E) in Pamlico Sound (Table 1-1).

At ca. 500 cal. yBP (1.1 m) BC/TOC abruptly increases from 18% to 46% and soot/TOC abruptly decreases from 50% to 15% (Fig 1-2D and E). This coincides with a period of active El Niño conditions (Fig. 1-2H). Active El Niño conditions may have caused a period of cool and wet conditions in the southeast U.S. (Ropelewski and Halpert, 1986; Kurtzman and Scanlon, 2007). The increase in precipitation would presumably result in conditions unfavorable for sustaining fires, but lead to transport of larger BC particles stored in soils from fires during previous inactive El Niño conditions. These conditions are observed by an increase in BC/TOC and decrease in soot/TOC during this time period (Fig. 1-2D and E).

Over the past ~500 years TOC has gradually increased to 1.0%, BC/TOC has gradually decreased from 46% to 30%, soot/TOC has remained relatively low at 15%, and $\delta^{13}C_{TOC}$ has gradually become depleted from -22.5‰ to -23.8‰ (Fig 1-2 C, D, E, F, and G). Notably, these geochemical observations occur over the same time period that the barrier islands have been in a redeveloping stage, leading to their current, more contiguous morphology, which has restricted exchange between marine water of the Atlantic Ocean and estuarine water of Pamlico Sound (Mallinson et al., 2011). The onset of active El Niño conditions after the MCA likely resulted in a decrease in frequency of hurricanes, allowing the barrier islands to develop without major disturbance. This is also during a time known as the Little Ice Age and has shown be a period of wet and cool conditions (Cronin et al., 2010). The presence of the barrier islands has prevented the physical export of phytoplankton and terrestrial particulate organic carbon from the Sound, which in turn resulted in a gradual increase of TOC buried in the Sound and depletion of $\delta^{13}C_{TOC}$ (Fig. 1-2C and G). The gradual increase in TOC resulted in the gradual decrease in BC/TOC and low soot/TOC (Fig. 1-2C, D, and E) (Table 1-1).

Conclusion:

The data presented suggest that variability in ENSO throughout the mid-to-late Holocene shows a link to precipitation and temperature in eastern North Carolina. During times of inactive El Niño, eastern North Carolina experiences warm and dry conditions, resulting in more frequent fires, leading to high soot/TOC and low BC/TOC deposition in the Sound. Conversely, during times of active El Niño, eastern North Carolina experiences cool and wet conditions, resulting in fewer fires, leading to high BC/TOC and low soot/TOC deposition in the Sound. Hurricane frequency and path throughout the mid-to-late Holocene have been linked to variability in ENSO and NAO. Time periods of inactive El Niño have been linked to an increase in hurricane frequency in the Atlantic, and during times of positive NAO, hurricanes tend to track northward along the U.S. east coast. Extensive barrier island segmentation presumably caused by intense storm activity is observed in the Sound ca. 1100 cal. yBP, which occurred simultaneously with inactive El Niño and suggested positive NAO conditions. Our results suggest that throughout the mid-to-late Holocene, meteorological and oceanographic conditions in the Pacific and Atlantic Oceans played a role in the evolution of the Outer Banks barrier island-Pamlico Sound coastal system, precipitation and temperature in eastern North Carolina, and regional wild fires in the mid-Atlantic region.

CHAPTER 2. EFFECT OF BARRIER ISLANDS ON CARBON BURIAL AND A 3500 YEAR RECORD OF CARBON SEQUESTRATION IN PAMLICO SOUND, NORTH CAROLINA, USA

Abstract:

Potential future impacts from greenhouse gases to climate are dictated by the magnitude of carbon sequestration in various sinks, and the increase in global mean temperatures has brought considerable attention to rising CO_2 levels in the atmosphere. Coastal systems represent a large carbon sink with short turnover time; however, little is known about the amount of carbon sequestered in estuaries, an important coastal system globally. Total particulate organic carbon abundance and composition were analyzed in Holocene sediments from Pamlico Sound, North Carolina, USA, a lagoonal estuarine system. The abundance of carbon was calculated for central Pamlico Sound, and labile and refractory pools of carbon deposited in Pamlico Sound were differentiated in order to determine how much of the carbon is ultimately sequestered. Between 4.97 to 31.0 Tg of total organic carbon (TOC) was sequestered in Pamlico Sound over the past 3500 years, of which 29% is refractory black carbon (BC) and 71% is labile organic carbon (OC). Down-core composition of organic matter, carbon and nitrogen stable isotopic ratio ($\delta^{13}C$ and $\delta^{15}N$) and molar ratio (TOC/TN), indicate that the presence of the Outer Banks barrier islands was a main factor in controlling abundance and source of carbon transported and deposited in the Sound, ultimately affecting the net carbon sequestration in this coastal system. In comparison with similar coastal systems, similar percentages of BC and OC have been sequestered (30% BC and 70% OC) and a significant amount of TOC has been sequestered in central Pamlico Sound sediments over the past 3500 years.

Introduction:

The increase in global mean temperatures has brought considerable attention to the rising levels of CO_2 in the atmosphere, especially as a result of fossil fuel combustion and land use practices (e.g., Follet, 2001; Lal, 2004a; Lal, 2004b; Smith et al., 2008). The fixation of CO_2 from the atmosphere through photosynthesis results in terrestrial plant and marine phytoplankton biomass. As terrestrial plants die, a portion of their tissue is added to soil as organic matter. Similarly, as marine phytoplankton senesce or die, their biomass is buried in sediments. In general, most of the organic matter fixed via photosynthesis is reintroduced to the atmosphere as CO_2 (Hedges et al., 1997; Yang et al., 2011). However, a small portion escapes this recycling process and becomes sequestered as part of the long term carbon pool (Fig. 2-1).

Throughout the Holocene, a majority of sedimentary organic carbon transported by the world's major rivers has been deposited on continental shelves (Berner, 1982). This is because of the sea-level rise associated with Termination 1. However, very little detailed attention has been given to the actual amount or composition of carbon sequestered in estuaries as sea level rose through the Holocene. Because the global emergence of estuaries through the Holocene, it is important to understand the abundance and composition of organic carbon in fine-grained river sediments in estuarine settings under different oceanographic and morphological configurations.

Sequestration of organic matter in coastal systems is controlled by organic matter source, accumulation rate, preservation potential, post-depositional diagenesis, and decomposition rate during transport and burial (Yang et al., 2011). It is important to quantify carbon sequestration in lagoons and estuaries during the Holocene because these systems formed as a result of post glacial sea-level rise and represent a large potential carbon sink as suggested by recent studies of carbon sequestration in surface sediments in these systems (Chmura et al., 2003).

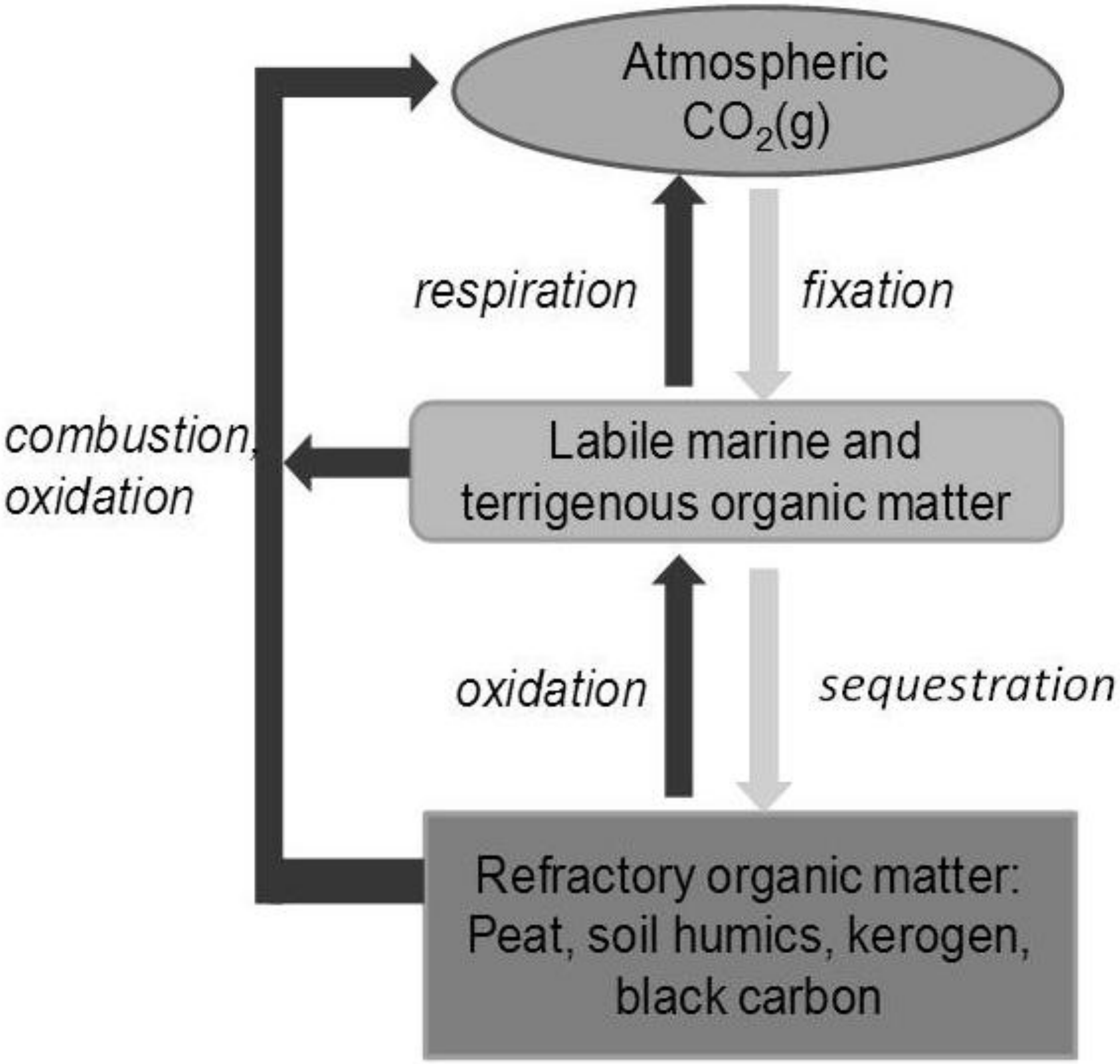

Figure 2-1. Conceptual model depicting the labile and refractory compartments of the global carbon cycle.

The total organic carbon (TOC) typically quantified in coastal carbon sequestration studies (e.g., Chmura et al, 2003; Brevik and Homburg, 2004) consists of organic molecules of varying reactivity. Pools of labile organic carbon, typically thought to be smaller in size and more digestible by marine microbial organisms, are more readily oxidized or respired (Fig. 2-1), leading to them being more readily recycled as CO_2(g). In contrast, pools of refractory carbon such as peat, humic substances, kerogen, and black carbon (BC) are refractory, and compose the majority of organic carbon ultimately sequestered in the geological record. Periods of sequestration of these pools of refractory carbon in the geological record are coeval with discrete intervals of reduced greenhouse gases and increased atmospheric O_2(g) (Berner, 2003).

Pamlico Sound is part of the Albemarle-Pamlico estuarine system, the second largest estuarine system in the contiguous United States, and covers an area of ~4350 km^2 (Fig. 2-2) (Pietrafesa et al., 1986). Pamlico Sound is surrounded by North Carolina’s mainland to the west and the Outer Banks barrier islands to the east (Fig. 2-2). The Sound formed during Holocene sea-level rise and now overlies drowned river valleys (Riggs and Ames, 2003; Mallinson et al., 2010). The evolution of Pamlico Sound and the Outer Banks throughout the Holocene has been extensively studied and constraints on developmental periods have been identified (Culver et al., 2007; Mallinson et al., 2010; Mallinson et al., 2011; Grand Pre et al., 2011). This allows for coastal organic matter sequestration in a lagoon to be studied as a function of evolving barrier island morphology. The Tar-Pamlico, Neuse, Roanoke, and Chowan Rivers are the main contributors of freshwater and terrigenous organic matter to the estuarine system. Other sediment contributions to the Sound are from shoreline erosion, the continental shelf through inlets, autochthonous biogenic production, and a minor contribution from windblown silt and sand from dunes on the Outer Banks (Wells and Kim, 1989).

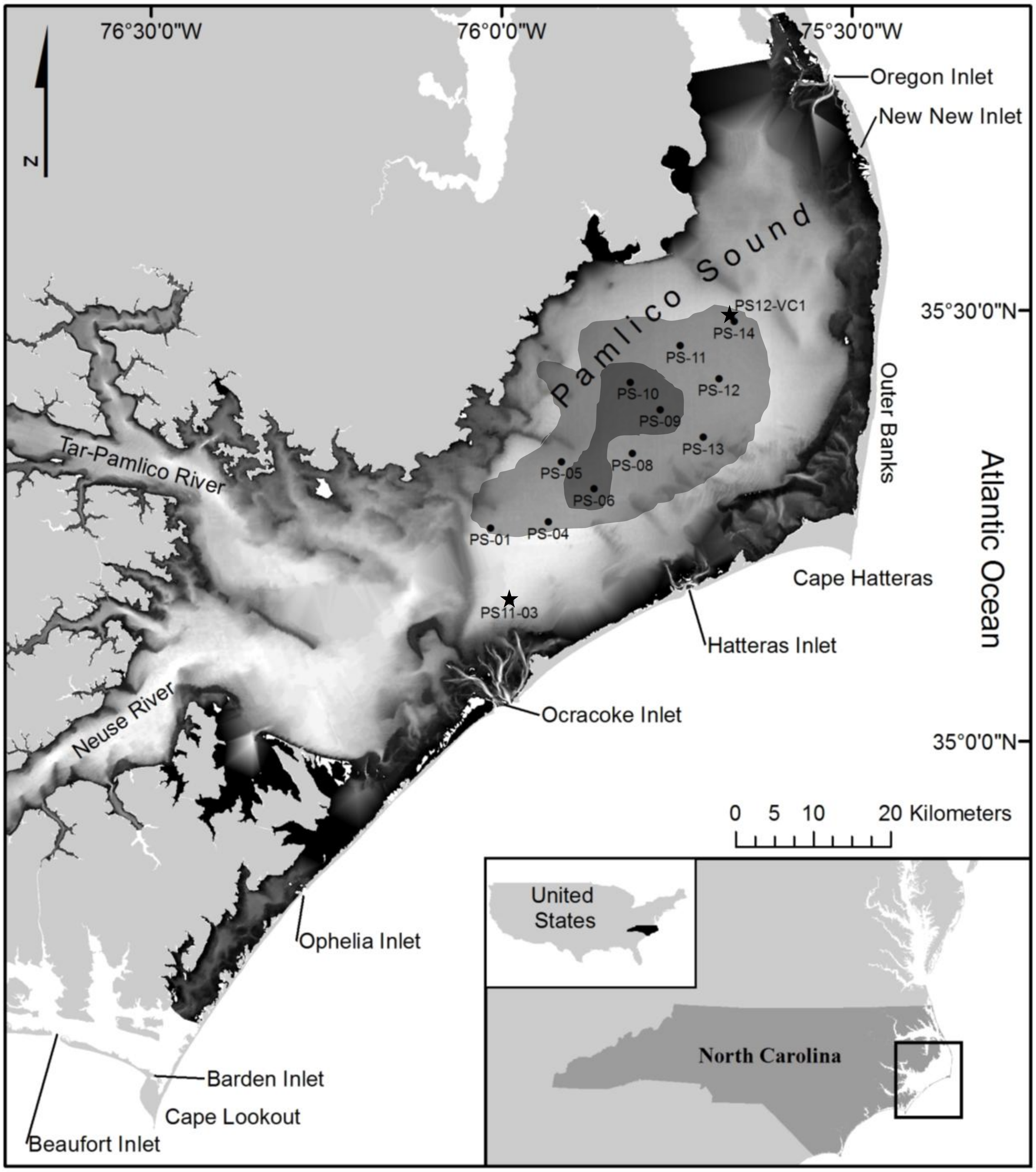

Figure 2-2. Map of North Carolina's northeast coast showing Pamlico Sound/Outer Banks barrier island system, bathymetry, and location of sediment cores PS11-03 and PS12-VC1 (★) collected as part of this study. Archive cores (●) (Foley, 2007) were used to determine the thickness of sediment deposited over the past 3500 years. The light gray area denotes the outer basin and the dark gray area denotes the inner basin in Pamlico Sound.

The objective of this research was (1) to determine how source and abundance of organic matter is related to the evolution of the Pamlico Sound/Outer Banks system in the mid-to-late Holocene and (2) to calculate the relative amounts of labile and refractory carbon sequestered in Pamlico Sound over the past 3500 years. The relative amounts of labile and refractory carbon buried in Pamlico Sound through the late Holocene were then compared to other coastal systems. Refractory carbon is operationally identified as BC, the residual material remaining after a rigorous demineralization followed by a 400h chemical oxidation. Since BC is the residual material from combustion of vegetation or fossil fuels, and does not react to typical environmental processes, it is removed from the short-term bio-atmospheric carbon cycle and transferred to the long term geologic carbon cycle (Forbes et al., 2006). The quantity of BC in each sediment sample is subtracted from the TOC typically quantified in carbon sequestration studies, with the difference being operationally defined as labile organic carbon (OC).

Methods:

Core Collection and Initial Processing:

Two vibracored sediment cores (7.62 cm diameter) were collected from Pamlico Sound (Fig. 2-2). Core PS11-03 (7.80 m length) was collected at latitude 35° 11’ 2.3” N and longitude 76° 0’ 48.1” W in a water depth of 6.5 m (Fig. 2-2). This core is a replicate core of PS-03 studied by Culver et al., (2007) and Grand Pre et al., (2011) (Fig. 2-3). Core PS12-VC1 (7.93 m length) was collected at latitude 35° 30’ 23.4” N and longitude 75° 41’ 14.4” W in a water depth of 5.5 m (Fig. 2-2). The cores were stored in a cooler (4 °C) until sectioned and sub-sampled. Half of each core was sampled and the other half was photographed and archived (see Appendices A and B). One centimeter samples were taken every five centimeters and stored in an ashed (450 °C for 4h) scintillation vial and frozen. Water content (see Appendices A and B)

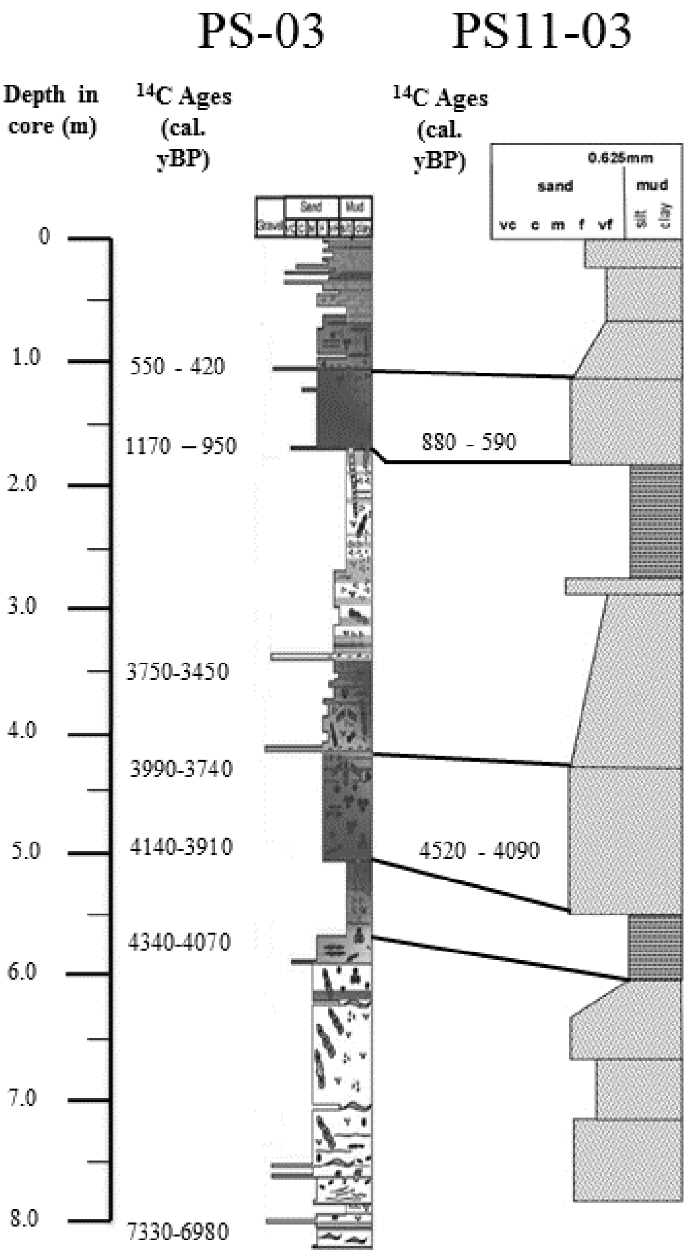

Figure 2-3. Core logs for PS-03 (Culver et al., 2007) and PS11-03 with comparison of radiocarbon age estimates determining that PS11-03 is a true replicate of PS-03.

was determined for each sample by weighing each sample before and after drying in an oven at 60 °C. All dried samples were ground to a powder with a mortar and pestle and stored in ashed scintillation vials.

Geochronology:

Radiocarbon age estimates were obtained via accelerated mass spectrometer at specific intervals in each core in order to constrain time periods of deposition (see Appendices A and B). Foraminifera (*Elphidium excavatum*) specimen were picked from two discrete intervals (826 specimens from 170-171 cm and 1012 specimens from 502-503 cm) in core PS11-03 to compare age estimates with existing radiocarbon age estimates from core PS-03 (Grand Pre et al., 2011). Age estimates from core PS-03 and replicate core PS11-03 coincide, allowing the more numerous age estimates from core PS-03 to be used to constrain time intervals in core PS11-03 (Fig 2-3). Complete and intact shells of bivalves, samples of TOC as well as BC were taken at discrete intervals in core PS12-VC1 and used for radiocarbon dating (see Appendix B).

Carbon Isolation:

In order to isolate TOC, approximately one gram of dried and ground bulk sediment sample was transferred to a cleaned scintillation vial then treated with increasing concentrations of HCl (0.2N to 4N) to remove all of the carbonates. Each successive concentration of HCl was added until effervescence ceased. This approach was used to prevent a vigorous reaction in case large amounts of carbonates were present in a sample. Samples were soaked in 4N HCl for 24 hours to ensure that all carbonates were dissolved and then placed on a heating plate at 60° C under a fume hood until they were dry. Samples were ground to a fine powder for quantification of TOC.

Black carbon was isolated from bulk sediments through a process of demineralization with HCl and HF, followed by potassium dichromate in sulfuric acid as a chemical oxidation (Masiello et al., 2002). Black carbon samples were centrifuged in Teflon tubes after each chemical soaking. Approximately 10 grams of bulk sediment was transferred into the tubes and treated with systematically increasing concentrations of HCl (0.2 N, 4N, 6N). Samples were soaked for 24 hours in 6N HCl to ensure removal of all carbonates. After removal of carbonates, samples were rinsed with distilled de-ionized (DDI) water. Hydrofluoric acid was then used to remove additional residual minerals in the sample. To avoid precipitation of CaF_2, 6N hydrochloric acid was added along with the HF. After HF demineralization, each sample was rinsed three times with DDI water to ensure that all acids were removed. Samples were then soaked in a sulfuric acid and potassium dichromate solution (0.25M $K_2Cr_2O_7$ in 2M H_2SO_4) for 400 hours. Color change of the solution was used to determine if fresh oxidant was required. Any residual carbon remaining after 400 hours was considered to be BC. After the 400 hour oxidation, samples were rinsed three times with DDI water and then dried at 60°C. The percentage of carbon in each sample after the isolation procedure is expressed as $BC_{residue}$. The ratio of the sample mass after BC isolation and the dry weight of the bulk sediment sample prior to isolation is expressed as the mass recovery ($M_{recovery}$). The percent of BC in each sediment sample was calculated using equation 2-1. Additional aliquots of dried and ground sedimentary TOC samples from core PS11-03 were treated with a chemothermal oxidation method (CTO-375) in order to isolate the soot portion of the BC continuum (Elmquist et al., 2006). The CTO-

375 method involves each sample being heated slowly (3°C per min) to a final temperature of 375°C and held at the temperature for 24 hours.

$BC_{sample}\ (\%) = BC_{residue}\ (\%) \times M_{recovered}$ (equation 2-1)

Labile organic carbon (OC) (non-BC organic carbon) abundance and the stable isotopic signature for each sample were determined mathematically using equations 2-2 and 2-3. The stable isotopic ratio of each pool of carbon is expressed as ‰ values relative to variation from the Vienna-PDB standard.

$OC\ (\%) = TOC\ (\%) - BC\ (\%)$ (equation 2-2)

$\delta^{13}C_{OC}\ (‰) = (\delta^{13}C_{TOC}\ (‰) \times TOC\ (\%)) - (\delta^{13}C_{BC}\ (‰) \times BC\ (\%)) \div OC\ (\%)$ (equation 2-3)

Carbon Quantification:

Samples of TOC and soot carbon were crimped in tin capsules and sent to Yale University's Stable Isotope Facility for quantification of carbon and nitrogen abundance and their stable isotopic signatures. Samples isolated for BC were crimped in tin capsules and analyzed at University of North Carolina, Wilmington's Stable Isotopic Facility to quantify abundance and stable isotopic signature.

Carbon Sequestration Calculations:

The amount of carbon sequestered in three pools of varying reactivity (TOC, BC, and OC) was calculated for sediments deposited over the past 3500 years in Pamlico Sound using equation 2-4. This calculation was done for the area in Pamlico Sound that is characterized by silt and clay and a water depth of ~6.5 m (Fig 2-2) (Wells and Kim, 1989). These finer sediment size classes are associated with higher carbon abundance to a greater degree than with sandy sediment (Mayer, 1994).

Carbon sequestered (g) = mass fraction of carbon (g C g^{-1} *sed) × depth of sediment (m) × area of basin (m*^{2}*) × bulk density (g m*$^{-3}$*)* Equation (2-4)

Along with the cores collected in this study, information from sediment cores previously collected in this area (Foley, 2007) was used to determine the total thickness of sediments younger than 3500 cal. yBP in the Sound. The study area was divided into two regions (Fig. 2-2). The outer basin, with an area of 540.7 km^{2} (Fig. 2-2), is the area where the Holocene/Pleistocene boundary is intercepted within the following cores (PS-01, PS-04, PS-05, PS-08, PS-11 through PS-14, and PS12-VC1) (Fig. 2-2). Other cores taken in the outer basin were not incorporated in calculations because sediments were predominantly sand. The average thickness of Holocene sediment in these cores, 2.30 ± 0.87 m, was used as the thickness of sediment for the outer basin. The inner basin has an area of 165.7 km^{2} (Fig. 2-2). Pleistocene sediment was not reached by vibracoring within the inner basin. Thus, the sediment in cores PS-06, PS-09, and PS-10 are entirely of Holocene age (Fig. 2-2). The average thickness of sediment deposited over the past 3500 years in the inner basin is 5.6 ± 1.9 m, and was calculated using average accumulation rates from cores PS-06 (1.66 to 1.86 mm/yr) and PS-09 (1.3 to 2.5 and 0.99 to 1.28 mm/yr) based upon radiocarbon age estimates (Zaremba, MS Thesis in prep.). The sediment accumulation rate of PS-10 was not determined.

Results:

Carbon Pool Calculation:

The mean mass values of each pool of carbon were calculated for selected intervals consisting predominantly of silt and clay in core PS11-03 (186 – 267 cm) and PS12-VC1 (0 – 117cm). These intervals were chosen because they accurately represent sediments (silt and clay) deposited in the inner and outer basin. The mass fraction of OC, BC, and TOC in these sediments was 0.0068 ± 0.0022, 0.0033 ± 0.0016, and 0.0101 ± 0.0025 g C g^{-1} sediment, respectively. The same intervals were used to calculate an average bulk density of 0.82 ± 0.22 g m^{-3}.

Core PS11-03:

7.8 – 5.5 m depth:

This depth interval represents a time interval from ca. 7000 – 4000 cal. yBP. Within this depth interval TOC, TN, OC, and BC abundances oscillate and range from 0.4% to 1.2%, 0.04% to 0.10%, 0.25% to 0.8%, and 0.15% to 0.6%, respectively (Fig. 2-4A, B, D, and E). Consequently, TOC/TN also oscillates and ranges from 10.5 to 17.0 (Fig. 2-4C). Soot carbon abundance remains steady at 0.1% and increases to 0.2% at a depth of 6.2 m (Fig. 2-4F).

Values of $\delta^{13}C_{TOC}$, $\delta^{15}N_{TN}$, and $\delta^{13}C_{OC}$ show oscillations ranging from -23.6‰ to -22.2‰, 3.0‰ to 4.8‰, and -23.8‰ to -21.0‰, respectively (Fig. 2-4A, B, and D). Progressing up-core, values of $\delta^{13}C_{BC}$ show an enrichment from -24.4‰ to -23.0‰ (Fig. 2-4E), and $\delta^{13}C_{soot}$ averages -10.0 ± 2.0‰ with a gradual depletion to -26.0‰ from 6.2 m to 5.5 m (Fig. 2-4F).

5.5 – 4.3 m depth:

This depth interval encompasses a time interval from ca. 4000 – 3850 cal. yBP. Abundances in TOC, TN, OC, BC, and soot remain relatively constant at 0.3 ± 0.1%, 0.03 ± 0.01%, 0.3 ± 0.05%, 0.1 ± 0.05%, and 0.2 ± 0.05%, respectively (Fig. 2-4A, B, D, E, and F). TOC/TN consequently remains relatively steady at 15 ± 2 (Fig. 2-4C).

Values of $\delta^{13}C_{TOC}$, $\delta^{15}N_{TN}$, $\delta^{13}C_{OC}$, and $\delta^{13}C_{BC}$ also oscillate with a general up-core enrichment trend from -23.0‰ to -21.8‰, 3.0‰ to 4.2‰, -22.8‰ to -21.6‰, and -24.0‰ to -22.5‰, respectively (Fig. 2-4A, B, D, and E). The composition of soot indicated by $\delta^{13}C_{soot}$ becomes abruptly enriched (from -25.0‰ to -20.0‰) at 5.3 m and remains at an average of 20.0 ± 2.0‰ until 4.4 m, where it abruptly becomes more depleted (-28.0‰) (Fig. 2-4F).

4.3 – 2.8 m depth:

This depth interval corresponds to a time interval from ca. 3850 – 2500 cal. yBP. Abundances of TOC, TN, OC, and BC gradually increase up-core from 0.3% to 0.6%, 0.03% to 0.06%, 0.25% to 0.45%, and 0.1% to 0.25%, respectively (Fig. 2-4A, B, D, and E). Consequently, TOC/TN gradually increases from 13.0 to 14.0 (Fig. 2-4C). Abundance of soot carbon is steady at 0.18 ± 0.2%. It abruptly increases to 0.35% at 3.6 m and then steadily decreases to 0.1% (Fig. 2-4F).

Values of $\delta^{13}C_{TOC}$ and $\delta^{13}C_{BC}$ remain relatively constant during this interval at -22.0 ± 0.2‰ and -22.4 ± 0.2‰, respectively (Fig. 2-4A and E). $\delta^{15}N_{TN}$ becomes enriched to a value of 4.2‰ at 4.0 m and remains relatively constant until 3.2 m, where it becomes depleted to a value of 3.3‰ (Fig. 2-4B). $\delta^{13}C_{OC}$ becomes gradually enriched from -22.2‰ to -21.0‰ (Fig. 2-4D).

Similarly, $\delta^{13}C_{soot}$ values become enriched at 3.6 m depth to -10.0‰ and remain relatively constant at -10.0 ± 2.0‰ (Fig. 2-4F).

2.8 – 1.8 m depth:

This depth interval encompasses a time interval from ca. 2500 – 1100 cal. yBP. At 2.8 m there is an abrupt up-core increase in TOC, TN, OC, and BC from 0.4% to 1.0%, 0.035% to 0.08%, 0.25% to 0.65%, and 0.1% to 0.35%, respectively (Fig. 2-4A, B, D, and E). These values remain constant to 1.8 m. Also, TOC/TN quickly increases from 14.4 to 16.0 (Fig. 2-4C). Abundance of soot carbon remains steady at 0.1 ± 0.05% (Fig. 2-4F).

At 2.8 m, $\delta^{13}C_{TOC}$, $\delta^{13}C_{OC}$, and $\delta^{13}C_{BC}$ all become depleted up-core from -22.2‰ to -23.6‰, -21.4‰ to -23.4‰, and -23.0‰ to -24.4‰, respectively (Fig. 2-4A, D, and E). Also at 2.8 m, an abrupt enrichment occurs in $\delta^{15}N_{TN}$ from 3.2‰ to 4.2‰ (Fig. 2-4B). These values remain constant until 1.8 m. The isotopic ratio of $\delta^{13}C_{soot}$ remains constant at -10.0‰ ± 2.0‰ (Fig. 2-4F).

1.8 – 1.1 m depth:

This depth interval encompasses a time interval from ca. 1100 – 500 cal. yBP. At 1.8 m there is an abrupt up-core decrease in TOC, TN, OC, and BC abundances. Abundances decrease from 1.0% to 0.1%, 0.08% to 0.016%, 0.65% to 0.16%, and 0.35% to 0.04%, respectively (Fig. 2-4A, B, D, and E). These values remain constant until 1.1 m. TOC/TN also abruptly decreases from 16 to 13 then gradually increases from 13 to 16 at 1.1 m (Fig. 2-4C). Abundance of soot carbon remains relatively constant at 0.08% until 1.1 m, where there is an abrupt increase to 0.2% (Fig. 2-4F). `

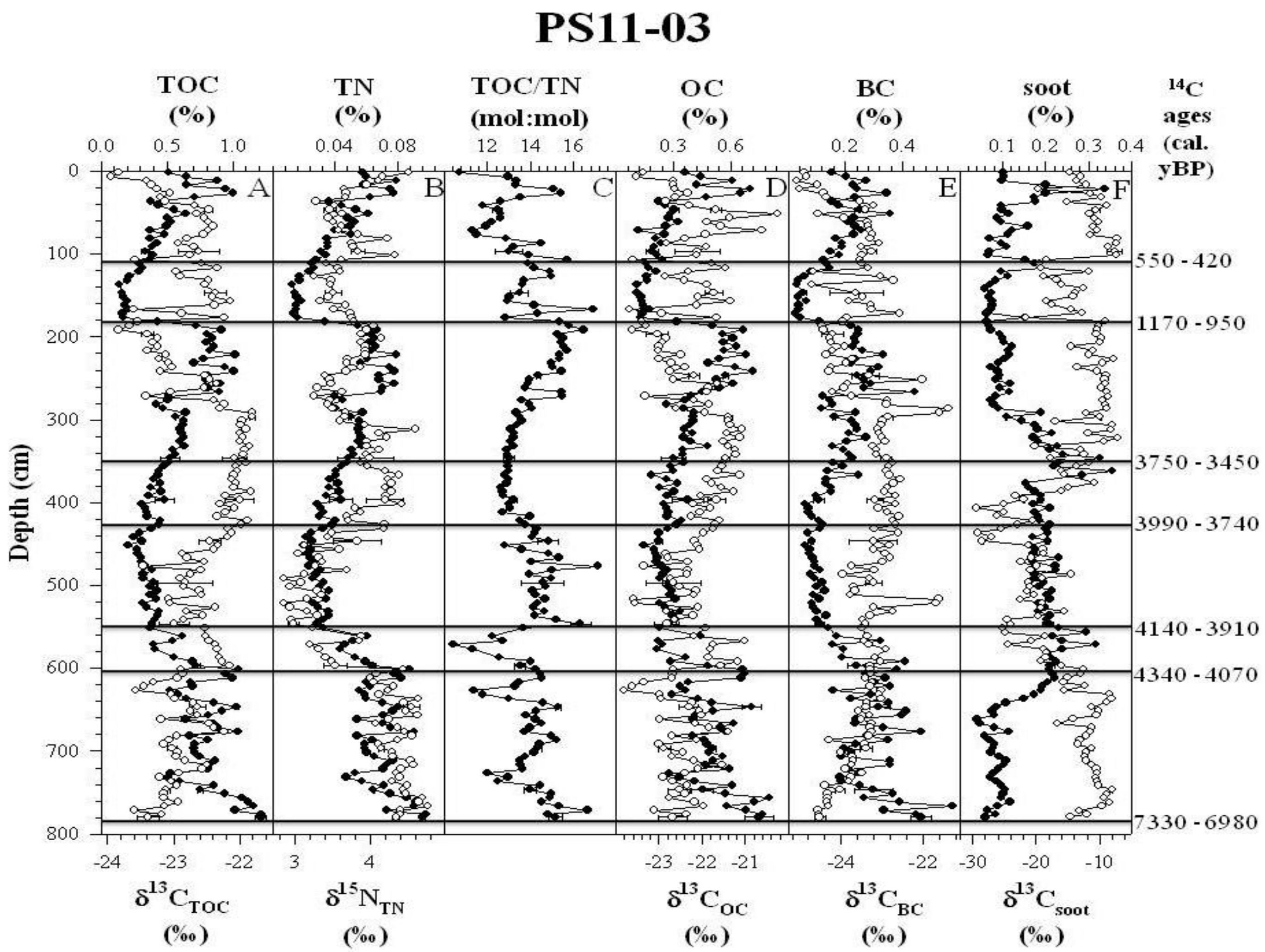

Figure 2-4. Sediment core PS11-03 with dates plotted according to cal. yBP and depth. Radiocarbon age estimates to the right were taken from core PS-03. Closed circles (●) represent abundances (top x axis) and open circles (○) represent stable isotopic ratios (bottom x axis). (A) Percent total organic carbon. (B) Percent total nitrogen. (C) TOC/TN molar ratio. (D) Percent labile organic carbon. (E) Percent black carbon. (F) Percent soot black carbon.
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There is an abrupt up-core enrichment at 1.8 m in $\delta^{13}C_{TOC}$, $\delta^{13}C_{OC}$, and $\delta^{13}C_{BC}$, with values ranging from -23.6‰ to -22.2‰, -23.4‰ to -21.6‰, and -24.4‰ to -22.4‰, respectively (Fig. 2-4A, D, and E). Proceeding upward from 1.8 m to 1.1 m, $\delta^{13}C_{TOC}$ and $\delta^{13}C_{OC}$ remain constant at values of -22.5 ± 0.5‰ and -21.8 ± 0.6‰, respectively (Fig. 2-4A and D). At this depth interval, $\delta^{13}C_{BC}$ shows several excursions from 1.8 m to 1.1 m ranging from -24.6‰ to -22.4‰ (Fig. 2-4E), whereas $\delta^{15}N_{TN}$ values remain relatively constant at 3.5 ± 0.2‰ until 1.1 m (Fig. 2-4B). $\delta^{13}C_{soot}$ shows an abrupt depletion at 1.8 m to -21.0‰ and multiple excursions until 1.1 m ranging from -21.0‰ to -11.0‰ (Fig. 2-4F).

1.1 m depth to top of core:

This depth interval encompasses a time interval from ca. 500 cal. yBP to the present. From 1.1 m to the top of the core there is a gradual increase in TOC, TN, OC, and BC abundances from 0.1% to 1.0%, 0.016% to 0.08%, 0.16% to 0.7%, and 0.04 to 0.35%, respectively (Fig. 2-4A, B, D, and E). There is an abrupt decline in these abundances at 0.3 m core depth. TOC/TN as well as soot carbon abundance show multiple excursions ranging from 11 to 16 and 0.5% to 0.35%, respectively (Fig. 2-4C and F).

$\delta^{13}C_{TOC}$ and $\delta^{13}C_{BC}$ values are depleted from -22.2‰ to -24.0‰ and -23.0‰ to -24.8‰, respectively (Fig. 2-4A and E). $\delta^{15}N_{TN}$ and $\delta^{13}C_{OC}$ show multiple excursions ranging from 3.7‰ to 4.5‰ and -20.2‰ to -23.4‰, respectively (Fig. 2-4B and D). $\delta^{13}C_{soot}$ becomes enriched abruptly at 1.1 m to -7.0‰ and gradually depletes to -14.0‰ at the top of the core (Fig. 2-4F).

Core PS12-VC1:

1.2 – 0.9 m depth:

The period of time represented by this depth interval is ca. 8000 – 3750 cal. yBP. Temporal resolution of data is low due to sampling resolution and low sedimentation rate (0.06 mm/yr). The abundances of TOC, TN, OC, and BC vary from 0.80% to 1.2%, 0.05% to 0.08%, 0.5% to 0.9%, and 0.2% to 0.3%, respectively (Fig. 2-5A, B, D, and E). There is a gradual decrease in TOC/TN molar ratio from 22 to 18 (Fig. 2-5C). $\delta^{13}C_{TOC}$, $\delta^{15}N_{TN}$, and $\delta^{13}C_{BC}$ are variable ranging from -25.1‰ to -24.1‰, 3.3‰ to 4.1‰, and -26.6‰ to -25.4‰, respectively (Fig. 2-5A, B, and E). Values of $\delta^{13}C_{OC}$ throughout this depth interval are not as variable as those observed for TOC or BC, and have an average value of -24.0 ± 0.5‰ (Fig. 2-5D).

0.9 m depth to top of core:

This depth interval represents ca. 3750 cal. yBP to the present. At 0.8 m there is an increase in sedimentation rate to ~0.4 mm/yr, which allows for trends in geochemistry to be observed at a higher resolution. Abundances in TOC, TN, OC, and BC all show multiple excursions and range from 0.7% to1.9%, 0.05% to 0.13%, 0.3% to 1.5%, and 0.3% to 1.0%, respectively (Fig. 2-5A, B, D, and E). TOC/TN shows a gradual up-core decreasing trend from 20.0 to 14.4 (Fig. 2-5C). $\delta^{13}C_{TOC}$ values enrich from -24.6‰ to -23.6‰ up to 0.67 m, where they begin to gradually deplete to -25.0‰ at the top of the core (Fig. 2-5A). $\delta^{15}N_{TN}$ values enrich from 3.8‰ at 0.80 m to 4.2‰ at the top of the core (Fig. 2-5B). $\delta^{13}C_{OC}$ and $\delta^{13}C_{BC}$ show multiple excursions and range from -24.0‰ to -19‰ and -26.5‰ to -25.0‰, respectively (Fig. 2-5D and E).

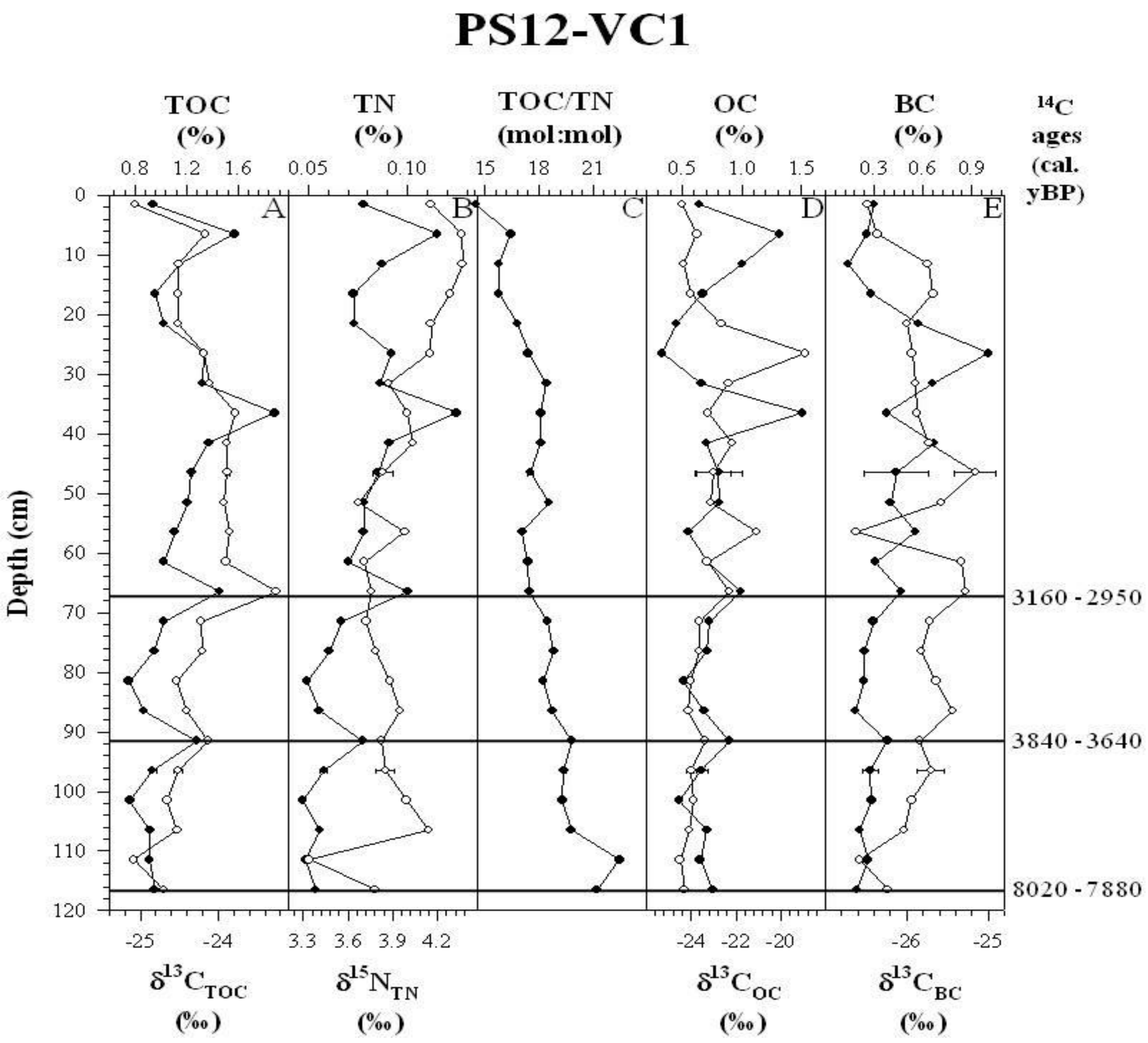

Figure 2-5. Sediment core PS12-VC1with data plotted according to cal. yBP and depth. Closed circles (●) represent abundances (top x axis) and open circles (○) represent stable isotopic ratios (bottom x axis). (A) Percent total organic carbon. (B) Percent total nitrogen. (C) Molar ratio of TOC/TN. (D) Percent labile organic carbon. (E) Percent black carbon.

4. Discussion:

4.1. Coastal Systems and Organic Matter:

A significant portion of sediments transported by major rivers throughout the Holocene has been deposited on the continental shelf in deltas and estuaries (Berner 1982). Sheltered coastal environments, such as lagoons and estuaries, are efficient at preserving thick sequences of Holocene sediments and associated organic matter (Lamb et al., 2006). Furthermore, enclosed systems like lagoons are reported to have the highest biomass production in coastal systems (Brevik and Homburg, 2004).

Coastal systems receive sediments and associated organic matter from autochthonous (biogenic production) and allochthonous (transported, such as river or shoreline erosion) sources. Within organic matter there are labile and refractory pools, and each reacts differently to environmental processes. The BC portion of organic matter is essentially inert so it will not be re-mineralized. As a result, over geologic time scales, BC is thought to represent a sink for the fast atmospheric-biospheric carbon cycle and a source of carbon to the long-term geological carbon cycle (Kuhlbusch, 1998). In general, it is assumed that ~20% of TOC in surface sediments will be re-mineralized into CO_2 and be released into the atmosphere, making it available for uptake by autotrophs (Berner, 1982). However, as demonstrated by the data throughout cores PS11-03 and PS12-VC1 (Fig. 2-4 and 2-5), the relative amounts of labile and refractory carbon (OC and BC respectively) vary tremendously. Thus, it is important to consider the reactivity of carbon in order to ultimately determine how much carbon is sequestered. The implications of the evolution of the Outer Banks barrier island system in relation to storage of these various pools of carbon are discussed below.

4.2. Evolution of the Barrier Island/Sound System:

The Holocene evolutionary history of Pamlico Sound and the Outer Banks barrier island system has previously been reconstructed (Culver et al., 2007; Mallinson et al., 2010; Mallinson et al., 2011; Grand Pre et al., 2011; Peek et al., 2013). Prior to the formation of the current barrier islands the coastal area surrounding North Carolina flooded as a result of sea-level rise, which allowed for initial estuarine/bay conditions to exist in flooded river drainages (Culver et al., 2007; Grand Pre et al., 2011). The barrier islands developed by ca. 7000 cal. yBP, endured extensive segmentation due to intense Atlantic storm activity ca. 4000 cal. yBP, and began to reform ca. 3500 cal. yBP. The barrier islands became continuous with few inlets allowing exchange between estuarine and marine water ca. 2500 cal. yBP (Culver et al., 2007; Mallinson et al., 2010; Mallinson et al., 2011; Grand Pre et al., 2011). Around 1100 cal. yBP there was catastrophic destruction of the barrier islands, presumably due to a major hurricane or hurricanes making landfall on the U.S. east coast causing extensive segmentation (Culver et al., 2007; Mallinson et al., 2011; Grand Pre et al., 2011; Peek et al., 2013). The barrier islands have re-formed again since their segmentation and are now continuous with five inlets allowing limited exchange between estuarine and marine water (Fig. 2-2) (see Chapter 1 for additional details). The data suggest that the different stages in evolution of the barrier islands correlate with quantifiable changes in abundance and composition of organic matter in the Sound.

4.3. Source of Organic Matter Related to the Evolution of the Pamlico Sound/Outer Banks System:

The composition of organic matter varies as a function of barrier island morphology. Molar and isotopic ratios of carbon and nitrogen down-core were used to determine how sources of organic matter to the Sound have changed due to the presence and absence of a relatively continuous barrier island system. When considering carbon and nitrogen molar and isotopic ratios it must be recognized that organic matter from all sources are subject to decomposition processes (e.g., autolysis, leaching, and microbial mineralization), which can lead to absolute or selective destruction of organic matter (Thorton and McManus, 1994). For example, microbial respiration can lead to an enrichment of $\delta^{13}C$, coarse sediment allows increased ability of bacteria to mineralize nitrogenous compounds, and ammonification, nitrification, and denitrification may change the composition of organic matter (Thorton and McManus, 1994). These examples indicate that measured carbon and nitrogen molar and isotopic ratios of an in situ sample can reflect both organic matter source and in situ biotic and abiotic degradation processes.

Cross plots of $\delta^{13}C_{TOC}$ vs. $\delta^{15}N_{TN}$ suggest a fairly homogenous source of organic matter in the Sound throughout the Holocene with respect to the stable isotopic ratio of carbon (Fig. 2-6A). However, there is a broader range in stable isotopic ratio of nitrogen before 3500 cal. yBP (Fig. 2-6A), indicating a greater variety of sources or diversity in microbial processing of organic matter in the Sound, likely due to the much shallower system and rapid erosion of coastal wetlands, and perhaps greater, but variable, river flux associated with the Hypsithermal. A comparison between abundance of carbon and nitrogen in the Sound indicate that values are consistently higher than the Redfield ratio given for marine organic matter (Fig. 2-6B). This implies that organic matter deposited in the Sound throughout the Holocene has always been predominantly terrestrial (Lamb et al., 2006). Visual comparison of $\delta^{13}C_{TOC}$ and TOC/TN molar ratios suggests that there is a difference between carbon in core PS11-03 and core PS12-VC1 (Fig. 2-6C). They both show C_3 terrestrial plants as a source of organic matter, but PS11-03 shows more of a marine influence whereas PS12-VC1 shows more of a terrestrial influence.

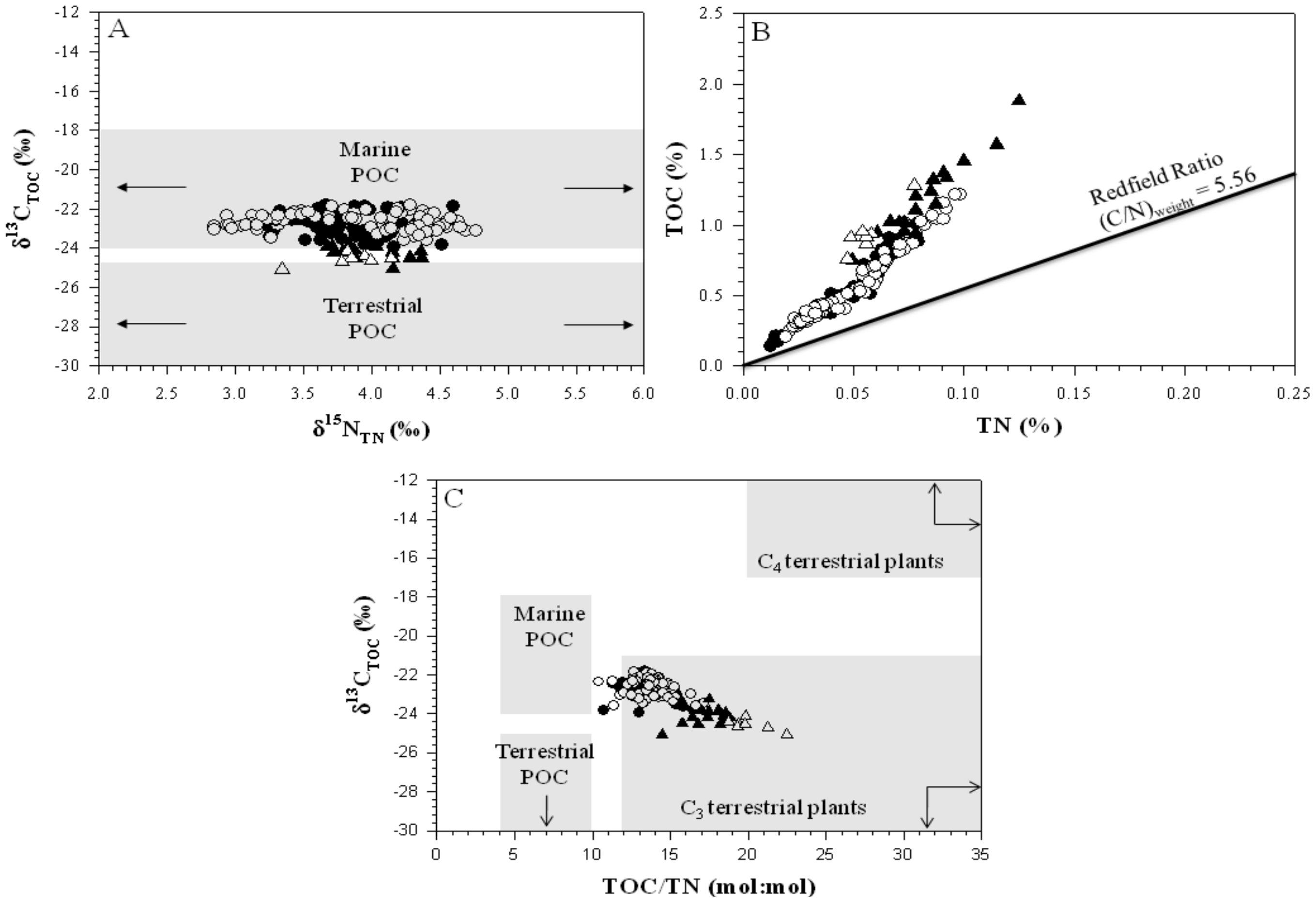

Figure 2-6. Solid circles (●) represent organic matter deposited after 3500 yBP in core PS11-03 and open circles (○) represent organic matter deposited before 3500 yBP in core PS11-03. Solid triangles (▲) represent organic matter deposited after 3500 yBP in core PS12-VC1 and open triangles (△) represent organic matter deposited before 3500 yBP in core PS12-VC1. (A) Cross plot between $\delta^{13}C_{TOC}$ and $\delta^{15}N_{TN}$ and stable isotopic ratio ranges for typical marine and terrestrial particulate organic matter. (B) Cross plot of TOC and TN with solid line indicating the Redfield ratio of marine organic matter. (C) Cross plot between $\delta^{13}C_{TOC}$ and TOC/TN with ranges of typical marine and terrestrial particulate organic matter and C3 and C4 terrestrial plants (Ranges from Peters et al., 1978; Peterson and Fry, 1987; Matson and Brinson, 1990; Lamb et al., 2006).

This difference is most likely due to location within the Sound from where cores were collected (Fig 2-2). For example, core PS11-03, being closer to a major inlet of the barrier islands that has existed throughout the Holocene, receives relatively more marine organic matter than PS12-VC1. In contrast, PS12-VC1 being farther away from any major inlets receives less marine organic matter. Comparison of these compositional properties of carbon and nitrogen indicate that barrier island morphology and location within the Sound are main factors in source of organic matter deposited in the Sound.

4.4. Changes in Carbon Abundance and Source in Response to Barrier Island Development:

Geochemical variables in sediments from PS11-03 and PS12-VC1 were analyzed and used to determine changes in abundance and source of organic matter deposited in the Sound throughout the mid-to-late Holocene. Marine organic matter is known to have a lower TOC/TN molar ratio (<10) and is more enriched in $\delta^{13}C_{TOC}$ (-18.0‰ to -21.0‰) in comparison to terrestrial organic matter (>12) (-25.0‰ to -33.0‰) (Lamb et al., 2006).

In core PS11-03, ca. 7000 to 4000 cal. yBP (7.8 – 5.5 m depth), TOC, $\delta^{13}C_{TOC}$, and TOC/TN (Fig. 2-4A and C) in the Sound were highly variable. Variability in TOC/TN and $\delta^{13}C_{TOC}$ (Fig. 2-4A and C) suggest a different depositional environment than an estuarine system (Peters et al., 1978; Peterson and Fry, 1987; Lamb et al., 2006) during this time period. A likely explanation for such an observation is that the estuarine system had very shallow water depths and rapid erosion of wetlands through a process of bay ravinement.

A low accumulation rate characterizing the ca. 7000 – 4000 cal. yBP time interval in core PS12-VC1 (0.06 mm/yr) (Fig. 2-5) resulted in low temporal resolution. This does not allow for a direct comparison between organic matter and barrier island evolution. However, the low sedimentation rate at this time is likely caused by the shallow water depth of the system not allowing accommodation space for sediment accumulation.

In PS11-03, from ca. 4000 to 3500 cal. yBP (5.5 – 3.5 m depth), TOC remains relatively low, $\delta^{13}C_{TOC}$ values gradually become more enriched, and TOC/TN shows frequent oscillations (Fig. 2-4A and C). These values indicate an increased influence of marine organic matter in the Sound during this time period. These values would have resulted from a highly segmented barrier island chain and rising sea-level, which would cause an increase of marine organic matter in the Sound. This corresponds with Culver et al., (2007) and Grand Pre et al. (2011), who showed that there was advection of Gulf Stream waters into the southern part of the Sound during this time period. In core PS12-VC1 sedimentation rate during this time remained low (0.06 mm/yr), resulting in low temporal resolution in the core at this time (Fig. 2-5). Such conditions do not allow for a direct comparison between organic matter and barrier island evolution. However, the highly segmented character of the barrier islands throughout this time allowed for more efficient transport of sediment out of the Sound, perhaps in response to greater tidal energy, which caused the low sedimentation rate at this location.

In core PS11-03 an increase in TOC, TOC/TN, and depletion in $\delta^{13}C_{TOC}$ occured ca. 3500 cal. yBP and this trend continue until ca. 2500 cal. yBP (4.3 – 2.8 m depth). This coincides with the reformation of the barrier islands, indicating that abundance and source of carbon deposited in Pamlico Sound changed considerably due to the greater continuity of the barrier islands. The presence of the barrier islands minimized sediment export from the Sound and resulted in an increase of carbon-rich and isotopically depleted $\delta^{13}C_{TOC}$ terrestrial organic matter deposition in the Sound.

Sediment accumulation rate increased in PS12-VC1 ca. 3500 cal. yBP (~0.4mm/yr), which coincides with the reformation of the barrier islands. Also, during this time TOC abundance in sediments became more variable and reached values higher than 1.5% and $\delta^{13}C_{TOC}$ became more depleted (Fig. 2-5A). The presence of the barrier islands most likely caused an increase of terrestrial sediment accumulation, which are more carbon rich and isotopically depleted in $\delta^{13}C_{TOC}$. This resulted in the increase in accumulation rate, higher abundance of TOC, and depletion of $\delta^{13}C_{TOC}$. Collectively, these observations indicate an increase in the relative abundance of terrestrial organic matter deposited in the Sound in response to greater barrier island continuity.

In core PS11-03, ca. 2500 yBP, $\delta^{13}C_{TOC}$ became depleted and TOC/TN increases, and values remained constant until ca. 1100 ca. yBP (2.8 – 1.8 m depth) (Fig. 2-4A and C). This coincides with a time period when the barrier islands were relatively continuous (like today) with few inlets allowing exchange between estuarine and marine waters. The fully developed barrier islands minimized export of terrestrial sediments and import of marine sediments, which resulted in relatively high TOC, TOC/TN, and depleted $\delta^{13}C_{TOC}$ terrestrial sediments deposited in the Sound. Resolution and time constraint of PS12-VC1 precludes ability to isolate changes in organic geochemistry during this time period (Fig. 2-5).

A decline in TOC, enrichment in $\delta^{13}C_{TOC}$, and decrease in TOC/TN occured ca. 1100 cal. yBP and values remained constant until ca. 500 cal. yBP (1.8 – 1.1 m depth) (Fig. 2-4A and C). This suggests an increased influence of marine organic matter deposited in the Sound, which is consistent with the idea that this was a time period of extensive segmentation of the barrier islands (Culver et al., 2007; Grand Pre et al., 2011). Extensive segmentation of the barrier islands allowed advection of Gulf Stream waters into the southern part of the Sound, which would have resulted in an increased amount of marine organic matter. This event decreased the amount of TOC deposited in the Sound by a factor of 10 (Fig. 2-4). Resolution and age limitations of PS12-VC1 preclude the ability to isolate changes in organic geochemistry during this time period (Fig. 2-5).

Over the past 500 years TOC has gradually increased and $\delta^{13}C_{TOC}$ has gradually become depleted in core PS11-03 (Fig 2-4A). These gradual trends occurred simultaneously with the re-formation of the barrier islands. Currently, TOC and $\delta^{13}C_{TOC}$ have returned to values similar to when the barrier island were continuous ca. 2500 cal. yBP.

4.5. Carbon Sequestration in Pamlico Sound:

Sequestration of organic matter is particularly important in Pamlico Sound because it is one of the largest embayments along the U.S. east coast covering ~4350 km^2 (Fig. 2-2) (Pietrafesa et al., 1986). The development of the Outer Banks barrier island system on the coast of North Carolina has significantly impeded the transport of terrestrial organic matter to the ocean, and for that reason, the lagoonal system (Pamlico Sound) located behind the barrier islands is acting as a sink for sediments and associated organic matter.

The mass of carbon stored in different pools (TOC, BC, and OC) was calculated for the time interval of ca. 3500 cal. yBP to the present for the area in central Pamlico Sound where a majority of silts and clays are deposited (Fig. 2-2) (Wells and Kim, 1989). These calculations were then compared with values of carbon sequestered in other coastal systems for which data are available. It is important to compare carbon sequestration in coastal systems to determine if a specific system is comparable to other similar systems at sequestering carbon in the sedimentary record.

The data gathered from this study suggest that the barrier islands allow for more efficient carbon sequestration. The amount of TOC deposited in central Pamlico Sound ca. 3500 cal. yBP ranges from 4.97 to 31.0 Tg (Table 2-1). On average about 29% is BC and 71% is OC. This is a conservative estimate of carbon sequestered in the entire system considering that sediments composed dominantly of clay and silt have been mapped in other areas of the system. For example, The Pamlico and Neuse estuaries contain organic-rich mud, which were not included in the estimates (Matson and Brinson, 1990). Also, silt and clay deposits are common in the bayhead delta area at the mouth of the rivers entering the Sound (Wells and Kim, 1989). Below, the total amount of carbon sequestered in Pamlico Sound is compared to other estuarine and lagoonal systems.

Chesapeake Bay is a geographically proximal drowned river-valley estuary inundated by late Quaternary sea-level rise ca. 6 – 8 ka (Cronin et al., 2000; Colman et al., 2002). It is the largest estuary in the U.S. covering 6500 km^2, of which 1540 km^2 comprises of silt and clay sediments (Cronin et al., 2000; www.mgs.md.gov/coastal/vmap/baysed.html). Accumulation rates of BC and OC were calculated from a core collected east of the Potomac River confluence in the Chesapeake Bay (Mitra et al., 2009), and with this information, the amount of different types of carbon deposited in the system was estimated. Over the past 3500 years 80.7 to 754 Tg of TOC has been sequestered in Chesapeake Bay (Table 2-1). On average 31% of the carbon deposited is BC and 69% is OC, a compositional distribution similar to that in Pamlico Sound. Chesapeake Bay carbon sequestration estimations indicate that the mass of TOC sequestered over the past 3500 years is 16 to 24 times more than in Pamlico Sound. This is not surprising, considering the size difference between the two systems, mass accumulation rates in Chesapeake

Table 2-1. Total organic carbon (TOC), labile organic carbon (OC), and refractory black carbon (BC) sequestered over the past 3500 years in various lagoon systems.

Location	Area (km^2)	Type of Carbon	Carbon Mass Accumulation Rate (10^{-5} TgC km^{-2} yr^{-1})	Carbon Sequestered (Tg)	Reference
Ballona Lagoon Southern California	0.484	TOC	4.88 - 5.52	0.0827 - 0.0935	Brevik and Homburg, 2004
Laguna de Términos, Mexico	2500	TOC	10.0 - 65.4	875 - 5720	Kjerfve, 1986; Chmura et al., 2003
Chesapeake Bay	1539	TOC	1.50 - 14.0	80.7 - 754	Mitra et al., 2009; www.mgs.md.gov/coastal/vmap/baysed.html
		OC	0.10 - 10.0	53.8 - 539	
		BC	0.50 - 3.99	26.9 - 215	
Pamlico Sound, NC	706	TOC	0.20 - 1.25	4.97 - 31.0	This study
		OC	0.15 - 0.83	3.80 - 20.4	
		BC	0.047 - 0.43	1.17 - 10.6	

Bay are an order of magnitude higher, and the conservative value calculated for Pamlico Sound (Table 2-1).

Laguna de Términos is the largest lagoon in Mexico and is surrounded by low-lying mangrove swamps (Kjerfve, 1986). This system has been estimated to sequester large amounts of TOC (875 to 5720 Tg) over the past 3500 years (Table 2-1). The actual amount of carbon sequestered most likely lies between these numbers because of higher carbon content on the edge of the mangrove/lagoon system, which decreases toward the middle of the lagoon (Gonneea et al., 2004). Certain areas of Laguna de Términos have also been affected by riverine input and anthropogenic influences over the past 3500 years but these areas were not specifically quantified. Values of TOC sequestered are much higher in Laguna de Términos than any other system considered in this study, which is possibly due to the larger size of the system, high mass accumulation rates, the carbon-rich mangrove surrounding the lagoon, and the year-round high productivity.

Lastly, the Ballona Lagoon, located in southern California, has sequestered 0.0827 to 0.0935 Tg of TOC over the past 3500 years (Table 2-1) (Brevik and Homburg, 2004). This is a conservative estimate for the entire system because only the lagoon was considered and not the surrounding marshes. Compared to other systems considered in this study, Ballona Lagoon sequesters significantly much less carbon (2 to 5 orders of magnitude) than any of the other systems. Mass accumulation rates at this site are similar to others considered in this study, but this system sequesters much less carbon due to its small area in comparison to the other systems. The different pools of carbon were not differentiated in the latter two systems.

Up to ~6500 Tg of carbon has been sequestered over the past 3500 years within these four systems. This is a small portion of estuaries and lagoons sequestering carbon naturally worldwide. However, little research has been done on carbon sequestration in such systems. Comparison of these systems indicates the importance on the carbon cycle of coastal estuaries and lagoons as these systems have continuously sequestered carbon throughout the late Holocene.

Conclusions:

This study illustrates that the degree of segmentation of barrier islands plays an important role in controlling source and abundance of carbon sequestered in Pamlico Sound and other estuarine lagoons. During the time period of early flooding of the Pamlico Sound area (ca. 7000 to 4000 cal. yBP), source and abundance of carbon sequestered in the Sound was highly variable. A mix between terrestrial and marine organic matter source was observed and the mass of carbon accumulating in the Sound was relatively low. This was likely due to a much shallower system, lower volume of water, and greater ease of exchange with marine waters, likely through a highly segmented barrier system, combined with variable input of carbon from coastal wetland erosion and river flux. As the system deepened and barriers became more continuous, the source of organic matter was dominantly terrestrial and carbon sequestration in the Sound increased by a factor of 10. This was a result of the barrier islands preventing terrestrial carbon from being exported from the Sound and marine carbon imported into the Sound.

Considering the effect in degree of barrier island segmentation, the amount in different pools of carbon (TOC, BC, and OC) sequestered since ca. 3500 cal. yBP was calculated. Distinguishing between types of carbon is important due to their different reactive properties. It was determined that 4.97 to 31.0 Tg of carbon has been sequestered in central Pamlico Sound over the past 3500 years, which on average 29% is BC and 71% is OC. Comparison of carbon sequestered in Pamlico Sound with other coastal systems over the past 3500 years indicates that Pamlico Sound is lower in terms of mass accumulation of carbon. Given the scarcity of such estimations of Holocene carbon sequestration in the literature, quantification in other coastal systems would be beneficial, as it is an important factor in determining the balance between CO_2 and O_2 in the atmosphere over time, which in return regulates climate.

Overall Conclusions:

In summary, this work suggests that variability of El Niño Southern Oscillation (ENSO) throughout the Holocene is a large factor of precipitation and temperature in eastern North Carolina. During times of inactive El Niño, eastern North Carolina undergoes warm and dry conditions causing vegetation to be more susceptible to combustion. This resulted in increased frequency of fires leading to high soot/TOC deposition in Pamlico Sound. Conversely, during times of acitvr El Niño, eastern North Carolina undergoes cool and wet conditions. During these times, high BC/TOC was deposited in the Sound due to fluvial erosion of larger BC particles stored in sediments from fires during the preceding inactive El Niño event (Fig. 3-1).

The frequency and path of hurricanes in the Atlantic is primarily determined by variability in ENSO and the position of the Bermuda High associated with the North Atlantic Oscillation (NAO). During times of inactive El Niño, hurricane frequency in the Atlantic increases and during times of positive NAO (Bermuda High in a northerly position) hurricanes tend to track up the U.S. east coast. Conversely, during times of active El Niño and negative NAO, hurricanes in the Atlantic are less frequent and tend to track into the Gulf of Mexico, respectively. Periods of inactive El Niño and positive NAO conditions coincide with barrier island segmentation caused by intense Atlantic storm activity, while periods of active El Niño and negative NAO coincide with greater barrier island continuity (fewer inlets) (Fig. 3-1).

These different climatic conditions, along with barrier island evolution, ultimately affected the organic matter associated with sediments deposited in Pamlico Sound (Fig. 3-1). The presence of the barrier islands is an important factor with respect to the source and abundance of carbon in Pamlico Sound. During the time period of initial flooding of the Pamlico Sound area, source and abundance of carbon sequestered in the Sound was highly variable. When marine conditions were present in the area, a mix between terrestrial and marine organic

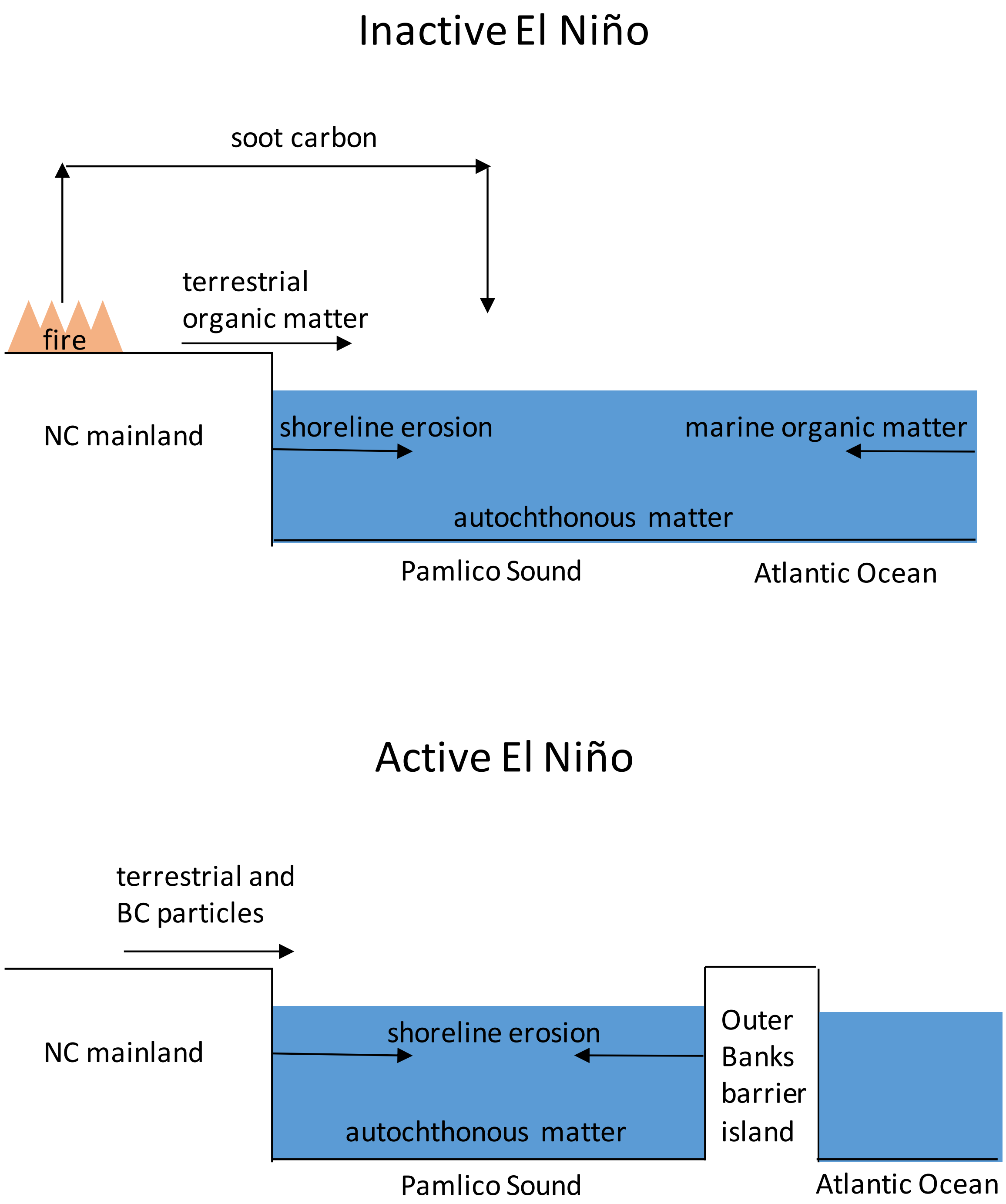

Figure 3-1. Diagram showing the sources of organic matter deposited in the Sound and the influence on barrier island evolution during active and inactive El Niño conditions.

matter source was observed and carbon accumulation in the Sound was relatively low. With continuous barrier islands, source of organic matter was dominantly terrestrial and carbon sequestration in the Sound increased. This was a result of the barrier islands preventing terrestrial carbon from being exported from the Sound and marine carbon being imported into the Sound. Considering the effect of barrier island presence and analyzed %TOC, %BC, and %OC representative of sediments deposited in central Pamlico Sound, the amount between different pools of carbon sequestered ca. 3500 cal. yBP was calculated. Over the past 3500 years Pamlico Sound has sequestered 4.97 – 31.0 Tg of carbon, which 29% was BC and 71% was OC. Comparison of these calculations and amount of carbon sequestered in other coastal systems indicates the importance of carbon sequestered in lagoons and estuaries over the past 3500 years. Given the scarcity of such information, quantification in other coastal systems would be beneficial, as it is an important factor in determining the budget of CO_2 in the terrestrial system, atmosphere, and oceans over time, which in return regulates climate.

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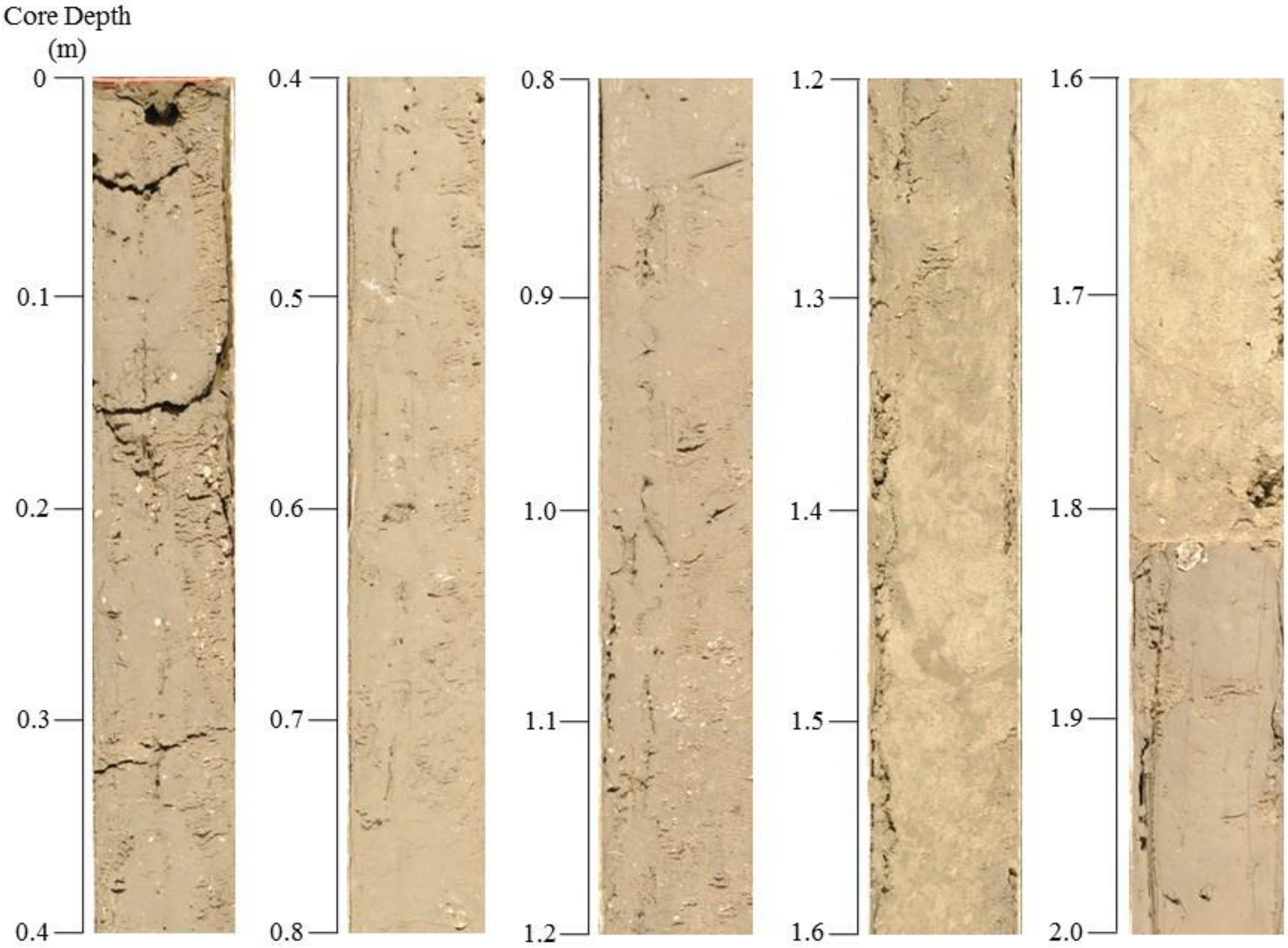
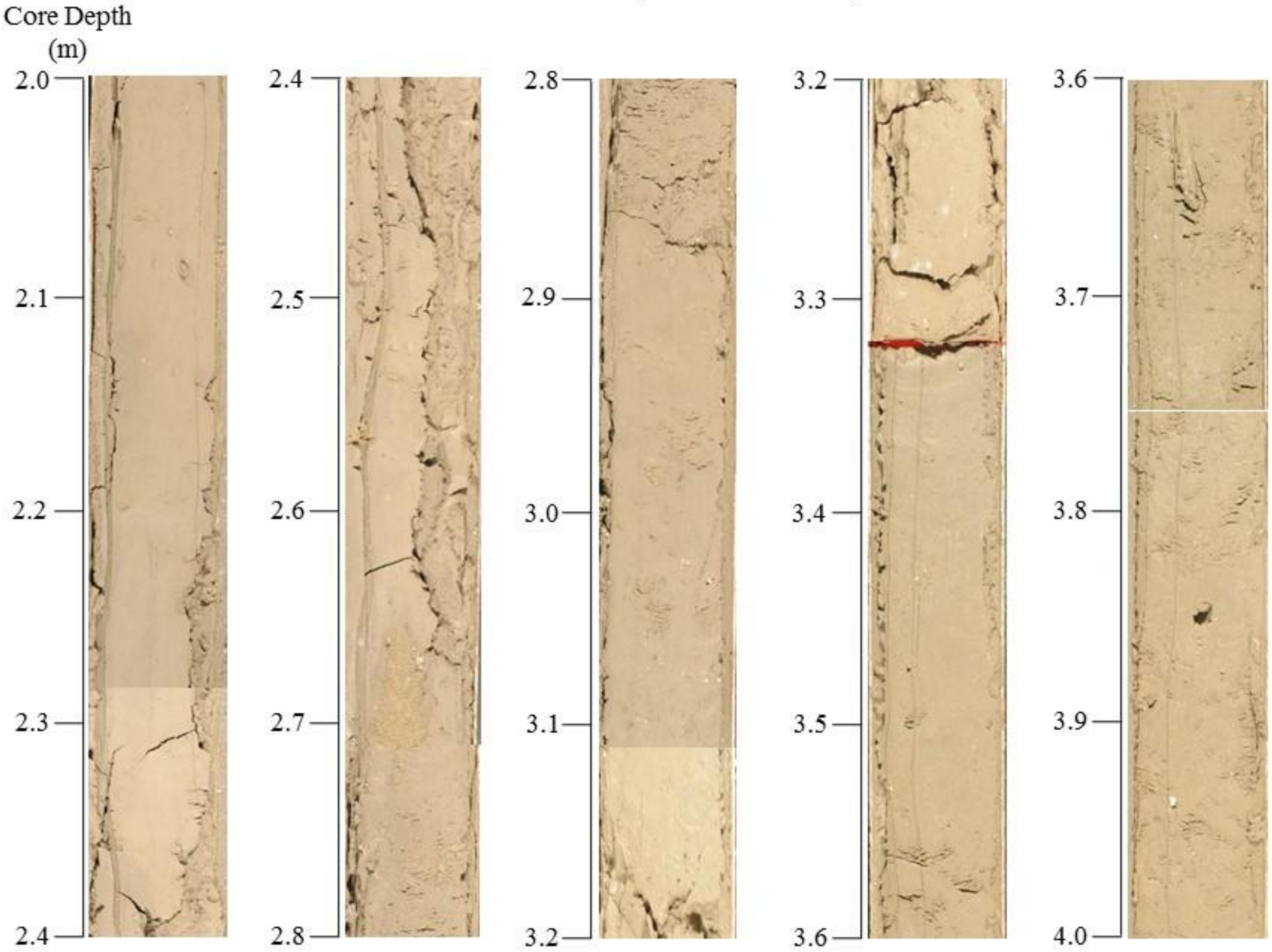
Appendix A

(Core PS11-03)

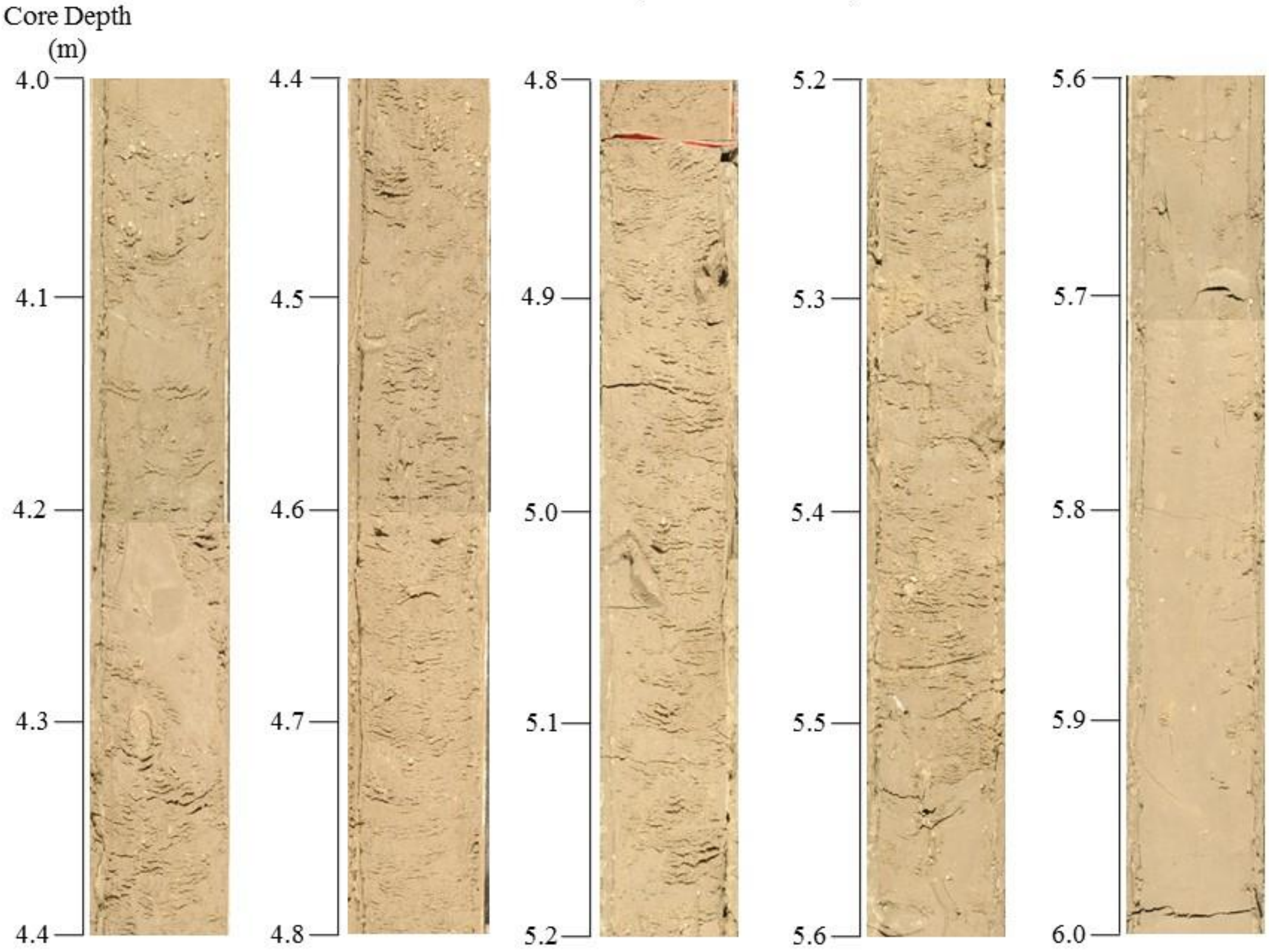
PS11-03


Core Depth
(m)
0
0.1
0.2
0.3
0.4
0.4
0.5
0.6
0.7
0.8
0.8
0.9
1.0
1.1
1.2
1.2
1.3
1.4
1.5
1.6
1.6
1.7
1.8
1.9
2.0

PS11-03 (continued)



PS11-03 (continued)



PS11-03 (continued)

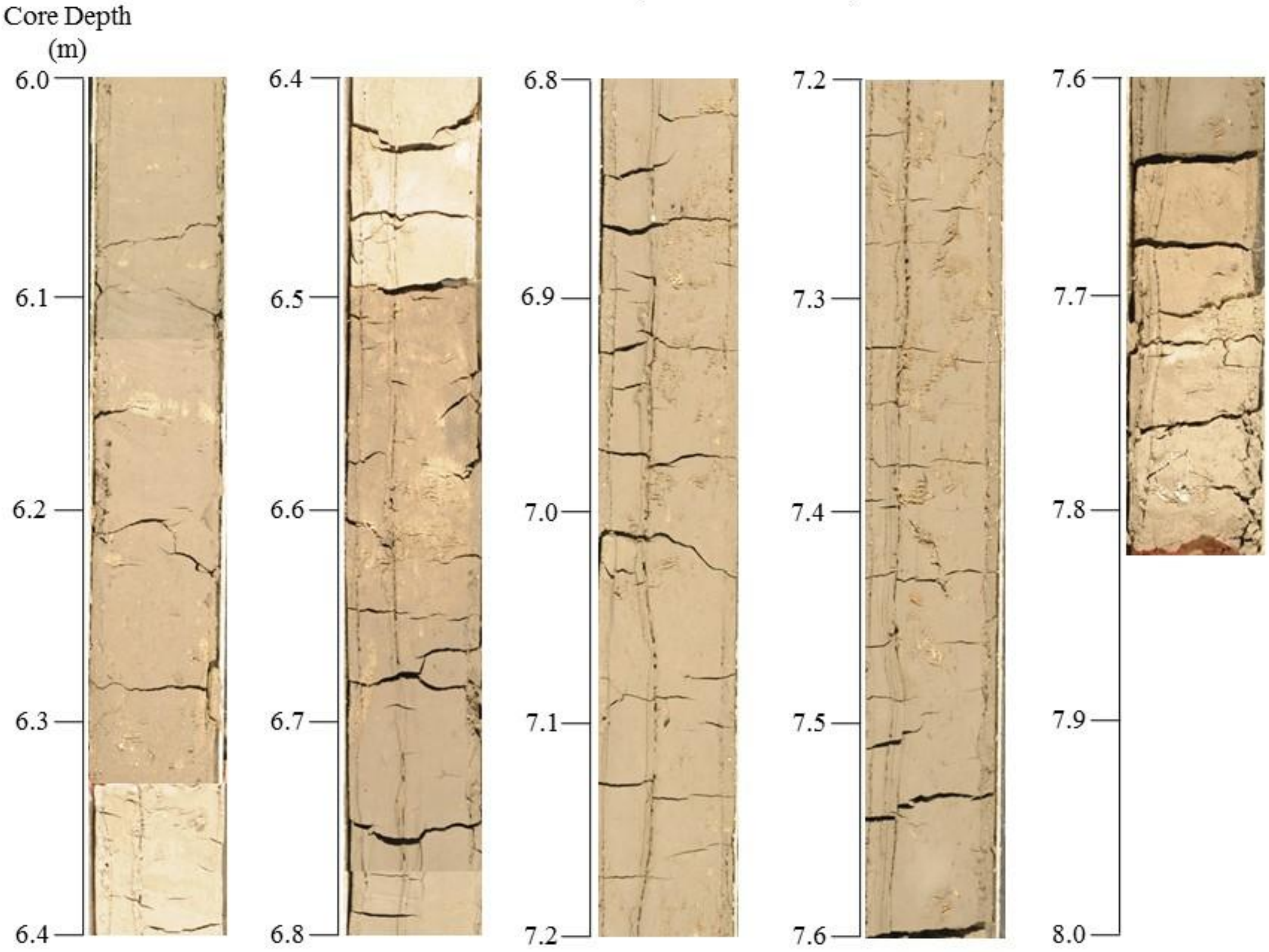


Table A1. Water content and bulk density of core PS11-03.

Sample (depth in cm)	wet weight (g)	dry weight (g)	water content (%)	bulk[1] density (g/cm^3)
PS11-03 (1-2)	2.66	1.87	29.92	0.33
PS11-03 (6-7)	4.55	3.28	27.88	0.57
PS11-03 (11-12)	3.12	2.16	30.67	0.39
PS11-03 (16-17)	5.26	3.81	27.66	0.66
PS11-03 (21-22)	4.03	2.72	32.60	0.51
PS11-03 (26-27)	6.75	4.56	32.39	0.85
PS11-03 (31-32)	5.17	3.63	29.84	0.65
PS11-03 (36-37)	7.96	6.16	22.63	1.00
PS11-03 (41-42)	8.84	6.59	25.47	1.11
PS11-03 (46-47)	6.53	4.89	25.07	0.82
PS11-03 (51-52)	7.20	5.29	26.51	0.90
PS11-03 (56-57)	9.87	7.44	24.60	1.24
PS11-03 (61-62)	11.20	8.61	23.12	1.40
PS11-03 (66-67)	7.91	5.97	24.61	0.99
PS11-03 (71-72)	11.25	8.59	23.65	1.41
PS11-03 (76-77)	13.00	9.72	25.21	1.63
PS11-03 (81-82)	10.83	8.34	22.97	1.36
PS11-03 (86-87)	10.43	7.82	25.05	1.31
PS11-03 (91-92)	7.58	5.80	23.48	0.95
PS11-03 (96-97)	13.21	10.28	22.24	1.66
PS11-03 (101-102)	11.59	8.87	23.51	1.45
PS11-03 (106-107)	13.10	10.18	22.29	1.64
PS11-03 (111-112)	11.40	8.90	21.91	1.43
PS11-03 (116-117)	8.33	6.50	22.03	1.04
PS11-03 (121-122)	10.00	7.91	20.94	1.25
PS11-03 (126-127)	7.75	6.26	19.21	0.97
PS11-03 (131-132)	7.87	6.37	19.02	0.99
PS11-03 (136-137)	7.55	6.14	18.62	0.95
PS11-03 (141-142)	9.85	8.03	18.46	1.23
PS11-03 (146-147)	13.94	11.16	19.92	1.75
PS11-03 (151-152)	10.04	8.02	20.10	1.26
PS11-03 (156-157)	15.72	12.59	19.92	1.97
PS11-03 (161-162)	11.80	9.56	19.02	1.48
PS11-03 (166-167)	14.37	11.54	19.67	1.80
PS11-03 (171-172)	14.65	11.89	18.87	1.84
PS11-03 (176-177)	9.90	7.94	19.76	1.24
PS11-03 (181-182)	10.04	7.81	22.14	1.26
PS11-03 (186-187)	10.29	7.24	29.65	1.29

Table A1. Water content and bulk density of core PS11-03 (continued).

Sample (depth in cm)	**wet weight (g)**	**dry weight (g)**	**water content (%)**	**bulk[1] density (g/cm^3)**
PS11-03 (191-192)	7.81	5.10	34.65	0.98
PS11-03 (196-197)	8.74	5.73	34.41	1.10
PS11-03 (201-202)	9.02	5.88	34.85	1.13
PS11-03 (206-207)	9.30	6.01	35.42	1.17
PS11-03 (211-212)	10.99	7.00	36.33	1.38
PS11-03 (216-217)	7.63	4.87	36.23	0.96
PS11-03 (221-222)	9.23	5.32	42.42	1.16
PS11-03 (226-227)	11.51	7.46	35.22	1.44
PS11-03 (231-232)	11.29	7.19	36.29	1.41
PS11-03 (236-237)	8.65	5.22	39.67	1.08
PS11-03 (241-242)	8.68	5.28	39.19	1.09
PS11-03 (246-247)	11.96	7.62	36.31	1.50
PS11-03 (251-252)	9.90	6.38	35.56	1.24
PS11-03 (256-257)	7.56	4.61	39.06	0.95
PS11-03 (261-262)	7.75	4.82	37.83	0.97
PS11-03 (266-267)	11.31	6.69	40.83	1.42
PS11-03 (271-272)	9.26	6.53	29.51	1.16
PS11-03 (276-277)	13.37	9.29	30.53	1.68
PS11-03 (281-282)	12.96	9.59	25.95	1.62
PS11-03 (286-287)	11.83	8.40	28.99	1.48
PS11-03 (291-292)	11.43	7.53	34.11	1.43
PS11-03 (296-297)	11.18	7.56	32.39	1.40
PS11-03 (301-302)	12.29	8.04	34.58	1.54
PS11-03 (306-307)	8.97	5.92	33.99	1.12
PS11-03 (311-312)	11.82	7.70	34.83	1.48
PS11-03 (316-317)	12.90	8.28	35.85	1.62
PS11-03 (321-322)	11.31	7.48	33.86	1.42
PS11-03 (326-327)	10.30	6.98	32.25	1.29
PS11-03 (331-332)	7.37	4.83	34.50	0.92
PS11-03 (336-337)	14.62	9.73	33.47	1.83
PS11-03 (341-342)	13.71	9.06	33.94	1.72
PS11-03 (346-347)	17.32	11.60	33.01	2.17
PS11-03 (351-352)	17.32	12.12	30.03	2.17
PS11-03 (356-357)	13.59	9.62	29.19	1.70
PS11-03 (361-362)	13.70	9.67	29.43	1.72
PS11-03 (366-367)	12.73	8.96	29.64	1.60
PS11-03 (371-372)	15.02	10.64	29.16	1.88
PS11-03 (376-377)	17.44	12.57	27.92	2.19

Table A1. Water content and bulk density of core PS11-03 (continued).

Sample (depth in cm)	**wet weight (g)**	**dry weight (g)**	**water content (%)**	**bulk[1] density (g/cm^3)**
PS11-03 (381-382)	14.29	10.35	27.55	1.79
PS11-03 (386-387)	15.68	11.34	27.72	1.97
PS11-03 (391-392)	14.22	10.27	27.74	1.78
PS11-03 (396-397)	15.86	11.51	27.43	1.99
PS11-03 (401-402)	16.02	11.91	25.68	2.01
PS11-03 (406-407)	16.90	12.88	23.78	2.12
PS11-03 (411-412)	19.20	14.59	24.03	2.41
PS11-03 (416-417)	18.67	14.17	24.12	2.34
PS11-03 (421-422)	17.42	12.43	28.63	2.18
PS11-03 (426-427)	19.42	13.86	28.61	2.43
PS11-03 (431-432)	14.36	10.45	27.26	1.80
PS11-03 (436-437)	15.43	11.79	23.60	1.93
PS11-03 (441-442)	14.81	11.38	23.16	1.86
PS11-03 (446-447)	15.66	11.74	25.00	1.96
PS11-03 (451-452)	15.09	11.61	23.10	1.89
PS11-03 (456-457)	17.21	12.82	25.51	2.16
PS11-03 (461-462)	18.59	14.13	23.97	2.33
PS11-03 (466-467)	19.96	15.05	24.59	2.50
PS11-03 (471-472)	13.36	9.84	26.34	1.67
PS11-03 (476-477)	19.49	14.72	24.47	2.44
PS11-03 (481-482)	18.92	14.27	24.57	2.37
PS11-03 (486-487)	18.40	13.97	24.07	2.31
PS11-03 (491-492)	19.89	14.71	26.02	2.49
PS11-03 (496-497)	17.02	12.67	25.59	2.13
PS11-03 (501-502)	18.51	14.02	24.22	2.32
PS11-03 (506-507)	18.35	13.64	25.68	2.30
PS11-03 (511-512)	17.35	12.99	25.14	2.17
PS11-03 (516-517)	19.27	14.43	25.11	2.42
PS11-03 (521-522)	20.74	15.69	24.34	2.60
PS11-03 (526-527)	19.50	14.59	25.17	2.44
PS11-03 (531-532)	17.13	12.23	28.59	2.15
PS11-03 (536-537)	19.10	13.90	27.24	2.39
PS11-03 (541-542)	14.75	10.86	26.40	1.85
PS11-03 (546-547)	15.36	11.58	24.57	1.92
PS11-03 (551-552)	18.87	14.17	24.89	2.36
PS11-03 (556-557)	15.39	10.83	29.65	1.93
PS11-03 (561-562)	17.19	11.04	35.78	2.15
PS11-03 (566-567)	14.63	9.88	32.48	1.83

Table A1. Water content and bulk density of core PS11-03 (continued).

Sample (depth in cm)	**wet weight (g)**	**dry weight (g)**	**water content (%)**	**bulk[1] density (g/cm^3)**
PS11-03 (571-572)	10.57	6.89	34.76	1.32
PS11-03 (576-577)	13.05	8.95	31.39	1.63
PS11-03 (581-582)	17.55	12.73	27.45	2.20
PS11-03 (586-587)	15.24	10.54	30.82	1.91
PS11-03 (591-592)	17.59	12.04	31.56	2.20
PS11-03 (596-597)	12.82	8.04	37.28	1.61
PS11-03 (601-602)	10.93	6.39	41.52	1.37
PS11-03 (606-607)	12.95	7.86	39.28	1.62
PS11-03 (611-612)	14.23	8.60	39.53	1.78
PS11-03 (616-617)	18.21	12.06	33.79	2.28
PS11-03 (621-622)	13.51	8.89	34.19	1.69
PS11-03 (626-627)	17.07	12.09	29.15	2.14
PS11-03 (631-632)	16.46	11.67	29.12	2.06
PS11-03 (636-637)	14.70	9.91	32.59	1.84
PS11-03 (641-642)	14.26	9.37	34.33	1.79
PS11-03 (646-647)	18.35	11.41	37.82	2.30
PS11-03 (651-652)	13.72	8.90	35.10	1.72
PS11-03 (656-657)	18.81	12.46	33.76	2.36
PS11-03 (661-662)	14.58	10.15	30.38	1.83
PS11-03 (666-667)	16.04	10.85	32.33	2.01
PS11-03 (671-672)	15.61	9.97	36.16	1.96
PS11-03 (676-677)	17.29	9.90	42.74	2.17
PS11-03 (681-682)	17.44	12.06	30.83	2.19
PS11-03 (686-687)	15.75	10.63	32.49	1.97
PS11-03 (691-692)	18.96	13.19	30.41	2.38
PS11-03 (696-697)	18.58	13.01	29.98	2.33
PS11-03 (701-702)	13.87	9.87	28.82	1.74
PS11-03 (706-707)	14.12	9.63	31.84	1.77
PS11-03 (711-712)	16.41	10.64	35.13	2.06
PS11-03 (716-717)	14.96	9.97	33.36	1.87
PS11-03 (721-722)	16.47	11.29	31.43	2.06
PS11-03 (726-727)	19.73	14.33	27.34	2.47
PS11-03 (731-732)	18.09	13.32	26.38	2.27
PS11-03 (736-737)	15.07	10.69	29.08	1.89
PS11-03 (741-742)	14.68	9.88	32.69	1.84
PS11-03 (746-747)	17.84	12.12	32.10	2.24
PS11-03 (751-752)	12.43	8.19	34.09	1.56
PS11-03 (756-757)	12.52	7.99	36.15	1.57

Table A1. Water content and bulk density of core PS11-03 (continued).

Sample (depth in cm)	**wet weight (g)**	**dry weight (g)**	**water content (%)**	**bulk[1] density (g/cm^3)**
PS11-03 (761-762)	11.69	7.41	36.60	1.47
PS11-03 (766-767)	13.36	8.19	38.72	1.67
PS11-03 (771-772)	13.17	8.89	32.46	1.65
PS11-03 (779-780)	12.48	7.86	37.02	1.56

[1] The volume of solids + pores spaces in each section was calculated to be 7.98 cm^3, and used to calculate bulk density.

Table A2. Radiocarbon age estimates for core PS11-03.

Core	Service	Depth in core (cm)	Material	Labcode	$\delta^{13}C$ (‰)	Radiocarbon age estimate (2 sigma calibration)
PS11-03	AMS-Standard delivery	170-171	foraminifera	Beta-344282	-1.6	880 to 590 cal. yBP
PS11-03	AMS-Standard delivery	502-503	foraminifera	Beta-344283	-2.5	4520 to 4090 cal. yBP

Table A3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), black carbon (BC), and soot carbon (soot) in core PS11-03.

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**OC[1] (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**BC (%)**	mean	stdev	**soot (%)**	*mean*	*stdev*
PS11-03 (1-2)	0.51			0.36			0.06			0.15			0.10		
PS11-03 (6-7)	0.65			0.44			0.06			0.20			0.10		
PS11-03 (11-12)	0.88			0.61			0.08			0.27			0.10		
PS11-03 (16-17)	0.65			0.42			0.06			0.23			0.20		
PS11-03 (21-22)	0.95			0.70			0.08			0.24			0.37, 0.31	0.34	
PS11-03 (26-27)	1.00			0.65			0.08			0.35			0.20		
PS11-03 (31-32)	0.71			0.47			0.06			0.23			0.17		
PS11-03 (36-37)	0.38			0.23			0.04			0.15			0.18		
PS11-03 (41-42)	0.43			0.26			0.04			0.18			0.10		
PS11-03 (46-47) rep1	0.55	0.55	0.01	0.28	0.30	0.03	0.05	0.05	0.00	0.27	0.25	0.02	0.10	0.10	0.00
PS11-03 (46-47) rep2	0.54			0.29			0.05			0.25			0.10		
PS11-03 (46-47) rep3	0.57			0.34			0.05			0.23			0.10		
PS11-03 (51-52)	0.64			0.28			0.06			0.36			0.10, 0.13	0.11	
PS11-03 (56-57)	0.50			0.27			0.05			0.23			0.09		
PS11-03 (61-62)	0.54			0.33			0.05			0.21			0.10		
PS11-03 (66-67)	0.50			0.26			0.05			0.23			0.16		
PS11-03 (71-72)	0.37			0.12			0.04			0.26			0.12		
PS11-03 (76-77)	0.48			0.25			0.05			0.23			0.11		
PS11-03 (81-82)	0.37			0.21			0.03			0.17			0.07		
PS11-03 (86-87)	0.43			0.24			0.04			0.19			0.10		
PS11-03 (91-92)	0.39			0.20			0.04			0.19			0.11		
PS11-03 (96-97) rep1	0.32	0.34	0.03	0.17	0.19	0.03	0.03	0.03	0.00	0.15	0.15	0.00	0.07	0.07	0.00
PS11-03 (96-97) rep2	0.31			0.16			0.03			0.15			0.07		
PS11-03 (96-97) rep3	0.38			0.23			0.03			0.15			0.07		
PS11-03 (101-102)	0.39			0.21			0.03			0.18			0.07		
PS11-03 (106-107)	0.37			0.24			0.03			0.12			0.15		
PS11-03 (111-112)	0.29			0.16			0.03			0.14			0.18		
PS11-03 (116-117)	0.31			0.17			0.03			0.15			0.19		

Table A3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), black carbon (BC), and soot carbon (soot) in core PS11-03 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**OC[1] (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**BC (%)**	*mean*	*stdev*	**soot (%)**	*mean*	*stdev*
PS11-03 (121-122)	0.29			0.21			0.02			0.08			0.10		
PS11-03 (126-127)	0.22			0.16			0.02			0.06			0.11		
PS11-03 (131-132)	0.20			0.16			0.02			0.04			0.08		
PS11-03 (136-137)	0.14			0.11			0.01			0.03			0.07		
PS11-03 (141-142)	0.11			0.03			0.01			0.08			0.06		
PS11-03 (146-147) rep1	0.17	0.16	0.01	0.11	0.11	0.01	0.02	0.01	0.00	0.06	0.05	0.01	0.07	0.07	0.00
PS11-03 (146-147) rep2	0.17			0.10			0.01			0.07			0.07		
PS11-03 (146-147) rep3	0.15			0.12			0.01			0.04			0.08		
PS11-03 (151-152)	0.17			0.13			0.02			0.04			0.07		
PS11-03 (156-157)	0.20			0.14			0.02			0.06			0.08		
PS11-03 (161-162)	0.18			0.14			0.02			0.04			0.08		
PS11-03 (166-167)	0.21			0.17			0.02			0.04			0.07		
PS11-03 (171-172)	0.17			0.14			0.01			0.03			0.06		
PS11-03 (176-177)	0.17			0.13			0.02			0.04			0.15		
PS11-03 (181-182)	0.43			0.32			0.03			0.11			0.06, 0.07	0.06	
PS11-03 (186-187)	0.72			0.50			0.05			0.22			0.06, 0.07	0.07	
PS11-03 (191-192)	0.91			0.67			0.07			0.25			0.07		
PS11-03 (196-197) rep1	0.80	0.80	0.00	0.56	0.56	0.00	0.06	0.06	0.00	0.24	0.25	0.00	0.09	0.09	0.00
PS11-03 (196-197) rep2	0.80			0.56			0.06			0.24			0.09, 0.09		
PS11-03 (196-197) rep3	0.80			0.55			0.06			0.25			0.09		
PS11-03 (201-202)	0.84			0.61			0.07			0.23			0.10		
PS11-03 (206-207)	0.80			0.56			0.06			0.24			0.10		
PS11-03 (211-212)	0.86			0.63			0.07			0.23			0.12		
PS11-03 (216-217)	0.83			0.57			0.06			0.26			0.11		
PS11-03 (221-222)	1.01			0.68			0.08			0.33			0.12		
PS11-03 (226-227)	0.78			0.54			0.06			0.24			0.11		
PS11-03 (231-232)	0.70			0.48			0.06			0.22			0.09		
PS11-03 (236-237)	0.94			0.62			0.07			0.32			0.07		
PS11-03 (241-242)	1.00			0.71			0.08			0.29			0.09		

Table A3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), black carbon (BC), and soot carbon (soot) in core PS11-03 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**OC[1] (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**BC (%)**	*mean*	*stdev*	**soot (%)**	*mean*	*stdev*
PS11-03 (246-247) rep1	0.81	0.82	0.01	0.55	0.57	0.01	0.07	0.07	0.00	0.26	0.24	0.02	0.09	0.09	0.00
PS11-03 (246-247) rep2	0.83			0.58			0.07			0.25			0.10		
PS11-03 (246-247) rep3	0.81			0.59			0.07			0.22			0.09		
PS11-03 (251-252)	0.79			0.53			0.07			0.27			0.08		
PS11-03 (256-257)	0.90			0.61			0.08			0.29			0.12		
PS11-03 (261-262)	0.81			0.54			0.07			0.27			0.09		
PS11-03 (266-267)	0.90			0.45			0.07			0.44			0.12		
PS11-03 (271-272)	0.51			0.39			0.04			0.12			0.08		
PS11-03 (276-277)	0.51			0.36			0.04			0.15			0.07		
PS11-03 (281-282)	0.42			0.26			0.04			0.16			0.08		
PS11-03 (286-287)	0.47			0.35			0.04			0.12			0.09		
PS11-03 (291-292)	0.64			0.41			0.06			0.24			0.19		
PS11-03 (296-297) rep1	0.56	0.57	0.00	0.41	0.40	0.01	0.05	0.05	0.00	0.16	0.16	0.01	0.11	0.11	0.00
PS11-03 (296-297) rep2	0.57			0.41			0.05			0.16			0.11		
PS11-03 (296-297) rep3	0.56			0.40			0.05			0.17			0.11		
PS11-03 (301-302)	0.63			0.40			0.06			0.22			0.00, 0.29	0.14	
PS11-03 (306-307)	0.62			0.39			0.06			0.24			0.18		
PS11-03 (311-312)	0.60			0.36			0.06			0.24			0.18		
PS11-03 (316-317)	0.61			0.40			0.06			0.21			0.22		
PS11-03 (321-322)	0.63			0.35			0.06			0.27			0.17		
PS11-03 (326-327)	0.60			0.39			0.05			0.21			0.18		
PS11-03 (331-332)	0.63			0.48			0.06			0.15			0.23		
PS11-03 (336-337)	0.54			0.35			0.05			0.19			0.21		
PS11-03 (341-342)	0.56			0.35			0.05			0.21			0.24		
PS11-03 (346-347) rep1	0.57	0.53	0.07	0.34	0.30	0.07	0.05	0.05	0.01	0.24	0.22	0.01			
PS11-03 (346-347) rep2	0.43			0.21			0.04			0.22					
PS11-03 (346-347) rep3	0.58			0.36			0.05			0.22			0.33		
PS11-03 (351-352)	0.51			0.35			0.05			0.16			0.23		
PS11-03 (356-357)	0.48			0.28			0.04			0.19			0.22		

Table A3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), black carbon (BC), and soot carbon (soot) in core PS11-03 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**OC[1] (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**BC (%)**	*mean*	*stdev*	**soot (%)**	*mean*	*stdev*
PS11-03 (361-362)	0.44			0.30			0.04			0.14			0.35		
PS11-03 (366-367)	0.43			0.19			0.04			0.25			0.29		
PS11-03 (371-372)	0.40			0.27			0.04			0.13					
PS11-03 (376-377)	0.45			0.32			0.04			0.13			0.15		
PS11-03 (381-382)	0.38			0.23			0.04			0.15			0.16		
PS11-03 (386-387)	0.45			0.30			0.04			0.15			0.18		
PS11-03 (391-392)	0.37			0.27			0.03			0.10			0.19		
PS11-03 (396-397) rep1	0.43	0.48	0.07	0.30	0.30	0.08	0.04	0.04	0.01	0.13	0.11	0.02	0.19	0.19	0.00
PS11-03 (396-397) rep2	0.58			0.49			0.05			0.09			0.19		
PS11-03 (396-397) rep3	0.43			0.34			0.04			0.10			0.18		
PS11-03 (401-402)	0.31			0.25			0.03			0.06			0.17		
PS11-03 (406-407)	0.33			0.26			0.03			0.07			0.21		
PS11-03 (411-412)	0.35			0.27			0.03			0.07			0.17		
PS11-03 (416-417)	0.35			0.27			0.03			0.08			0.18		
PS11-03 (421-422)	0.45			0.34			0.04			0.11			0.19		
PS11-03 (426-427)	0.44			0.32			0.04			0.12			0.21		
PS11-03 (431-432)	0.38			0.27			0.03			0.11			0.20		
PS11-03 (436-437)	0.29			0.22			0.02			0.07			0.21		
PS11-03 (441-442)	0.25			0.18			0.02			0.06			0.17		
PS11-03 (446-447) rep1	0.33	0.31	0.01	0.24	0.23	0.02	0.03	0.03	0.00	0.08	0.08	0.00	0.21	0.20	0.01
PS11-03 (446-447) rep2	0.31			0.23			0.02			0.08			0.20		
PS11-03 (446-447) rep3	0.29			0.20			0.02			0.09			0.21		
PS11-03 (451-452)	0.21			0.15			0.02			0.06			0.16		
PS11-03 (456-457)	0.28			0.20			0.02			0.08			0.18		
PS11-03 (461-462)	0.28			0.21			0.02			0.07			0.17		
PS11-03 (466-467)	0.30			0.22			0.02			0.09			0.23		
PS11-03 (471-472)	0.30			0.21			0.03			0.09			0.17		
PS11-03 (476-477)	0.33			0.24			0.02			0.09			0.22		
PS11-03 (481-482)	0.39			0.27			0.03			0.11			0.23		

Table A3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), black carbon (BC), and soot carbon (soot) in core PS11-03 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**OC[1] (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**BC (%)**	*mean*	*stdev*	**soot (%)**	*mean*	*stdev*
PS11-03 (486-487)	0.32			0.24			0.03			0.08			0.17		
PS11-03 (491-492)	0.32			0.23			0.03			0.09			0.17		
PS11-03 (496-497) rep1	0.38	0.40	0.03	0.25	0.28	0.03	0.03	0.03	0.00	0.13	0.12	0.01	0.20	0.20	0.00
PS11-03 (496-497) rep2	0.44			0.33			0.03			0.12			0.20		
PS11-03 (496-497) rep3	0.38			0.27			0.03			0.11			0.19		
PS11-03 (501-502)	0.37			0.27			0.03			0.10			0.18		
PS11-03 (506-507)	0.42			0.29			0.04			0.13			0.22		
PS11-03 (511-512)	0.37			0.28			0.03			0.09			0.20		
PS11-03 (516-517)	0.42			0.31			0.03			0.11			0.21		
PS11-03 (521-522)	0.31			0.23			0.03			0.08			0.19		
PS11-03 (526-527)	0.35			0.26			0.03			0.09			0.20		
PS11-03 (531-532)	0.44			0.34			0.04			0.10			0.18		
PS11-03 (536-537)	0.43			0.30			0.04			0.13			0.21		
PS11-03 (541-542)	0.41			0.31			0.03			0.10			0.20		
PS11-03 (546-547) rep1	0.37	0.39	0.02	0.24	0.28	0.03	0.03	0.03	0.00	0.13	0.11	0.02	0.20	0.21	0.01
PS11-03 (546-547) rep2	0.41			0.32			0.03			0.09			0.20		
PS11-03 (546-547) rep3	0.40			0.28			0.03			0.12			0.22		
PS11-03 (551-552)	0.37			0.23			0.03			0.14			0.23		
PS11-03 (556-557)	0.11			-0.07			0.03			0.18			0.29		
PS11-03 (561-562)	0.61			0.44			0.06			0.17			0.22		
PS11-03 (566-567)	0.55			0.22			0.05			0.32			0.24		
PS11-03 (571-572)	0.40			0.24			0.05			0.16			0.32		
PS11-03 (576-577)	0.41			0.21			0.04			0.19			0.24		
PS11-03 (581-582)	0.11			-0.05			0.03			0.16			0.21		
PS11-03 (586-587)	0.55			0.36			0.05			0.19			0.21		
PS11-03 (591-592)	0.69			0.29			0.06			0.41			0.23		
PS11-03 (596-597) rep1	0.67	0.72	0.03	0.47	0.48	0.01	0.06	0.06	0.00	0.20	0.24	0.03	0.22	0.21	0.01
PS11-03 (596-597) rep2	0.75			0.49			0.07			0.26			0.22		
PS11-03 (596-597) rep3	0.74			0.48			0.07			0.26			0.20		

Table A3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), black carbon (BC), and soot carbon (soot) in core PS11-03 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**OC[1] (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**BC (%)**	*mean*	*stdev*	**soot (%)**	*mean*	*stdev*
PS11-03 (601-602)	1.04			0.66			0.09			0.38			0.21		
PS11-03 (606-607)	0.94			0.67			0.08			0.27			0.22		
PS11-03 (611-612)	1.00			0.66			0.08			0.34			0.22		
PS11-03 (616-617)	0.68			0.38			0.06			0.30			0.21		
PS11-03 (621-622)	0.69			0.34			0.06			0.36			0.19		
PS11-03 (626-627)	0.52			0.37			0.06			0.16			0.19		
PS11-03 (631-632)	0.58			0.29			0.06			0.29			0.17		
PS11-03 (636-637)	0.65			0.43			0.06			0.22			0.15		
PS11-03 (641-642)	0.85			0.50			0.07			0.35			0.11		
PS11-03 (646-647) rep1	1.04	1.03	0.01	0.77	0.71	0.05	0.08	0.08	0.00	0.27	0.32	0.04	0.09	0.09	0.00
PS11-03 (646-647) rep2	1.03			0.72			0.08			0.31			0.08		
PS11-03 (646-647) rep3	1.01			0.64			0.08			0.37			0.09		
PS11-03 (651-652)	0.92			0.51			0.08			0.41			0.08		
PS11-03 (656-657)	0.82			0.42			0.07			0.40			0.08		
PS11-03 (661-662)	0.64			0.40			0.05			0.24			0.04		
PS11-03 (666-667)	0.85			0.62			0.07			0.23			0.05		
PS11-03 (671-672)	0.88			0.55			0.08			0.33			0.08		
PS11-03 (676-677)	1.04			0.57			0.09			0.46			0.12		
PS11-03 (681-682)	0.68			0.40			0.05			0.28			0.06		
PS11-03 (686-687)	0.81			0.46			0.06			0.35			0.07		
PS11-03 (691-692)	0.71			0.48			0.06			0.24			0.08		
PS11-03 (696-697) rep1	0.70	0.71	0.00	0.49	0.51	0.01	0.06	0.06	0.00	0.22	0.20	0.01	0.08	0.08	0.00
PS11-03 (696-697) rep2	0.71			0.51			0.06			0.20			0.08		
PS11-03 (696-697) rep3	0.70			0.52			0.06			0.18			0.08		
PS11-03 (701-702)	0.71			0.49			0.06			0.22			0.07		
PS11-03 (706-707)	0.75			0.56			0.07			0.19			0.09		
PS11-03 (711-712)	0.87			0.51			0.08			0.36			0.11		
PS11-03 (716-717)	0.82			0.47			0.07			0.36			0.10		
PS11-03 (721-722)	0.81			0.59			0.07			0.21			0.09		

Table A3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), black carbon (BC), and soot carbon (soot) in core PS11-03 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**OC[1] (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**BC (%)**	*mean*	*stdev*	**soot (%)**	*mean*	*stdev*
PS11-03 (726-727)	0.53			0.28			0.05			0.25			0.08		
PS11-03 (731-732)	0.51			0.33			0.05			0.18			0.07		
PS11-03 (736-737)	0.60			0.41			0.06			0.19			0.09		
PS11-03 (741-742)	0.86			0.61			0.07			0.25			0.10		
PS11-03 (746-747) rep1	0.77	0.75	0.02	0.48	0.45	0.06	0.07	0.06	0.00	0.29	0.30	0.07	0.11	0.11	0.00
PS11-03 (746-747) rep2	0.73			0.51			0.06			0.22			0.11		
PS11-03 (746-747) rep3	0.76			0.37			0.06			0.38			0.11		
PS11-03 (751-752)	0.94			0.57			0.08			0.37			0.10		
PS11-03 (756-757)	1.07			0.80			0.09			0.27			0.10		
PS11-03 (761-762)	1.11			0.72			0.09			0.39			0.12		
PS11-03 (766-767)	1.16			0.58			0.09			0.58			0.09		
PS11-03 (771-772)	1.02			0.68			0.07			0.34			0.06, 0.06	0.06	
PS11-03 (776-777)	1.21			0.77			0.10			0.45			0.08, 0.09	0.08	
PS11-03 (779-780) rep1	1.17	1.21	0.04	0.69	0.75	0.07	0.09	0.10	0.00	0.48	0.46	0.04	0.06	0.06	0.00
PS11-03 (779-780) rep2	1.20			0.70			0.10			0.50			0.06		
PS11-03 (779-780) rep3	1.27			0.85			0.10			0.41			0.06		

[1] OC=TOC-BC

Table A4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), black carbon ($\delta^{13}C_{BC}$), and soot carbon ($\delta^{13}C_{soot}$) in core PS11-03.

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}$[1] (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{soot}$ (‰)**	*mean*	*stdev*
PS11-03 (1-2)	-23.83			-23.37			4.52			-24.91			-14.76		
PS11-03 (6-7)	-23.95			-23.53			4.17			-24.85			-12.93		
PS11-03 (11-12)	-23.41			-22.66			4.11			-25.08			-13.58		
PS11-03 (16-17)	-23.33			-22.66			3.95			-24.59			-12.13		
PS11-03 (21-22)	-23.25			-22.64			3.65			-25.02			-19.70, -19.55	-19.63	
PS11-03 (26-27)	-23.06			-22.33			3.68			-24.44			-11.47		
PS11-03 (31-32)	-23.19			-22.62			3.67			-24.36			-9.73		
PS11-03 (36-37)	-23.13			-22.84			3.28			-23.54			-15.10		
PS11-03 (41-42)	-22.67			-22.30			3.53			-23.22			-8.88		
PS11-03 (46-47) rep1	-22.56	-22.47	0.07	-21.78	-21.67	0.13	3.46	3.46	0.08	-23.34	-23.42	0.05	-9.59	-10.62	0.60
PS11-03 (46-47) rep2	-22.40			-21.49			3.37			-23.46			-10.92		
PS11-03 (46-47) rep3	-22.44			-21.76			3.56			-23.45			-11.03		
PS11-03 (51-52)	-22.65			-20.25			3.63			-24.56			-9.24, -13.99	-11.62	
PS11-03 (56-57)	-22.53			-21.37			3.45			-23.92			-10.80		
PS11-03 (61-62)	-22.47			-21.89			3.51			-23.37			-10.19		
PS11-03 (66-67)	-22.40			-21.57			3.62			-23.33			-11.01		
PS11-03 (71-72)	-22.47			-20.62			3.58			-23.31			-10.46		
PS11-03 (76-77)	-22.54			-21.92			3.83			-23.24			-11.54		
PS11-03 (81-82)	-22.80			-22.39			4.23			-23.29			-7.28		
PS11-03 (86-87)	-22.93			-22.82			3.76			-23.07			-7.33		
PS11-03 (91-92)	-22.69			-21.91			3.77			-23.51			-8.71		
PS11-03 (96-97) rep1	-22.39	-22.62	0.32	-21.56	-22.11	0.53	3.95	3.84	0.10	-23.34	-23.26	0.12	-6.61	-7.69	1.17
PS11-03 (96-97) rep2	-23.07			-22.82			3.71			-23.35			-7.15		
PS11-03 (96-97) rep3	-22.39			-21.94			3.85			-23.09			-9.32		
PS11-03 (101-102)	-22.75			-22.13			4.33			-23.49			-7.41		
PS11-03 (106-107)	-23.58			-23.60			3.62			-23.55			-18.37		
PS11-03 (111-112)	-22.57			-21.77			3.42			-23.50			-19.43		

Table A4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), black carbon ($\delta^{13}C_{BC}$), and soot carbon ($\delta^{13}C_{soot}$) in core PS11-03 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}$**[1] **(‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{soot}$ (‰)**	*mean*	*stdev*
PS11-03 (116-117)	-22.33			-21.46			3.57			-23.35			-19.23		
PS11-03 (121-122)	-22.96			-22.32			3.60			-24.68			-11.76		
PS11-03 (126-127)	-22.90			-22.85			3.25			-23.03			-18.90		
PS11-03 (131-132)	-22.47			-22.41			3.48			-22.73			-16.78		
PS11-03 (136-137)	-22.52			-21.89			3.48			-24.72			-16.08		
PS11-03 (141-142)	-22.09			-13.70			4.41			-24.95			-12.65		
PS11-03 (146-147) rep1	-22.57	-22.36	0.16	-21.55	-21.68	0.20	3.35	3.51	0.11	-24.45	-23.64	0.65	-13.86	-13.78	0.11
PS11-03 (146-147) rep2	-22.35			-21.52			3.57			-23.61			-13.62		
PS11-03 (146-147) rep3	-22.18			-21.96			3.60			-22.85			-13.85		
PS11-03 (151-152)	-22.40			-22.10			3.44			-23.47			-14.20		
PS11-03 (156-157)	-22.14			-21.35			3.33			-23.80			-18.43		
PS11-03 (161-162)	-22.38			-22.13			3.67			-23.27			-17.49		
PS11-03 (166-167)	-23.60			-23.68			3.51			-23.26			-14.47		
PS11-03 (171-172)	-22.87			-22.93			3.74			-22.58			-12.86		
PS11-03 (176-177)	-22.23			-21.66			3.75			-23.87			-21.66		
PS11-03 (181-182)	-23.54			-23.39			3.79			-23.96			-9.05, 9.15	-9.10	
PS11-03 (186-187)	-23.66			-23.31			4.05			-24.47			-10.33, -10.07	-10.20	
PS11-03 (191-192)	-23.83			-23.61			3.95			-24.43			-10.44		
PS11-03 (196-197) rep1	-23.53	-23.40	0.10	-23.40	-23.04	0.26	3.86	3.88	0.02	-23.84	-24.22	0.27	-10.29	-10.52	0.20
PS11-03 (196-197) rep2	-23.30			-22.84			3.91			-24.37			-10.39, -10.55		
PS11-03 (196-197) rep3	-23.36			-22.87			3.88			-24.45			-10.83		
PS11-03 (201-202)	-23.24			-22.84			4.14			-24.28			-9.80		
PS11-03 (206-207)	-23.32			-22.92			3.88			-24.25			-9.97		
PS11-03 (211-212)	-23.24			-23.00			3.94			-23.91			-14.58		
PS11-03 (216-217)	-23.40			-23.02			3.94			-24.22			-11.10		
PS11-03 (221-222)	-23.11			-22.49			3.94			-24.37			-11.76		
PS11-03 (226-227)	-23.22			-23.00			3.70			-23.72			-7.90		
PS11-03 (231-232)	-23.08			-22.71			3.69			-23.88			-9.61		

Table A4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), black carbon ($\delta^{13}C_{BC}$), and soot carbon ($\delta^{13}C_{soot}$) in core PS11-03 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}$[1] (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{soot}$ (‰)**	*mean*	*stdev*
PS11-03 (236-237)	-23.02			-22.40			3.87			-24.25			-13.53		
PS11-03 (241-242)	-23.20			-22.75			3.68			-24.30			-10.33		
PS11-03 (246-247) rep1	-22.53	-22.52	0.02	-22.04	-22.18	0.13	3.39	3.40	0.01	-23.58	-23.33	0.25	-8.97	-9.02	0.22
PS11-03 (246-247) rep2	-22.55			-22.36			3.41			-22.98			-8.79		
PS11-03 (246-247) rep3	-22.49			-22.15			3.40			-23.41			-9.31		
PS11-03 (251-252)	-22.45			-22.67			3.46			-22.02			-9.25		
PS11-03 (256-257)	-22.35			-21.64			3.48			-23.84			-9.08		
PS11-03 (261-262)	-22.54			-21.85			3.29			-23.93			-9.70		
PS11-03 (266-267)	-23.04			-21.89			3.63			-24.22			-8.99		
PS11-03 (271-272)	-23.42			-23.32			3.25			-23.75			-8.66		
PS11-03 (276-277)	-22.38			-22.18			3.46			-22.88			-9.64		
PS11-03 (281-282)	-22.23			-21.84			3.44			-22.89			-9.18		
PS11-03 (286-287)	-22.29			-22.60			3.50			-21.37			-8.87		
PS11-03 (291-292)	-21.81			-21.93			3.67			-21.60			-12.07		
PS11-03 (296-297) rep1	-21.77	-21.81	0.04	-21.36	-21.39	0.09	3.73	3.67	0.05	-22.84	-22.86	0.13	-9.98	-9.96	0.12
PS11-03 (296-297) rep2	-21.86			-21.51			3.61			-22.70			-10.09		
PS11-03 (296-297) rep3	-21.81			-21.29			3.65			-23.03			-9.80		
PS11-03 (301-302)	-21.96			-21.40			3.60			-22.99			-18.13, -15.86	-17.00	
PS11-03 (306-307)	-21.98			-21.35			3.93			-23.02			-8.05		
PS11-03 (311-312)	-21.90			-21.09			4.60			-23.11			-8.24		
PS11-03 (316-317)	-22.00			-21.42			4.12			-23.07			-11.83		
PS11-03 (321-322)	-21.95			-21.13			4.22			-23.00			-7.10		
PS11-03 (326-327)	-22.00			-21.51			3.95			-22.92			-9.26		
PS11-03 (331-332)	-21.85			-21.40			3.95			-23.23			-20.21		
PS11-03 (336-337)	-21.92			-21.23			4.12			-23.15			-13.07		
PS11-03 (341-342)	-21.95			-21.22			3.95			-23.13			-12.46		
PS11-03 (346-347) rep1	-21.94	-22.07	0.19	-21.35	-21.44	0.10	4.21	3.99	0.32	-22.77	-22.90	0.14			
PS11-03 (346-347) rep2	-22.35			-21.57			3.54			-23.09					

Table A4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), black carbon ($\delta^{13}C_{BC}$), and soot carbon ($\delta^{13}C_{soot}$) in core PS11-03 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}$[1] (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{soot}$ (‰)**	*mean*	*stdev*
PS11-03 (346-347) rep3	-21.94			-21.39			4.22			-22.83			-17.74		
PS11-03 (351-352)	-21.90			-21.52			3.87			-22.74			-11.72		
PS11-03 (356-357)	-22.06			-21.54			3.96			-22.83			-13.57		
PS11-03 (361-362)	-22.03			-21.63			4.21			-22.88			-16.06		
PS11-03 (366-367)	-22.09			-21.12			4.38			-22.82			-15.67		
PS11-03 (371-372)	-22.11			-21.89			4.24			-22.55					
PS11-03 (376-377)	-22.05			-21.77			4.28			-22.73			-10.83		
PS11-03 (381-382)	-22.09			-21.56			4.20			-22.87			-14.94		
PS11-03 (386-387)	-21.83			-21.27			4.29			-22.95			-16.09		
PS11-03 (391-392)	-22.21			-22.03			4.21			-22.68			-23.23		
PS11-03 (396-397) rep1	-22.20	-22.00	0.22	-21.70	-21.65	0.20	4.45	4.20	0.25	-23.30	-23.17	0.19	-22.00	-21.95	0.04
PS11-03 (396-397) rep2	-21.69			-21.38			3.86			-23.31			-21.91		
PS11-03 (396-397) rep3	-22.10			-21.87			4.28			-22.90			-21.93		
PS11-03 (401-402)	-22.30			-22.21			4.42			-22.68			-25.03		
PS11-03 (406-407)	-22.08			-21.80			3.80			-23.09			-29.38		
PS11-03 (411-412)	-22.22			-22.04			3.87			-22.88			-25.02		
PS11-03 (416-417)	-22.33			-22.25			3.69			-22.59			-26.20		
PS11-03 (421-422)	-21.88			-21.61			3.71			-22.74			-20.56		
PS11-03 (426-427)	-21.97			-21.70			4.19			-22.68			-22.89		
PS11-03 (431-432)	-22.17			-21.74			4.18			-23.19			-25.48		
PS11-03 (436-437)	-22.12			-21.97			3.49			-22.60			-29.11		
PS11-03 (441-442)	-22.18			-20.33			3.43			-27.46			-26.93		
PS11-03 (446-447) rep1	-22.61	-22.46	0.17	-22.20	-22.19	0.04	3.47	3.83	0.33	-23.80	-23.21	0.59	-28.54	-28.44	0.11
PS11-03 (446-447) rep2	-22.54			-22.24			4.26			-23.42			-28.28		
PS11-03 (446-447) rep3	-22.22			-22.14			3.76			-22.41			-28.51		
PS11-03 (451-452)	-22.32			-22.11			3.12			-22.83			-21.24		
PS11-03 (456-457)	-22.39			-22.07			3.59			-23.20			-18.94		
PS11-03 (461-462)	-22.86			-22.84			3.05			-22.93			-18.79		

Table A4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), black carbon ($\delta^{13}C_{BC}$), and soot carbon ($\delta^{13}C_{soot}$) in core PS11-03 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}$[1] (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{soot}$ (‰)**	*mean*	*stdev*
PS11-03 (466-467)	-22.80			-22.79			3.31			-22.81			-20.73		
PS11-03 (471-472)	-22.53			-22.33			3.36			-22.98			-22.38		
PS11-03 (476-477)	-23.46			-23.35			3.26			-23.75			-19.92		
PS11-03 (481-482)	-22.59			-22.33			3.69			-23.20			-20.85		
PS11-03 (486-487)	-22.75			-22.35			3.12			-23.96			-14.46		
PS11-03 (491-492)	-22.90			-22.73			2.85			-23.31			-19.01		
PS11-03 (496-497) rep1	-22.59	-22.83	0.43	-22.11	-22.63	0.63	3.09	3.08	0.01	-23.47	-23.20	0.21	-21.02	-21.23	0.20
PS11-03 (496-497) rep2	-23.42			-23.51			3.09			-23.17			-21.16		
PS11-03 (496-497) rep3	-22.46			-22.25			3.07			-22.97			-21.49		
PS11-03 (501-502)	-22.84			-22.53			2.94			-23.69			-20.96		
PS11-03 (506-507)	-22.61			-22.14			3.30			-23.66			-21.33		
PS11-03 (511-512)	-22.57			-22.19			3.35			-23.78			-20.31		
PS11-03 (516-517)	-23.07			-23.59			3.16			-21.62			-22.44		
PS11-03 (521-522)	-23.06			-23.56			2.85			-21.69			-19.00		
PS11-03 (526-527)	-22.37			-22.09			2.94			-23.20			-19.31		
PS11-03 (531-532)	-22.80			-22.82			3.16			-22.75			-15.51		
PS11-03 (536-537)	-22.55			-22.21			3.30			-23.30			-19.66		
PS11-03 (541-542)	-22.84			-22.64			2.95			-23.48			-24.55		
PS11-03 (546-547) rep1	-22.96	-22.99	0.23	-22.70	-22.82	0.29	2.87	2.97	0.08	-23.46	-23.42	0.06	-24.07	-23.95	0.15
PS11-03 (546-547) rep2	-22.71			-22.54			3.00			-23.33			-23.73		
PS11-03 (546-547) rep3	-23.28			-23.21			3.05			-23.45			-24.04		
PS11-03 (551-552)	-22.52			-21.92			3.24			-23.50			-25.36		
PS11-03 (556-557)	-22.67			-23.93			3.68			-23.18			-24.79		
PS11-03 (561-562)	-22.51			-22.19			3.88			-23.36			-18.53		
PS11-03 (566-567)	-22.46			-21.02			3.86			-23.45			-20.85		
PS11-03 (571-572)	-22.36			-21.75			3.20			-23.32			-24.41		
PS11-03 (576-577)	-22.34			-21.81			3.31			-22.91			-18.88		
PS11-03 (581-582)	-22.36			-24.07			3.38			-22.87			-18.35		

Table A4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), black carbon ($\delta^{13}C_{BC}$), and soot carbon ($\delta^{13}C_{soot}$) in core PS11-03 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}$[1] (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{soot}$ (‰)**	*mean*	*stdev*
PS11-03 (586-587)	-22.31			-21.86			3.41			-23.17			-18.51		
PS11-03 (591-592)	-22.27			-21.18			3.49			-23.03			-19.20		
PS11-03 (596-597) rep1	-22.17	-22.15	0.02	-21.69	-21.57	0.09	3.32	3.54	0.16	-23.30	-23.30	0.04	-15.92	-15.94	0.05
PS11-03 (596-597) rep2	-22.12			-21.49			3.59			-23.34			-16.01		
PS11-03 (596-597) rep3	-22.15			-21.54			3.70			-23.25			-15.88		
PS11-03 (601-602)	-22.89			-22.66			4.44			-23.29			-12.58		
PS11-03 (606-607)	-22.85			-22.68			4.09			-23.27			-12.97		
PS11-03 (611-612)	-22.93			-22.69			4.00			-23.41			-15.04		
PS11-03 (616-617)	-23.30			-23.36			4.05			-23.24			-15.68		
PS11-03 (621-622)	-23.45			-23.61			4.31			-23.29			-12.39		
PS11-03 (626-627)	-23.57			-23.81			4.24			-23.02			-15.65		
PS11-03 (631-632)	-23.03			-22.98			4.12			-23.08			-8.52		
PS11-03 (636-637)	-22.98			-22.95			4.65			-23.02			-8.14		
PS11-03 (641-642)	-22.71			-22.24			4.45			-23.37			-8.83		
PS11-03 (646-647) rep1	-22.76	-22.64	0.12	-22.56	-22.29	0.23	4.41	4.55	0.10	-23.34	-23.39	0.09	-11.34	-11.26	0.08
PS11-03 (646-647) rep2	-22.67			-22.31			4.66			-23.51			-11.16		
PS11-03 (646-647) rep3	-22.48			-22.00			4.59			-23.32			-11.29		
PS11-03 (651-652)	-22.74			-22.06			4.48			-23.58			-10.20		
PS11-03 (656-657)	-22.64			-22.01			4.64			-23.30			-10.55		
PS11-03 (661-662)	-23.18			-22.99			4.24			-23.52			-14.19		
PS11-03 (666-667)	-22.46			-22.16			4.07			-23.26			-16.64		
PS11-03 (671-672)	-22.39			-21.83			4.36			-23.30			-11.31		
PS11-03 (676-677)	-22.23			-21.40			4.46			-23.26			-11.55		
PS11-03 (681-682)	-22.95			-22.70			4.56			-23.33			-12.05		
PS11-03 (686-687)	-23.06			-22.12			4.37			-24.30			-13.09		
PS11-03 (691-692)	-23.14			-23.00			4.11			-23.43			-13.36		
PS11-03 (696-697) rep1	-23.07	-23.02	0.07	-22.99	-22.88	0.15	4.19	4.15	0.04	-23.24	-23.39	0.15	-11.17	-11.21	0.06
PS11-03 (696-697) rep2	-22.93			-22.68			4.10			-23.60			-11.29		

Table A4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), black carbon ($\delta^{13}C_{BC}$), and soot carbon ($\delta^{13}C_{soot}$) in core PS11-03 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}$**[1] **(‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{soot}$ (‰)**	*mean*	*stdev*
PS11-03 (696-697) rep3	-23.07			-22.98			4.14			-23.32			-11.17		
PS11-03 (701-702)	-22.94			-22.45			4.29			-24.01			-12.19		
PS11-03 (706-707)	-22.96			-22.70			4.30			-23.73			-12.31		
PS11-03 (711-712)	-22.82			-22.19			4.54			-23.71			-12.20		
PS11-03 (716-717)	-22.49			-21.54			4.58			-23.75			-11.23		
PS11-03 (721-722)	-22.57			-22.09			4.41			-23.90			-10.50		
PS11-03 (726-727)	-22.91			-22.40			4.35			-23.49			-10.41		
PS11-03 (731-732)	-23.21			-22.91			4.39			-23.77			-10.61		
PS11-03 (736-737)	-23.04			-22.68			4.29			-23.81			-10.39		
PS11-03 (741-742)	-22.95			-22.35			4.50			-24.39			-10.24		
PS11-03 (746-747) rep1	-23.15	-23.12	0.06	-22.57	-22.51	0.25	4.47	4.44	0.03	-24.09	-24.03	0.11	-7.89	-7.99	0.08
PS11-03 (746-747) rep2	-23.18			-22.78			4.46			-24.12			-8.06		
PS11-03 (746-747) rep3	-23.03			-22.17			4.40			-23.87			-8.03		
PS11-03 (751-752)	-23.15			-22.40			4.48			-24.33			-8.97		
PS11-03 (756-757)	-23.15			-22.75			4.69			-24.33			-9.42		
PS11-03 (761-762)	-22.93			-22.17			4.65			-24.34			-8.42		
PS11-03 (766-767)	-23.14			-21.96			4.77			-24.32			-9.65		
PS11-03 (771-772)	-23.59			-23.11			4.41			-24.56			-13.59, -12.91	-13.25	
PS11-03 (776-777)	-23.17			-22.37			4.41			-24.55			-12.63, -11.44	-12.03	
PS11-03 (779-780) rep1	-23.30	-23.39	0.17	-22.39	-22.66	0.34	4.36	4.35	0.05	-24.63	-24.53	0.13	-14.59	-14.60	0.30
PS11-03 (779-780) rep2	-23.24			-22.45			4.40			-24.34			-14.24		
PS11-03 (779-780) rep3	-23.62			-23.14			4.28			-24.61			-14.97		

[1] $\delta^{13}C_{OC} = (\%TOC*\delta^{13}C_{TOC}) - (\%BC*\delta^{13}C_{BC}) / \%OC$

Table A5. Ratios of total organic carbon to total nitrogen (TOC/TN), black carbon to TOC, and soot carbon to TOC in core PS11-03.

Sample (depth in cm)	**TOC/TN (mol:mol)**	*mean*	*stdev*	**BC/TOC (%)**	*mean*	*stdev*	**soot/TOC (%)**	*mean*	*stdev*
PS11-03 (1-2)	10.70			29.90			19.72		
PS11-03 (6-7)	12.97			31.59			16.02		
PS11-03 (11-12)	13.35			31.05			11.13		
PS11-03 (16-17)	13.32			34.81			30.85		
PS11-03 (21-22)	15.06			25.63			35.71		
PS11-03 (26-27)	15.43			34.59			20.06		
PS11-03 (31-32)	13.54			33.04			24.61		
PS11-03 (36-37)	12.62			40.38			46.80		
PS11-03 (41-42)	11.80			40.79			22.23		
PS11-03 (46-47) rep1	12.51	12.48	0.21	49.73	45.49	3.88	18.17	17.91	0.51
PS11-03 (46-47) rep2	12.21			46.38			18.37		
PS11-03 (46-47) rep3	12.71			40.35			17.21		
PS11-03 (51-52)	12.61			55.75			17.78		
PS11-03 (56-57)	12.60			45.50			17.26		
PS11-03 (61-62)	12.21			39.15			18.14		
PS11-03 (66-67)	11.94			47.23			32.18		
PS11-03 (71-72)	11.31			68.61			32.92		
PS11-03 (76-77)	11.51			47.40			23.39		
PS11-03 (81-82)	12.86			44.91			18.67		
PS11-03 (86-87)	14.49			44.33			22.84		
PS11-03 (91-92)	13.22			48.74			28.32		
PS11-03 (96-97) rep1	12.90	12.99	0.65	46.75	44.36	3.66	21.51	20.73	1.22
PS11-03 (96-97) rep2	12.25			47.14			21.66		
PS11-03 (96-97) rep3	13.83			39.18			19.01		
PS11-03 (101-102)	13.91			45.80			16.96		
PS11-03 (106-107)	15.72			34.05			41.95		
PS11-03 (111-112)	13.88			46.58			60.47		
PS11-03 (116-117)	14.18			46.31			60.15		
PS11-03 (121-122)	14.91			27.23			33.20		
PS11-03 (126-127)	14.96			26.89			51.92		
PS11-03 (131-132)	13.69			18.52			42.49		
PS11-03 (136-137)	13.64			22.33			51.34		
PS11-03 (141-142)	12.49			74.56			53.48		
PS11-03 (146-147) rep1	13.54	13.49	0.43	35.19	32.94	6.61	42.55	45.46	2.84
PS11-03 (146-147) rep2	14.00			39.68			44.52		
PS11-03 (146-147) rep3	12.95			23.96			49.32		
PS11-03 (151-152)	13.03			22.10			40.47		
PS11-03 (156-157)	12.95			32.22			38.03		

Table A5. Ratios of total organic carbon to total nitrogen (TOC/TN), black carbon to TOC, and soot carbon to TOC in core PS11-03 (continued).

Sample (depth in cm)	**TOC/TN (mol:mol)**	*mean*	*stdev*	**BC/TOC (%)**	*mean*	*stdev*	**soot/TOC (%)**	*mean*	*stdev*
PS11-03 (161-162)	14.18			21.76			42.22		
PS11-03 (166-167)	16.92			18.32			34.03		
PS11-03 (171-172)	14.34			16.92			38.65		
PS11-03 (176-177)	12.84			25.82			88.65		
PS11-03 (181-182)	15.35			25.69			14.93		
PS11-03 (186-187)	15.82			30.39			9.43		
PS11-03 (191-192)	16.46			27.02			8.08		
PS11-03 (196-197) rep1	15.28	15.28	0.06	30.07	30.57	0.49	11.58	11.57	0.04
PS11-03 (196-197) rep2	15.20			30.39			11.61		
PS11-03 (196-197) rep3	15.34			31.23			11.52		
PS11-03 (201-202)	15.50			27.44			11.95		
PS11-03 (206-207)	15.41			29.71			13.01		
PS11-03 (211-212)	15.54			26.52			14.27		
PS11-03 (216-217)	15.69			31.46			13.66		
PS11-03 (221-222)	15.37			32.86			11.42		
PS11-03 (226-227)	15.34			30.61			13.56		
PS11-03 (231-232)	14.99			31.31			12.83		
PS11-03 (236-237)	15.05			33.64			7.80		
PS11-03 (241-242)	15.47			28.82			8.92		
PS11-03 (246-247) rep1	14.27	14.37	0.08	31.86	29.70	2.00	11.53	11.59	0.06
PS11-03 (246-247) rep2	14.47			30.22			11.67		
PS11-03 (246-247) rep3	14.36			27.04			11.56		
PS11-03 (251-252)	13.94			33.63			10.54		
PS11-03 (256-257)	13.91			32.20			13.05		
PS11-03 (261-262)	13.77			32.94			11.66		
PS11-03 (266-267)	15.46			49.51			12.89		
PS11-03 (271-272)	15.48			23.64			16.42		
PS11-03 (276-277)	13.62			28.86			14.15		
PS11-03 (281-282)	13.94			37.09			19.02		
PS11-03 (286-287)	14.09			25.16			19.16		
PS11-03 (291-292)	13.36			36.77			29.55		
PS11-03 (296-297) rep1	13.56	13.51	0.04	27.47	28.71	0.95	19.38	19.27	0.10
PS11-03 (296-297) rep2	13.47			28.91			19.28		
PS11-03 (296-297) rep3	13.50			29.76			19.14		
PS11-03 (301-302)	13.61			35.57			23.06		
PS11-03 (306-307)	13.37			37.74			28.19		
PS11-03 (311-312)	13.09			40.30			30.31		
PS11-03 (316-317)	13.25			34.85			35.11		
PS11-03 (321-322)	13.22			43.72			27.40		

Table A5. Ratios of total organic carbon to total nitrogen (TOC/TN), black carbon to TOC, and soot carbon to TOC in core PS11-03 (continued).

Sample (depth in cm)	**TOC/TN (mol:mol)**	*mean*	*stdev*	**BC/TOC (%)**	*mean*	*stdev*	**soot/TOC (%)**	*mean*	*stdev*
PS11-03 (326-327)	13.07			34.53			30.87		
PS11-03 (331-332)	13.22			24.46			35.84		
PS11-03 (336-337)	12.91			35.77			38.69		
PS11-03 (341-342)	12.95			37.91			42.53		
PS11-03 (346-347) rep1	12.84	13.02	0.25	41.27	43.47	5.48			
PS11-03 (346-347) rep2	13.38			51.01					
PS11-03 (346-347) rep3	12.85			38.13			56.64		
PS11-03 (351-352)	12.95			30.97			44.97		
PS11-03 (356-357)	12.96			40.21			46.16		
PS11-03 (361-362)	12.99			31.82			80.74		
PS11-03 (366-367)	12.79			56.95			65.96		
PS11-03 (371-372)	13.01			33.55					
PS11-03 (376-377)	12.91			29.31			34.24		
PS11-03 (381-382)	12.63			40.08			42.28		
PS11-03 (386-387)	12.70			33.46			38.53		
PS11-03 (391-392)	12.76			26.81			51.87		
PS11-03 (396-397) rep1	13.34	13.23	0.17	30.97	23.15	6.08	45.14	39.93	5.64
PS11-03 (396-397) rep2	12.98			16.14			32.10		
PS11-03 (396-397) rep3	13.36			22.33			42.55		
PS11-03 (401-402)	12.99			19.60			54.73		
PS11-03 (406-407)	13.06			21.48			62.63		
PS11-03 (411-412)	12.71			20.88			50.42		
PS11-03 (416-417)	13.98			23.74			51.92		
PS11-03 (421-422)	13.50			24.06			41.21		
PS11-03 (426-427)	13.77			27.92			47.51		
PS11-03 (431-432)	14.32			29.46			52.25		
PS11-03 (436-437)	14.21			23.64			69.74		
PS11-03 (441-442)	14.07			25.92			68.44		
PS11-03 (446-447) rep1	15.36	14.84	0.48	25.58	27.24	2.39	63.76	66.13	3.54
PS11-03 (446-447) rep2	14.95			25.52			63.50		
PS11-03 (446-447) rep3	14.20			30.62			71.14		
PS11-03 (451-452)	12.80			29.16			78.46		
PS11-03 (456-457)	13.60			28.11			63.95		
PS11-03 (461-462)	14.84			26.39			61.43		
PS11-03 (466-467)	15.31			28.76			75.84		
PS11-03 (471-472)	14.05			30.60			56.25		
PS11-03 (476-477)	17.13			28.23			66.52		
PS11-03 (481-482)	15.02			29.50			58.32		
PS11-03 (486-487)	13.96			24.34			53.91		

Table A5. Ratios of total organic carbon to total nitrogen (TOC/TN), black carbon to TOC, and soot carbon to TOC in core PS11-03 (continued).

Sample (depth in cm)	**TOC/TN (mol:mol)**	*mean*	*stdev*	**BC/TOC (%)**	*mean*	*stdev*	**soot/TOC (%)**	*mean*	*stdev*
PS11-03 (491-492)	14.99			28.75			54.25		
PS11-03 (496-497) rep1	13.90	14.59	0.99	35.17	30.37	3.61	52.01	48.99	3.44
PS11-03 (496-497) rep2	15.99			26.48			44.17		
PS11-03 (496-497) rep3	13.88			29.46			50.77		
PS11-03 (501-502)	14.72			26.91			49.68		
PS11-03 (506-507)	14.10			30.59			50.71		
PS11-03 (511-512)	14.24			24.18			54.25		
PS11-03 (516-517)	14.68			26.26			49.77		
PS11-03 (521-522)	14.34			26.97			59.06		
PS11-03 (526-527)	14.15			25.51			57.07		
PS11-03 (531-532)	14.65			23.10			41.61		
PS11-03 (536-537)	14.20			31.31			48.71		
PS11-03 (541-542)	15.20			24.53			49.22		
PS11-03 (546-547) rep1	15.68	16.33	0.49	34.80	28.72	5.50	53.93	52.98	3.39
PS11-03 (546-547) rep2	16.85			21.48			48.43		
PS11-03 (546-547) rep3	16.44			29.87			56.58		
PS11-03 (551-552)	13.65			38.25			62.17		
PS11-03 (556-557)	3.79			168.94			280.07		
PS11-03 (561-562)	12.24			27.78			35.18		
PS11-03 (566-567)	12.71			59.28			43.66		
PS11-03 (571-572)	10.41			39.19			78.89		
PS11-03 (576-577)	11.32			47.75			58.75		
PS11-03 (581-582)	4.08			142.83			184.64		
PS11-03 (586-587)	12.56			34.30			38.35		
PS11-03 (591-592)	14.01			58.80			32.40		
PS11-03 (596-597) rep1	13.17	13.53	0.27	29.54	33.17	2.62	32.33	29.33	2.31
PS11-03 (596-597) rep2	13.81			34.30			28.96		
PS11-03 (596-597) rep3	13.60			35.67			26.71		
PS11-03 (601-602)	14.24			36.43			20.09		
PS11-03 (606-607)	14.48			28.70			22.95		
PS11-03 (611-612)	14.55			34.11			22.18		
PS11-03 (616-617)	13.47			44.33			30.32		
PS11-03 (621-622)	13.27			51.33			27.87		
PS11-03 (626-627)	11.37			30.31			36.13		
PS11-03 (631-632)	11.79			49.88			29.74		
PS11-03 (636-637)	13.01			34.00			23.02		
PS11-03 (641-642)	14.58			41.12			12.69		
PS11-03 (646-647) rep1	15.40	15.30	0.13	26.10	30.90	4.24	8.45	8.35	0.12
PS11-03 (646-647) rep2	15.39			30.19			8.18		
PS11-03 (646-647) rep3	15.11			36.42			8.41		

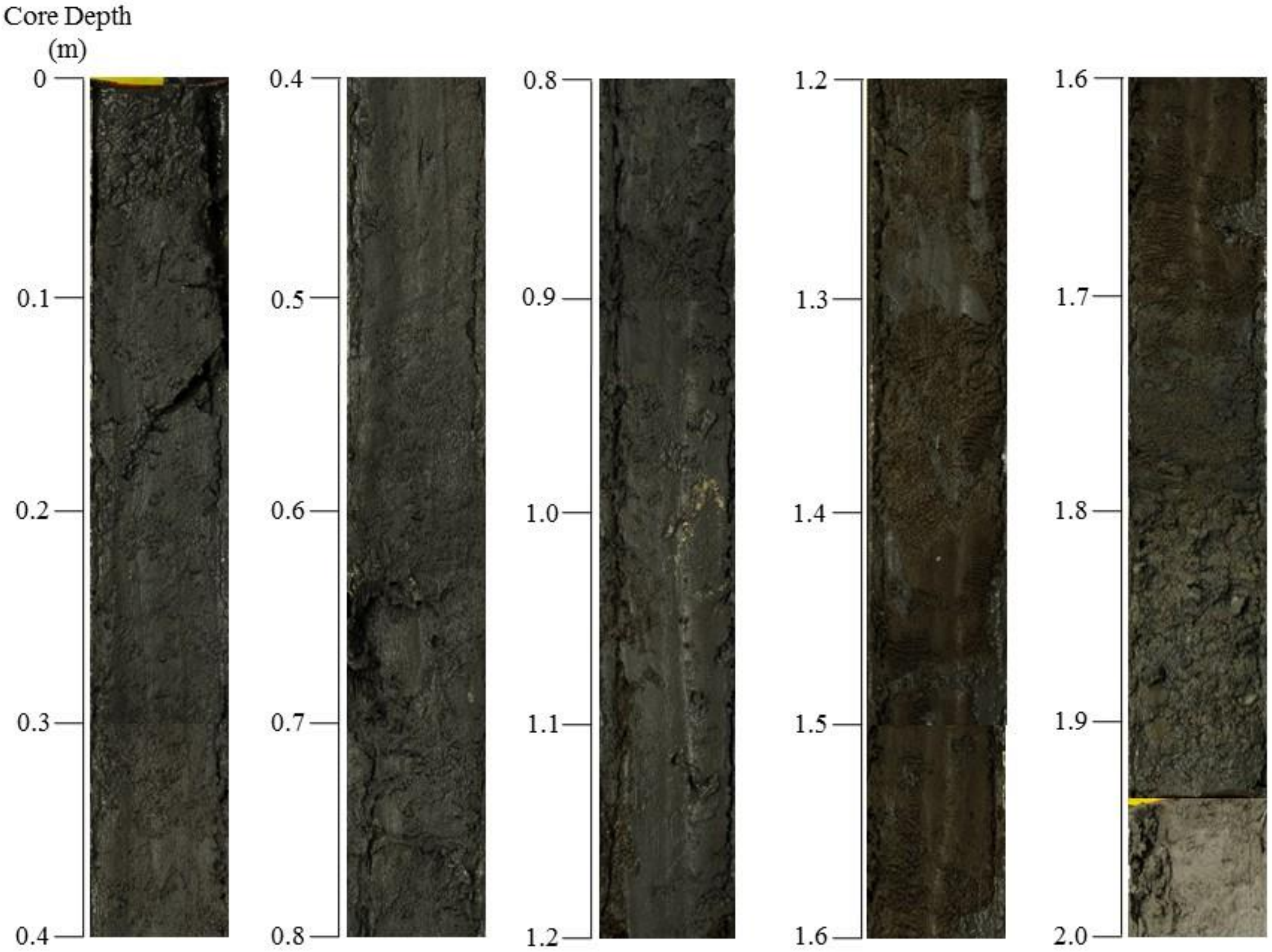
Table A5. Ratios of total organic carbon to total nitrogen (TOC/TN), black carbon to TOC, and soot carbon to TOC in core PS11-03 (continued).

Sample (depth in cm)	**TOC/TN (mol:mol)**	*mean*	*stdev*	**BC/TOC (%)**	*mean*	*stdev*	**soot/TOC (%)**	*mean*	*stdev*
PS11-03 (651-652)	14.26			44.78			8.28		
PS11-03 (656-657)	13.81			48.66			10.03		
PS11-03 (661-662)	14.25			37.21			6.33		
PS11-03 (666-667)	14.54			27.52			5.66		
PS11-03 (671-672)	13.98			37.90			9.17		
PS11-03 (676-677)	13.74			44.69			11.08		
PS11-03 (681-682)	14.98			40.88			8.75		
PS11-03 (686-687)	15.22			43.02			8.62		
PS11-03 (691-692)	14.43			33.30			11.33		
PS11-03 (696-697) rep1	14.43	14.33	0.19	30.74	28.03	2.05	10.70	10.98	0.20
PS11-03 (696-697) rep2	14.06			27.55			11.06		
PS11-03 (696-697) rep3	14.48			25.78			11.18		
PS11-03 (701-702)	14.16			31.46			10.22		
PS11-03 (706-707)	13.77			25.17			12.26		
PS11-03 (711-712)	13.50			41.25			12.48		
PS11-03 (716-717)	13.54			43.17			12.54		
PS11-03 (721-722)	13.64			26.39			11.24		
PS11-03 (726-727)	12.00			47.15			15.07		
PS11-03 (731-732)	12.97			35.46			14.02		
PS11-03 (736-737)	12.50			31.19			14.36		
PS11-03 (741-742)	14.48			29.16			11.39		
PS11-03 (746-747) rep1	14.22	13.99	0.26	37.92	39.51	8.46	14.02	14.22	0.30
PS11-03 (746-747) rep2	13.62			30.03			14.64		
PS11-03 (746-747) rep3	14.12			50.58			13.99		
PS11-03 (751-752)	14.98			39.06			10.79		
PS11-03 (756-757)	14.93			24.92			9.14		
PS11-03 (761-762)	14.54			35.02			10.52		
PS11-03 (766-767)	15.32			49.75			7.73		
PS11-03 (771-772)	16.67			33.07			6.34		
PS11-03 (776-777)	14.83			36.81			6.89		
PS11-03 (779-780) rep1	14.98	15.15	0.32	40.80	38.33	4.05	5.09	4.99	0.29
PS11-03 (779-780) rep2	14.88			41.56			5.29		
PS11-03 (779-780) rep3	15.59			32.62			4.60		

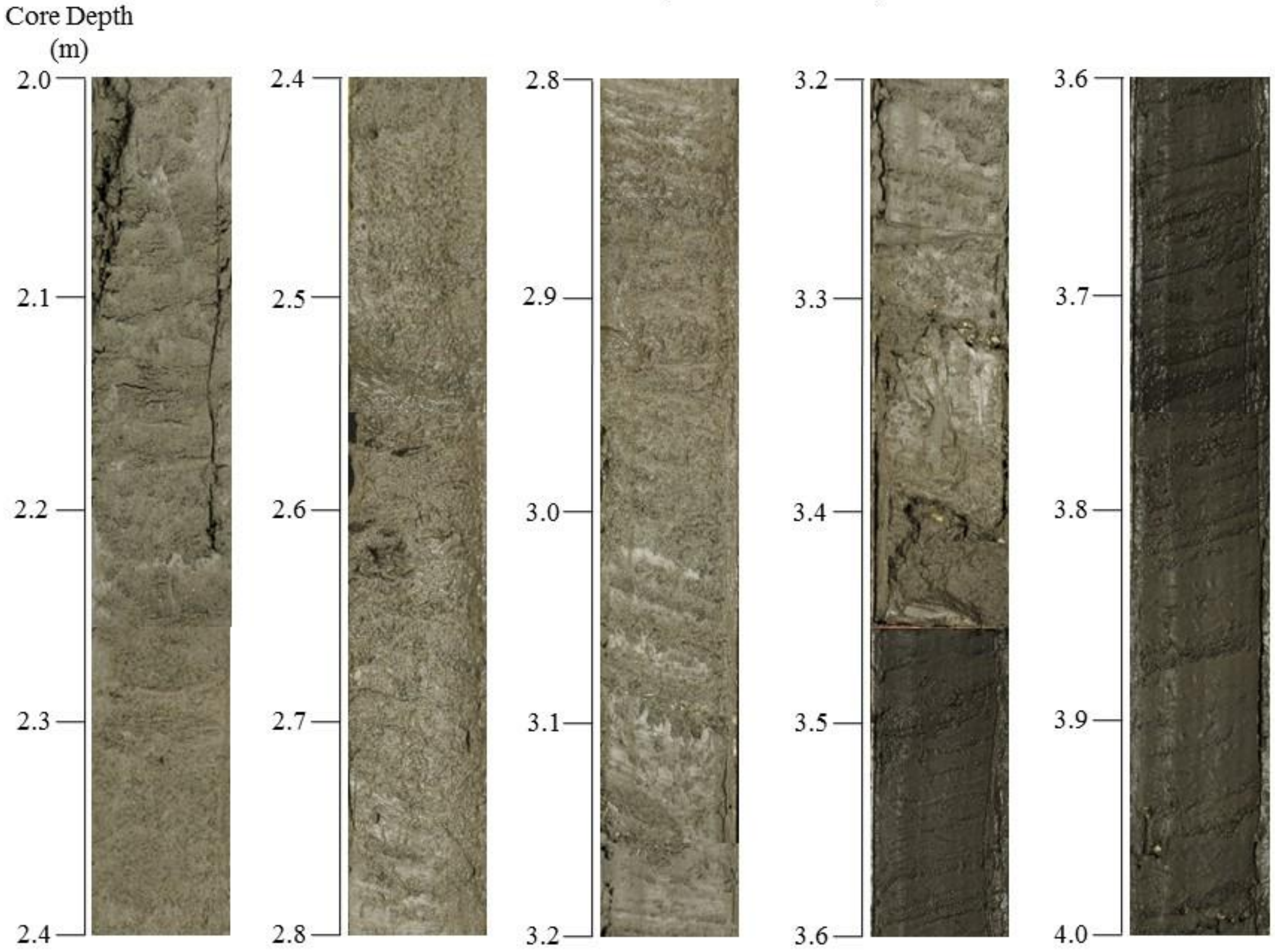
Appendix B

(Core PS12-VC1)

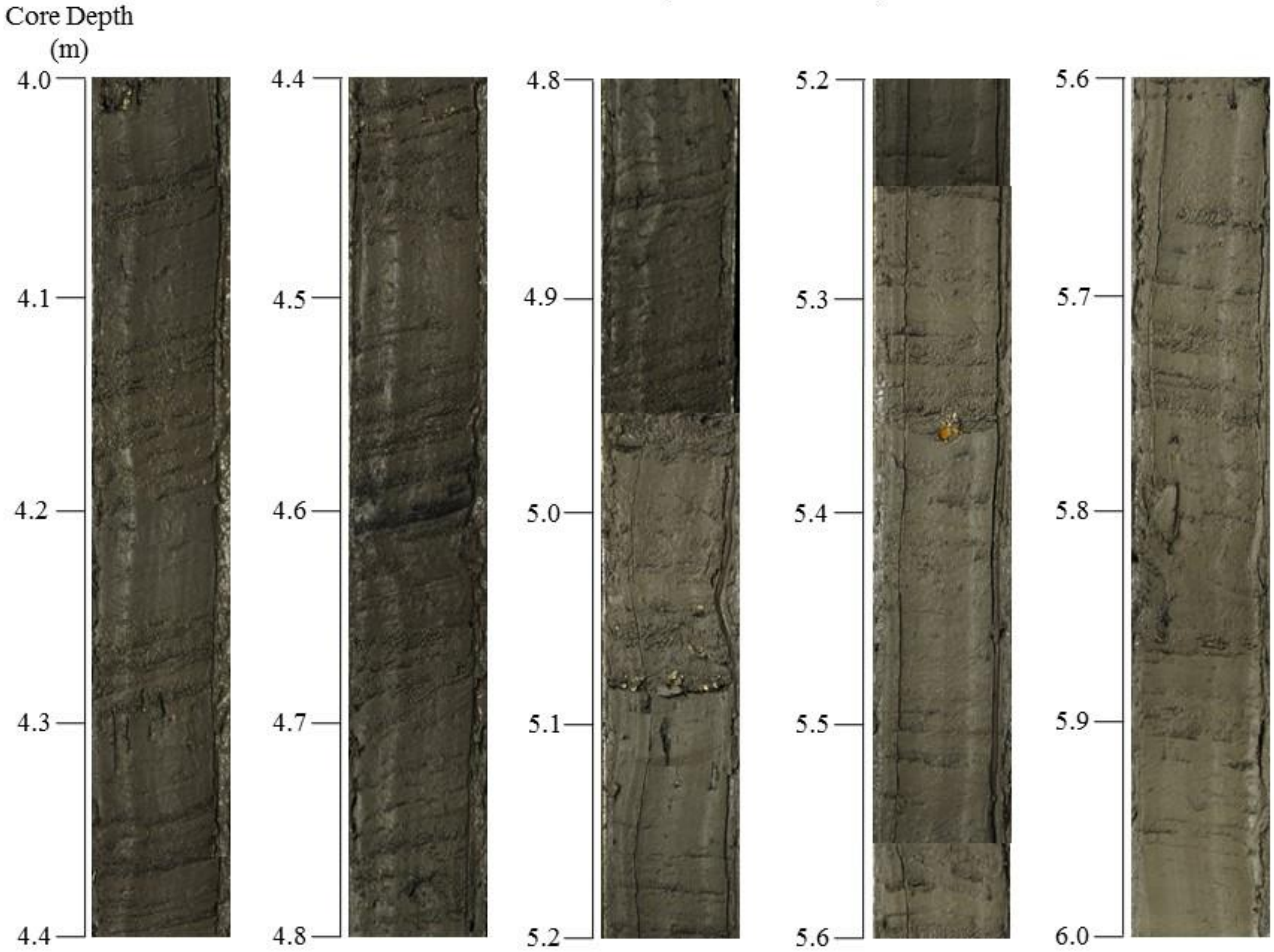
PS12-VC1


Core Depth
(m)
0
0.1
0.2
0.3
0.4
0.4
0.5
0.6
0.7
0.8
0.8
0.9
1.0
1.1
1.2
1.2
1.3
1.4
1.5
1.6
1.6
1.7
1.8
1.9
2.0

PS12-VC1 (continued)



PS12-VC1 (continued)



PS12-VC1 (continued)

Table B1. Water content and bulk density of core PS12-VC1.

Sample (depth in cm)	wet weight (g)	dry weight (g)	water content (%)	[1]bulk density (g/cm^3)
PS12-VC1 (1-2)	13.14	7.50	42.95	0.47
PS12-VC1 (6-7)	9.33	4.96	46.85	0.31
PS12-VC1 (11-12)	11.19	6.68	40.36	0.42
PS12-VC1 (16-17)	20.74	12.79	38.33	0.80
PS12-VC1 (21-22)	13.83	8.65	37.45	0.54
PS12-VC1 (26-27)	22.60	12.96	42.64	0.81
PS12-VC1 (31-32)	26.86	16.71	37.78	1.05
PS12-VC1 (36-37)	24.76	13.03	47.39	0.82
PS12-VC1 (41-42)	15.33	9.76	36.34	0.61
PS12-VC1 (46-47)	17.78	11.27	36.60	0.71
PS12-VC1 (51-52)	24.51	14.97	38.95	0.94
PS12-VC1 (56-57)	23.49	14.88	36.66	0.93
PS12-VC1 (61-62)	22.63	14.35	36.58	0.90
PS12-VC1 (66-67)	18.24	9.79	46.32	0.61
PS12-VC1 (71-72)	23.05	14.84	35.61	0.93
PS12-VC1 (76-77)	28.95	18.99	34.38	1.19
PS12-VC1 (81-82)	24.34	17.05	29.95	1.07
PS12-VC1 (86-87)	27.94	19.14	31.49	1.20
PS12-VC1 (91-92)	25.76	16.10	37.52	1.01
PS12-VC1 (96-97)	26.86	17.60	34.49	1.10
PS12-VC1 (101-102)	28.83	19.61	31.96	1.23
PS12-VC1 (106-107)	28.71	18.67	34.96	1.17
PS12-VC1 (111-112)	19.20	13.19	31.33	0.83
PS12-VC1 (116-117)	27.37	17.92	34.51	1.12
PS12-VC1 (121-122)	25.92	17.68	31.79	1.11
PS12-VC1 (126-127)	24.21	16.42	32.18	1.03
PS12-VC1 (131-132)	28.35	19.65	30.68	1.23
PS12-VC1 (136-137)	28.91	20.24	30.00	1.27
PS12-VC1 (141-142)	16.78	8.99	46.43	0.56
PS12-VC1 (146-147)	25.93	16.09	37.95	1.01
PS12-VC1 (151-152)	26.37	15.50	41.23	0.97
PS12-VC1 (156-157)	20.94	12.64	39.63	0.79
PS12-VC1 (161-162)	24.91	14.78	40.66	0.93
PS12-VC1 (166-167)	25.62	15.19	40.71	0.95
PS12-VC1 (171-172)	32.44	25.26	22.15	1.58
PS12-VC1 (176-177)	36.38	28.79	20.85	1.80
PS12-VC1 (181-182)	35.33	27.40	22.45	1.72
PS12-VC1 (186-187)	22.97	18.56	19.21	1.16
PS12-VC1 (191-192)	24.95	19.99	19.90	1.25
PS12-VC1 (196-197)	27.79	22.18	20.18	1.39

Table B1. Water content and bulk density of core PS12-VC1 (continued).

Sample (depth in cm)	wet weight (g)	dry weight (g)	water content (%)	[1]bulk density (g/cm^3)
PS12-VC1 (201-202)	29.97	22.97	23.36	1.44
PS12-VC1 (206-207)	25.14	19.88	20.90	1.25
PS12-VC1 (211-212)	26.01	20.39	21.62	1.28
PS12-VC1 (216-217)	28.03	21.73	22.48	1.36
PS12-VC1 (221-222)	31.48	24.85	21.07	1.56
PS12-VC1 (226-227)	34.79	27.45	21.11	1.72
PS12-VC1 (231-232)	23.63	18.61	21.22	1.17
PS12-VC1 (236-237)	29.86	24.07	19.38	1.51
PS12-VC1 (241-242)	25.36	19.97	21.24	1.25
PS12-VC1 (246-247)	27.85	22.32	19.84	1.40
PS12-VC1 (251-252)	24.48	18.61	24.00	1.17
PS12-VC1 (256-257)	25.40	19.92	21.59	1.25
PS12-VC1 (261-262)	24.60	19.26	21.71	1.21
PS12-VC1 (266-267)	27.19	21.14	22.24	1.32
PS12-VC1 (271-272)	27.49	21.11	23.20	1.32
PS12-VC1 (276-277)	32.19	22.70	29.48	1.42
PS12-VC1 (281-282)	23.16	16.65	28.11	1.04
PS12-VC1 (286-287)	28.50	22.77	20.10	1.43
PS12-VC1 (291-292)	28.28	21.12	25.32	1.32
PS12-VC1 (296-297)	21.04	15.94	24.24	1.00
PS12-VC1 (301-302)	29.82	23.73	20.41	1.49
PS12-VC1 (306-307)	25.09	18.80	25.06	1.18
PS12-VC1 (311-312)	22.39	16.47	26.41	1.03
PS12-VC1 (316-317)	19.87	14.60	26.50	0.91
PS12-VC1 (321-322)	24.40	17.70	27.45	1.11
PS12-VC1 (326-327)	33.73	25.03	25.80	1.57
PS12-VC1 (331-332)	24.09	18.18	24.56	1.14
PS12-VC1 (336-337)	21.68	14.91	31.20	0.93
PS12-VC1 (341-342)	16.76	11.21	33.13	0.70
PS12-VC1 (346-347)	18.36	12.30	33.03	0.77
PS12-VC1 (351-352)	21.16	14.30	32.42	0.90
PS12-VC1 (356-357)	16.91	12.11	28.41	0.76
PS12-VC1 (361-362)	24.83	17.20	30.74	1.08
PS12-VC1 (366-367)	25.83	18.81	27.15	1.18
PS12-VC1 (371-372)	23.21	17.69	23.81	1.11
PS12-VC1 (376-377)	20.55	15.04	26.83	0.94
PS12-VC1 (381-382)	20.39	15.03	26.28	0.94
PS12-VC1 (386-387)	21.39	16.22	24.19	1.02
PS12-VC1 (391-392)	24.75	16.04	35.20	1.00
PS12-VC1 (396-397)	17.11	11.37	33.54	0.71

Table B1. Water content and bulk density of core PS12-VC1 (continued).

Sample (depth in cm)	wet weight (g)	dry weight (g)	water content (%)	[1]bulk density (g/cm^3)
PS12-VC1 (401-402)	17.33	10.79	37.72	0.68
PS12-VC1 (406-407)	20.36	15.46	24.07	0.97
PS12-VC1 (416-417)	26.79	20.17	24.72	1.26
PS12-VC1 (421-422)	18.86	10.97	41.84	0.69
PS12-VC1 (426-427)	30.84	22.26	27.82	1.39
PS12-VC1 (431-432)	19.77	13.15	33.49	0.82
PS12-VC1 (436-437)	17.90	12.30	31.27	0.77
PS12-VC1 (441-442)	19.18	13.66	28.80	0.86
PS12-VC1 (446-447)	24.24	17.40	28.22	1.09
PS12-VC1 (451-452)	24.94	17.09	31.47	1.07
PS12-VC1 (456-457)	25.95	19.44	25.10	1.22
PS12-VC1 (461-462)	24.54	17.17	30.02	1.08
PS12-VC1 (466-467)	27.66	20.52	25.82	1.29
PS12-VC1 (471-472)	25.34	17.06	32.67	1.07
PS12-VC1 (476-477)	22.65	15.61	31.06	0.98
PS12-VC1 (481-482)	21.26	14.30	32.72	0.90
PS12-VC1 (486-487)	20.44	13.73	32.85	0.86
PS12-VC1 (491-492)	22.21	16.04	27.78	1.00
PS12-VC1 (496-497)	18.35	13.81	24.78	0.87
PS12-VC1 (501-502)	21.75	15.85	27.13	0.99
PS12-VC1 (506-507)	21.93	15.72	28.33	0.98
PS12-VC1 (511-512)	22.32	14.75	33.91	0.92
PS12-VC1 (516-517)	24.44	16.33	33.16	1.02
PS12-VC1 (521-522)	22.96	14.11	38.53	0.88
PS12-VC1 (526-527)	21.07	14.36	31.84	0.90
PS12-VC1 (531-532)	14.94	10.42	30.27	0.65
PS12-VC1 (536-537)	15.18	9.31	38.67	0.58
PS12-VC1 (541-542)	24.69	17.19	30.36	1.08
PS12-VC1 (546-547)	23.29	14.64	37.14	0.92
PS12-VC1 (551-552)	19.33	11.77	39.13	0.74
PS12-VC1 (556-557)	18.49	12.15	34.27	0.76
PS12-VC1 (561-562)	24.93	15.81	36.60	0.99
PS12-VC1 (566-567)	17.38	11.48	33.97	0.72
PS12-VC1 (571-572)	16.27	11.26	30.78	0.71
PS12-VC1 (576-577)	17.08	11.13	34.82	0.70
PS12-VC1 (581-582)	24.07	17.02	29.29	1.07
PS12-VC1 (586-587)	22.17	15.01	32.29	0.94
PS12-VC1 (591-592)	18.32	11.45	37.51	0.72
PS12-VC1 (596-597)	16.27	9.78	39.86	0.61
PS12-VC1 (601-602)	19.37	13.36	31.02	0.84

Table B1. Water content and bulk density of core PS12-VC1 (continued).

Sample (depth in cm)	wet weight (g)	dry weight (g)	water content (%)	[1]bulk density (g/cm^3)
PS12-VC1 (606-607)	21.07	13.35	36.65	0.84
PS12-VC1 (611-612)	22.16	14.96	32.51	0.94
PS12-VC1 (616-617)	20.54	14.32	30.31	0.90
PS12-VC1 (621-622)	21.41	14.39	32.77	0.90
PS12-VC1 (626-627)	21.48	15.54	27.65	0.97
PS12-VC1 (631-632)	24.65	18.57	24.65	1.16
PS12-VC1 (636-637)	23.61	18.10	23.33	1.13
PS12-VC1 (641-642)	18.40	12.11	34.19	0.76
PS12-VC1 (646-647)	26.27	17.72	32.56	1.11
PS12-VC1 (651-652)	24.95	17.19	31.12	1.08
PS12-VC1 (656-657)	24.87	18.39	26.07	1.15
PS12-VC1 (661-662)	27.56	18.70	32.13	1.17
PS12-VC1 (666-667)	24.15	16.82	30.36	1.05
PS12-VC1 (671-672)	23.93	17.75	25.83	1.11
PS12-VC1 (676-677)	20.88	13.71	34.30	0.86
PS12-VC1 (681-682)	21.68	16.38	24.43	1.03
PS12-VC1 (686-687)	22.55	13.82	38.71	0.87
PS12-VC1 (691-692)	23.93	17.87	25.35	1.12
PS12-VC1 (696-697)	17.11	12.13	29.11	0.76
PS12-VC1 (701-702)	22.01	16.76	23.85	1.05
PS12-VC1 (706-707)	24.52	18.52	24.48	1.16
PS12-VC1 (711-712)	27.01	19.38	28.24	1.21
PS12-VC1 (716-717)	26.98	16.83	37.62	1.05
PS12-VC1 (721-722)	25.65	19.33	24.63	1.21
PS12-VC1 (726-727)	21.91	14.79	32.52	0.93
PS12-VC1 (731-732)	16.81	12.06	28.26	0.76
PS12-VC1 (736-737)	22.23	14.92	32.88	0.93
PS12-VC1 (741-742)	23.12	16.64	28.01	1.04
PS12-VC1 (746-747)	23.31	18.03	22.65	1.13
PS12-VC1 (751-752)	25.03	18.80	24.90	1.18
PS12-VC1 (756-757)	25.14	19.16	23.78	1.20
PS12-VC1 (761-762)	15.49	11.79	23.85	0.74
PS12-VC1 (766-767)	23.47	16.08	31.48	1.01
PS12-VC1 (771-772)	20.63	16.89	18.12	1.06
PS12-VC1 (776-777)	29.10	22.92	21.22	1.44
PS12-VC1 (781-782)	22.67	18.41	18.80	1.15
PS12-VC1 (786-787)	28.13	22.66	19.44	1.42
PS12-VC1 (791-792)	20.05	15.95	20.44	1.00

[1] The volume of solids + pores spaces in each section was calculated to be 15.96 cm^3, and used to calculate bulk density.

Table B2. Radiocarbon age estimates for core PS12-VC1.

Core	**Service**	**Depth in core (cm)**	**Material**	**Labcode**	**$\delta^{13}C$ (‰)**	**Radiocarbon age estimate (2 sigma calibration)**
PS12-VC1	AMS-Standard delivery	66-67	total organic carbon	Beta-344284	-23.6	3160 to 2950 cal. yBP
PS12-VC1	AMS-Standard delivery	91-92	total organic carbon	Beta-344285	-24.3	3840 to 3640 cal. yBP
PS12-VC1	AMS-Standard delivery	116-117	total organic carbon	Beta-344286	-24.6	8020 to 7880 cal. yBP
PS12-VC1	AMS-Standard delivery	162-163	total organic carbon	Beta-336379	-25.8	18640 to 18560 cal. yBP
PS12-VC1	AMS-Standard delivery	162-163	black carbon	Beta-336378	-26.8	17710 to 17470 cal. yBP
PS12-VC1	AMS-Standard delivery	182-183	total organic carbon	Beta-336381	-26.4	19550 to 19410 cal. yBP
PS12-VC1	AMS-Standard delivery	182-183	black carbon	Beta-336380	-26.4	22920 to 22450 cal. yBP
PS12-VC1	AMS-Standard delivery	443	shell	Beta-329918	-2.7	beyond range
PS12-VC1	AMS-Standard delivery	508	shell	Beta-329919	-1.1	44800 to 43410 cal. yBP
PS12-VC1	AMS-Standard delivery	536	shell	Beta-329920	-2.5	beyond range

Table B3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), and black carbon (BC), in core PS12-VC1.

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**OC[1] (%)**	*mean*	*stdev*	**BC (%)**	*mean*	*stdev*
PS12-VC1 (1-2)	0.94			0.08			0.64			0.30		
PS12-VC1 (6-7)	1.57			0.11			1.32			0.26		
PS12-VC1 (11-12)	1.15			0.09			1.01			0.14		
PS12-VC1 (16-17)	0.96			0.07			0.67			0.28		
PS12-VC1 (21-22)	1.02			0.07			0.45			0.57		
PS12-VC1 (26-27)	1.34			0.09			0.33			1.00		
PS12-VC1 (31-32)	1.32			0.09			0.66			0.66		
PS12-VC1 (36-37)	1.88			0.12			1.51			0.38		
PS12-VC1 (41-42)	1.37			0.09			0.70			0.67		
PS12-VC1 (46-47) rep1	1.26	1.24	0.01	0.09	0.09	0.00	0.83	0.80	0.20	0.42	0.44	0.20
PS12-VC1 (46-47) rep2	1.24			0.08			1.03			0.20		
PS12-VC1 (46-47) rep3	1.23			0.09			0.55			0.68		
PS12-VC1 (51-52)	1.21			0.08			0.81			0.40		
PS12-VC1 (56-57)	1.11			0.08			0.55			0.56		
PS12-VC1 (61-62)	1.02			0.07			0.71			0.31		
PS12-VC1 (66-67)	1.46			0.10			0.99			0.47		
PS12-VC1 (71-72)	1.02			0.07			0.73			0.30		
PS12-VC1 (76-77)	0.95			0.06			0.71			0.24		
PS12-VC1 (81-82)	0.75			0.05			0.52			0.24		
PS12-VC1 (86-87)	0.87			0.06			0.68			0.18		
PS12-VC1 (91-92)	1.28			0.08			0.90			0.38		
PS12-VC1 (96-97) rep1	0.91	0.94	0.03	0.06	0.06	0.00	0.62	0.66	0.04	0.30	0.28	0.05
PS12-VC1 (96-97) rep2	0.98			0.06			0.65			0.33		
PS12-VC1 (96-97) rep3	0.92			0.06			0.71			0.21		
PS12-VC1 (101-102)	0.76			0.05			0.48			0.28		
PS12-VC1 (106-107)	0.92			0.06			0.71			0.21		
PS12-VC1 (111-112)	0.91			0.05			0.65			0.26		
PS12-VC1 (116-117)	0.95			0.05			0.76			0.20		
PS12-VC1 (121-122)	2.05			0.09			1.63			0.42		
PS12-VC1 (126-127)	1.70			0.08			1.51			0.19		
PS12-VC1 (131-132)	1.77			0.07			1.47			0.30		
PS12-VC1 (136-137)	1.66			0.07			1.51			0.15		
PS12-VC1 (141-142)	5.06			0.23			3.03			2.03		
PS12-VC1 (146-147) rep1	1.53	1.54	0.01	0.08	0.08	0.00	1.29	1.25	0.05	0.25	0.29	0.06
PS12-VC1 (146-147) rep2	1.53			0.08			1.28			0.25		
PS12-VC1 (146-147) rep3	1.56			0.08			1.18			0.38		
PS12-VC1 (151-152)	3.49			0.16			3.04			0.45		
PS12-VC1 (156-157)	2.75			0.12			2.43			0.32		
PS12-VC1 (161-162)	2.34			0.11			1.79			0.55		
PS12-VC1 (166-167)	1.34			0.08			1.09			0.24		

Table B3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), and black carbon (BC), in core PS12-VC1 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**OC^1 (%)**	*mean*	*stdev*	**BC (%)**	*mean*	*stdev*
PS12-VC1 (171-172)	0.54			0.03			0.41			0.14		
PS12-VC1 (176-177)	0.26			0.02			0.20			0.05		
PS12-VC1 (181-182)	0.37			0.04			0.25			0.12		
PS12-VC1 (186-187)	0.36			0.03			0.26			0.09		
PS12-VC1 (191-192)	0.31			0.03			0.25			0.06		
PS12-VC1 (196-197) rep1	0.19	0.19	0.00	0.02	0.02	0.00	0.11	0.12	0.01	0.08	0.07	0.01
PS12-VC1 (196-197) rep2	0.19			0.02			0.14			0.06		
PS12-VC1 (196-197) rep3	0.18			0.02			0.13			0.06		
PS12-VC1 (201-202)	0.21			0.02								
PS12-VC1 (206-207)	0.16			0.02								
PS12-VC1 (211-212)	0.17			0.02								
PS12-VC1 (216-217)	0.17			0.02								
PS12-VC1 (221-222)	0.14			0.01								
PS12-VC1 (226-227)	0.14			0.01								
PS12-VC1 (231-232)	0.18			0.02								
PS12-VC1 (236-237)	0.11			0.01								
PS12-VC1 (241-242)	0.18			0.02								
PS12-VC1 (246-247) rep1	0.09	0.10	0.01	0.01	0.01	0.00						
PS12-VC1 (246-247) rep2	0.11			0.01								
PS12-VC1 (246-247) rep3	0.11			0.01								
PS12-VC1 (251-252)	0.19			0.02								
PS12-VC1 (256-257)	0.15			0.02								
PS12-VC1 (261-262)	0.17			0.02								
PS12-VC1 (266-267)	0.16			0.02								
PS12-VC1 (271-272)	0.19			0.02								
PS12-VC1 (276-277)	0.27			0.03								
PS12-VC1 (281-282)	0.25			0.03								
PS12-VC1 (286-287)	0.11			0.01								
PS12-VC1 (291-292)	0.20			0.02								
PS12-VC1 (296-297) rep1	0.17	0.18	0.01	0.02	0.02	0.00						
PS12-VC1 (296-297) rep2	0.18			0.02								
PS12-VC1 (296-297) rep3	0.19			0.02								
PS12-VC1 (301-302)	0.13			0.01								
PS12-VC1 (306-307)	0.22			0.02								
PS12-VC1 (311-312)	0.23			0.03								
PS12-VC1 (316-317)	0.25			0.03								
PS12-VC1 (321-322)	0.26			0.03								
PS12-VC1 (326-327)	0.25			0.03								
PS12-VC1 (331-332)	0.23			0.02								
PS12-VC1 (336-337)	0.33			0.04								
PS12-VC1 (341-342)	0.37			0.04								

Table B3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), and black carbon (BC), in core PS12-VC1 (continued).

Sample	TOC			TN			OC[1]			BC		
(depth in cm)	**(%)**	*mean*	*stdev*	**(%)**	*mean*	*stdev*	**(%)**	*mean*	*stdev*	**(%)**	*mean*	*stdev*
PS12-VC1 (346-347) rep1	0.39	0.39	0.00	0.04	0.04	0.00						
PS12-VC1 (346-347) rep2	0.39			0.04								
PS12-VC1 (346-347) rep3	0.40			0.04								
PS12-VC1 (351-352)	0.34			0.04								
PS12-VC1 (356-357)	0.29			0.03								
PS12-VC1 (361-362)	0.33			0.04								
PS12-VC1 (366-367)	0.24			0.03								
PS12-VC1 (371-372)	0.19			0.02								
PS12-VC1 (376-377)	0.25			0.03								
PS12-VC1 (381-382)	0.23			0.02								
PS12-VC1 (386-387)	0.20			0.02								
PS12-VC1 (391-392)	0.40			0.05								
PS12-VC1 (396-397) rep1	0.43	0.43	0.00	0.04	0.04	0.00						
PS12-VC1 (396-397) rep2	0.43			0.04								
PS12-VC1 (396-397) rep3	0.42			0.04								
PS12-VC1 (401-402)	0.49			0.05								
PS12-VC1 (406-407)	0.23			0.02								
PS12-VC1 (411-412)	0.38			0.04								
PS12-VC1 (416-417)	0.21			0.02								
PS12-VC1 (421-422)	0.53			0.06								
PS12-VC1 (426-427)	0.28			0.03								
PS12-VC1 (431-432)	0.42			0.04								
PS12-VC1 (436-437)	0.36			0.04								
PS12-VC1 (441-442)	0.31			0.03								
PS12-VC1 (446-447) rep1	0.27	0.28	0.01	0.03	0.03	0.00						
PS12-VC1 (446-447) rep2	0.28			0.03								
PS12-VC1 (446-447) rep3	0.28			0.03								
PS12-VC1 (451-452)	0.34			0.04								
PS12-VC1 (456-457)	0.21			0.02								
PS12-VC1 (461-462)	0.29			0.03								
PS12-VC1 (466-467)	0.24			0.03								
PS12-VC1 (471-472)	0.33			0.04								
PS12-VC1 (476-477)	0.29			0.04								
PS12-VC1 (481-482)	0.34			0.04								
PS12-VC1 (486-487)	0.35			0.04								
PS12-VC1 (491-492)	0.27			0.03								
PS12-VC1 (496-497) rep1	0.19	0.20	0.01	0.02	0.02	0.00						
PS12-VC1 (496-497) rep2	0.19			0.02								
PS12-VC1 (496-497) rep3	0.21			0.02								
PS12-VC1 (501-502)	0.25			0.03								
PS12-VC1 (506-507)	0.23			0.02								

Table B3. Abundances of total organic carbon (TOC), labile organic carbon (OC), total nitrogen (TN), and black carbon (BC), in core PS12-VC1 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**OC[1] (%)**	*mean*	*stdev*	**BC (%)**	*mean*	*stdev*
PS12-VC1 (511-512)	0.36			0.04								
PS12-VC1 (516-517)	0.36			0.04								
PS12-VC1 (521-522)	0.49			0.05								
PS12-VC1 (526-527)	0.34			0.03								
PS12-VC1 (531-532)	0.27			0.03								
PS12-VC1 (536-537)	0.43			0.05								
PS12-VC1 (541-542)	0.33			0.03								
PS12-VC1 (546-547) rep1	0.46	0.47	0.00	0.05	0.05	0.00						
PS12-VC1 (546-547) rep2	0.46			0.05								
PS12-VC1 (546-547) rep3	0.47			0.05								

1 OC = TOC - BC

Table B4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), and black carbon ($\delta^{13}C_{BC}$), in core PS12-VC1.

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}{}^{1}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*
PS12-VC1 (1-2)	-25.07			4.16			-24.41			-26.48		
PS12-VC1 (6-7)	-24.16			4.36			-23.73			-26.36		
PS12-VC1 (11-12)	-24.50			4.37			-24.33			-25.74		
PS12-VC1 (16-17)	-24.51			4.28			-24.02			-25.68		
PS12-VC1 (21-22)	-24.52			4.16			-22.65			-26.00		
PS12-VC1 (26-27)	-24.18			4.15			-18.91			-25.93		
PS12-VC1 (31-32)	-24.11			3.87			-22.34			-25.89		
PS12-VC1 (36-37)	-23.78			4.00			-23.25			-25.87		
PS12-VC1 (41-42)	-23.89			4.03			-22.15			-25.73		
PS12-VC1 (46-47) rep1	-23.92	23.88	0.03	3.85	3.83	0.07	-23.47	23.00	0.77	-24.81	25.16	0.25
PS12-VC1 (46-47) rep2	-23.88			3.91			-23.61			-25.29		
PS12-VC1 (46-47) rep3	-23.84			3.74			-21.91			-25.38		
PS12-VC1 (51-52)	-23.93			3.67			-23.11			-25.58		
PS12-VC1 (56-57)	-23.85			3.98			-21.06			-26.62		
PS12-VC1 (61-62)	-23.90			3.71			-23.28			-25.33		
PS12-VC1 (66-67)	-23.25			3.76			-22.30			-25.28		
PS12-VC1 (71-72)	-24.22			3.72			-23.62			-25.72		
PS12-VC1 (76-77)	-24.20			3.79			-23.65			-25.82		
PS12-VC1 (81-82)	-24.53			3.88			-24.03			-25.64		
PS12-VC1 (86-87)	-24.40			3.95			-24.12			-25.44		
PS12-VC1 (91-92)	-24.13			3.82			-23.39			-25.84		
PS12-VC1 (96-97) rep1	-24.51	24.51	0.06	3.92	3.85	0.06	-23.83	23.99	0.22	-25.93	25.70	0.17
PS12-VC1 (96-97) rep2	-24.44			3.87			-23.84			-25.64		
PS12-VC1 (96-97) rep3	-24.59			3.77			-24.31			-25.54		
PS12-VC1 (101-102)	-24.65			3.99			-23.88			-25.94		
PS12-VC1 (106-107)	-24.52			4.14			-24.07			-26.04		
PS12-VC1 (111-112)	-25.08			3.34			-24.48			-26.58		
PS12-VC1 (116-117)	-24.70			3.78			-24.30			-26.23		
PS12-VC1 (121-122)	-25.19			2.54			-24.35			-28.47		
PS12-VC1 (126-127)	-24.92			3.12			-24.70			-26.69		
PS12-VC1 (131-132)	-25.02			2.35			-24.43			-27.91		
PS12-VC1 (136-137)	-24.90			2.65			-24.65			-27.43		
PS12-VC1 (141-142)	-24.59			3.10			-21.95			-28.52		
PS12-VC1 (146-147) rep1	-24.49	24.50	0.05	3.52	3.54	0.02	-24.10	24.05	0.04	-26.48	26.45	0.08
PS12-VC1 (146-147) rep2	-24.44			3.56			-24.03			-26.53		
PS12-VC1 (146-147) rep3	-24.57			3.55			-24.00			-26.33		
PS12-VC1 (151-152)	-24.29			3.16			-23.72			-28.14		
PS12-VC1 (156-157)	-24.43			3.08			-23.97			-27.93		
PS12-VC1 (161-162)	-24.91			3.13			-23.99			-27.93		
PS12-VC1 (166-167)	-24.06			3.70			-23.79			-25.29		

Table B4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), and black carbon ($\delta^{13}C_{BC}$), in core PS12-VC1 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}{}^{1}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*
PS12-VC1 (171-172)	-25.24			3.81			-25.07			-25.75		
PS12-VC1 (176-177)	-25.19			3.22			-25.09			-25.53		
PS12-VC1 (181-182)	-25.42			4.87			-25.51			-25.21		
PS12-VC1 (186-187)	-25.93			5.01			-26.07			-25.54		
PS12-VC1 (191-192)	-25.33			4.41			-25.29			-25.50		
PS12-VC1 (196-197) rep1	-25.75	25.64	0.07	2.73	2.76	0.10	-27.03	26.56	0.44	-23.97	23.98	0.65
PS12-VC1 (196-197) rep2	-25.60			2.89			-25.97			-24.78		
PS12-VC1 (196-197) rep3	-25.58			2.65			-26.68			-23.18		
PS12-VC1 (201-202)	-25.60			2.72								
PS12-VC1 (206-207)	-25.48			2.53								
PS12-VC1 (211-212)	-25.32			2.63								
PS12-VC1 (216-217)	-25.31			2.71								
PS12-VC1 (221-222)	-25.06			2.64								
PS12-VC1 (226-227)	-25.26			2.39								
PS12-VC1 (231-232)	-25.15			2.53								
PS12-VC1 (236-237)	-25.02			2.49								
PS12-VC1 (241-242)	-25.49			2.86								
PS12-VC1 (246-247) rep1	-24.93	25.11	0.14	1.95	2.19	0.17						
PS12-VC1 (246-247) rep2	-25.27			2.34								
PS12-VC1 (246-247) rep3	-25.15			2.28								
PS12-VC1 (251-252)	-25.47			2.89								
PS12-VC1 (256-257)	-25.37			3.89								
PS12-VC1 (261-262)	-25.51			2.72								
PS12-VC1 (266-267)	-25.56			3.06								
PS12-VC1 (271-272)	-25.60			3.10								
PS12-VC1 (276-277)	-25.46			3.09								
PS12-VC1 (281-282)	-25.72			3.08								
PS12-VC1 (286-287)	-25.19			2.16								
PS12-VC1 (291-292)	-25.42			3.15								
PS12-VC1 (296-297) rep1	-25.44	25.35	0.12	2.68	2.77	0.10						
PS12-VC1 (296-297) rep2	-25.17			2.73								
PS12-VC1 (296-297) rep3	-25.42			2.90								
PS12-VC1 (301-302)	-25.45			2.55								
PS12-VC1 (306-307)	-25.62			2.87								
PS12-VC1 (311-312)	-25.61			3.04								
PS12-VC1 (316-317)	-25.55			2.91								
PS12-VC1 (321-322)	-25.42			3.09								
PS12-VC1 (326-327)	-25.64			3.08								
PS12-VC1 (331-332)	-25.31			3.12								
PS12-VC1 (336-337)	-25.56			3.17								
PS12-VC1 (341-342)	-25.52			3.59								

Table B4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), and black carbon ($\delta^{13}C_{BC}$), in core PS12-VC1 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}{}^{1}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*
PS12-VC1 (346-347) rep1	-25.57	25.59	0.03	3.68	3.35	0.24						
PS12-VC1 (346-347) rep2	-25.64			3.26								
PS12-VC1 (346-347) rep3	-25.56			3.10								
PS12-VC1 (351-352)	-25.31			3.09								
PS12-VC1 (356-357)	-25.57			2.89								
PS12-VC1 (361-362)	-25.66			3.68								
PS12-VC1 (366-367)	-25.92			2.69								
PS12-VC1 (371-372)	-25.63			2.50								
PS12-VC1 (376-377)	-25.55			2.90								
PS12-VC1 (381-382)	-25.41			2.61								
PS12-VC1 (386-387)	-25.39			2.53								
PS12-VC1 (391-392)	-25.25			3.53								
PS12-VC1 (396-397) rep1	-25.52	25.54	0.01	3.33	3.09	0.18						
PS12-VC1 (396-397) rep2	-25.54			3.06								
PS12-VC1 (396-397) rep3	-25.55			2.89								
PS12-VC1 (401-402)	-25.55			3.05								
PS12-VC1 (406-407)	-25.70			2.33								
PS12-VC1 (411-412)	-25.46			3.02								
PS12-VC1 (416-417)	-25.54			2.75								
PS12-VC1 (421-422)	-25.26			3.31								
PS12-VC1 (426-427)	-25.72			2.80								
PS12-VC1 (431-432)	-25.64			3.27								
PS12-VC1 (436-437)	-25.80			3.21								
PS12-VC1 (441-442)	-25.82			2.57								
PS12-VC1 (446-447) rep1	-25.54	25.54	0.01	2.98	2.85	0.13						
PS12-VC1 (446-447) rep2	-25.54			2.68								
PS12-VC1 (446-447) rep3	-25.55			2.88								
PS12-VC1 (451-452)	-25.75			2.88								
PS12-VC1 (456-457)	-26.01			2.58								
PS12-VC1 (461-462)	-25.52			3.00								
PS12-VC1 (466-467)	-25.74			3.05								
PS12-VC1 (471-472)	-25.52			3.26								
PS12-VC1 (476-477)	-25.39			3.09								
PS12-VC1 (481-482)	-25.53			3.05								
PS12-VC1 (486-487)	-25.52			3.24								
PS12-VC1 (491-492)	-25.77			2.86								
PS12-VC1 (496-497) rep1	-25.67	25.48	0.15	3.55	3.32	0.19						
PS12-VC1 (496-497) rep2	-25.48			3.33								
PS12-VC1 (496-497) rep3	-25.31			3.08								
PS12-VC1 (501-502)	-25.75			2.69								
PS12-VC1 (506-507)	-25.39			3.34								

Table B4. Isotopic ratios of total organic carbon ($\delta^{13}C_{TOC}$), labile organic carbon ($\delta^{13}C_{OC}$), total nitrogen ($\delta^{15}N_{TN}$), and black carbon ($\delta^{13}C_{BC}$), in core PS12-VC1 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*	**$\delta^{13}C_{OC}$[1] (‰)**	*mean*	*stdev*	**$\delta^{13}C_{BC}$ (‰)**	*mean*	*stdev*
PS12-VC1 (511-512)	-25.19			3.49								
PS12-VC1 (516-517)	-25.28			3.66								
PS12-VC1 (521-522)	-25.15			4.12								
PS12-VC1 (526-527)	-25.70			4.71								
PS12-VC1 (531-532)	-25.82			4.41								
PS12-VC1 (536-537)	-25.14			4.42								
PS12-VC1 (541-542)	-25.84			4.60								
PS12-VC1 (546-547) rep1	-25.75	25.76	0.07	4.37	4.19	0.23						
PS12-VC1 (546-547) rep2	-25.68			4.32								
PS12-VC1 (546-547) rep3	-25.85			3.87								

[1] $\delta^{13}C_{OC} = (\%TOC*\delta^{13}C_{TOC}) - (\%BC*\delta^{13}C_{BC}) / \%OC$

Table B5. Ratios of total organic carbon to total nitrogen (TOC/TN), black carbon to TOC (BC/TOC), in core PS12-VC1.

Sample (depth in cm)	**TOC/TN (mol:mol)**	*mean*	*stdev*	**BC/TOC (%)**	*mean*	*stdev*
PS12-VC1 (1-2)	14.48			31.67		
PS12-VC1 (6-7)	16.44			16.36		
PS12-VC1 (11-12)	15.78			12.39		
PS12-VC1 (16-17)	15.76			29.66		
PS12-VC1 (21-22)	16.78			55.83		
PS12-VC1 (26-27)	17.41			75.04		
PS12-VC1 (31-32)	18.44			50.02		
PS12-VC1 (36-37)	18.11			19.99		
PS12-VC1 (41-42)	18.12			48.60		
PS12-VC1 (46-47) rep1	17.69	17.49	0.15	33.75	35.22	16.11
PS12-VC1 (46-47) rep2	17.48			16.28		
PS12-VC1 (46-47) rep3	17.32			55.65		
PS12-VC1 (51-52)	18.55			33.13		
PS12-VC1 (56-57)	17.06			50.14		
PS12-VC1 (61-62)	17.39			30.38		
PS12-VC1 (66-67)	17.47			32.01		
PS12-VC1 (71-72)	18.45			28.83		
PS12-VC1 (76-77)	18.83			25.43		
PS12-VC1 (81-82)	18.23			31.24		
PS12-VC1 (86-87)	18.75			21.21		
PS12-VC1 (91-92)	19.83			29.90		
PS12-VC1 (96-97) rep1	19.49	19.40	0.11	32.36	29.52	4.98
PS12-VC1 (96-97) rep2	19.46			33.67		
PS12-VC1 (96-97) rep3	19.24			22.52		
PS12-VC1 (101-102)	19.31			37.45		
PS12-VC1 (106-107)	19.80			23.02		
PS12-VC1 (111-112)	22.49			28.62		
PS12-VC1 (116-117)	21.25			20.52		
PS12-VC1 (121-122)	27.89			20.51		
PS12-VC1 (126-127)	25.59			11.12		
PS12-VC1 (131-132)	29.00			16.97		
PS12-VC1 (136-137)	28.89			9.18		
PS12-VC1 (141-142)	26.74			40.12		
PS12-VC1 (146-147) rep1	22.42	22.54	0.11	16.11	19.06	3.89
PS12-VC1 (146-147) rep2	22.52			16.51		
PS12-VC1 (146-147) rep3	22.69			24.55		
PS12-VC1 (151-152)	26.91			12.80		
PS12-VC1 (156-157)	26.61			11.57		
PS12-VC1 (161-162)	25.87			23.45		
PS12-VC1 (166-167)	20.81			18.10		

Table B5. Ratios of total organic carbon to total nitrogen (TOC/TN), black carbon to TOC (BC/TOC), in core PS12-VC1 (continued).

Sample (depth in cm)	**TOC/TN (mol:mol)**	*mean*	*stdev*	**BC/TOC (%)**	*mean*	*stdev*
PS12-VC1 (171-172)	18.83			25.25		
PS12-VC1 (176-177)	16.36			21.48		
PS12-VC1 (181-182)	12.43			31.82		
PS12-VC1 (186-187)	13.41			26.39		
PS12-VC1 (191-192)	13.80			18.70		
PS12-VC1 (196-197) rep1	12.81	12.87	0.07	42.02	34.66	5.22
PS12-VC1 (196-197) rep2	12.82			30.52		
PS12-VC1 (196-197) rep3	12.97			31.44		
PS12-VC1 (201-202)	12.47					
PS12-VC1 (206-207)	11.82					
PS12-VC1 (211-212)	11.93					
PS12-VC1 (216-217)	11.57					
PS12-VC1 (221-222)	11.55					
PS12-VC1 (226-227)	11.73					
PS12-VC1 (231-232)	12.82					
PS12-VC1 (236-237)	11.83					
PS12-VC1 (241-242)	12.29					
PS12-VC1 (246-247) rep1	10.19	10.45	0.28			
PS12-VC1 (246-247) rep2	10.84					
PS12-VC1 (246-247) rep3	10.32					
PS12-VC1 (251-252)	11.49					
PS12-VC1 (256-257)	11.19					
PS12-VC1 (261-262)	10.67					
PS12-VC1 (266-267)	10.88					
PS12-VC1 (271-272)	11.17					
PS12-VC1 (276-277)	11.03					
PS12-VC1 (281-282)	10.14					
PS12-VC1 (286-287)	10.55					
PS12-VC1 (291-292)	10.52					
PS12-VC1 (296-297) rep1	10.39	10.71	0.29			
PS12-VC1 (296-297) rep2	11.09					
PS12-VC1 (296-297) rep3	10.64					
PS12-VC1 (301-302)	10.97					
PS12-VC1 (306-307)	11.53					
PS12-VC1 (311-312)	11.10					
PS12-VC1 (316-317)	10.26					
PS12-VC1 (321-322)	10.06					
PS12-VC1 (326-327)	10.45					
PS12-VC1 (331-332)	11.94					
PS12-VC1 (336-337)	10.35					

Table B5. Ratios of total organic carbon to total nitrogen (TOC/TN), black carbon to TOC (BC/TOC), in core PS12-VC1 (continued).

Sample (depth in cm)	**TOC/TN (mol:mol)**	*mean*	*stdev*	**BC/TOC (%)**	*mean*	*stdev*
PS12-VC1 (341-342)	10.29					
PS12-VC1 (346-347) rep1	10.68	10.93	0.18			
PS12-VC1 (346-347) rep2	11.00					
PS12-VC1 (346-347) rep3	11.11					
PS12-VC1 (351-352)	10.56					
PS12-VC1 (356-357)	11.02					
PS12-VC1 (361-362)	10.73					
PS12-VC1 (366-367)	10.98					
PS12-VC1 (371-372)	10.48					
PS12-VC1 (376-377)	10.01					
PS12-VC1 (381-382)	10.88					
PS12-VC1 (386-387)	9.84					
PS12-VC1 (391-392)	10.45					
PS12-VC1 (396-397) rep1	11.63	11.87	0.19			
PS12-VC1 (396-397) rep2	11.91					
PS12-VC1 (396-397) rep3	12.09					
PS12-VC1 (401-402)	11.58					
PS12-VC1 (406-407)	12.06					
PS12-VC1 (411-412)	11.36					
PS12-VC1 (416-417)	11.57					
PS12-VC1 (421-422)	11.40					
PS12-VC1 (426-427)	11.77					
PS12-VC1 (431-432)	11.49					
PS12-VC1 (436-437)	11.13					
PS12-VC1 (441-442)	10.83					
PS12-VC1 (446-447) rep1	10.39	10.55	0.12			
PS12-VC1 (446-447) rep2	10.57					
PS12-VC1 (446-447) rep3	10.67					
PS12-VC1 (451-452)	10.89					
PS12-VC1 (456-457)	10.45					
PS12-VC1 (461-462)	10.28					
PS12-VC1 (466-467)	10.49					
PS12-VC1 (471-472)	9.95					
PS12-VC1 (476-477)	9.96					
PS12-VC1 (481-482)	10.06					
PS12-VC1 (486-487)	10.32					
PS12-VC1 (491-492)	10.68					
PS12-VC1 (496-497) rep1	10.94	11.20	0.32			
PS12-VC1 (496-497) rep2	11.01					
PS12-VC1 (496-497) rep3	11.65					
PS12-VC1 (501-502)	11.63					

Table B5. Ratios of total organic carbon to total nitrogen (TOC/TN), black carbon to TOC (BC/TOC), in core PS12-VC1 (continued).

Sample (depth in cm)	**TOC/TN (mol:mol)**	*mean*	*stdev*	**BC/TOC (%)**	*mean*	*stdev*
PS12-VC1 (506-507)	11.25					
PS12-VC1 (511-512)	11.41					
PS12-VC1 (516-517)	11.32					
PS12-VC1 (521-522)	12.10					
PS12-VC1 (526-527)	11.77					
PS12-VC1 (531-532)	10.92					
PS12-VC1 (536-537)	10.65					
PS12-VC1 (541-542)	12.07					
PS12-VC1 (546-547) rep1	12.24	12.25	0.07			
PS12-VC1 (546-547) rep2	12.17					
PS12-VC1 (546-547) rep3	12.35					

Appendix C

(Core Tump 08)

Table C1. Water content and bulk density of core Tump 08.

Sample (depth in cm)	wet weight (g)	dry weight (g)	water content (%)	[1]bulk density (g/cm^3)
Tump 08 (0-2)	4.44	1.33	70.11	0.09
Tump 08 (2-4)	7.82	3.03	61.34	0.19
Tump 08 (4-6)	3.86	0.81	78.99	0.05
Tump 08 (6-8)	5.03	1.05	79.05	0.07
Tump 08 (8-10)	7.92	1.76	77.85	0.11
Tump 08 (10-12)	9.43	1.86	80.30	0.12
Tump 08 (12-14)	9.49	1.98	79.14	0.13
Tump 08 (14-16)	10.26	2.12	79.35	0.14
Tump 08 (16-18)	13.82	2.97	78.51	0.19
Tump 08 (18-20)	22.28	6.33	71.60	0.41
Tump 08 (20-22)	14.29	4.04	71.72	0.26
Tump 08 (22-24)	11.57	2.28	80.31	0.15
Tump 08 (24-26)	12.77	2.76	78.37	0.18
Tump 08 (26-28)	13.59	2.71	80.06	0.17
Tump 08 (28-30)	14.57	2.22	84.74	0.14
Tump 08 (30-32)	13.76	2.24	83.69	0.14
Tump 08 (32-34)	16.01	2.79	82.54	0.18
Tump 08 (34-36)	15.19	2.36	84.44	0.15
Tump 08 (36-38)	15.11	1.87	87.64	0.12
Tump 08 (38-40)	15.44	2.09	86.45	0.13
Tump 08 (40-42)	14.62	2.37	83.42	0.15
Tump 08 (42-44)	14.93	2.17	85.49	0.14
Tump 08 (44-46)	14.81	2.33	84.46	0.15
Tump 08 (46-48)	14.17	2.24	84.25	0.14
Tump 08 (48-50)	12.05	1.95	83.59	0.13
Tump 08 (50-52)	15.15	2.23	85.30	0.14
Tump 08 (52-54)	19.36	4.15	78.54	0.27
Tump 08 (54-56)	15.38	2.16	85.95	0.14
Tump 08 (56-58)	14.47	1.85	87.20	0.12
Tump 08 (58-60)	17.89	2.43	86.42	0.16
Tump 08 (60-62)	18.54	2.37	87.20	0.15
Tump 08 (62-64)	18.88	3.15	83.29	0.20
Tump 08 (64-66)	19.04	3.01	84.20	0.19
Tump 08 (66-68)	22.49	4.60	79.55	0.30
Tump 08 (68-70)	19.94	4.29	78.50	0.28
Tump 08 (70-72)	18.15	2.48	86.32	0.16
Tump 08 (72-74)	18.71	2.60	86.13	0.17
Tump 08 (74-76)	19.11	3.19	83.30	0.21
Tump 08 (76-78)	19.52	2.87	85.30	0.18
Tump 08 (78-80)	15.78	2.44	84.55	0.16

Table C1. Water content and bulk density of core Tump 08 (continued).

Sample (depth in cm)	**wet weight (g)**	**dry weight (g)**	**water content (%)**	[1]**bulk density (g/cm^3)**
Tump 08 (80-82)	15.30	2.63	82.56	0.17
Tump 08 (82-84)	14.74	1.93	86.92	0.12
Tump 08 (84-86)	14.89	1.80	87.95	0.12
Tump 08 (86-88)	14.61	1.71	88.31	0.11
Tump 08 (88-90)	13.69	1.75	87.28	0.11
Tump 08 (90-92)	16.56	2.71	83.63	0.17
Tump 08 (92-94)	20.47	3.18	84.45	0.21
Tump 08 (94-96)	18.48	2.70	85.36	0.17
Tump 08 (96-98)	18.21	2.31	87.33	0.15
Tump 08 (98-100)	19.31	2.37	87.74	0.15
Tump 08 (100-102)	17.36	2.09	87.95	0.13
Tump 08 (102-104)	17.00	1.89	88.90	0.12
Tump 08 (104-106)	17.27	1.94	88.77	0.12
Tump 08 (106-108)	18.06	2.34	87.07	0.15
Tump 08 (108-110)	18.46	2.65	85.65	0.17
Tump 08 (110-112)	18.74	3.44	81.62	0.22
Tump 08 (112-114)	20.25	3.83	81.09	0.25
Tump 08 (114-116)	18.43	3.27	82.27	0.21
Tump 08 (116-118)	22.08	3.48	84.24	0.22
Tump 08 (118-120)	16.73	2.41	85.58	0.16
Tump 08 (120-122)	16.77	2.59	84.19	0.17
Tump 08 (122-124)	16.20	2.18	86.81	0.14
Tump 08 (124-126)	15.84	2.20	86.23	0.14
Tump 08 (126-128)	17.11	2.44	85.79	0.16
Tump 08 (128-130)	15.76	2.94	81.08	0.19
Tump 08 (130-132)	19.25	2.99	84.49	0.19
Tump 08 (132-134)	23.41	7.84	66.52	0.51
Tump 08 (134-136)	24.63	9.05	63.26	0.58
Tump 08 (136-138)	23.70	9.96	57.98	0.64
Tump 08 (138-140)	26.04	10.52	59.60	0.68
Tump 08 (140-142)	23.40	10.31	55.96	0.66
Tump 08 (142-144)	25.26	11.50	54.49	0.74
Tump 08 (144-146)	28.45	15.87	44.20	1.02
Tump 08 (146-148)	28.82	17.80	38.25	1.15
Tump 08 (148-150)	29.70	16.94	42.96	1.09
Tump 08 (150-152)	28.45	16.41	42.31	1.06
Tump 08 (152-154)	29.74	18.51	37.76	1.19
Tump 08 (154-156)	26.75	15.02	43.83	0.97
Tump 08 (156-158)	27.53	16.44	40.29	1.06

Table C1. Water content and bulk density of core Tump 08 (continued).

Sample (depth in cm)	wet weight (g)	dry weight (g)	water content (%)	[1]bulk density (g/cm^3)
Tump 08 (158-160)	28.57	16.82	41.13	1.08
Tump 08 (160-162)	14.16	15.46	38.38	1.00
Tump 08 (162-164)	26.36	16.96	40.65	1.09
Tump 08 (164-166)	26.92	18.43	36.40	1.19
Tump 08 (166-168)	27.83	19.60	34.69	1.26
Tump 08 (168-170)	28.06	20.14	33.61	1.30
Tump 08 (170-172)	30.00	16.18	46.05	1.04
Tump 08 (172-174)	22.79	11.61	49.05	0.75
Tump 08 (174-176)	29.53	17.70	40.06	1.14
Tump 08 (176-178)	26.36	17.13	35.02	1.10
Tump 08 (178-180)	32.15	22.80	29.07	1.47
Tump 08 (180-182)	32.25	23.32	27.69	1.50
Tump 08 (182-184)	30.70	21.90	28.68	1.41
Tump 08 (184-186)	28.64	17.89	37.52	1.15
Tump 08 (186-188)	27.29	15.12	44.62	0.97
Tump 08 (188-190)	24.79	13.28	46.42	0.86
Tump 08 (190-192)	24.96	14.00	43.91	0.90
Tump 08 (192-194)	25.76	15.72	38.97	1.01
Tump 08 (194-196)	30.15	19.22	36.26	1.24
Tump 08 (196-198)	33.41	23.79	28.79	1.53
Tump 08 (198-200)	30.07	22.79	24.22	1.47
Tump 08 (200-202)	33.08	25.58	22.68	1.65
Tump 08 (202-204)	30.28	23.72	21.68	1.53
Tump 08 (204-206)	28.24	22.06	21.87	1.42
Tump 08 (206-208)	20.43	16.02	21.59	1.03
Tump 08 (208-210)	29.30	23.22	20.75	1.50

[1] The volume of solids + pores spaces in each section was calculated to be 15.52 cm^3, and used to calculate bulk density.

Table C2. Abundances and molar ratio of total organic carbon (TOC) and total nitrogen (TN) in core Tump 08.

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**TOC/TN (mol:mol)**	*mean*	*stdev*
Tump 08 (0-2) rep1	12.32	13.09	0.55	0.64	0.67	0.02	23.01	23.37	0.28
Tump 08 (0-2) rep2	13.38			0.68			23.68		
Tump 08 (0-2) rep3	13.57			0.69			23.42		
Tump 08 (2-4) rep1	5.66	5.29		0.34	0.33		19.70	19.26	
Tump 08 (2-4) rep2	4.92			0.31			18.81		
Tump 08 (4-6) rep1	17.13	16.86		0.97	0.96		21.23	21.11	
Tump 08 (4-6) rep2	16.60			0.95			20.99		
Tump 08 (6-8) rep1	15.52	15.57		0.99	0.99		18.88	18.96	
Tump 08 (6-8) rep2	15.62			0.98			19.04		
Tump 08 (8-10) rep1	14.20	14.08	0.09	0.91	0.91	0.00	18.74	18.58	0.13
Tump 08 (8-10) rep2	13.99			0.91			18.43		
Tump 08 (8-10) rep3	14.04			0.91			18.57		
Tump 08 (10-12)	16.01			0.83			23.10		
Tump 08 (12-14)	12.76			0.74			20.57		
Tump 08 (14-16)	13.29			0.84			18.89		
Tump 08 (16-18)	14.99			0.78			22.99		
Tump 08 (18-20)	9.98			0.51			23.60		
Tump 08 (20-22)	10.52			0.55			22.80		
Tump 08 (22-24)	20.23			0.88			27.49		
Tump 08 (24-26)	12.69			0.75			20.39		
Tump 08 (26-28)	12.60			0.77			19.75		
Tump 08 (28-30)	27.86			1.39			24.07		
Tump 08 (30-32)	22.83			1.24			22.14		
Tump 08 (32-34)	22.13			1.03			25.89		
Tump 08 (34-36)	22.18			1.06			25.08		
Tump 08 (36-38)	29.74			1.27			28.00		
Tump 08 (38-40)	26.05			1.14			27.47		
Tump 08 (40-42) rep1	19.81	19.23	1.47	0.99	0.93	0.06	24.03	24.73	0.76
Tump 08 (40-42) rep2	21.22			0.98			25.92		
Tump 08 (40-42) rep3	17.63			0.85			24.87		
Tump 08 (40-42) rep4	18.24			0.91			24.10		
Tump 08 (42-44) rep1	19.87	20.10		1.02	1.02		23.33	23.53	
Tump 08 (42-44) rep2	20.34			1.03			23.74		
Tump 08 (44-46) rep1	26.75	26.40		1.27	1.19		25.29	26.61	
Tump 08 (44-46) rep2	26.05			1.12			27.93		
Tump 08 (46-48) rep1	30.56	29.67		1.25	1.22		29.38	29.30	
Tump 08 (46-48) rep2	28.79			1.18			29.23		
Tump 08 (48-50) rep1	23.89	23.04	0.51	1.06	1.11	0.06	27.11	25.00	2.09
Tump 08 (48-50) rep2	23.67			1.05			27.04		
Tump 08 (48-50) rep3	22.72			1.17			23.25		

Table C2. Abundances and molar ratio of total organic carbon (TOC) and total nitrogen (TN) in core Tump 08 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**TOC/TN (mol:mol)**	*mean*	*stdev*
Tump 08 (48-50) rep4	21.88			1.16			22.60		
Tump 08 (50-52)	26.53			1.01			31.53		
Tump 08 (52-54)	15.07			0.67			27.00		
Tump 08 (54-56)	24.11			0.94			30.80		
Tump 08 (56-58)	24.68			1.06			28.06		
Tump 08 (58-60)	22.34			0.96			28.00		
Tump 08 (60-62)	27.66			1.07			31.11		
Tump 08 (62-64)	19.93			0.81			29.52		
Tump 08 (64-66)	21.11			0.92			27.49		
Tump 08 (66-68)	13.37			0.64			25.10		
Tump 08 (68-70)	14.47			0.61			28.30		
Tump 08 (70-72)	29.77			1.07			33.36		
Tump 08 (72-74)	27.24			1.08			30.35		
Tump 08 (74-76)	17.22			0.81			25.64		
Tump 08 (76-78)	25.98			1.10			28.38		
Tump 08 (78-80)	24.16			1.06			27.42		
Tump 08 (80-82) rep1	24.25	21.14	2.29	1.06	0.91	0.08	27.41	27.71	1.96
Tump 08 (80-82) rep2	23.92			0.93			30.98		
Tump 08 (80-82) rep3	19.23			0.87			26.38		
Tump 08 (80-82) rep4	17.14			0.79			26.06		
Tump 08 (82-84) rep1	27.83	25.53		1.17	1.14		28.64	26.88	
Tump 08 (82-84) rep2	23.22			1.11			25.13		
Tump 08 (84-86) rep1	30.91	29.01		1.21	1.27		30.65	27.62	
Tump 08 (84-86) rep2	27.11			1.32			24.58		
Tump 08 (86-88) rep1	27.27	26.40		1.27	1.30		25.71	24.40	
Tump 08 (86-88) rep2	25.53			1.33			23.09		
Tump 08 (88-90) rep1	27.65	24.59	2.85	1.33	1.21	0.11	25.04	24.37	0.67
Tump 08 (88-90) rep2	27.58			1.32			25.02		
Tump 08 (88-90) rep3	21.57			1.10			23.64		
Tump 08 (88-90) rep4	21.53			1.09			23.76		
Tump 08 (90-92)	17.44			0.85			24.72		
Tump 08 (92-94)	21.37			0.94			27.23		
Tump 08 (94-96)	25.64			1.08			28.61		
Tump 08 (96-98)	25.91			1.11			28.13		
Tump 08 (98-100)	24.50			1.02			28.75		
Tump 08 (100-102)	24.29			0.98			29.65		
Tump 08 (102-104)	25.81			1.01			30.76		
Tump 08 (104-106)	32.43			1.20			32.43		
Tump 08 (106-108)	30.81			1.20			30.94		
Tump 08 (108-110)	26.90			1.12			28.70		
Tump 08 (110-112)	21.47			0.80			32.10		

Table C2. Abundances and molar ratio of total organic carbon (TOC) and total nitrogen (TN) in core Tump 08 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**TOC/TN (mol:mol)**	*mean*	*stdev*
Tump 08 (112-114)	22.69			0.87			31.42		
Tump 08 (114-116)	30.02			1.15			31.32		
Tump 08 (116-118)	33.39			1.21			33.00		
Tump 08 (118-120)	29.59			1.09			32.69		
Tump 08 (120-122) rep1	28.43	27.60	1.64	1.06	1.01	0.08	32.14	32.79	0.67
Tump 08 (120-122) rep2	29.06			1.07			32.53		
Tump 08 (120-122) rep3	25.31			0.90			33.71		
Tump 08 (122-124) rep1	28.50	24.57		0.96	0.88		35.51	33.35	
Tump 08 (122-124) rep2	20.63			0.79			31.19		
Tump 08 (124-126) rep1	31.29	25.17		1.08	0.91		34.79	32.87	
Tump 08 (124-126) rep2	19.04			0.74			30.95		
Tump 08 (126-128) rep1	26.96	24.43		0.92	0.87		35.25	33.53	
Tump 08 (126-128) rep2	21.90			0.83			31.80		
Tump 08 (128-130) rep1	19.17	20.86	1.44	0.62	0.72	0.09	36.84	34.90	2.34
Tump 08 (128-130) rep2	21.82			0.70			37.60		
Tump 08 (128-130) rep3	22.52			0.84			32.37		
Tump 08 (128-130) rep4	19.92			0.73			32.79		
Tump 08 (130-132)	22.08			0.86			30.99		
Tump 08 (132-134)	9.52			0.38			30.33		
Tump 08 (134-136)	6.94			0.29			28.55		
Tump 08 (136-138)	5.97			0.24			29.31		
Tump 08 (138-140)	6.95			0.27			31.25		
Tump 08 (140-142)	4.96			0.19			31.52		
Tump 08 (142-144)	4.99			0.20			29.84		
Tump 08 (144-146)	3.41			0.14			29.91		
Tump 08 (146-148)	2.40			0.10			28.67		
Tump 08 (148-150)	4.45			0.18			30.04		
Tump 08 (150-152)	3.47			0.14			30.02		
Tump 08 (152-154)	3.29			0.12			33.64		
Tump 08 (154-156)	4.03			0.14			34.55		
Tump 08 (156-158)	3.87			0.13			35.80		
Tump 08 (158-160)	3.62			0.12			34.92		
Tump 08 (160-162) rep1	3.39	3.69	0.18	0.10	0.14	0.03	39.57	32.99	6.49
Tump 08 (160-162) rep2	3.53			0.11			39.38		
Tump 08 (160-162) rep3	3.82			0.17			26.38		
Tump 08 (160-162) rep4	4.03			0.18			26.63		
Tump 08 (162-164) rep1	3.42	4.28		0.10	0.14		39.24	37.86	
Tump 08 (162-164) rep2	5.13			0.17			36.48		
Tump 08 (164-166) rep1	2.10	2.93		0.06	0.11		41.14	34.31	
Tump 08 (164-166) rep2	3.77			0.16			27.47		
Tump 08 (166-168) rep1	2.10	2.83		0.06	0.11		43.34	34.94	

Table C2. Abundances and molar ratio of total organic carbon (TOC) and total nitrogen (TN) in core Tump 08 (continued).

Sample (depth in cm)	**TOC (%)**	*mean*	*stdev*	**TN (%)**	*mean*	*stdev*	**TOC/TN (mol:mol)**	*mean*	*stdev*
Tump 08 (166-168) rep2	3.55			0.16			26.55		
Tump 08 (168-170) rep1	1.74	2.37	0.88	0.05	0.09	0.05	38.44	33.99	5.42
Tump 08 (168-170) rep2	1.77			0.06			37.18		
Tump 08 (168-170) rep3	3.62			0.16			26.36		
Tump 08 (170-172)	4.31			0.17			30.05		
Tump 08 (172-174)	5.13			0.21			29.30		
Tump 08 (174-176)	2.78			0.13			26.16		
Tump 08 (176-178)	2.22			0.10			27.52		
Tump 08 (178-180)	1.54			0.06			30.30		
Tump 08 (180-182)	1.21			0.05			28.85		
Tump 08 (182-184)	1.27			0.05			28.91		
Tump 08 (184-186)	1.92			0.09			25.16		
Tump 08 (186-188)	3.27			0.20			19.46		
Tump 08 (188-190)	3.08			0.19			19.52		
Tump 08 (190-192)	2.91			0.18			19.87		
Tump 08 (192-194)	2.28			0.12			22.06		
Tump 08 (194-196)	1.97			0.10			24.19		
Tump 08 (196-198)	1.23			0.06			25.14		
Tump 08 (198-200)	0.71			0.03			25.25		
Tump 08 (200-202) rep1	0.66	0.64	0.02	0.03	0.03	0.00	24.20	24.19	0.06
Tump 08 (200-202) rep2	0.64			0.03			24.27		
Tump 08 (200-202) rep3	0.61			0.03			24.11		
Tump 08 (202-204) rep1	0.59	0.59		0.03	0.03		23.75	23.92	
Tump 08 (202-204) rep2	0.59			0.03			24.10		
Tump 08 (204-206) rep1	0.66	0.66		0.04	0.04		21.66	22.13	
Tump 08 (204-206) rep2	0.67			0.04			22.61		
Tump 08 (206-208) rep1	0.65	0.66		0.04	0.04		21.14	21.31	
Tump 08 (206-208) rep2	0.67			0.04			21.48		
Tump 08 (208-210) rep1	0.75	0.72	0.03	0.04	0.04	0.00	21.97	21.71	0.19
Tump 08 (208-210) rep2	0.73			0.04			21.59		
Tump 08 (208-210) rep3	0.69			0.04			21.56		

Table C3. Isotopic ratio of total organic carbon ($\delta^{13}C_{TOC}$) and total nitrogen ($d^{15}N_{TN}$) in core Tump 08.

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*
Tump 08 (0-2) rep1	-20.78	-20.26	0.39	1.73	1.78	0.05
Tump 08 (0-2) rep2	-19.84			1.85		
Tump 08 (0-2) rep3	-20.17			1.75		
Tump 08 (2-4) rep1	-17.35	-17.79		0.70	1.68	
Tump 08 (2-4) rep2	-18.22			2.65		
Tump 08 (4-6) rep1	-16.43	-16.45		1.88	1.91	
Tump 08 (4-6) rep2	-16.47			1.94		
Tump 08 (6-8) rep1	-17.98	-17.92		1.85	1.86	
Tump 08 (6-8) rep2	-17.86			1.86		
Tump 08 (8-10) rep1	-20.01	-19.97	0.05	1.85	1.82	0.02
Tump 08 (8-10) rep2	-20.00			1.80		
Tump 08 (8-10) rep3	-19.90			1.81		
Tump 08 (10-12)	-21.00			1.48		
Tump 08 (12-14)	-20.54			0.81		
Tump 08 (14-16)	-20.93			1.31		
Tump 08 (16-18)	-23.70			0.99		
Tump 08 (18-20)	-23.88			0.96		
Tump 08 (20-22)	-23.02			0.90		
Tump 08 (22-24)	-21.99			0.95		
Tump 08 (24-26)	-22.61			1.47		
Tump 08 (26-28)	-22.37			1.17		
Tump 08 (28-30)	-21.78			0.07		
Tump 08 (30-32)	-23.87			0.60		
Tump 08 (32-34)	-23.77			-0.83		
Tump 08 (34-36)	-22.95			-1.83		
Tump 08 (36-38)	-24.53			0.23		
Tump 08 (38-40)	-24.53			0.38		
Tump 08 (40-42) rep1	-23.73	-23.44	0.91	1.06	0.47	0.62
Tump 08 (40-42) rep2	-24.80			0.16		
Tump 08 (40-42) rep3	-22.57			-0.46		
Tump 08 (40-42) rep4	-22.65			1.13		
Tump 08 (42-44) rep1	-23.34	-23.35		0.90	0.89	
Tump 08 (42-44) rep2	-23.35			0.87		
Tump 08 (44-46) rep1	-24.33	-23.66		-0.10	-0.07	
Tump 08 (44-46) rep2	-22.99			-0.04		
Tump 08 (46-48) rep1	-24.01	-23.48		-0.36	-0.29	
Tump 08 (46-48) rep2	-22.96			-0.23		
Tump 08 (48-50) rep1	-24.65	-25.54	1.52	0.14	0.46	0.31
Tump 08 (48-50) rep2	-24.60			0.11		
Tump 08 (48-50) rep3	-27.83			0.79		

Table C3. Isotopic ratio of total organic carbon ($\delta^{13}C_{TOC}$) and total nitrogen ($d^{15}N_{TN}$) in core Tump 08 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*
Tump 08 (48-50) rep4	-25.07			0.82		
Tump 08 (50-52)	-23.79			-0.11		
Tump 08 (52-54)	-23.53			0.97		
Tump 08 (54-56)	-24.60			-0.09		
Tump 08 (56-58)	-24.58			0.22		
Tump 08 (58-60)	-24.59			-0.17		
Tump 08 (60-62)	-24.75			-0.31		
Tump 08 (62-64)	-25.30			-0.14		
Tump 08 (64-66)	-25.51			-0.01		
Tump 08 (66-68)	-24.46			1.00		
Tump 08 (68-70)	-24.16			0.56		
Tump 08 (70-72)	-24.72			-0.13		
Tump 08 (72-74)	-25.21			-0.48		
Tump 08 (74-76)	-24.08			0.93		
Tump 08 (76-78)	-23.93			-0.07		
Tump 08 (78-80)	-24.45			0.27		
Tump 08 (80-82) rep1	-24.73	-23.73	0.64	0.09	0.31	0.28
Tump 08 (80-82) rep2	-23.78			0.73		
Tump 08 (80-82) rep3	-23.17			0.22		
Tump 08 (80-82) rep4	-23.26			0.20		
Tump 08 (82-84) rep1	-25.35	-25.35		0.53	0.51	
Tump 08 (82-84) rep2	-25.34			0.49		
Tump 08 (84-86) rep1	-25.54	-25.24		0.71	0.77	
Tump 08 (84-86) rep2	-24.94			0.83		
Tump 08 (86-88) rep1	-26.07	-25.74		0.51	0.87	
Tump 08 (86-88) rep2	-25.40			1.23		
Tump 08 (88-90) rep1	-25.53	-25.77	0.07	0.66	1.03	0.32
Tump 08 (88-90) rep2	-25.64			0.77		
Tump 08 (88-90) rep3	-25.45			1.40		
Tump 08 (88-90) rep4	-26.47			1.28		
Tump 08 (90-92)	-25.80			1.28		
Tump 08 (92-94)	-25.16			0.92		
Tump 08 (94-96)	-25.52			1.05		
Tump 08 (96-98)	-25.83			1.26		
Tump 08 (98-100)	-25.59			1.41		
Tump 08 (100-102)	-26.25			1.33		
Tump 08 (102-104)	-25.74			1.22		
Tump 08 (104-106)	-25.07			0.56		
Tump 08 (106-108)	-24.95			0.70		
Tump 08 (108-110)	-25.24			0.78		
Tump 08 (110-112)	-24.01			1.04		

Table C3. Isotopic ratio of total organic carbon ($\delta^{13}C_{TOC}$) and total nitrogen ($d^{15}N_{TN}$) in core Tump 08 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*
Tump 08 (112-114)	-25.27			0.97		
Tump 08 (114-116)	-24.88			0.76		
Tump 08 (116-118)	-25.05			0.58		
Tump 08 (118-120)	-25.34			1.25		
Tump 08 (120-122) rep1	-24.59	-24.02	0.53	1.04	1.32	0.26
Tump 08 (120-122) rep2	-24.16			1.24		
Tump 08 (120-122) rep3	-23.32			1.67		
Tump 08 (122-124) rep1	-22.51	-23.21		1.23	1.77	
Tump 08 (122-124) rep2	-23.91			2.31		
Tump 08 (124-126) rep1	-22.95	-23.33		1.37	1.57	
Tump 08 (124-126) rep2	-23.72			1.78		
Tump 08 (126-128) rep1	-22.59	-22.61		0.77	1.17	
Tump 08 (126-128) rep2	-22.63			1.57		
Tump 08 (128-130) rep1	-21.92	-22.09	0.15	0.01	0.66	0.65
Tump 08 (128-130) rep2	-21.83			0.04		
Tump 08 (128-130) rep3	-22.18			1.40		
Tump 08 (128-130) rep4	-22.44			1.21		
Tump 08 (130-132)	-22.42			1.41		
Tump 08 (132-134)	-22.74			1.34		
Tump 08 (134-136)	-22.98			1.20		
Tump 08 (136-138)	-22.70			1.58		
Tump 08 (138-140)	-22.61			1.67		
Tump 08 (140-142)	-22.66			1.62		
Tump 08 (142-144)	-23.65			1.72		
Tump 08 (144-146)	-24.28			1.53		
Tump 08 (146-148)	-24.36			1.78		
Tump 08 (148-150)	-24.23			2.05		
Tump 08 (150-152)	-24.79			1.86		
Tump 08 (152-154)	-25.42			2.07		
Tump 08 (154-156)	-24.77			2.13		
Tump 08 (156-158)	-24.27			2.44		
Tump 08 (158-160)	-24.38			2.38		
Tump 08 (160-162) rep1	-24.74	-23.89	0.74	2.46	2.25	0.20
Tump 08 (160-162) rep2	-24.66			2.53		
Tump 08 (160-162) rep3	-23.14			2.08		
Tump 08 (160-162) rep4	-23.05			1.94		
Tump 08 (162-164) rep1	-24.75	-24.80		2.37	2.04	
Tump 08 (162-164) rep2	-24.84			1.72		
Tump 08 (164-166) rep1	-25.05	-24.25		2.19	2.17	
Tump 08 (164-166) rep2	-23.44			2.15		
Tump 08 (166-168) rep1	-25.37	-24.29		3.29	2.68	

Table C3. Isotopic ratio of total organic carbon ($\delta^{13}C_{TOC}$) and total nitrogen ($d^{15}N_{TN}$) in core Tump 08 (continued).

Sample (depth in cm)	**$\delta^{13}C_{TOC}$ (‰)**	*mean*	*stdev*	**$\delta^{15}N_{TN}$ (‰)**	*mean*	*stdev*
Tump 08 (166-168) rep2	-23.20			2.08		
Tump 08 (168-170) rep1	-25.69	-24.80	1.18	3.65	3.20	0.70
Tump 08 (168-170) rep2	-25.58			3.73		
Tump 08 (168-170) rep3	-23.14			2.21		
Tump 08 (170-172)	-24.29			1.82		
Tump 08 (172-174)	-23.40			1.45		
Tump 08 (174-176)	-23.18			2.35		
Tump 08 (176-178)	-24.07			2.84		
Tump 08 (178-180)	-25.55			3.75		
Tump 08 (180-182)	-26.06			4.12		
Tump 08 (182-184)	-25.71			3.84		
Tump 08 (184-186)	-23.47			2.30		
Tump 08 (186-188)	-21.44			1.62		
Tump 08 (188-190)	-21.03			1.43		
Tump 08 (190-192)	-21.12			1.48		
Tump 08 (192-194)	-21.45			1.66		
Tump 08 (194-196)	-22.28			1.87		
Tump 08 (196-198)	-24.14			2.71		
Tump 08 (198-200)	-26.58			3.79		
Tump 08 (200-202) rep1	-27.06	-27.11	0.04	4.19	4.04	0.12
Tump 08 (200-202) rep2	-27.10			3.92		
Tump 08 (200-202) rep3	-27.17			4.00		
Tump 08 (202-204) rep1	-27.43	-27.47		4.04	4.01	
Tump 08 (202-204) rep2	-27.51			3.98		
Tump 08 (204-206) rep1	-27.17	-27.18		4.16	4.16	
Tump 08 (204-206) rep2	-27.19			4.16		
Tump 08 (206-208) rep1	-27.15	-27.10		3.63	3.95	
Tump 08 (206-208) rep2	-27.05			4.26		
Tump 08 (208-210) rep1	-26.93	-26.98	0.04	4.13	4.13	0.03
Tump 08 (208-210) rep2	-26.99			4.17		
Tump 08 (208-210) rep3	-27.02			4.10		