FINAL REPORT

Project Title:	**Investigation of a 10,000-yr Estuarine Record of Cascadia Tsunamis and Coastal Subsidence in Oregon**
Project Award Number:	NEHRP award 04HQR0014

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INVESTIGATION OF A 10,000-YR ESTUARINE RECORD OF CASCADIA COASTAL SUBSIDENCE AND TSUNAMIS IN OREGON

Introduction

On the evening of January 26, 1700 a large earthquake shook the length of the Cascadia subduction zone (CSZ), producing a tsunami and causing much of the Pacific Northwest coastline to subside below sea level (Satake et al. 1996). Geological evidence from coastal marsh and lake sites along the length of Washington and Oregon (summarized in Atwater et al. 1995; Kelsey et al. 1998), as well as from localities in northern California (Garrison-Laney 1998) and southern British Columbia (Clague et al. 2000), indicates rapid changes in relative sea level and/or tsunami inundation associated with this event. This AD1700 year event is also recorded off-shore in the form of turbidites, submarine landslides on the continental margin triggered by seismic movement along the CSZ (Goldfinger et al. 2003).

Turbidites, marshes, and lakes provide records of plate-boundary rupture events dating to before 300 years ago (Darienzo and Peterson 1990; Clague 1996; Nelson et al. 1996a; Atwater and Hemphill-Haley 1997; Garrison-Laney 1998; Kelsey et al. 2002; Witter et al. 2003; Kelsey et al. 2005). The longest record of great (magnitude >8) earthquakes on the CSZ is derived from offshore turbidite stratigraphy, which indicates that 18 events have occurred along the entire length of the subduction zone offshore from Washington and Oregon during the last ~9800 years (Goldfinger et al. 2003). An onshore record from Bradley Lake, Oregon, yields a 7300-year history of tsunami inundation resulting from rupture of the CSZ plate boundary (Ollerhead et al. 2001; Kelsey et al. 2005). Research on early marsh deposits from the Coquille and Sixes rivers on the southern Oregon coast has provided evidence of coseismic subsidence associated with great earthquakes dating back nearly 7000 and 5500 years before present, respectively (Witter et al. 2003, Kelsey et al. 2002). Further north, evidence from Coos Bay provides an almost 5000 year history of earthquake-associated subsidence (Nelson et al. 1996a, 1998), and work in the areas of Willapa Bay and Grays Harbor, Washington, has resulted in earthquake records dating to as early as 5000 years ago (Atwater and Hemphill-Haley 1997; Shennan et al. 1996).

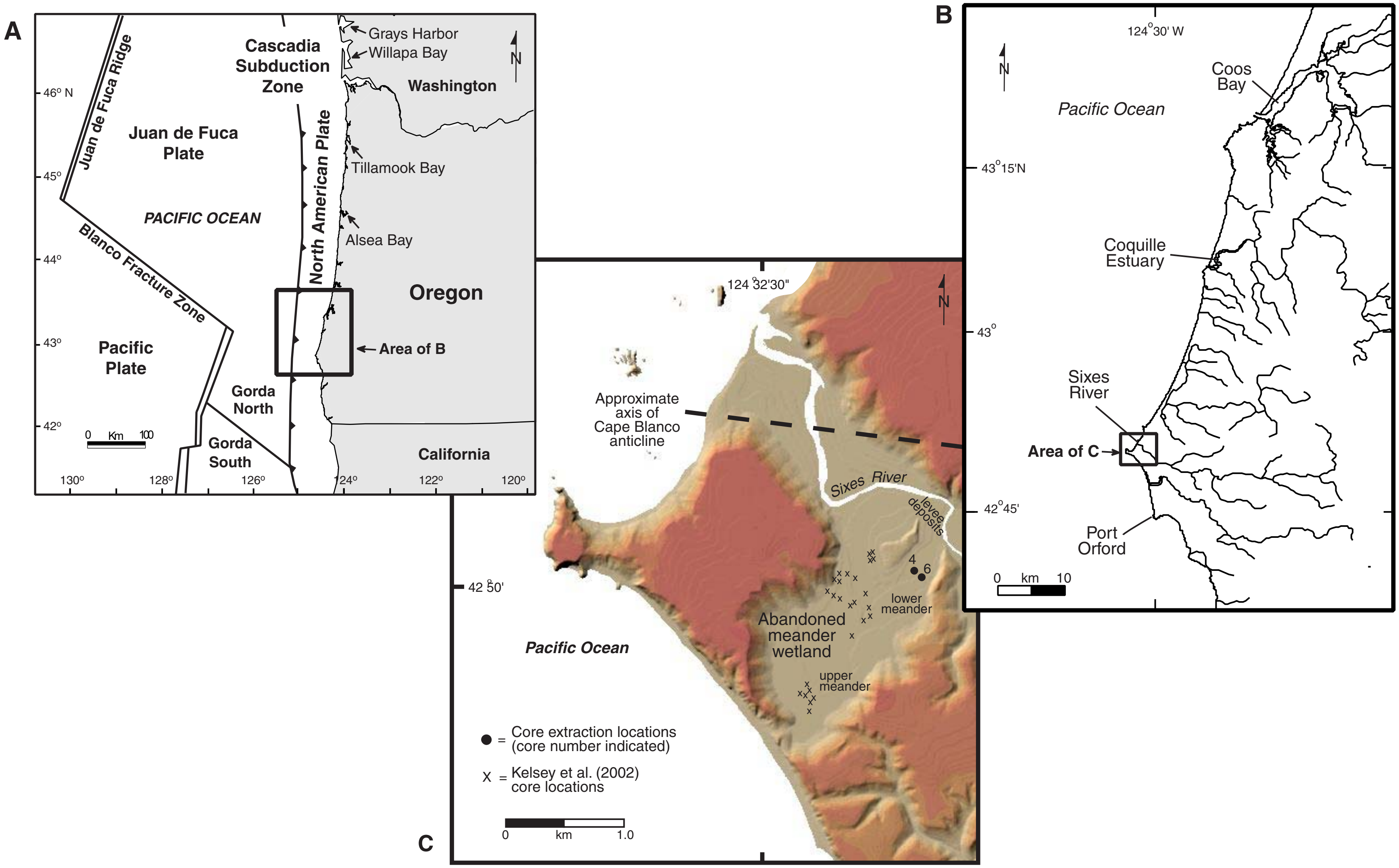

Figure 1. (A) Setting of southern coastal Oregon in relation to major plate boundaries. Locations of regional coastal estuaries discussed in text indicated. (B) Local setting of Sixes River in relation to other local estuaries and the tidal datum at Port Orford. (C) Map of lower Sixes River valley showing location of abandonded meander area, core extraction location, and approximate axis of Cape Blanco anticline (Kelsey 1990).

Long records of plate-boundary earthquake events from locations along the length of the CSZ are necessary for determining the nature of CSZ fault rupture. Not only are long records vital to the production of conditional probability estimations for earthquake recurrence intervals (Biasi et al. 2002) and the possibility of interval patterning (Goldfinger et al. 2003; Kelsey et al. 2005), they also address issues of earthquake size and fault segmentation. It is still unclear what role upper-plate structures play in the segmentation of the Cascadia fault zone, or how these structures operate in association with slip on the plate-boundary margin. Longer records of CSZ seismic activity are needed to address these issues.

This paper represents an investigative study of a coastal marsh setting on the lower Sixes River, southern Oregon (Figure 1), within which records of late to middle Holocene coseismic subsidence are well represented (Kelsey et al. 1998; 2002). The goal of this study is to reconstruct the depositional history of the estuary and to determine if deposits indicative of earthquake-generated subsidence or tsunami inundation dating to the early Holocene or late Pleistocene are preserved at the site. If such deposits are present, we aim to determine whether they preserve a record of coseismic subsidence in a manner similar to younger event records from the same area (Kelsey et al. 2002). In order to accomplish this goal, we collected and analyzed litho-, bio-, and chronostratigraphic data from a 27 m long sediment core recovered from the lower Sixes River valley near the area of work by Kelsey et al. (2002). These data allow us to determine the depositional evolution of the location through time and highlight sudden changes within the depositional record that we may then evaluate for a coseismic origin following criteria outlined by Nelson et al. (1996b) and Hemphill-Haley (1995a).

The criteria proposed by Nelson et al.(1996) and Hemphill-Haley (1995a) utilized by this study to evaluate the depositional record for a coseismic origin include the following: the suddenness of submergence, as evidenced by an abrupt rise in relative sea level and a sharp upper soil contact; a laterally expansive record of submergence; lasting relative sea level rise of >0.5m; tsunami deposition concurrent with soil burial; and synchronous submergence with events recorded at other CSZ sites. We expect to see stratigraphic evidence that meets some of the criteria outlined above for determining a coseismic origin of events in the lower, older sections of our core. However, we also understand that the stratigraphic record of older events may be different from records dating to the mid or late Holocene. Because we have a depositional record that dates to as early as the late Pleistocene, we have the opportunity to assess the threshold for earthquake and tsunami detection in coastal marsh settings.

Setting and Core Recovery

The Sixes River valley is located nearly 60 km from the seaward edge of the CSZ (Figure 1). Modern rates of uplift for the area are estimated between 4-5 mm/yr (Mitchell et al. 1994) based on repeated leveling surveys of US Highway 101, located 6 km to the east of the valley. Long term, permanent uplift rates based on marine-terrace data indicate ca. 0.85 to 1.25 m of net uplift per thousand years (Muhs et al. 1990; Kelsey 1990). Both long- and short-term rates of uplift are relatively high compared with most of the CSZ (cf. Kelsey and Bockheim 1994:Fig.7), and may be due to the effects of regional uplift coupled with uplift on the Cape Blanco anticline, a local, upper-plate tectonic structure (Kelsey 1990; Kelsey et al. 1996; 2002). The Cape Blanco anticline is an east-striking, eastward plunging fold formed during ongoing compression of the forearc region of CSZ (Kelsey 1990). This upper plate structure is an onshore extension of the Cascadia fold-and-thrust belt, mapped by Goldfinger et al. (1992) and McNeill et al. (1998), that Kelsey et al. (2002) argue ruptures coseismically in association with some larger, plate-boundary earthquakes along the CSZ.

The Sixes River estuary is confined within the active river channel, with head of tide reaching approximately three river kilometers upstream (Kelsey et al. 1996). The coastal lowland surrounding the river is currently higher than mean higher high water (MHHW), which is 0.98m relative to the National Geodetic Vertical Datum (NGVD). All elevations reported in this paper are relative to NGVD and are tied to the Port Orford tidal gauge located 11 km to the south of Cape Blanco (Figure 1). All ground surface elevations were determined by Total Station survey and referenced by benchmark to NGVD. Accuracy is to the nearest 0.01m.

Much of the lower Sixes valley is an abandoned meander wetland cut into surrounding Pleistocene marine terrace deposits (Figure 1). It is thought that the meander was cut sometime during the last sea level low stand and filled in with fine-grained estuarine, tidal marsh, and freshwater marsh sediments as sea level rose in the late Pleistocene and early Holocene periods (Kelsey et al. 2002). We recovered four long cores in the lower Sixes River valley, with the two longest and most complete cores, Cores 4 and 6, extracted from a dry pasture area within the abandoned meander located to the south of the river within 3.5 km of

Table 1. Radiocarbon Ages, Lower Sixes River Valley

Stratigraphic Discontinuity (SD)	Core : Section	Elevation relative to NGVD (m)	Material dated	Beta Analytic Lab Number	Conventional radiocarbon age and reported error (C14 yr BP)	Calibrated age (2 sigma)
B	4 : 2	4.18 to 4.16	small woody debris	Beta-203257	2300+/-40 BP	Cal BP 2350 to 2300 and Cal BP 2260 to 2160
G	4 : 7	-2.125 to -2.135	small, woody detritus	Beta-203256	5600+/-40 BP	Cal BP 6450 to 6300
H	4 : 7	-2.51 to -2.50	small woody debris, sharp edged	Beta-203255	5860+/-40 BP	Cal BP 6690 to 6500
I	4 : 9	-4.42	Seeds	Beta-199710	5970+/-40 BP	Cal BP 6890 to 6690
J	4 : 15	-11.63 to -11.66	Wood	Beta-199712	8280+/-50 BP	Cal BP 9440 to 9120
K	4 : 18	-16.25	Plant material	Beta-199709	8900+/-50 BP	Cal BP 10190 to 9880
No event associated	4 : 22	-20.62 to -20.64	Seeds	Beta-199715	8980+/-40 BP	Cal BP 10220 and 10140 and Cal BP 10000 to 9960

the modern channel mouth (Figure 1). Previous work within the abandoned meander conducted by Kelsey et al. (2002) focused on the southern and northwestern upper and lower meander areas (Figure 1). Using hand-operated gouge cores, their efforts recovered sediments to a maximum depth of just over -3 m NGVD. Our team utilized an alternative coring technology, a hydraulically powered, truck-mounted Geoprobe, to recover sediments to a maximum depth of -21.2 m NGVD in Core 4. AMS radiocarbon dating of seeds from near the bottom of the longest core resulted in a date of 10220 and 10140 cal yr BP or 10000 to 9960 cal yr BP (Table 1) for sediments buried -20.6 m NGVD (uncertainty in calibrated date due to the nature of the radiocarbon calibration curve during this time period). The two other cores extracted during this reconnaissance also reached depths below those attained by previous researchers in the area and remain at the core storage facility at Oregon State University for future research.

Methods

Lithostratigraphic investigations included magnetic susceptibility, gamma density, and loss on ignition (LOI) analyses, as well as detailed description of coastal wetland stratigraphy as revealed in core sections. Diatom biostratigraphic analyses were designed to assess general trends in depositional setting evolution and to determine whether significant changes in salinity accompanied the abrupt changes in lithostratigraphy. Diatom assemblage investigations were also used to estimate the magnitude of vertical relative sea level change associated with each wetland soil burial event (Hemphill-Haley 1995b). Elevation ranges of intertidal zones are estimated from modern ecological transect studies conducted in marshes on the Oregon and Washington coasts by Nelson and Kashima (1993) and Hemphill-Haley (1995a). Elevation of intertidal zones relative to mean tide level (MTL) used for this study are as follows: tidal flats and shallow subtidal channels (0.3 to -0.7m); low marsh (0.0 to 0.9m); high marsh (0.7 to 1.6m); and freshwater wetland (1.4 to 2.4m). Overlap in elevation ranges of 20-30cm reflects vertical variation in zone elevation and is included in estimations of diatom assemblages' paleo-mean tide levels (Figure 2, Table 2).

Chronostratigraphic investigations entailed the AMS radiocarbon dating of organic materials associated with abrupt burial of tidal wetland soils. Event ages were used for correlation of core stratigraphy between this study and prior work in the area (Kelsey et al. 2002), as well as for comparison with CSZ earthquake events recorded at locations along the

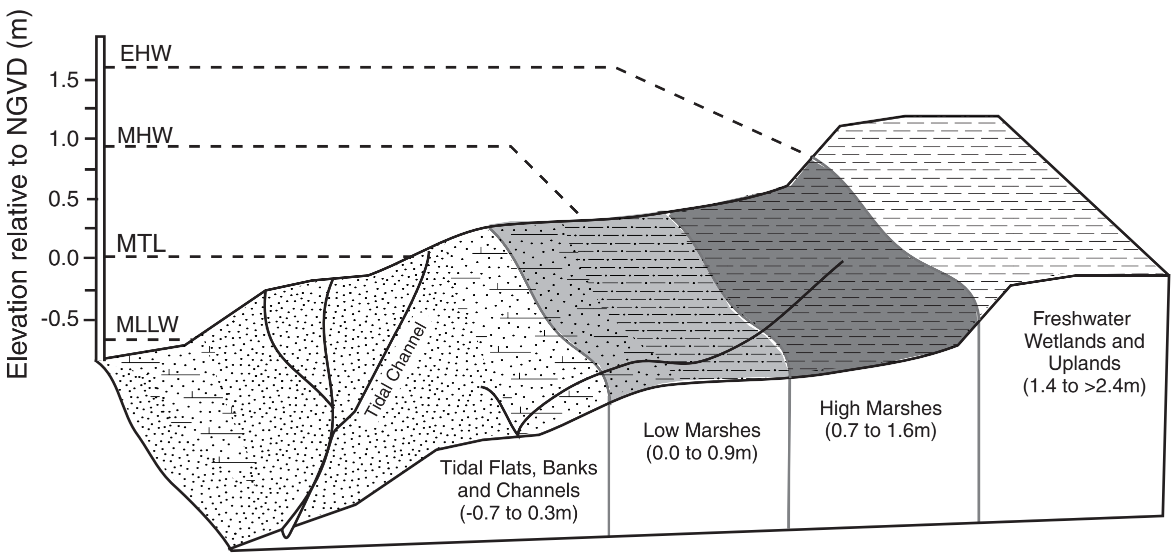

Figure 2. Elevation ranges for intertidal zones at the Sixes River Estuary based on information from Jennings and Nelson (1992), Nelson and Kashima (1993), and Hemphill-Haley (1995a). Tidal information from the National Ocean Service (1992). EHW, extreme high water; MHW, mean high water; MTL, mean tide level. Intertidal zones overlap by 20-30cm, reflecting variations in vertical zone boundaries (Nelson and Kashima 1993)

Table 2. Paleo-Mean Tide Levels Before and After Submergence for Events Recorded in Cores 4 and 6

Stratigraphic Discontinuity	Kelsey et al. (2002) Event Number	Diatom Sample Numbers	Elevation (NGVD) diatom samples (m)	Paleo-environment of diatom sample After submergence, before submergence	Vertical position of diatom sample relative to paleo-MTL (m)[1]	Elevation (NGVD), paleo-MTL (m)	Range of Submergence (m)[2]	Age (cal yr BP) Calibrated 2-sigma[3]
CORE 4								
			4.26	High Marsh,	0.7 to 1.6	3.6 to 2.7		
A	III	21,20	4.20	High Marsh	0.7 to 1.6	3.5 to 2.6	0 to 1.0	
			4.18	High to low marsh,	0.0 to 1.6	4.2 to 2.6		
B	IV	22, 23	4.15	Freshwater wetland	1.4 to 2.4	2.8 to 1.8	0 to 2.4	ca. 2160-2350
			4.07	Low Marsh,	0.0 to 0.9	4.1 to 3.2		
C	V	154, 24	4.03	Frashwater Wetland	1.4 to 2.4	2.6 to 1.6	0.6 to 2.5	
			3.96	Low Marsh,	0.0 to 0.9	4.0 to 3.1		
D	VI	155, 26	3.95	High Marsh	0.7 to 1.6	3.3 to 2.4	0 to 1.6	
			3.91	Low Marsh,	0.0 to 0.9	3.9 to 3.0		
E	VII	156, 157	3.90	High Marsh	0.7 to 1.6	3.2 to 2.3	0 to 1.6	
			3.55	Tidal flat,	-0.7 to 0.3	4.3 to 3.3		
F	VIII	158, 28	3.54	High marsh	0.7 to 1.6	2.8 to 1.9	0.5 to 2.4	
			-2.11	Tidal flat?,	-0.7 to 0.3	-1.4 to -2.4		
G		120,121	-2.16	High to low marsh?	0.0 to 1.6	-2.2 to -3.8	0 to 2.4	6300-6450
			-2.51	Tidal Flat,	-0.7 to 0.3	-1.8 to -2.8		
H		116,117	-2.49	Low Marsh	0.0 to 0.9	-2.5 to -3.4	0 to 1.6	6500-6690
			-4.33	Tidal Flat,	-0.7 to 0.3	-3.6 to -4.6		
I		107,106	-4.50	High Marsh	0.7 to 1.6	-5.2 to -6.1	0.6 to 2.5	6690-6890
			-11.63	High to low marsh?,	0.0 to 1.6	-11.6 to -13.2		
J		77,78	-11.65	Freshwater wetland	1.4 to 2.4	-13.1 to -14.1	0 to 2.5	9120-9440
				High to low marsh,				
			-16.23	High Marsh to	0.0 to 1.6	-16.2 to -17.8		
K		51,52	-16.29	freshwater wetland	0.7 to 2.4	-17.0 to -18.7	0 to 2.5	9880 to 10190
				Low Marsh or				
			-17.93	intertidal flat,	-0.7 to 0.9	-17.2 to -18.8		>9880 and
L		40,41	-17.95	High Marsh	0.7 to 1.6	-18.7 to -19.6	0 to 2.4	<10220
No event				Estuarine tidal flat or				ca. 9960 to
associated		4	-20.63	channel	-0.7 to 0.3	-19.9 to -20.9		10220
CORE 6								
			-4.36	Tidal Flat or Channel,	-0.7 to 0.3	-3.7 to -4.7		
G		20,21	-4.40	High to Low Marsh	0.0 to 1.6	-4.4 to -6.0	0 to 2.3	
				Tidal Flat,				
			-4.90	High Marsh to	-0.7 to 0.3	-4.2 to -5.2		
H		15,16	-4.96	Freshwater Wetland	0.7 to 2.4	-5.7 to -7.4	0.5 to 3.2	

[1] Elevation ranges for marsh and tidal flat environments, relative to Mean Tide Level (MTL), from Nelson and Kashima (1993) and Hemphill-Haley (1995)

[2] We infer that negative minimum values are invalid estimates of submergence because, in each case, the diatom assemblage data indicate a change from a higher to a lower intertidal zone across the buried soil horizon.

[3] ca. ages incorporate error range due to multiple intercepts on radiocarbon calibration curve

coasts of Washington (Atwater and Hemphill-Haley 1997), Oregon (Nelson et al. 1996a, 1998; Witter et al. 2003; Kelsey et al. 2005), northern California (Abramson 1998; Garrison-Laney 1998), and with events recorded from offshore turbidite records (Goldfinger et al. 2003). Age data also helped to constrain the timing and evolution of depositional systems at the site. For more details on the litho-, bio-, and chronostratigraphic methods employed, see Appendix A.

Unlike stratigraphic records from other Cascadia marsh sequences, buried peats (organic content >40%) or O horizons of Histosols (>50% organic content; Soil Survey Staff 1998) did not appear in Core 4 below 2.44m below the land surface. Buried soils in many of the core sections, especially in the lowest elevations, were identified using the definition of an A horizon: "Mineral horizons that have formed at the surface or below an O horizon. They exhibit obliteration of all or much of the original rock structure and show. . . an accumulation of humified organic matter closely mixed with the mineral fraction" (USDA 1998). We identified buried surface layers based on a slight darkening of sediment color, often a change in sediment texture, an accumulation of humic matter or elevated organic content relative to surrounding sediments, and a diatom assemblage indicative of a marsh or upland surface. The term "mud" is used in this paper to indicate a non-organic silty-clay loam or silty clay.

Results

Core 4 Stratigraphy

Core 4 records a total of 12 stratigraphic discontinuities (SDs), spanning ~10,000 years of depositional history. We present stratigraphic evidence pertaining to these 12 SDs in two sections. The first section presents data pertaining to the youngest six SDs (A through F). These younger SDs either dated to within the time range of events reported by Kelsey et al. (2002) or were inferred to be younger than our second youngest dated SD (~6300 cal yr BP) based on stratigraphic position. The second section presents data concerning our oldest six SDs (G through L), that all returned dates older than the oldest event date reported by Kelsey et al. (2002), of ~6200 cal yr BP.

An idealized model of a stratigraphic section showing both litho- and biostratigraphic discontinuities that are consistent with the types of changes associated with coseismic

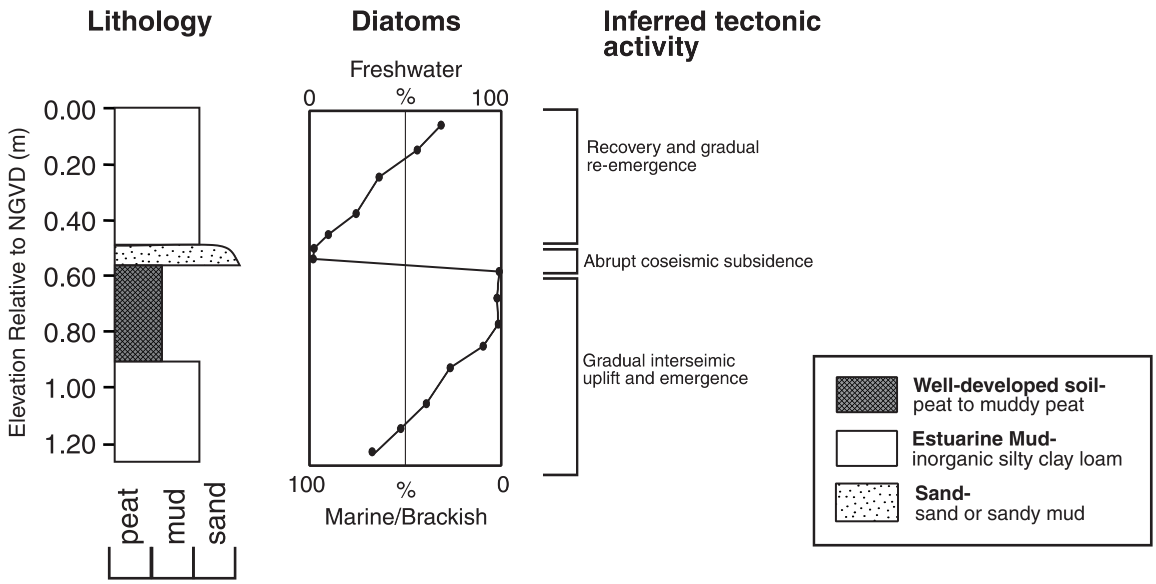

Figure 3. Idealized stratigraphic sediment section displaying litho- and biostratigraphic evidence of tectonic alteration of the landscape, as might result from a subduction zone earthquake. Interseismic uplift causes gradual emergence and a change from estuarine muds to a peaty soil. This is accompanied by an increase in relative percentage of freshwater diatoms. Abrupt subsidence of the landscape results in inundation by tsunami waters and associated sand deposition. The sudden rise in sea level relative to the land causes infilling by intertidal muds. Diatom biostratigraphy displays a sudden drop in freshwater diatom percentage and an influx of marine/brackish diatoms in association with the tsunami deposit and influx of intertidal mud.

subsidence of the landscape and relative sea level rise is shown in Figure 3. For each of the 12 stratigraphic discontinuities (SDs) described below, we have constructed representative litho- and biostratigraphic sections for comparison to the model (Figure 4).

Stratigraphic Discontinuities (SDs) Younger than 6200 yr BP

Buried soils

In all cases, well-developed or incipient soils, identified based on sediment structure, aggregation of organic materials, or higher relative LOI readings, are associated with the SDs (Figure 4). Contact abruptness between buried soils and overlying sediments is one indication of the sudden submergence of a soil (Nelson et al. 1996b). For almost every younger SD recorded in our core, an abrupt (<1mm) to sharp (1-3mm) boundary between units is noted. Only SD C displays a gradational (4-10mm) boundary.

Sandy Deposits Overlying Buried Soils

Sediment deposits with significantly higher percentages of sand than the units directly underlying them occurs in association with SD D and F (Figure 4, Table 3). Texture of the overlying sediments are massive sandy clay loams and are <2cm thick, sharply overlying the soils below. Events A, B, C, and E have no notable layers of sand associated, or experience a drop in relative sand percentage across the event boundary. Because the boundaries between each of the buried soils and overlying sandy units associated with Events D and F are abrupt, and because no soil development is noted to occur within the top portions of these sandy units, we infer that the sandy beds were deposited rapidly and subsequently buried by intertidal mud deposits.

Diatom Biostratigraphy

On the basis of relative percentages of diatoms with freshwater, fresh-brackish, brackish, marine-brackish, and marine salinity preferences, the general environmental setting of the lower meander site for the past 10,000 years can be characterized (Figure 5). Within this general evolution of a fluctuating brackish or freshwater paleoecological setting, sudden shifts in assemblage salinity were apparent. These abrupt changes in salinity are characterized by diatom assemblages indicative of higher intertidal environments shifting suddenly across a lithostratigraphic boundary to assemblages typical of lower intertidal

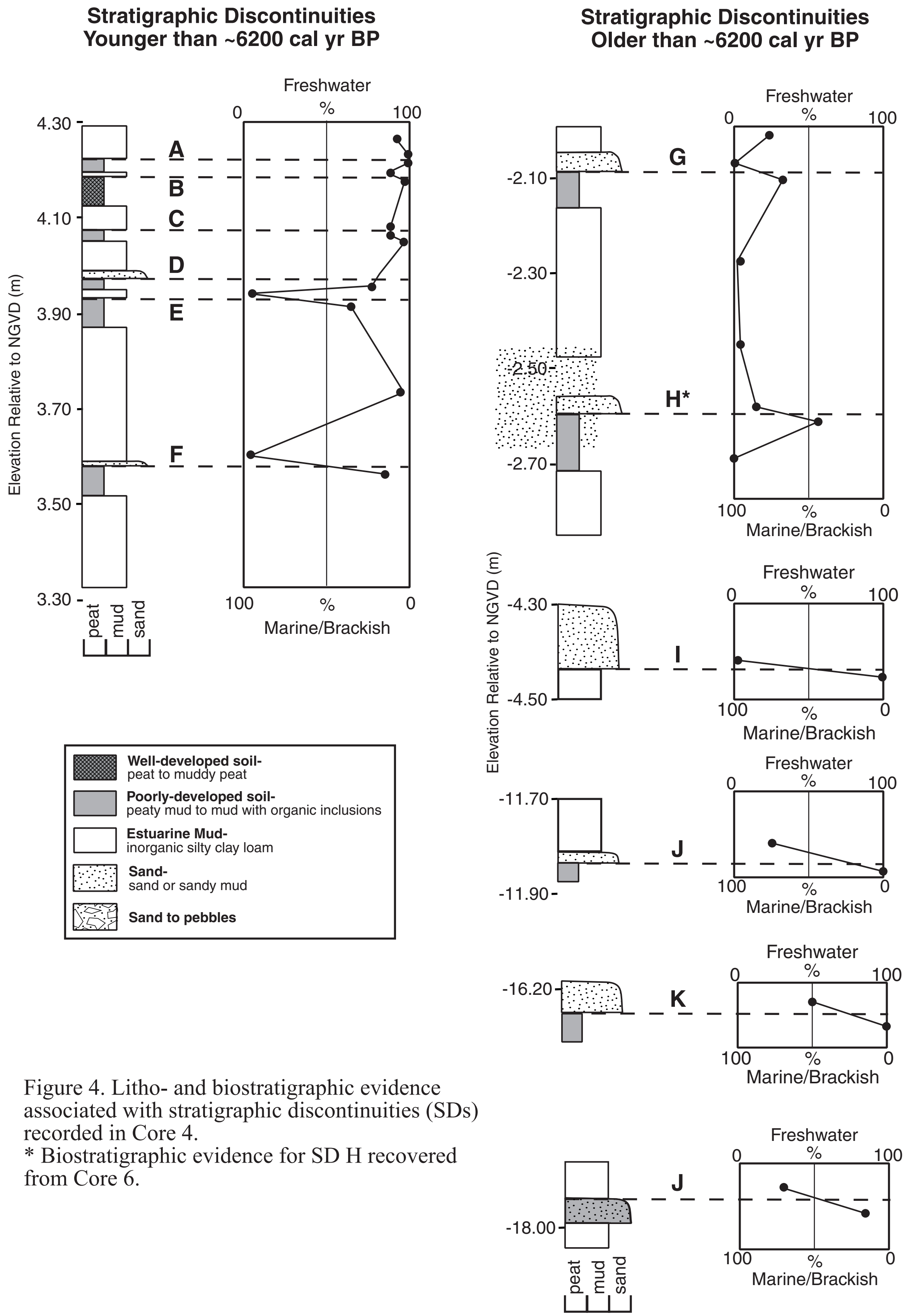

Figure 4. Litho- and biostratigraphic evidence associated with stratigraphic discontinuities (SDs) recorded in Core 4.
* Biostratigraphic evidence for SD H recovered from Core 6.

Table 3. Attributes of Stratigraphic Discontinuities (SDs) from Cores at Lower Sixes River Valley.

Stratigraphic Discontinuity (SD)[1]	Correlative with Kelsey et al. (2002) Buried Soil number:	Depth to SD (m)[2]	Number of cores that sample SD[3]	Abruptness of contact[4]	Sandy deposit overlying buried horizon?	Thickness of sand overlying buried horizon (cm)	Stratigraphic separation between SDs (m)[5]
A	III	1.34	1 (11)	Sharp	No	N.A.	N.A.
B	IV	1.38	1 (11)	Abrupt	No	N.A.	0.04
C	V	1.50	1 (20)	Gradational	No	N.A.	0.12
D	VI	1.59	1 (10)	Sharp	Yes	2.0	0.09
E	VII	1.64	1 (10)	Sharp	No	N.A.	0.05
F	VIII	2.00	1 (10)	Sharp	Yes	1.0	0.36
G		7.68	2	Sharp	Yes	3.0	N.A.
H		8.06	2	Abrupt	Yes	4.5	0.46
I		9.96	1	Sharp	Yes	10.0	0.74
J		17.18	1	Sharp	Yes	3.0	N.A.
K		21.80	1	Sharp	Yes	4.0	N.A.
L		23.49	1	Sharp	No	N.A.	N.A.

[1] We use the term "Stratigraphic Discontinuity (SD)" rather than "Buried Soil" because in the case of Events I and L, no buried soil is associated with the burial event.

[2] Depth to event is averaged for events G and H from cores 4 and 6

[3] Parentheses around the second number indicates the minimum number of cores identified by Kelsey et al. (2002) containing evidence of the burial event. See text for discussion of correlation between soil burial events reported by Kelsey et al. (2002) and events identified through this study.

[4] Abrupt = <1mm; Sharp = 1-3mm; Gradational = 4-10mm; Diffuse = >11mm

[5] Stratigraphic separation calcuated for those events between which no sediment was lost during coring activities.

environments. Each of the six younger SDs correlates to such a sudden shift in diatom assemblage (Figure 5; Appendix C). Because the sandy sediment that overlies buried soils D and F contains brackish and/or marine diatoms (Appendix B, C), we infer that each depositional event that transports sand to the site also transports brackish and/or marine diatoms onto the buried marsh soils.

Age assignments for buried soils

An age range of cal BP 2350 to 2300 and cal BP 2260 to 2160 was assigned to SD B based on AMS radiocarbon dating of a sample extracted from the upper 2cm of the buried soil horizon (Table 1).

Correlation with Previously Recorded Events within the Sixes River Wetland

Correlation between SDs recorded in Core 4 and events reported by Kelsey et al. (2002) for the same area is attempted based on stratigraphic signatures such as depth, litho- and biostratigraphy, stratigraphic separation, and radiocarbon information. SDs A through C can be correlated with Kelsey et al.'s (2002) buried soil events III through V based on a date returned on our SD B and associated stratigraphic signatures (Figure 6). A date range of cal BP 2350 to 2300 and cal BP 2260 to 2160 for our SD B (Table 1) falls between the dates for Kelsey et al.'s (2002) soil burial events III and V, thus correlating with their burial event IV. SDs A-C occur at stratigraphic positions consistent with the depth and stratigraphic separation between their events III through V, summarized in their Tables 1 and 3 (Kelsey et al. 2002:302,303). Our SD B is found less than 5cm below SD A in the stratigraphic column, placement which is consistent with the stratigraphic coupling reported by Kelsey et al. for their buried soils III and IV. Our SD C occurs 12cm below SD B, over double the separation between the two upper events, which is consistent with separations between Kelsey et al.'s buried soils III and IV as compared to IV and V. We correlate our SDs D through F with Kelsey et al.'s soil burial events VI through VIII based on the stratigraphic similarities in the positioning of event horizons (Figure 6). As with their events VI and VII, our SDs D and E display little stratigraphic separation (~4cm). This coupling aids in the determination of correlation between cores from the same study area. Kelsey et al.'s (2002) events IX through XII are not preserved in Core 4 due to discontinuous sediment retrieval.

Although the stratigraphic separation between SDs A through F in our core is smaller than that reported by Kelsey et al. (2002:Table 3), this is consistent with their contention that

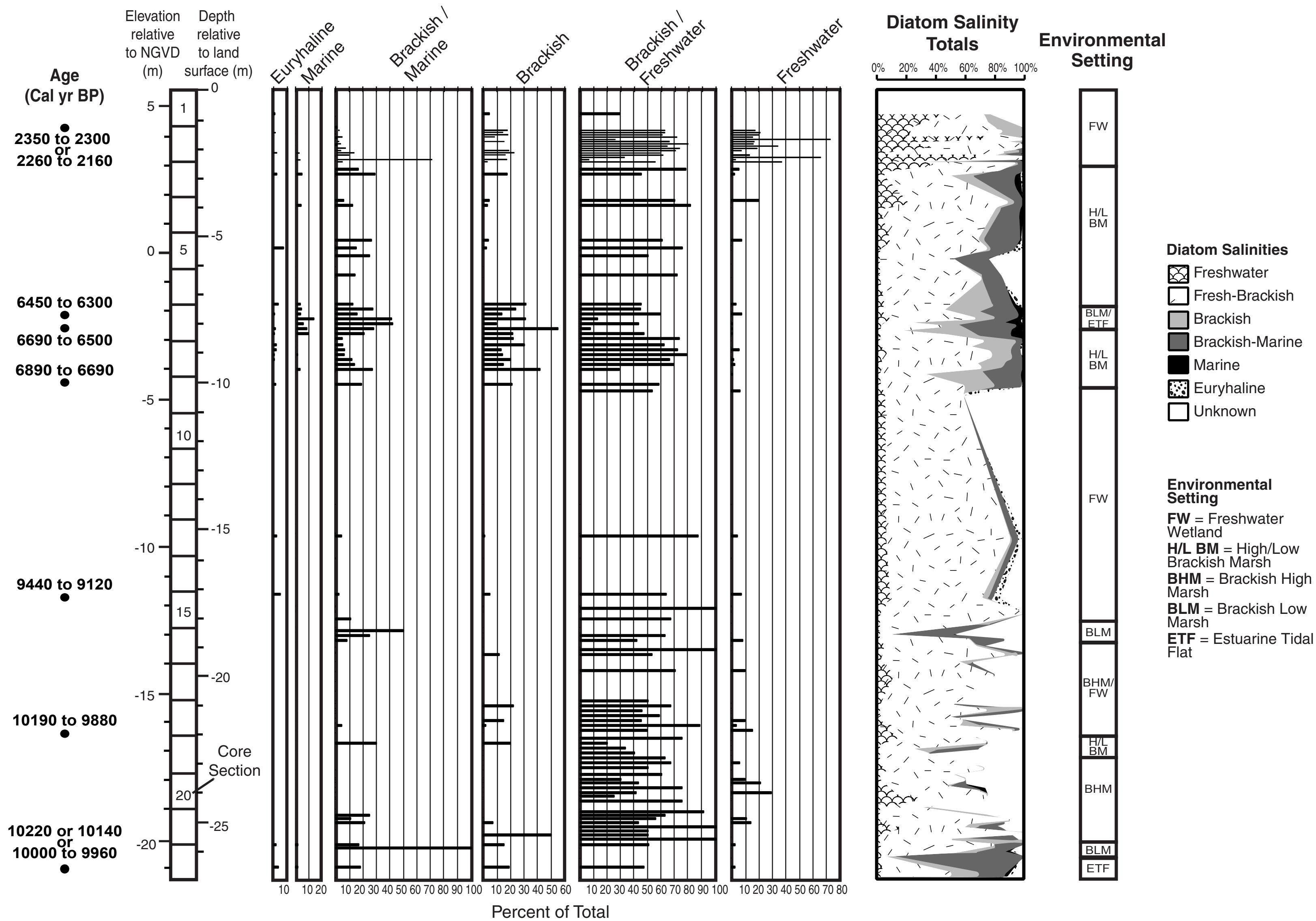

Figure 5. Diatom percentages organized by salinity tolerances used to infer environmental setting.

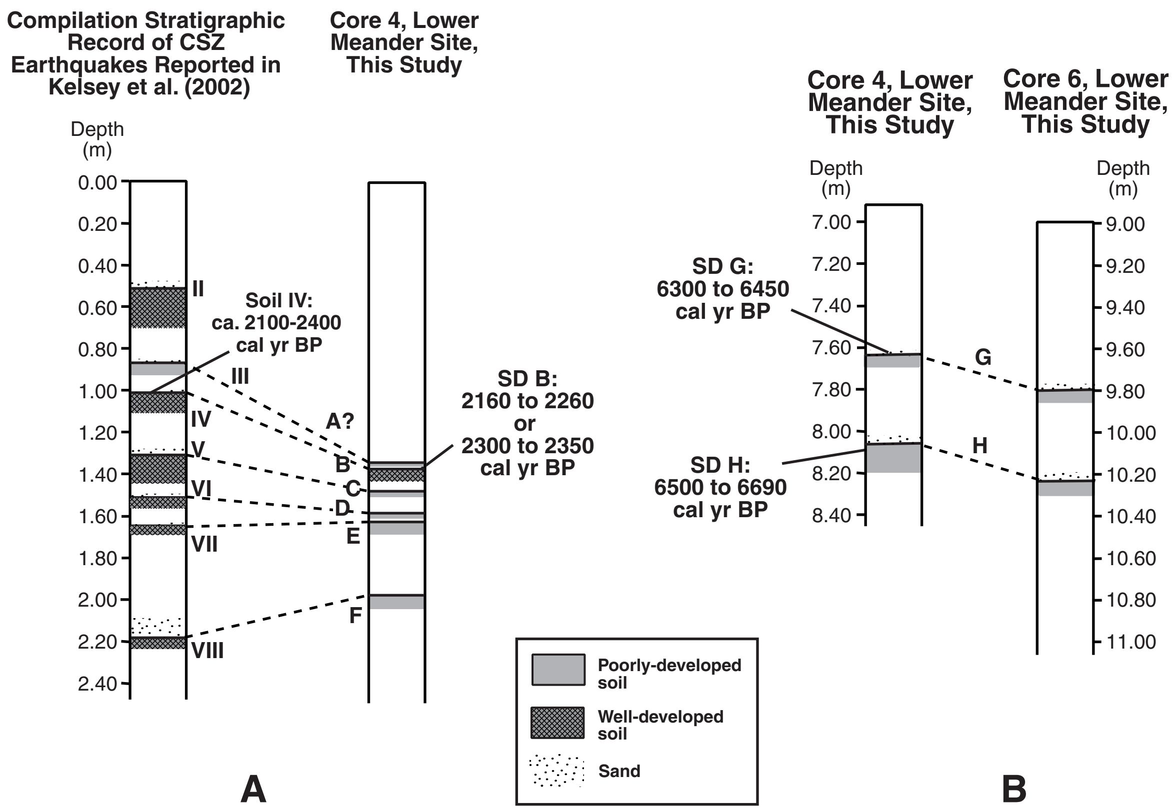

Figure 6. (A) Stratigraphic record correlation between events reported in Kelsey et al. (2002) and six youngest Stratigraphic Discontinuities (SDs) reported in this study. Compilation lower meander sediment core constructed from information included in Kelsey et al. (2002): average depth to buried soil from their Table 3, buried soil characteristics from their Figure 3, and average thickness of sand deposits associated with buried soils from their Table 1. Soil IV estimatebased on their Table 5, their Figure 12 and correlation with Witter et al.'s buried soil number 4 (2003: Table 1). (B) Stratigraphic correlation of SDs G and H between Cores 4 and 6, this study.

core sites located closer to the Cape Blanco anticline will display less net sediment accretion between events than those further away from the anticline axis. They argue that coseismic tightening of the anticline negates in part the total amount of subsidence caused by regional slip on the underlying megathrust (Kelsey et al. 2002:313). Since the location of Core 4 is nearer to the anticline axis than any of the cores retrieved in their study (Figure 1), a smaller amount of stratigraphic separation between events should be expected.

Correlation of our SDs A-F with events III-VIII reported by Kelsey et al. (2002) is substantiated by diatom assemblage analysis (Figures 4, 5; Table 2; Appendix B, C). Diatom assemblages across stratigraphic boundaries B-F shift from a higher to a lower intertidal setting. The diatom assemblage from our SD A shows little change in species dominance, with high brackish marsh settings indicated both above and below the event boundary (Figure 4; Table 2). This lack of change is consistent with the abundance of freshwater diatoms seen above and below Kelsey et al.'s (2002) Event III, as revealed in their Lower-Meander Core V (2002:Figure 6, Core V diatom graph). This same graph also clearly displays a significant change in intertidal setting associated with their Event V, a jump from nearly 100% freshwater diatoms to 100% brackish/marine diatoms across the event boundary. Our correlative SD C shows a similar significant drop in freshwater diatom abundance, indicating a shift from a freshwater wetland to a low marsh (Figure 4; Table 2; Appendix B, C).

Ages for buried soils A and C-F (Table 2) were estimated based on correlation with events and ages reported by Kelsey et al. (2002), as shown in Figure 6.

Stratigraphic Discontinuities (SDs) Older than 6200 cal yr BP

Buried soils

In all cases except for SD I and L, well-developed or incipient soils, identified based on sediment structure, aggregation of organic materials, or higher relative LOI readings, are associated with the SDs (Figure 4). In the case of SD I and L, no macroscopically visible buried soil is associated. In these two cases, other lithostratigraphic data, such as contact abruptness and overlying sediment texture, in addition to biostratigraphic data, are used to identify buried former land surfaces. Contact abruptness between buried soils and overlying sediments is one indication of the sudden submergence of a soil (Nelson et al. 1996b). For every older SD recorded in our core, an abrupt (<1mm) to sharp (1-3mm) boundary between units is noted.

Sandy Deposits Overlying Buried Soils

Sediment deposits with significantly higher percentages of sand than the units directly underlying them occur in association with SDs G-K (Figure 4; Table 3). Texture of the sediment ranges from medium to very fine sand with variable amounts of silt/clay. Thicknesses of the sand layers range from ~1.0 to 10.0cm. SD L has no notable layer of sand associated. Buried soils underlie sandy deposits in SDs G, H, J, and K. In each of these cases, the boundary between the buried soil and the overlying sandy unit is sharp or abrupt. No buried soil is apparent in the case of SD I. The underlying unit is a silty clay loam with no apparent organic inclusions. The boundary between this and the overlying lithologic unit is abrupt, slanted in the core section, and appears erosional. The overlying unit is loamy sand, poorly sorted, with some clasts ranging in size from pebbles to fine sand.

Sandy deposits associated with SDs G, J, and K are massive sands to sandy loams with no apparent internal bedding. In the case of SD H, however, a fining upward sequence of medium to fine sand occurs between -2.46 and -2.50 m NGVD, abruptly overlying an organically laminated clay loam. Because the boundaries between each of the buried soils and overlying sandy units associated with SDs G, H, J, and K are abrupt to sharp, and because no soil development is noted to occur within the top portions of these sandy units, we infer that the sandy beds were deposited rapidly and immediately buried by intertidal mud deposits.

Diatom Biostratigraphy

Each of the six older SDs correlates to a sudden shift in fossil diatom salinity percentages (Figures 4, 5), from an assemblage indicative of a higher intertidal environment to an assemblage typical of a lower intertidal environment (Table 2; Appendix C). Because the sandy sediment that overlies SDs G, H, J, and K contains brackish and/or marine diatoms (Appendix B,C), we infer that each depositional event that transports sand to the site also transports brackish and/or marine diatoms onto the buried marsh soils.

Age Assignments for Buried Soils

Ages were assigned to SDs G, I, J, K, and L based on AMS radiocarbon dating of samples extracted from the upper 2cm of each buried soil horizon (Table 1). There is no radiocarbon age for the oldest buried soil, SD L. However, if we use the age ranges from dates recovered above and below this event, a bounding age range for the event can be proposed. The youngest possible age on material associated with SD K from core Section 18 is 9880 cal yr BP. The oldest reliable age from material below SD L is 10,220 cal yr BP, from seeds at -20.63m, core Section 22 (Table 1). Based on the stratigraphic position of SD L lower in the core than SD K and higher than the date from core Section 22, the age range for SD L is >9880 and <10,220 cal yr BP (Table 2).

Correlation with Core 6 Sediments

By matching magnetic susceptibility patterns recorded in Cores 4 and 6, and then closely examining the litho- and biostratigraphies of corresponding sediment units, we correlate SDs G and H between the two cores (Figure 6). Older buried soils recorded in Core 4 were recovered from depths below the lowest section of Core 6, which could not be pushed below a coarse gravel layer at -12.12 m below the surface. Therefore, no correlation within the meander locality of SDs I, J, K, or L was possible with the cores we acquired.

Relative Sea Level Curve Construction

Figure 7 displays a relative sea level curve constructed for the site based on radiocarbon dates and diatom biostratigraphy produced by this study (see Appendix A for a full description of relative sea level curve construction). Superimposed upon the general trend in relative sea level rise since the late Pleistocene are six instances of sudden sea level rise, correlative with our six dated stratigraphic discontinuities. The amounts of submergence and relative sea level rise associated with each radiocarbon dated stratigraphic boundary are estimated using diatom assemblage data from above and below the event boundaries (Table 2). The maximum amount of submergence associated with these events is 3.2m. The minimum amount of submergence incurred is estimated to be ≥0. For some events a negative amount of submergence is estimated based on diatom assemblage elevation ranges, but in each case we reject any negative estimate due to the change in litho- and/or biostratigraphy from a higher to a lower intertidal setting.

Evidence for Coseismic Subsidence and Tsunamis Induced by Great Earthquakes

We present evidence to satisfy criteria proposed by Nelson et al. (1996b) and Hemphill-Haley (1995b) in support of a coseismic origin for soil submergence and burial for the 12 stratigraphic discontinuities/burial events recorded in the lower Sixes River valley (SDs A-L). These criteria include the suddenness of submergence, as evidenced by an abrupt rise in relative sea level and a sharp upper soil contact; a laterally expansive record of submergence; lasting relative sea level rise of >0.5m; tsunami deposition concurrent with soil burial; and synchronous submergence with events recorded at other CSZ sites (Table 4).

Of the 12 candidate paleoseismic events presented here, we believe the first six events (SDs A-F) correlate to events III-VIII presented in Kelsey et al. (2002). This contention is based on the stratigraphic signatures such as depth, litho- and biostratigraphy, stratigraphic separation, and radiocarbon information discussed above (Figure 6). If this correlation is correct, then each of these events satisfy from four to six of the criteria used to assess a coseismic origin for soil submergence and burial, listed in Table 4 (Kelsey et al. 2002:Table 7). Therefore, we will concentrate our discussion on the older, lower six events recorded in our cores, SDs G through L.

Candidate Paleoseismic Events Older than 6,200 cal yr BP

Soil/mud couplets

We have identified six instances of sudden submergence and burial of sediments older than the oldest event reported by Kelsey et al. (2002) for the same abandoned meander wetland. These buried sediments are identified as former freshwater or brackish marsh soils based on incipient soil development and/or diatom assemblage analysis. (Tables 2 and 3, Figure 4, Appendices 1 and 2). In most of these cases, development of buried soil horizons is weak or non-detectable. This poor development may be due to post-burial degradation of the soil due to pedoturbation by plants or animals, microbial activity, or non-reducing conditions (Atwater 1992; Hart 1994). Erosion of the uppermost soil surfaces may have occurred in association with tsunami deposition. Alternatively, marsh soils at this locality may have not developed enough to produce strong pedologic signatures to be preserved. Poor preservation or lack of recognizable marsh soil horizons is not an uncommon occurrence in tidal marsh studies. Both Kelsey et al. (2002) and Witter et al. (2003) have reported degradation of soils in deeper core sections from southern Oregon marshes, and Mathewes and Clague (1994) relied upon paleoecologic studies of fossil assemblages to identify buried marsh soils. In each case in the lower sections of our cores where soil development is poor or lacking, biostratigraphic data provide evidence that the sediment represents freshwater or high brackish marsh deposits (Table 2; Appendix C).

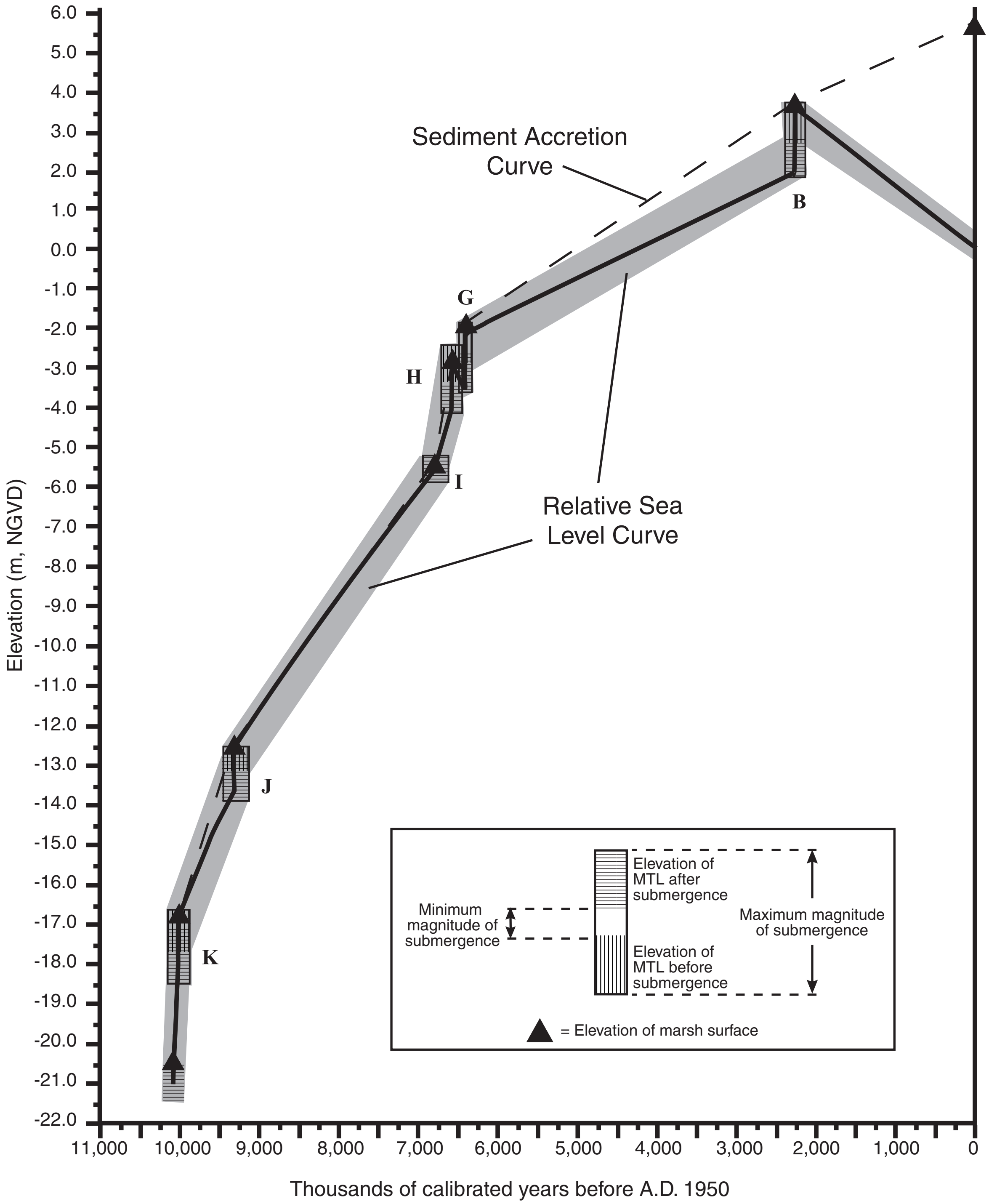

Figure 7. Elevation of mean tidal level (MTL) over time ("Relative Sea Level Curve"). Vertical elevation of mean tide level across each stratigraphic discontinuity (SDs A, G, I, J, K, and L) based on elevation ranges relative to NGVD of intertidal zones inferred from diatom assemblage data (see Table 2 and Appendix B). Rectangle height incorporates error margins related to ranges in elevation for each intertidal zone. Errors in age estimates for each sample are listed in Table 1 and are portrayed as rectangle width. Shaded area represents sea level curve with error margins incorporated. Triangles mark buried surface horizons (i.e. buried wetland soils) and are connected with dashed line that indicates sediment aggradation over time.

Evidence for Rapid Subsidence

The sharp (<3mm) boundary recorded at all six lower SDs (G-L) indicates a rapid shift from a higher intertidal setting to a lower one (Table 2). If deposition of the overlying sediments had not been rapid, a more gradational boundary would have formed. SDs G, H, and I also exhibit diatom assemblages across these sharp boundaries from non-contiguous intertidal settings. Because diatoms that characterize intermediate intertidal settings are not abundant in these assemblages, we infer that very little time passed between deposition of diatom-associated sediments above and below the lithologic boundaries. In the case of SD I, however, the uneven nature of the boundary and the large grain size of the overlying sediment unit leaves open the possibility that a higher energy event eroded and removed sediments from the location before deposition resumed.

Evidence for Lasting Submergence

The litho- and biostratigraphic data imply a lasting, rather than ephemeral, shift in depositional setting from a higher to a lower intertidal zone for SDs G, H, I and K. Using estimates of marsh accretion rates by Kelsey et al. (2002:Figure 11), 10cm of sediment represents from 70 to 140 years. Because at least 10cm of intertidal mud overlies each buried event horizon, we infer that the change in RSL associated with each event was long-lasting. In the case of SD I, over 65cm of intertidal sands and muds (tidal flats or lower brackish marsh deposits) bury the high brackish marsh deposit. While some of this sediment is coarse-grained and probably indicates rapid deposition, at least 50cm of the overlying deposit is fine-grained silts and clays. Additionally, diatom assemblages from centimeters above SDs G, H, I, and K are all indicative of lower intertidal environments than assemblages from the underlying, buried units associated with each event (Figure 4, Appendix C). This implies a lasting change in environment from a higher to a lower intertidal zone. Such long-term submergence and subsequent sediment accretion argues against more short-term fluctuations in sea level and sediment deposition caused by unusually high tides, storm surges, or El Niño events (Nelson et al. 1996b; Witter et al. 2003).

It is difficult to determine whether the submergence associated with SD J was a long- or short-term episode. While at least 10cm of relatively inorganic, intertidal mud overlies the freshwater marsh material, the diatom samples extracted from this unit and from all sediments of the core section above this were barren of identifiable valves. Additionally, no radiocarbon dates were retrieved from the upper units. Unequivocal evidence, therefore, is lacking to determine the lasting nature of the subsidence. In the case of SD L, it is also difficult to determine the lasting nature of the change in depositional environment, as diatom preservation from overlying sediments is extremely poor. However, the lithology of the overlying sediments continues to be loamy for at least 20cm further upcore before gradually fining into a mud, implying a lasting change in depositional setting.

Lateral Extent of Buried Horizon

As stated above, SDs A-F are correlated with buried soils from throughout the abandoned marsh locality, an area ranging from 150,000m^3 to 220,000m^3. Of the older candidate events, only SDs G and H are correlated with other cores extracted from the same area. These core localities are spaced approximately 90m apart within the same region of the abandoned meander (Figure 1). While this does not rule out the possibility that the recorded burial events were caused by localized, rather than estuary-wide, sedimentation or hydrodynamic events, the spacing does imply wide-spread change. We are able to eliminate local-scale, river flooding events as the cause of the shift in depositional zones for all of the older SDs, G-L, because in each case the rapidly deposited overlying sediment contains higher relative percentages of marine or brackish fossil diatoms, not freshwater diatoms as would be the case if the sediment derived from upriver.

Amount of Coseismic Subsidence

The amount of submergence associated with each SD was estimated based on diatom assemblage analysis relative to intertidal zone elevation ranges from Nelson and Kashima (1993). The maximum amount of submergence associated with any of the lower six SDs is 3.2m (using diatom data from Core 6) and the minimum is ≥0 (Table 2). We infer that for each SD some amount of subsidence and relative sea level rise occurred because in each case the overlying diatom assemblage is distinctly different from the underlying assemblage, with a lower percentage of freshwater diatoms and a higher percentage of brackish or marine diatoms relative to the underlying unit.

Evidence for Tsunami Inundation

Based on our litho- and biostratigraphic investigations, evidence suggests that both SDs G and H were accompanied by tsunami inundation. Both SDs have sandy units overlying sharp stratigraphic boundaries (Table 2) and both of these sandy units contain a high proportion of epipsammic, tidal flat fossil diatoms (Appendix C). A bed of coarse to fine sand abruptly overlies a brackish marsh surface in the case of SD I, which implies a surge of sandy sediment concurrent with the sudden subsidence and rise in RSL. The diatom assemblage is characteristic of an intertidal flat or subtidal channel, which suggests an estuary or marine source for the deposit. However, other features of the sandy deposit are not consistent with tsunami deposition, including poor sorting of sediment and no evidence for upward fining.

The overlying unit of SD J is a sandy deposit with numerous planktonic diatoms associated. While the character of the diatom assemblage of the overlying unit could be indicative of standing water within a high marsh environment, the sudden nature of its burial and the sandy texture of the sediment in comparison with the underlying mud makes a moving source for the overlying unit more probable. We attribute the burial of the underlying unit of SD J to a surge of sandy water, such as a tsunami, accompanying sudden subsidence of the landscape.

The sandy nature of the overlying sediment associated with SD K could imply tsunami inundation, but the diatom assemblage includes no tidal flat, shallow subtidal channel, or brackish planktonic forms that would indicate a marine or estuary source of the sands.

Although the overlying loam associated with SD L is slightly sandier (42% sand versus 34% sand in the lower unit), the diatom assemblage is not indicative of a sandy tidal flat. However, the significant change in species' salinity preference and the intertidal nature of many of the valves from the underlying unit suggests that water from an estuary source abruptly buried the high marsh. This may indicate that sand was not available for deposition by a tsunami surge. Rather, diatoms living within tidal flats and on intertidal plants were carried in and deposited by a sudden influx of water, possibly due to tsunami activity.

Synchroneity of Submergence

Event chronologies from an estuary and a freshwater lake on the coast of Oregon (Witter et al. 2003; Kelsey et al. 2005) and from offshore turbidite localities on the continental shelf and slope (Goldfinger et al. 2003), provide age comparisons to the older events recorded in our cores from the lower Sixes River valley (Figure 8). The woody detritus extracted from the upper boundary of the underlying unit of SD G dates to Cal BP 6450 to 6300 (Table 1). While this date is older than any event recorded from within the Sixes River valley (Kelsey et al. 2002), it does overlap, within two standard deviations, the age range reported by Witter et al. (2003:Table 7) for the Coquille River valley (6200 to 6310 cal yr BP). It also falls within the range proposed by Kelsey et al. (2005:Table 4) for their Disturbance Event 16 (6510 to 6310 cal yr BP) from Bradley Lake, just 30km to the north of the Sixes River valley. Additionally, Goldfinger et al. (2003) also report a coseismic offshore turbidite deposit from the Juan de Fuca Channel that dates to this time period, from 6375 to 6507 cal yr BP.

The age ranges for SDs H and I, 6500 to 6690 and 6690 to 6890 cal yr BP, respectively (Table 1), are older than any event previously recorded at the Sixes River or in the Coquille River valley. No events reported from Bradley Lake (Kelsey et al. 2005) or from offshore turbidite studies (Goldfinger et al. 2003) appear to correlate with the dates for SDs H or I.

The AMS radiocarbon date on woody debris extracted from the lower freshwater marsh deposit underlying the sharp stratigraphic boundary of SD J resulted in an age of Cal BP 9440 to 9120 (Table 1). This age is older than any event recorded at an onshore site on the Pacific Northwest coast. It falls directly within the age range reported by Goldfinger et al.'s (2003) event 17 from within the Juan de Fuca channel, which dates from 9011 to 9755 cal yr BP and overlaps with ages on events 31 and 32 from the Noyo channel (8960-9131 and 8981-9749 cal yr BP, respectively).

A date of 9880 to 10190 cal yr BP (Table 1) was obtained on plant material from the underlying unit of burial SD K. This date falls within the age range returned on turbidite buried material from the Noyo Canyon, 9886 to 11098 cal yr BP (Goldfinger et al. 2003).

Not enough datable material was available from the stratigraphic horizons associated with SD L for AMS radiocarbon dating. However, if we use the age ranges from dates recovered above and below this event, a bounding age range BP for the event of >9880 to <10,220 cal yr can be proposed (Table 2). This age range correlates with dates from offshore turbidite-associated event 33 from Noyo Canyon, which is from 9886 to 11098 cal yr BP (Goldfinger et al. 2003).

Criteria Assessment

Of the six oldest burial events recorded in our cores from the lower Sixes River valley, one burial event, SD G, meets five of the criteria proposed by Nelson et al. (1996b) and Hemphill-Haley (1995b) for determining a coseismic origin (Table 4). SDs H, J, K, and L meet four of the criteria, while SD I meets only two of the criteria. We infer, based on the multiple lines of evidence presented in this paper, that SDs G, H, J, K, and L represent stratigraphic indicators of plate boundary earthquakes. SD I does not provide enough evidence to support a coseismic origin. While none of these burial events are correlated laterally throughout the abandoned meander locality, our initial attempts at correlation with sediment extracted from a distance of nearly 100m away (Core 6) were successful for SDs G and H. Unfortunately, we were unable to extract deeper, older sediments at the Core 6 location, so correlation of SDs I, J, K, and L was not possible.

Table 4. Summary of Evidence for Coseismic Origin of Stratigraphic Discontinuities, Lower Sixes River Valley

		Evidence for coseismic subsidence							
Candidate Paleo-seismic Event (Same designation as stratigraphic discontinuity)	Age (cal yr BP) Calibrated 2-sigma[1]	Rapid relative sea level rise	Permanence of relative sea level rise (>10cm of tidal mud overlies buried soil)	Lateral extent of event >150,000m^2	Estimated relative sea level rise >0.5m	Tsunami concurrent with submergence	Similar age to regional earthquake events	Relative confidence level (number of criteria met)	Candidate Events Younger than ~6200 cal yr BP
A	1940-2130[#]	X*	X*	X*		X*		4	
B	ca. 2160-2350	X*	X*	X*	X*	X*	X*	6	
C	2460-2750[#]	X*	X*	X*	X*	X*	X*	6	
D	2880-3160[#]	X*	X*	X*	X*	X*	X*	6	
E	3390-3560[#]	X*	X*	X*	X*	X*	X*	6	
F	4150-4410[#]	X*	X*	X*	X*	X*	X*	6	
									Candidate Events Older than ~6200 cal yr BP
G	6300-6450	X	X		X	X	X	5	
H	6500-6690	X	X		X	X		4	
I	6690-6890		X		X			2	
J	9120-9440	X			X	X	X	4	
K	ca. 9880-10190	X	X		X		X	4	
L	9880-10220	X	X		X	X	X? (see text)	4	

* Evidence marked with an asterisk is based on data provided by this study and/or correlation of event with evidence from soil burial event reported by Kelsey et al. (2002:Table 7)

1 Ages marked with # are estimated based on correlation with events reported in Kelsey et al. (2002: Tables 4 and 5); ca. ages incorporate error range due to multiple intercepts on radiocarbon calibration curve; age for Event L estimated using bounding ages from radiocarbon dates acquired above and below Event L (see text)

Based on comparison of our radiocarbon age estimates for SDs B, G, H, J, K, and L with events recorded at marsh and lake localities inland, and with offshore turbidite events, we contend that SDs G, H, J, K, and possibly L represent evidence for rupture along much of the length of the CSZ (Figure 8). Correlation of SDs G and H with events seen at Bradley Lake and the Coquille River of coastal Oregon, as well as events recorded in the Juan de Fuca canyon off the coast of northern Washington and southern British Columbia, implies a rupture length of up to 400km for these events. This contention relies upon the assumption that these records are of a single event rather than multiple events at intervals too closely spaced in time to be differentiated by AMS radiocarbon dating . SDs J, K, and L potentially record plate rupture along the length of the fault zone from northern California or southern Oregon up to northern Washington, again assuming a single event. SD B supports the argument put forth by Kelsey et al. (2002) and Witter et al. (2003) that an earthquake rupturing only a portion of the subduction zone affected regions around the Coquille and Sixes rivers around 2200-2300 cal yr BP.

Intervals of Time Between Events

Calculation of average recurrence intervals for a study site requires a continuous stratigraphic record of coseismic subsidence. The record of deposition acquired through this study does not provide sufficient downcore resolution for recurrence interval determination. At onshore estuaries and marshes along the Northwest Coast, the early Holocene is most

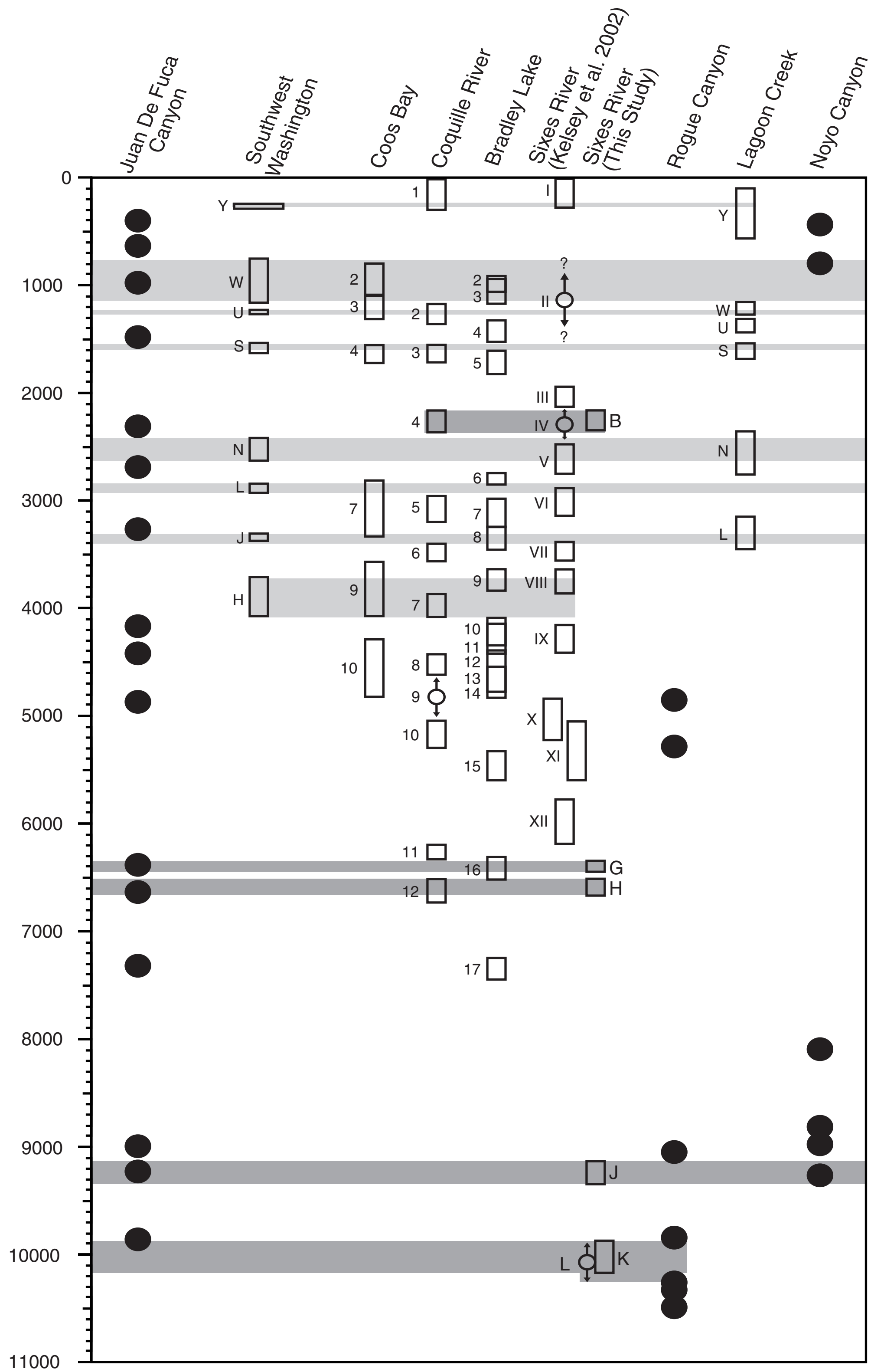

Figure 8. Comparison of radiocarbon age estimates for Cascadia subduction zone earthquakes reported in this study for the lower Sixes River valley with earthquake age estimates from onshore and offshore study sites. Southwestern Washington (Atwater and Hemphill-Haley 1997; Atwater, unpublished data); Coos Bay (Nelson et al. 1996a, 1998); Coquille River (Witter et al. 2003); Bradley Lake (Kelsey et al. 2005); Sixes River (Kelsey et al. 1998, 2002); Lagoon Creek (Abramson 1998; Garrison-Laney 1998); Juan de Fuca, Rogue, and Noyo Canyons (Goldfinger et al. 2001)

often represented in the depositional record by fluvial sediments (Glenn 1978; Peterson et al. 1984; Peterson and Phipps 1992; Peterson and Darienzo 1996; Byram and Witter 2000). These fluvial sediments are poor recorders of sudden land level change relative to sea level, because they show no significant change in diatom assemblage character if relative sea level change is insufficient to cause a change from freshwater conditions. Our Core 4 does contain a dominantly freshwater facies dating from approximately 9000 to 7000 cal yr BP (Figure 4) and during this time no subsidence events are recorded. However, unlike other estuaries along the Northwest Coast, intertidal wetland sediments are preserved in the lower sections of our core, dating to the late Pleistocene/early Holocene. These sediments have the potential to, and indeed do, record sudden changes in land level relative to sea level on a timescale comparable to offshore turbidite records, thousands of years older than other early onshore records.

Conclusion

The lower Sixes River valley preserves over 10,000 years of intertidal wetland deposits capable of recording stratigraphic signatures of subsidence that meet multiple criteria for determining a coseismic origin. Litho- and biostratigraphic evidence of six Cascadia subduction zone earthquakes younger than 4,000 cal yr BP is recorded in a long sediment core extracted from an abandoned meander within the river valley. All six of these events correlate with events previously reported by Kelsey et al. (2002).

At least five plate boundary earthquakes lowered tidal marshes and freshwater wetlands into the lower intertidal zone prior to 6,000 cal yr BP. Each of these subsidence episodes resulted in a stratigraphic record meeting at least four of the six criteria for determining coseismic subsidence, including the following evidence: rapid, lasting relative sea level rise; fossil diatom assemblage changes over lithologic boundaries indicating as much as 3.2m of subsidence; tsunami deposition concurrent with submergence and soil burial; and similarity in age to other earthquake events reported along the Cascadia subduction zone. Future study in the lower Sixes River valley involving the extraction, analysis, and dating of deep sediment cores from localities hundreds of meters apart will provide evidence pertaining to the lateral extent of buried soils.

Comparison of the earthquake record presented here with earthquake records from other onshore and offshore records of Cascadia earthquakes indicates that, like the AD1700 Cascadia earthquake that affected the entire plate boundary from northern California to southern British Columbia, some older earthquakes impacted the length of the margin. Although the record of deposition acquired through this study does not provide the continuous stratigraphic evidence required to determine recurrence interval patterning, this study proves the site's ability to record stratigraphic evidence of coseismic subsidence as early as the late Pleistocene.

References Cited

Abramson, H.A. 1998, Evidence for tsunamis and earthquakes during the last 3500 years from Lagoon Creek, a coastal freshwater marsh, northern California [M.S.Thesis]: Arcata, California, Humboldt State University, 76 p.

Adams, J. 1990. Paleoseismicity of the Cascadia subduction zone—Evidence from turbidites off the Oregon-Washington margin. *Tectonics*, 9(4):569-583.

Atwater, B.F. 1987. Evidence for Great Holocene Earthquakes Along the Outer Coast of Washington State. *Science*, 236:942-944.

Atwater, B.F. 1992. Geologic evidence for earthquakes during the past 2000 yr along the Copalis River, south coastal Washington: *Journal of Geophysical Research*. 97:1901–1919.

Atwater, B., Nelson, A., Clague, J., Carver, G., Yamaguchi, D., Bobrowsky, P., Bourgeois, J., Darienzo, M., Grant, W., Hemphill-Haley, E., Kelsey, H., Jacoby, G., Nishenko, S., Palmer, S., Peterson, C., and Reinhart, M. 1995. Summary of coastal geologic evidence of great earthquakes at the Cascadia subduction zone: *Earthquake Spectra*, 11:1–17.

Atwater, B.F., and Hemphill-Haley, E. 1997. Recurrence intervals for great earthquakes of the past 3500 yr at northeastern Willapa Bay, Washington: *U.S. Geological Survey Professional Paper* 1576, 108 p.

Bacon, C.R. 1983. Eruptive history of Mount Mazama and Crater Lake Caldera, Cascade Range, USA. *Journal of Volcanology and Geothermal Research*. 18(1-4): 57-115

Biasi, G.P., R.J. Weldon II, T.E. Fumal, and G.G. Seitz. 2002. Paleoseismic Event dating and the conditional probability of large earthquakes on the southern San Andreas Fault, California. *Bulletin of the Seismological Society of America*, Vol. 92(7):2761–2781

Byram, S. and R. C. Witter. 2000. Wetland landscapes and archaeological sites in the Coquille Estuary, Middle Holocene to recent times. In *Changing Landscapes.* Proceedings of the 3rd Annual Coquille Cultural Preservation Conference, 1999*,* Losey, Robert J., ed. Coquille Indian Tribe, North Bend, Oregon.

Clague, J.J. 1996. Paleoseismology and seismic hazards, Southwestern British Columbia. *Geological Survey of Canada Bulletin*, 494, 88p.

Clague, J.J., Bobrowski, P.T., and Hutchinson, I. 2000. A review of Geological records of large tsunamis at Vancouver Island, British Columbia, and implications for hazard. *Quaternary Science Reviews*, 19:849-863.

Darienzo, M.E. and C.D. Peterson. 1990. Episodic Tectonic Subsidence of Late Holocene Salt Marshes, Northern Oregon Central Cascadia Margin. *Tectonics*, 9:1-22.

DOGAMI (Oregon Department of Geology and Mineral Industries). 2001. Tsunami Inundation Line. 00 05lineORlam_polyline: vector digital data. Oregon Department of Geology and Mineral Industries, Portland, Oregon.

Fleming, K., P. Johnston , D. Zwartz, Y. Yokoyama , K. Lambeck and J. Chappell. 1998. Refining the eustatic sea-level curve since the Last Glacial Maximum using far- and intermediate-field sites*. Earth and Planetary Science Letters*, 163(1-4):327-342

Fletcher, C.H. III, H.J. Knebal, and J.C. Kraft. 1990. Holocene evolution of an estuarine coast and tidal wetlands. *Geological Society of America Bulletin*: Vol. 102, No. 3, pp. 283–297.

Garrison-Laney, C.E., 1998, Diatom evidence for tsunami inundation from Lagoon Creek, a coastal freshwater pond, Del Norte County, California [M.S.Thesis]: Arcata, California, Humboldt State University, 97 p.

Glenn, J.L. 1978. *Sediment sources and Holocene sedimentation history in Tillamook Bay,* *Oregon: data and preliminary interpretations*. USGS Water Resources Division Open File Report 76-680, 64p.

GEODAS. 1998. Geophysical Data System for Hydrographic Survey Data, National Ocean Service. Hydrographic Surveys Volumes 1 and 2, National Geophysical Data Center, NOAA.

Goldfinger, C., L.D. Kulm, R.S. Yeats, C. Mitchell, R. Weldon II, C.D. Peterson, M. Darienzo, W. Grant, and G.R. Priest. 1992. Neotectonic map of the Oregon continental margin and adjacent abyssal plain. State of Oregon, Department of Geology and Mineral Industries Open-File Report 0-92-4. Oregon: DOGAMI.

Goldfinger, C., C.H. Nelson, and J.E. Johnson. 2002. Cascadia great earthquake chronology based on the turbidite event record. Paper presented at GSA Cordilleran Section - 98th Annual Meeting (May 13–15, 2002): Session No. 18: Active Tectonics of Cascadia: Geodesy and Great Earthquakes.

Goldfinger, C., C.H. Nelson, and J.E. Johnson. 2003. Holocene earthquake records from the Cascadia subduction zone and Northern San Andreas Fault based on precise dating of offshore turbidites, *Annu. Rev. Geophys.,* 31, 555-577.

Hart, G. F., 1994, Maceral palynofacies of the Louisiana deltaic plain in terms of organic constituents and hydrocarbon potential, in Traverse, A., ed., *Sedimentation of Organic Particles*: 141-176.

Heaton T.H. and S.H. Hartzell. 1987. Earthquake hazards on the Cascadia subduction zone. *Science* 236(4798):162-168.

Hemphill-Haley, E. 1995a. Intertidal diatoms from Willapa Bay, Washington: application to studies of small-scale sea-level changes. *Northwest Science* 69:29–45.

Hemphill-Haley, E. 1995b. Diatom evidence for earthquake induced subsidence and tsunami 300 yr ago in southern coastal Washington. *Geological Society of America Bulletin*, 107:367–378.

Jennings, A.E. and A.R. Nelson. 1992. Foraminiferal assemblage zones in Oregon Tidal Marshes—Relation to marsh floral zones and sea level. *Journal of Foraminiferal Research*, 22(1):13-29.

Kelsey, H.M.1990.Late Quaternary deformation of marine terraces on the Cascadia subduction zone near Cape Blanco, Oregon. *Tectonics,* 9(5): 983-1014.

Kelsey, H. M. and J. G. Bockheim. 1994. Coastal landscape evolution as a function of eustasy and surface uplift, southern Cascadia margin, USA. *Geological Society of America Bulletin* 106: 840-854.

Kelsey, H.M., R.L. Ticknor, J.G. Bockheim, and C.E. Mitchell. 1996. Quaternary upper plate deformation in coastal Oregon. *Geological Society of America Bulletin* 108(7): 843-860.

Kelsey, H.M., R.C. Witter, and E. Hemphill-Haley. 1998. Response of a Small Oregon Estuary to Coseismic Subsidence and Postseismic Uplift in the Past 300 Years. *Geology*, 26:231-234.

Kelsey, H.M., R.C. Witter, and E. Hemphill-Haley. 2002. Plate Boundary Earthquakes and Tsunamis of the Past 5,500 yr, Sixes River Estuary, Southern Oregon. *Geological Society of America Bulletin*, 114(3):298-314

Kelsey, H.M., A.R. Nelson, E. Hemphill-Haley, and R.C. Witter. 2005. Tsunami history of an Oregon coastal lake reveals a 4600 yr record of great earthquakes on the Cascadia subduction zone. *Geological Society of America Bulletin*, v.117(7/8):1009-1032.

Mathewes, R.W. and J.J. Clague. 1994. Detection of Large Prehistoric Earthquakes in the Pacific Northwest by Microfossil Analysis. *Science* 264:688-691.

McNeil, L.C., C. Goldfinger, R.S. Yeats, and L.D. Kulm. 1998. The effects of upper-plate deformation on records of prehistoric Cascadia subduction zone earthquakes, in Stewart, I., and Vita-Finzi, C., eds*., Coastal tectonics: Geological Society of London Special Publication*, v. 146. London: Geological Society of London.

Muhs, D.R., H.M. Kelsey, G.H. Miller, G.L. Kennedy, J.F. Whelan, and G.W. McInelly. 1990. Age estimates and uplift rates for Late Pleistocene marine terracesóSouthern Oregon portion of the Cascadia Forearc. *Journal of Geophysical Research* 95(B5):6685-6698.

Nelson, A. R. 1992. Discordant 14C ages from buried tidal-marsh soils in the Cascadia subduction zone, southern Oregon coast. *Quaternary Research*, v. 38, p. 74–90.

Nelson, A. R., and Kashima, K. 1993. Diatom zonation in southern Oregon tidal marshes relative to vascular plants, foraminifera, and sea level. *Journal of Coastal Research*, 9:673–697.

Nelson, A.R. and S. F. Personius. 1996. Great-earthquake potential in Oregon and Washington—An overview of recent coastal geologic studies and their bearing on segmentation of Holocene ruptures, central Cascadia subduction zone. In *Assessing the Earthquake Hazards and Reducing Risk in the Pacific Northwest, Vol. 1*. A.M. Rogers, T.J. Walsh, W.J. Kockelman, and G.R. Priest, eds. USGS Professional Paper 1560:91-115.

Nelson, A.R., I. Shennan, and A.J. Long. 1996a. Identifying Coseismic Subsidence in Tidal-Wetland Stratigraphic Sequences at the Cascadia Subduction Zone of Western North America. *Journal of Geophysical Research*, 101(B3):6115-6135.

Nelson, A.R., Jennings, A.E., and Kashima, K. 1996b. An earthquake history derived from stratigraphic and microfossilevidence of relative sea level change at Coos Bay, southern coastal Oregon: *Geological Society of America Bulletin*, v. 108, p. 141–154.

Nelson, A.R., Ota, Y., Umitsu, M., Kashima, K. and Matsushima, Y. 1998. Seismic or hydrodynamic control of rapid late-Holocene sea-level rises in southern coastal Oregon, USA. *The Holocene* 8: 287–99.

Noller, J.S, J. M. Sowers, and W. R. Lettis, Eds. 2000. *Quaternary Geochronology: Methods and Applications*. American Geophysical Union Reference Shelf Series, Vol. 4, 2000. 582 pages, hardbound; ISBN 0-87590-950-7.

North American Commission on Stratigraphic Nomenclature (NACSN). 1983. North American Stratigraphic Code: *American Association of Petroleum Geologists Bulletin*, v.67, p.841-875.

Ollerhead, J., Huntley, D.J., Nelson, A.R. and Kelsey, H.M. (2001). Optical dating of tsunami-laid sands from an Oregon coastal lake. *Quaternary Science Reviews* 20:1915-1926.

Peterson, C.D., K.F. Scheidegger, and H.J. Schrader. 1984. Holocene Depositional Evolution of a Small Active-Margin Estuary of the Northwestern United States. *Marine Geology,* 59:51-83.

Peterson, C.D. and J.B. Phipps. 1992. Holocene Sedimentary Framework of Grays Harbor Basin, Washington, USA. In Quaternary Coasts of the United States: Marine and Lacustrine Systems, Fletcher, C.H. III and J.F. Wehmiller, eds. SEPM Special Publication No. 48: 273-287.

Peterson, C.D. and Darienzio, M.E. 1996. Discrimination of climatic, oceanic, and tectonic mechanisms of cyclic marsh burial, Alsea Bay, Oregon. In *Assessing the Earthquake Hazards and Reducing Risk in the Pacific Northwest, Vol. 1*. A.M. Rogers, T.J. Walsh, W.J. Kockelman, and G.R. Priest, eds. USGS Professional Paper 1560:115-147.

Priest, G.R. 1995. Explanation of Mapping Methods and Use of the Tsunami Hazard Maps of the Oregon Coast. Oregon Department of Geology and Mineral Industries. Open-File Report O-95-67:1-23.

Ruff, L.J. 1996. Large earthquakes in subduction zones: Segment interaction and recurrence times, in Bebout, G.E., et al., eds., Subduction: Top to bottom: American Geophysical Union Geophysical Monograph 96, p. 91–104.

Satake, K., K. Shimazaki, Y. Tsuji and K. Ueda. 1996. Time and size of a giant earthquake in Cascadia inferred from Japanese tsunami records of January, 1700, *Nature*, 379:246-249.

Shennan, I., Long, A.J., Rutherford, M.M., Green, F.M., Innes, J.B., Lloyd, J.M., Zong, Y. and Walker, K.J. 1996. Tidal marsh stratigraphy, sea-level change and large earthquakes, 1: a 5000 year record in Washington, USA. *Quaternary Science Reviews* 15: 1023–59.

Shennan, I., Long, A.J., Rutherford, M.M., Innes, J.B., Green, F.M. and Walker, K.J. 1998. Tidal marsh stratigraphy, sea-level change and large earthquakes II: submergence events during the last 3500 years at Netarts Bay, Oregon, USA. *Quaternary Science Reviews* 17: 365–93.

Thatcher, W. 1990. Order and diversity in the modes of circum-Pacific earthquake recurrence. Journal of Geophysical Research, 95(B3):2609-2624.

Troels-Smith, J. 1955. Characterization of unconsolidated sediments: *Geological Survey of Denmark*, ser. IV, v. 3, no. 10, p. 72.

United States Department of Agriculture. 1998. *Keys to Soil Taxonomy, 8th ed*. USDA, Washington, D.C.

Wells, R.E., Blakely, R., Sugiyama, Y., and Scholl, D., 2002, Coseismic slip beneath forearc basins in Great Subduction Zone earthquakes: Implications for the size and mode of rupture on the Cascadia Subduction Zone [abs]: Eos (Transactions, American Geophysical Union), 83, F1073

Witter, R.C.1999. Late Holocene Paleoseismicity, Tsunamis and Relative Sea-Level Changes along the South-Central Cascadia Subduction Zone, Southern Oregon, U.S.A. Doctoral Dissertation, Department of Geology, University of Oregon, Eugene.

Witter, R.C., H.M. Kelsey, and E. Hemphill-Haley. 2003. Great Cascadia earthquakes and tsunamis of the past 6700 years, Coquille River estuary, southern coastal Oregon. *Geological Society of America Bulletin*: Vol. 115, No. 10, pp.

APPENDIX A: LITHO-,BIO-, AND CHRONOSTRATIGRAPHIC METHODS

Core 4 was extracted in 22 sections, measuring 1.22m each, to a depth of -21.2 m NGVD. In order to minimize mixing of sediments between sections, the Geoprobe corer was lowered to the appropriate depth within the core hole before the probe barrel was opened for sediment retrieval. In this way, only those sediments encountered between a known range of depths spanning 1.22 m were recovered and compaction amounts due to coring activities could be determined on a section-by-section basis. Unfortunately, due to the nature of the coring device, some of the wetter sediments from core Sections 1, 3, and 4 were lost during the coring process. All sections below Section 4 (below 0.67 m) were recovered intact with minimal amounts of compaction or sediment loss.

Following recovery of sediment cores, we employed a number of litho-, bio- and chronostratigraphic analyses to reconstruct the evolution of depositional environments at the site. Our objective was to determine general trends in relative sea level (RSL) rise and fall at the site, as well as to differentiate between dominant depositional forces operating through time. We aimed to identify instances of rapid RSL rise that left a stratigraphic signal consistent with those identified in other studies of great CSZ earthquakes, and to gather evidence to assess the plausibility of a coseismic origin for the subsidence following the criteria outlined by Nelson et al. (1996b) and Hemphill-Haley (1995b). We concentrated our efforts on the longest of the cores, Core 4, in order to determine the site's potential as an on-shore recorder of coseismic subsidence dating back to the late Pleistocene/early Holocene time period. We also performed some limited litho- and biostratigraphic analyses of Core 6 in order to assess the lateral extent of buried soil horizons older than the oldest event reported by Kelsey et al. (2002).

Lithostratigraphic Investigations

Laterally extensive, sudden submergence of tidal wetlands and tsunami deposits overlying buried wetland soils are two forms of lithostratigraphic evidence for plate boundary earthquakes (Nelson et al. 1996b). Research in coastal settings along the CSZ indicates that a coseismic vertical drop in land level of over 0.5m will result in widespread stratigraphic and ecological changes in coastal wetlands that lie within the range of mean tide to mean higher high water. These changes indicate sudden rises in relative sea level as the land drops in relation to tidal levels and are recorded in the stratigraphy of the wetland sediments (Atwater 1987; Darienzo and Peterson 1990; Nelson and Kashima 1993; Darienzo et al. 1994; Guilbault et al. 1995; Hemphill-Haley 1995; Nelson et al. 1996a; Shennan et al. 1996; Atwater and Hemphill-Haley 1997; Nelson et al. 1998; Shennan et al. 1998; Kelsey et al. 2002; Witter et al. 2003). Tsunamis accompanying regional slip along the CSZ will result the landward transport and deposition of continuous or discontinuous sheets of sandy sediment onto coastal areas within 3-10m above sea level. A sharp (<3mm) boundary will separate underlying, buried wetland sediments and these rapidly deposited tsunami deposits (Bourgeois and Reinhart 1989; Minoura and Nakaya 1991; Clague and Bobrowsky 1994; Dawson 1994; Hemphill-Haley 1995; Atwater and Hemphill-Haley 1997).

Prior to splitting, we analyzed each core section for magnetic susceptibility and gamma density. Each section was passed through the Geotek multi-sensor core logger at Oregon State University's Department of Oceanography and Atmospheric Sciences core analysis and storage facility to determine downcore magnetic susceptibility of sediments. Sediments with higher proportions of magnetic minerals give higher susceptibility readings. A study conducted by Boggs (1969) of heavy minerals from within the Sixes River basin shows that greater relative amounts of the highly susceptible mineral magnetite are found within river sediments versus beach or estuary sediments. General trends in the relative influence of river deposition versus deposition from an estuary or beach source appear as relatively higher or lower magnetic susceptibility readings through the stratigraphic record in the extracted cores. Gamma density is a remotely sensed measure of bulk density, which can be considered a proxy for grain size in that smaller grains will be consolidated more tightly and with less porosity than larger grains for a given volume of sediment under conditions of high compaction (Brady 1990).

Cores were split into halves, digitally and x-ray photographed, and described with special attention to color, grain size, sorting, bedding, inclusions, and boundaries (Figure 3). Physical grain size was determined by visual inspection and manual measurement of the sediments using sieves to separate clays/silts from sand sizes. We also conducted loss on ignition (LOI) tests on core sediments to determine relative amounts of organic carbon content.

Biostratigraphic Investigations

Environments of deposition can be inferred through the identification of litho-stratigraphic boundaries and analysis of fossil diatom assemblages within sediments on each side of these boundaries (Nelson and Kashima 1993; Hemphill-Haley 1995; Nelson et al. 1996b). Because specific diatom assemblages are associated with distinct freshwater, brackish, and marine settings, identification of changes in assemblage composition over lithologic boundaries can inform about shifts in depositional environments. Studies of extant diatom species extracted from defined elevation ranges in tidal marsh settings reveals patterns in assemblage composition based on intertidal zone (Nelson and Kashima 1993; Hemphill-Haley 1995). Based on these observations, sudden relative sea level fluctuations can be identified and magnitudes of local elevation shifts during burial events estimated.

Samples from Core 4 were chosen for extraction based on three primary factors: lithology and/or soil characteristics, magnetic susceptibility readings, and gamma density. Apparent changes in any of these factors within a core section may imply a change in depositional state. Sediments on each side of these changes were sampled for quantitative biostratigraphic examination. About 1-2cc of sediment was extracted for each sample. Sediment samples were cleaned by oxidizing in 30% H_2O_2 and rinsing with distilled water. Silica was separated from heavy mineral sediments by flotation in a sodium polytungstate solution with a specific gravity of 2.56, transferred to a separate centrifuge tube, and repeatedly rinsed using distilled water. An aliquot of approximately 0.05 to 0.10 ml of the cleaned water-silica solution was then transferred to a cover slip, allowed to dry, and permanently mounted on a glass slide using Hyrax.

Diatom preservation throughout the core was variable, with the best preservation occurring in the upper eight core sections (to approximately -4.00 m NGVD). Where possible, 100+ diatoms were identified to the species level and counted per slide at a magnification of 1000x. In cases where <100 diatoms were counted, paleosalinity and paleoenvironmental inferences were based on those diatoms valves that could be identified. Salinity tolerances for each species and variety were compiled from a number of sources, including Patrick and Reimer (1966; 1975); Nelson and Kashima (1993); Hemphill-Haley (1993); Hemphill-Haley and Lewis (1995); Laws (1988); John (1983); Foged (1981); Pankow (1990); and Krammer and Lange-Bertalot (1986-1991). We gave special attention to studies from the Pacific Northwest region that compare modern assemblage data to intertidal depositional environment, including Laws (1988); Nelson and Kashima (1993); Hemphill-Haley (1993); Hemphill-Haley and Lewis (1995); and Hemphill-Haley (1995a,b).

Chronostratigraphic Investigations

Samples for radiocarbon dating were chosen based on their association with buried wetland soils. Materials were extracted for dating from within 1 cm of the boundary between the buried wetland soil and the overlying tsunami deposit or intertidal mud in order to best estimate the time of land subsidence and burial. Each sample was mixed with 30 ml of distilled water and sodium metahexaphoshate to allow botanical and charcoal remains to deflocculate from clays and float to the surface. These samples were then filtered through a fine mesh and allowed to dry. When present, specimens of identifiable seeds or woody detritus, botanical fossils considered most reliable for dating (Nelson 1992; Kelsey et al. 2002), were picked using a dissecting microscope and submitted for accelerator mass spectrometry (AMS) radiocarbon dating. Charcoal fragments were selected for dating when other biological remains were absent. In these cases, care was taken to choose angular rather than rounded specimens to avoid redeposited samples.

GENERAL PALEOENVIRONMENTAL SETTING EVOLUTION AND RELATIVE SEA LEVEL (RSL) CHANGES

Using information from the diatom assemblage analysis and the radiocarbon dates returned on organic materials from buried soils, we reconstruct dominant depositional setting trends and relative sea level history within the meander study site beginning with the lowest section of the core, Section 22, which reaches a depth of nearly 27 meters below the ground surface. The earliest radiocarbon age returned on organic material from Core 4 is from this lowest section, at -20.63m NGVD, and dates to Cal BP 10220 or 10140 or Cal BP 10000 to 9960 (Radiocarbon dates returned on all organic samples are listed in Table 1).

Diatom counts for each sample extracted from all of the core sections are organized based on salinity preference. Salinity organizational groups include freshwater species (does not tolerate any amount of salt), freshwater-brackish species (salinity tolerance range from 0 to <0.2 $^{o}/_{oo}$), brackish (0.2-10 $^{o}/_{oo}$), brackish-marine (10-30 $^{o}/_{oo}$), marine (>30 $^{o}/_{oo}$), and euryhaline (tolerate a range of salinity). Those diatom valves which could not be identified to species level or for which no salinity preference information was available are classified as “unknown”. For each sediment sample, we compute what percentage of the total diatoms counted per slide each salinity group represents. From this salinity data and based on the dominant species present at each sediment interval, we make inferences about the paleo-environmental setting at the coring site through time. A discussion of diatom salinities and inferred depositional setting is presented in Appendix 1 and summarized in Figure 4.

Freshwater and fresh-brackish diatoms are most dominant in the upper two meters of the core, with assemblages indicating a predominantly freshwater marsh or upland environment. While our chronostratigraphic data does not directly indicate when the change from predominantly freshwater deposition at the site to brackish high and low marsh deposition occurred, accretion of the marsh surface in nearby areas reached elevations above brackish high marsh elevation (assuming a maximum elevation of 1.6m above MTL for a brackish high marsh (Nelson and Kashima 1993)) around 3,000 cal yr BP (Kelsey et al. 2002:Fig. 7).

From around -2 to -10m depth below the ground surface (~ 3.5 to -4.75m NGVD), diatom assemblages are mixed, with spikes in low salinity tolerant species interspersed with more saline-tolerant species assemblages. Dominant diatoms include high and low brackish marsh species, with occasional build up of a more freshwater assemblage or sudden influxes of predominantly brackish to marine valves. A heavier conglomeration of brackish to brackish-marine species occurs at a depth of -6.5 to -8m (~ -1.0 to -2.5m NGVD). Species associated with intertidal mud or sand flats, *Zostera* beds, and subtidal channels are common in this interval, indicating a brackish low marsh or estuarine tidal flat environment. Using age data from seeds extracted from -9.97m depth (-4.42m NGVD) this area remained an intertidal wetland depositional setting until ca. 6690 to 6890 cal yr BP (Table 1).

At approximately 10m below the coring surface (-4.75m NGVD) to nearly -17m depth, the diatom assemblage data becomes sparse, with only a few valves and valve fragments preserved for analysis. The identifiable whole and fragmented valves indicate a dominantly freshwater depositional environment at this time, from nearly 7,000 cal yr BP lasting until around 9,000 years ago. By 9120 to 9440 (Table 1) diatom salinity preferences again become predominantly fresh-brackish, with punctuated episodes of more saline-tolerant assemblages, especially in the lowest 2.5 meters of the core. Brackish high or low marshes are indicated by samples extracted from a depth of approximately -17m (-11.5m NGVD) to -25.5m depth (-18.5m NGVD). The lowest 1.5 meters of core sediments are characterized by brackish assemblages, with numerous tidal flat and low to high brackish marsh species identified.

We construct a general history of relative sea level (RSL) at the site using radiocarbon age assignments for buried soils (Table 1) in association with diatom-derived estimates of paleo-mean tide levels (MTL) (Table 2). No attempt to estimate downcore compaction amounts was attempted. In general, the slope of the sea level curve is steepest from around 10,000 to 6,500 cal yr BP, whereupon the curve begins to level out (Figure 5). This implies that the highest rate of RSL rise is during the late Pleistocene to the mid Holocene, a contention that agrees well with global estimates of eustatic sea level rise (Bloom 1980; Fairbanks 1989). After 6,500 cal yr BP, RSL rise slows until ca. 2500 years ago, when it levels to near its present elevation. Sediment accretion at the site kept pace with sea level rise until ca. 2500 years ago (Dashed line, Figure 5). At that time, the site became emergent as the marsh surface continued to accrete sediment while eustatic sea level maintained a near steady state. This is recorded in Figure 5 as RSL fall.

Superimposed upon the general sea level curve constructed for the area are six instances of sudden relative sea level change (Figure 5). As with the paleo-environmental setting reconstruction, diatom assemblage data compiled in Appendix 1 are used to infer intertidal zonation of diatom samples extracted from above and below buried soil horizons. Based on elevation ranges relative to NGVD of intertidal zones derived from Nelson and Kashima (1993), we estimate the magnitude of vertical change across each of the six radiocarbon dated buried soils (Events A, G, I, J, K, and L). The constructed relative sea level curve (Figure 5) incorporates error margins related to these ranges in elevation for each diatom assemblage as rectangle height. Additionally, errors in age estimates for each sample are listed in Table 2 and are portrayed in Figure 5 as rectangle width. The amount of subsidence incurred by the site during each event ranged from 0 to 3.2m (Table 2). We infer that submergence for each event exceeded the estimated minimum because in each case the diatom assemblage data indicate a change from a higher to a lower intertidal zone across the buried soil horizon.

The paleoenvironmental reconstruction of the environment is important for determining what sediments have a higher likelihood of preserving a record of marsh surface burial by sudden inundation and a lasting change to a lower intertidal environment. If intertidal marsh sediments are preserved throughout the length of the core, then preservation of stratigraphic data that meets the criteria in support of a coseismic origin for soil burial is possible. Our Core 4 contains intertidal sediments as deep as the lowest section of the core, which dates to the late Pleistocene/early Holocene transition. Although this record is not continuous, as fluvial deposition of larger grained sediments dominates the middle portion of the core, the record does provide excellent preservation of intertidal sediments dating to the late to middle Holocene, a time period sorely underrepresented in the current database of CSZ tectonic study.

Appendix B: Diatom Counts

				Core 22			Core 21								Core20							Core 19							Core 18						
Genus	Species	Variety	**Salinity**	4	7	8	10	11	12	13	14	15	16	17	35	37	38	39	40	41	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Achnanthes	*coarctata*		F								1																								
Achnanthes	*suchlandtii*		F																																
Cymbella	*similis*		F																																
Cymbella	*tumidula*	*lancettula*	F																																
Diatoma	*anceps*		F								1																		1						
Eunotia	*flexuosa*		F																																
Eunotia	*incisa*		F																																
Eunotia	*maior*		F									1					1																		
Eunotia	*monodon*		F																																
Eunotia	*naegelii*		F																																
Eunotia	*parallela*		F																																
Eunotia	*pectinalis*		F	1													2		1										1		1				
Eunotia	*praerupta*	*bidens*	F	1																2										2					
Eunotia	*van heurckii*		F																																
Eunotia	*van heurckii*	*intermedia*	F																																
Eunotia	*valida*		F																																
Eunotia	*spp.*		F														2		1	1			1												
Fragilaria	*exigua*		F																																
Frustulia	*rhomboids*		F																																
Gomphonema	*truncatum*		F																																
Navicula	*digitulus*		F																																
Navicula	*leptostriata*		F																																
Navicula	*pupula*	*elliptica*	F																																
Nedium	*hercynicum*		F																												1				
Nedium	*iridis*	*iridis*	F																																
Nitzschia	*angustulata*		F																																
Opephora	*martyii*		F	1																															
Pinnularia	*acrosphaeria*		F			1																													
Pinnularia	*bogotensis*		F																																
Pinnularia	*divergentissima*		F																																
Pinnularia	*gibba*	*linearis*	F																1				1												
Pinnularia	*krockii*		F																																
Pinnularia	*maior*		F																																
Pinnularia	*microstauron*		F																																
Pinnularia	*nodosa*		F																																
Pinnularia	*stomataphora*		F																																
Pinnularia	*subcapitata*	*paucistriata*	F																																
Pinnularia	*subgibba*		F			2																													
Stauroneis	*phoenicenteron*	*brunii*	F																																
Stauroneis	*smithii*	*incisa*	F																																
Synedra	*rumpens*		F																1																
Total				3	0	3	0	0	0	0	2	1	0	0	0	0	5	0	4	3	0	0	2	0	0	0	0	0	2	2	2	0	0	0	0
% of Slide Total				2.6	0	2.7	0	0	0	0	14	10	0	0	0	0	29	0	14	6.3	0	0	6.1	0	0	0	0	0	14	3.6	10	0	0	0	0
Achnanthes	*hustedtii*		F/B	2																															
Achnanthes	*lanceolata*	*dubia*	F/B	1																										3					
Achnanthes	*lanceolata*	*ssp.*	F/B																																
Achnanthes	*lanceolata*	*lanceolata*	F/B	2		1								1																		1			
Achnanthes	*minutissima*		F/B																																
Amphora	*coffeiformis*		F/B																																
Amphora	*ovalis*		F/B																																
Amphora	*ovalis*	*affinis*	F/B																	1				1											
Amphora	*perpusilla*		F/B	1																															
Aulacosira	*granulata*		F/B			1	1	1			1	1																							
Aulacosira	*islandica*		F/B	1										1														1							

				Core 22			Core 21								Core20							Core 19							Core 18						
Genus	Species	Variety	**Salinity**	4	7	8	10	11	12	13	14	15	16	17	35	37	38	39	40	41	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Aulacosira	*italica*		F/B	1																															
Calonesis	*bacillum*		F/B			2																													
Cocconeis	*diminuta*		F/B									1								1					1					1			1		
Cocconeis	*placentula*		F/B	1		1																								2	1	2			
Cocconeis	*placentula*	*euglypta*	F/B	1						2				1		1	1	1	5	2	1	2	6	1			1	2		4	3	1	2	1	
Cyclotella	*meneghiniana*		F/B																																
Cyclotella	*compta*		F/B																																
Cyclotella	*ocellata*		F/B																																
Cyclotella	*stelligera*		F/B																																
Cymbella	*aspera*		F/B																																
Cymbella	*cistula*		F/B									1																							
Cymbella	*minuta*		F/B																											1					
Cymbella	*sinuata*		F/B															1	1				1							1					
Cymbella	*tumida*		F/B																																
Diatoma	*mesodon*		F/B			1													1																
Diploneis	*pseudovalis*		F/B																																
Epithemia	*sorex*		F/B															1					1						1						
Epithemia	*turgida*		F/B	1									2																						
Epithemia	*turgida*	*westermannii*	F/B														1	1	1	1										4	1	1		1	
Epithemia	*zebra*		F/B																				1											1	
Eunotia	*pectinalis*	*minor*	F/B																																
Fragilaria	*brevistriata*		F/B																				1												
Fragilaria	*capucina*	*vaucheriae*	F/B																															1	
Fragilaria	*construens*		F/B																																
Fragilaria	*construens*	*pumila*	F/B	1																															
Fragilaria	*construens*	*venter*	F/B			1																													
Fragilaria	*leptostauron*		F/B																																
Fragilaria	*parasitica*		F/B																																
Fragilaria	*pinnata*		F/B	1																															
Fragilaria	*virescens*		F/B																																
Frustulia	*vulgaris*		F/B																																
Gomphoneis	*herculeana*		F/B																																
Gomphonema	*acutiusculum*		F/B																																
Gomphonema	*angustatum*		F/B																																
Gomphonema	*gracile*		F/B																																
Gomphonema	*parvulum*		F/B			1												2												2				1	1
Hantzschia	*amphioxys*		F/B			1																								3					
Melosira	*roeseana*		F/B																1											1					
Meridion	*circulare*	*constricta*	F/B																												1				
Navicula	*accomoda*		F/B																																
Navicula	*cari*		F/B																																
Navicula	*contenta*		F/B	2										1					1																
Navicula	*cryptotenella*		F/B																																
Navicula	*elegans*		F/B																										1						
Navicula	*elginensis*		F/B																																
Navicula	*elginensis*	*cuneata*	F/B																																
Navicula	*gallica*	*perpusilla*	F/B											1					1			1											1		
Navicula	*lanceolata*		F/B																																
Navicula	*minima*		F/B																																
Navicula	*mutica*		F/B	29		15												2	1	1	1	1	4	1		1			1	9	1			1	
Navicula	*mutica*	*undulata*	F/B																				1												
Navicula	*muticoides*		F/B																																
Navicula	*placentula*		F/B																																
Navicula	*pupula*		F/B																	1															
Navicula	*pusilla*		F/B	3		21																								1					
Navicula	*pusilla*	*1*	F/B																								1								
Navicula	*radiosa*		F/B			1																													
Navicula	*stankovicii*		F/B																																
Navicula	*tenelloides*		F/B																																

				Core 22			Core 21								Core20							Core 19							Core 18						
Genus	Species	Variety	**Salinity**	4	7	8	10	11	12	13	14	15	16	17	35	37	38	39	40	41	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Navicula	*tripuctata*		F/B	1																															
Nitzschia	*brevissima*		F/B																																
Nitzschia	*capitellata*		F/B																																
Nitzschia	*commutata*		F/B																	2										1					
Nitzschia	*dissipata*		F/B			1																							1	1					
Nitzschia	*inconspicua*		F/B	1																1															
Nitzschia	*nana*		F/B				1																												
Nitzschia	*palea*		F/B	2																												1			
Nitzschia	*parvula*		F/B																																
Nitzschia	*pellucida*		F/B																																
Nitzschia	*perminuta*		F/B																																
Nitzschia	*pusilla*		F/B																																
Nitzschia	*scapelliformis*		F/B			2																								2					
Nitzschia	*terrestris*		F/B																			2													
Nitzschia	*trybilonella*		F/B																																
Pinnularia	*appendiculata*		F/B																																
Pinnularia	*borealis*		F/B											1	1						1	1	3							2					
Pinnularia	*intermedia*		F/B																																
Pinnularia	*lagerstedtii*		F/B	1		5																													
Pinnularia	*similiformis*		F/B	1							2														1										
Pinnularia	*subcapitata*		F/B																2	5										1					
Pinnularia	*viridis*		F/B																	3															
Pinnularia	*viridis*	*minor*	F/B			1																													
Rhoicosphenia	*curvata*		F/B																3	2			1	1					2	2					
Rhopalodia	*gibba*		F/B																																
Rhopalodia	*gibberula*		F/B																																
Stauroneis	*anceps*		F/B																	3													1		
Stauroneis	*kriegerii*		F/B												1																				
Stauroneis	*phoenicenteron*		F/B																													1			
Stephanodiscus	*astrea*		F/B																																
Surirella	*brebissonii*		F/B																																
Synedra	*ulna*		F/B			1	2		1	2	3	2	3	4	1		5	1	5	5		1	3	1					1	8	2				1
Tabellaria	*fenestrata*		F/B																																
Thalassiosira	*westflogii*		F/B	1																															
Total				54	0	56	4	1	1	4	6	5	5	10	3	1	7	9	22	28	3	8	22	5	2	1	2	3	7	49	9	7	5	6	2
% of Slide Total				47	0	50	80	50	50	100	43	50	63	91	75	25	41	75	76	58	60	50	67	63	40	33	20	75	50	89	45	58	45	67	50
Achnanthes	*brevipes*		B																																
Achnanthes	*brevipes*	*intermedia*	B								1									1															
Achnanthes	*exigua*		B																																
Achnanthes	*hauckina*		B	7		4																													
Achnanthes	*hauckina*	*rostrata*	B																																
Amphora	*mexicana*		B																																
Amphora	*ovalis*	*pediculus*	B																																
Calonesis	*westii*		B	1		1																													
Cocconeis	*disculus*		B					1																										1	
Cyclotella	*striata*		B																																
Denticula	*subtilis*		B																																
Diploneis	*didyma*		B																																
Diploneis	*interrupta*		B																								1								
Diploneis	*ovalis*		B																																
Frustulia	*linkei*		B																																
Gomphonema	*pseudexigum*		B																																
Gyrosigma	*balticum*		B																																
Gyrosigma	*eximium*		B									1																							
Mastogloia	*exigua*		B																																
Melosira	*nummuloides*		B																																
Navicula	*cincta*		B	10		5													1								1			1	3			1	
Navicula	*cryptolyra*		B																																

				Core 22			Core 21								Core20							Core 19							Core 18						
Genus	Species	Variety	**Salinity**	4	7	8	10	11	12	13	14	15	16	17	35	37	38	39	40	41	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Navicula	*peregrina*		B	1		2																													
Navicula	*pygmaea*		B	1																															
Navicula	*salinarum*		B																																
Nitzschia	*aerophila*		B																																
Nitzschia	*debilis*		B																																
Nitzschia	*fasciculata*		B																																
Nitzschia	*levidensis*		B																																
Nitzschia	*levidensis*	*victoriae*	B																																
Nitzschia	*littoralis*		B																																
Nitzschia	*longissima*		B																																
Nitzschia	*navicularis*		B																																
Nitzschia	*plana*		B																																
Nitzschia	*sigma*		B																																
Nitzschia	*vitrea*		B																																
Rhopalodia	*musculus*		B			1														1															
Synedra	*fasciculata*		B	2		4														2															
Synedra	*gaillonii*		B																																
Total				22	0	17	0	1	0	0	1	1	0	0	0	0	0	0	1	4	0	0	0	0	0	0	2	0	0	1	3	0	0	2	0
% of Slide Total				19	0	15	0	50	0	0	7.1	10	0	0	0	0	0	0	3.4	8.3	0	0	0	0	0	0	20	0	0	1.8	15	0	0	22	0
Achnanthes	*delicatula*		M/B																																
Actinocyclus	*spp.*		M/B																	1															
Actinoptychus	*senarius*		M/B																																
Amphora	*proteus*		M/B																											1					
Amphora	*ventricosa*		M/B																																
Bacillaria	*paradoxa*		M/B																																
Camplyodiscus	*echineis*		M/B																																
Catentula	*adherens*		M/B																																
Cerataulus	*turgidus*		M/B																																
Cocconeis	*scutellum*		M/B	3									1							8															
Cocconeis	*scutellum*	*parva*	M/B	1		1						1																							
Delphineis	*surirella*		M/B			7																													
Dimeregramma	*minor*		M/B	3	1																														
Diploneis	*smithii*		M/B																																
Grammatophora	*oceanica*		M/B																																
Gyrosigma	*spencerii*		M/B																																
Hantzschia	*virgata*		M/B																																
Hyalodiscus	*scoticus*		M/B																																
Melosira	*moniliformis*		M/B																																
Navicula	*digitoradiata*		M/B																																
Navicula	*granulata*		M/B																																
Navicula	*lyra*		M/B																																
Navicula	*lyra*	*elliptica*	M/B	1																															
Navicula	*perminuta*		M/B																											1					
Navicula	*phyllepta*		M/B																																
Navicula	*rhyncocephala*		M/B																																
Nitzschia	*acuminata*		M/B			1																													
Nitzschia	*bilobata*		M/B																																
Nitzschia	*compressa*		M/B								1																								
Nitzschia	*constricta*		M/B			1																					1								
Nitzschia	*granulata*		M/B			1																					1								
Nitzschia	*lanceola*		M/B																																
Nitzschia	*obtusa*		M/B	2																															
Nitzschia	*punctata*		M/B																																
Opephora	*pacifica*		M/B																																
Opephora	*parva*		M/B	6																															
Paralia	*sulcata*		M/B	4	1	7	1																				1								
Plagiogramma	*staurophorum*		M/B																																
Rhabdonema	*arcuatum*		M/B																																

				Core 22			Core 21								Core20							Core 19							Core 18						
Genus	Species	Variety	**Salinity**	4	7	8	10	11	12	13	14	15	16	17	35	37	38	39	40	41	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Rhaphoneis	*amphiceros*		M/B																																
Rhaphoneis	*psammicola*		M/B	1																															
Rhaphoneis	*surirella*		M/B			1																													
Scoliopleura	*tumida*		M/B																																
Surirella	*fastuosa*		M/B																																
Thalassiosira	*discepens*		M/B										1																						
Thalassiosira	*lacustris*		M/B								2																								
Total				21	2	19	1	0	0	0	3	1	2	0	0	0	0	0	0	9	0	0	0	0	0	0	3	0	0	2	0	0	0	0	0
% of Slide Total				18	100	17	20	0	0	0	21	10	25	0	0	0	0	0	0	19	0	0	0	0	0	0	30	0	0	3.6	0	0	0	0	0
Amphora	*angusta*		M																																
Amphora	*granulata*		M	1																															
Bidduluphia	*aurita*		M																																
Calonesis	*brevis*		M																																
Coscinodiscus	*radiatus*	*f. obscurus*	M																																
Cyclotella	*styrolum*		M																																
Diploneis	*smithii*	*rhombica*	M																1																
Endictya	*sp.1*		M																																
Nitzschia	*compressa*	*vexans*	M	1																															
Odontella	*obtusa*		M																																
Opephora	*marina*		M																																
Rhaphoneis	*margaritalimbata*		M																																
Thalassionema	*nitzschioides*		M																																
Thalassiosira	*eccentrica*		M																																
Thalassiosira	*pacifica*		M			1																													
Trachyneis	*aspera*		M																																
Trachysphenia	*australis*		M																																
Actinoptychus	*vulgaris*		M			1																													
Nitzschia	*coarctata*		M																																
Total				2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% of Slide Total				1.7	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Navicula	*capitata*		E	1																															
Navicula	*capitata*	*hungarica*	E																																
Navicula	*cryptocephala*		E	3		2																													
Tabellaria	*flocculosa*		E																																
Total				4	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% of Slide Total				3.5	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Achnanthes	*spp.*		Unknown																																
Amphora	*spp.*		Unknown								1																						1		
Calonesis	*spp.*		Unknown			1																													
Cocconeis	*klamathensis*		Unknown																																
Cocconeis	*spp.*		Unknown																		1	1	1								1			1	
Cyclotella	*caspia*		Unknown																																
Cyclotella	*spp.*		Unknown																																
Cymbella	*spp.*		Unknown			1							1																						
Diploneis	*spp.*		Unknown																			1			1	1									
Epithemia	*spp.*		Unknown			2					1	2		1			2					3	1	2					1	1	3	2	3		
Fragilaria	*spp.*		Unknown																																
Gomphonema	*bipunctum*		Unknown																																
Gomphonema	*spp.*		Unknown																			1													
Gyrosigma	*spp.*		Unknown																																
Hantzschia	*spp.*		Unknown																																
Mastogloia	*spp.*		Unknown																																
Melosira	*spp.*		Unknown																																
Navicula	*lapidosa*		Unknown																																
Navicula	*stroemii*		Unknown																																
Navicula	*sublucidula*		Unknown																																

				Core 22			Core 21								Core20							Core 19							Core 18						
Genus	Species	Variety	**Salinity**	4	7	8	10	11	12	13	14	15	16	17	35	37	38	39	40	41	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Navicula	*spp.*		Unknown															1					1				1								
Nedium	*spp.*		Unknown																																
Nitzschia	*palustris*		Unknown																																
Nitzschia	*spp.*		Unknown	8		5																1			1	1	2				1	2	1		
Pinnularia	*spp.*		Unknown																1	1			2						1						
Pleurosigma	*spp.*		Unknown																																
Rhopalodia	*spp.*		Unknown																																
Stauroneis	*spp.*		Unknown															4		3															
Surirella	*spp.*		Unknown																																
Synedra	*spp.*		Unknown	1											1	3	3	2			1	1	4	1	1			1	3		1	1	1		2
Tabellaria	*spp.*		Unknown						1																										
Thalassiosira	*spp.*		Unknown			3																													
Total				9	0	12	0	0	1	0	2	2	1	1	1	3	5	7	1	4	2	8	9	3	3	2	3	1	5	1	6	5	6	1	2
% of Slide Total				7.8	0	11	0	0	50	0	14	20	13	9.1	25	75	29	58	3.4	8.3	40	50	27	38	60	67	30	25	36	1.8	30	42	55	11	50
Total # of valves counted on slide				115	2	111	5	2	2	4	14	10	8	11	4	4	17	12	29	48	5	16	33	8	5	3	10	4	14	55	20	12	11	9	4
.																																			

Appendix B: Diatom Counts

				C17		Core 16					Core 15						C13	Core7		Core 8						Core 7								Core6
Genus	Species	Variety	**Salinity**	59	63	64	65	66	67	68	70	71	72	73	77	78	87	106	107	108	109	110	111	112	113	115	116	117	118	119	120	121	122	125
Achnanthes	*coarctata*		F																															
Achnanthes	*suchlandtii*		F																														1	
Cymbella	*similis*		F																			1												
Cymbella	*tumidula*	*lancettula*	F																															
Diatoma	*anceps*		F					1																										
Eunotia	*flexuosa*		F																					1									1	
Eunotia	*incisa*		F														2																	
Eunotia	*maior*		F																					1										
Eunotia	*monodon*		F		1											1								2										
Eunotia	*naegelii*		F																															
Eunotia	*parallela*		F																															
Eunotia	*pectinalis*		F														1										1				1			
Eunotia	*praerupta*	*bidens*	F																		1													
Eunotia	*van heurckii*		F																															
Eunotia	*van heurckii*	*intermedia*	F																1															
Eunotia	*valida*		F																															
Eunotia	*spp.*		F				1	1								2					2								1		1			
Fragilaria	*exigua*		F																															
Frustulia	*rhomboids*		F																					1										
Gomphonema	*truncatum*		F																															
Navicula	*digitulus*		F													1															2			
Navicula	*leptostriata*		F																												3		1	
Navicula	*pupula*	*elliptica*	F																															
Nedium	*hercynicum*		F																															
Nedium	*iridis*	*iridis*	F																															
Nitzschia	*angustulata*		F																			1						1						
Opephora	*martyii*		F																															
Pinnularia	*acrosphaeria*		F																												1			
Pinnularia	*bogotensis*		F																															
Pinnularia	*divergentissima*		F																															
Pinnularia	*gibba*	*linearis*	F																					1							1			
Pinnularia	*krockii*		F																												2			
Pinnularia	*maior*		F																															
Pinnularia	*microstauron*		F													1																		
Pinnularia	*nodosa*		F																															
Pinnularia	*stomataphora*		F														1																	
Pinnularia	*subcapitata*	*paucistriata*	F																															
Pinnularia	*subgibba*		F																			1												
Stauroneis	*phoenicenteron*	*brunii*	F																															
Stauroneis	*smithii*	*incisa*	F																														1	
Synedra	*rumpens*		F															1																
Total				0	1	0	1	2	0	0	0	0	0	0	0	5	4	1	1	0	3	3	0	6	0	0	1	1	1	0	11	0	4	0
% of Slide Total				0	10	0	2.1	4.8	0	0	0	0	0	0	0	6	4.4	3.8	0.8	0	2.5	1.6	0	5.7	0	0	0.6	0.6	0.7	0	7.5	0	3.4	0
Achnanthes	*hustedtii*		F/B																														1	
Achnanthes	*lanceolata*	*dubia*	F/B																												2		1	
Achnanthes	*lanceolata*	*ssp.*	F/B													1																		
Achnanthes	*lanceolata*	*lanceolata*	F/B				2	2													4	1	1	3				3		3	15	11	6	
Achnanthes	*minutissima*		F/B																							2	5	3				8	4	
Amphora	*coffeiformis*		F/B																											3		1		
Amphora	*ovalis*		F/B																															
Amphora	*ovalis*	*affinis*	F/B					1																								1		
Amphora	*perpusilla*		F/B																															
Aulacosira	*granulata*		F/B													10	4				2													
Aulacosira	*islandica*		F/B													17	32																	

				C17		Core 16					Core 15						C13	Core7		Core 8						Core 7								Core6
Genus	Species	Variety	**Salinity**	59	63	64	65	66	67	68	70	71	72	73	77	78	87	106	107	108	109	110	111	112	113	115	116	117	118	119	120	121	122	125
Aulacosira	*italica*		F/B													5																	1	
Calonesis	*bacillum*		F/B																		2	4	3	1	5	1	12							
Cocconeis	*diminuta*		F/B				2										2		1	1	1	1										1	1	
Cocconeis	*placentula*		F/B			1	1	4	1														3	1		1					3	1	4	1
Cocconeis	*placentula*	*euglypta*	F/B			3	3	6										2		1	5	2					1			3	4	2	5	
Cyclotella	*meneghiniana*		F/B																															
Cyclotella	*compta*		F/B													1																		
Cyclotella	*ocellata*		F/B																															
Cyclotella	*stelligera*		F/B													3																		
Cymbella	*aspera*		F/B																															
Cymbella	*cistula*		F/B																															
Cymbella	*minuta*		F/B					1																							1			
Cymbella	*sinuata*		F/B				3	6			1								1		2						2				2		1	
Cymbella	*tumida*		F/B																															
Diatoma	*mesodon*		F/B					1															1	1							3		1	
Diploneis	*pseudovalis*		F/B																		1	2	6											1
Epithemia	*sorex*		F/B				3														1			1							2			
Epithemia	*turgida*		F/B															2			2	1		3								1		
Epithemia	*turgida*	*westermannii*	F/B				2	1	1											3	6		1	2						1	4	1		1
Epithemia	*zebra*		F/B																		1		1											
Eunotia	*pectinalis*	*minor*	F/B																															
Fragilaria	*brevistriata*		F/B													1	4																	
Fragilaria	*capucina*	*vaucheriae*	F/B																															
Fragilaria	*construens*		F/B														3																	
Fragilaria	*construens*	*pumila*	F/B													3	3																	
Fragilaria	*construens*	*venter*	F/B					1								1	6										1						1	
Fragilaria	*leptostauron*		F/B				1									1	3																	
Fragilaria	*parasitica*		F/B													3	5																	
Fragilaria	*pinnata*		F/B													1	3												1	2	1			
Fragilaria	*virescens*		F/B				1																	1										
Frustulia	*vulgaris*		F/B					1														2		1	2	4		1						
Gomphoneis	*herculeana*		F/B																												1			
Gomphonema	*acutiusculum*		F/B																															
Gomphonema	*angustatum*		F/B																															
Gomphonema	*gracile*		F/B																		1							2						
Gomphonema	*parvulum*		F/B		1		2	1													2			4				1	1		6	1	1	
Hantzschia	*amphioxys*		F/B															2			1		1											1
Melosira	*roeseana*		F/B					1								4													1					
Meridion	*circulare*	*constricta*	F/B																1														1	
Navicula	*accomoda*		F/B																													1		
Navicula	*cari*		F/B																										1	1				
Navicula	*contenta*		F/B		1	1	1										1		1		1				1	11	1						1	
Navicula	*cryptotenella*		F/B																											1	3		2	
Navicula	*elegans*		F/B															1	1						2						1			
Navicula	*elginensis*		F/B																	1														
Navicula	*elginensis*	*cuneata*	F/B													1													1					
Navicula	*gallica*	*perpusilla*	F/B																					1								1		
Navicula	*lanceolata*		F/B					1											1			1												
Navicula	*minima*		F/B													1										1					1			
Navicula	*mutica*		F/B		1	1		3	1		1						6		12	13	18	28	39	3	27	33	37	1	26		2	1	4	
Navicula	*mutica*	*undulata*	F/B																															
Navicula	*muticoides*		F/B																								5							
Navicula	*placentula*		F/B																															
Navicula	*pupula*		F/B				1																									1	1	
Navicula	*pusilla*		F/B															1	43	6	8	47	70	35	12	13	7		21		1		2	2
Navicula	*pusilla*	*1*	F/B																			1	5											
Navicula	*radiosa*		F/B																							1					1			
Navicula	*stankovicii*		F/B														1									3								
Navicula	*tenelloides*		F/B																												3			

				C17		Core 16					Core 15						C13	Core7		Core 8						Core 7								Core6
Genus	Species	Variety	**Salinity**	59	63	64	65	66	67	68	70	71	72	73	77	78	87	106	107	108	109	110	111	112	113	115	116	117	118	119	120	121	122	125
Navicula	*tripuctata*		F/B																												1	1		
Nitzschia	*brevissima*		F/B										1																					2
Nitzschia	*capitellata*		F/B																															
Nitzschia	*commutata*		F/B				1	1											1	7	1	1	1	1	4		2		3		2			
Nitzschia	*dissipata*		F/B																												1			
Nitzschia	*inconspicua*		F/B																	1						1	1				5			
Nitzschia	*nana*		F/B																1	2	9	6	5		10	7	3		1					
Nitzschia	*palea*		F/B				1									1				5		2	2		8	1			1		2	1		
Nitzschia	*parvula*		F/B																								1							
Nitzschia	*pellucida*		F/B				1									1				1					1	2	1				1		1	
Nitzschia	*perminuta*		F/B																											3				
Nitzschia	*pusilla*		F/B														1			1			3		3	1					2	2	4	
Nitzschia	*scapelliformis*		F/B																6	4		1	1		2		1	1						
Nitzschia	*terrestris*		F/B																										1					
Nitzschia	*trybilonella*		F/B																															
Pinnularia	*appendiculata*		F/B																												1			
Pinnularia	*borealis*		F/B					1			1							4			4			2										
Pinnularia	*intermedia*		F/B																										1	1		12		
Pinnularia	*lagerstedtii*		F/B															1	6			18	13	5	15	5			2			1	1	
Pinnularia	*similiformis*		F/B															1			5			1		1	1							1
Pinnularia	*subcapitata*		F/B																															
Pinnularia	*viridis*		F/B																								1						1	
Pinnularia	*viridis*	*minor*	F/B																															
Rhoicosphenia	*curvata*		F/B			2	8	1													3			3	2	1					11	1	8	1
Rhopalodia	*gibba*		F/B				2	2																							1	1		
Rhopalodia	*gibberula*		F/B																	3		1	1	1			1							
Stauroneis	*anceps*		F/B						1							2																		
Stauroneis	*kriegerii*		F/B																													1		
Stauroneis	*phoenicenteron*		F/B													1			1		1													
Stephanodiscus	*astrea*		F/B																										1					
Surirella	*brebissonii*		F/B																											1	1			
Synedra	*ulna*		F/B		4	1	6	3	1		3								1		3	2	1	2	1						4			
Tabellaria	*fenestrata*		F/B													5	5						2	4	1									
Thalassiosira	*westflogii*		F/B																															
Total				0	7	9	41	38	5	0	6	0	1	0	0	63	79	14	77	49	84	121	160	76	96	89	83	12	62	19	88	52	53	10
% of Slide Total				0	70	53	85	90	63	0	67	0	100	0	0	76	87	54	59	29	69	66	78	72	63	73	47	7.5	43	13	60	44	45	71.4
Achnanthes	*brevipes*		B																												1		1	
Achnanthes	*brevipes*	*intermedia*	B																1		2						3	1	1					
Achnanthes	*exigua*		B													2																		
Achnanthes	*hauckina*		B																11			3	2		3		1	5		2	1			
Achnanthes	*hauckina*	*rostrata*	B																									73	2	34	2	7	7	
Amphora	*mexicana*		B																															
Amphora	*ovalis*	*pediculus*	B				3																					1			1	1	1	
Calonesis	*westii*		B																1	8	1	3			1		3	1	2		1		1	
Cocconeis	*disculus*		B																3		1	2	4		1		2		1	1	5	1	7	
Cyclotella	*striata*		B													1												1					2	
Denticula	*subtilis*		B																			1											10	
Diploneis	*didyma*		B																									1						
Diploneis	*interrupta*		B				1												1	1														
Diploneis	*ovalis*		B																						1									
Frustulia	*linkei*		B																															
Gomphonema	*pseudexigum*		B																											2				
Gyrosigma	*balticum*		B																	8		1								2	1			
Gyrosigma	*eximium*		B																	6	3		1		15	10	14	2						
Mastogloia	*exigua*		B																								1					1		
Melosira	*nummuloides*		B																														1	
Navicula	*cincta*		B			2													6	10	3	14	14	10	17	8	3	1	3	5	8	14	3	
Navicula	*cryptolyra*		B																															

				C17		Core 16					Core 15						C13	Core7		Core 8						Core 7								Core6
Genus	Species	Variety	**Salinity**	59	63	64	65	66	67	68	70	71	72	73	77	78	87	106	107	108	109	110	111	112	113	115	116	117	118	119	120	121	122	125
Navicula	*peregrina*		B														1			2	1	1		1				1					1	
Navicula	*pygmaea*		B																							5	1					1		
Navicula	*salinarum*		B																													2		
Nitzschia	*aerophila*		B																						2									
Nitzschia	*debilis*		B																			1					4		1				1	
Nitzschia	*fasciculata*		B																				1		1									
Nitzschia	*levidensis*		B																										1					
Nitzschia	*levidensis*	*victoriae*	B																								1							
Nitzschia	*littoralis*		B																			1										1		
Nitzschia	*longissima*		B																															
Nitzschia	*navicularis*		B																	1														
Nitzschia	*plana*		B																															
Nitzschia	*sigma*		B																	24	3	8	1	2	1	1	5		2					
Nitzschia	*vitrea*		B																														1	
Rhopalodia	*musculus*		B																	6	3													
Synedra	*fasciculata*		B													1			4	5	1	2	6	1	4	3		1	1				1	
Synedra	*gaillonii*		B																															
Total				0	0	2	4	0	0	0	0	0	0	0	0	4	1	0	27	71	18	37	29	14	46	27	38	88	14	46	20	28	37	0
% of Slide Total				0	0	12	8.3	0	0	0	0	0	0	0	0	4.8	1.1	0	21	42	15	20	14	13	30	22	22	55	9.7	31	14	24	31	0
Achnanthes	*delicatula*		M/B																1		2	1				1	2		1	42	2	13	7	
Actinocyclus	*spp.*		M/B																															
Actinoptychus	*senarius*		M/B																															
Amphora	*proteus*		M/B																			1								1	1			
Amphora	*ventricosa*		M/B																1											2	1		1	
Bacillaria	*paradoxa*		M/B																															
Camplyodiscus	*echineis*		M/B																	2														
Catentula	*adherens*		M/B																									5						
Cerataulus	*turgidus*		M/B																									1						
Cocconeis	*scutellum*		M/B						1								1			3					1	1		2						
Cocconeis	*scutellum*	*parva*	M/B						1	1	1								1		4	5	1					1	1		1			
Delphineis	*surirella*		M/B																	22	1	1					13	7	28	1	1		2	
Dimeregramma	*minor*		M/B																4				7		1		2	3	4					
Diploneis	*smithii*		M/B				2																											
Grammatophora	*oceanica*		M/B																										1					
Gyrosigma	*spencerii*		M/B																													1		
Hantzschia	*virgata*		M/B																															
Hyalodiscus	*scoticus*		M/B																															
Melosira	*moniliformis*		M/B																															
Navicula	*digitoradiata*		M/B																	2	1										1			
Navicula	*granulata*		M/B																															
Navicula	*lyra*		M/B																															
Navicula	*lyra*	*elliptica*	M/B																															
Navicula	*perminuta*		M/B																															
Navicula	*phyllepta*		M/B																					3				1		1	9	3	1	
Navicula	*rhyncocephala*		M/B					2												1		1		2		2	3			1	1	6		
Nitzschia	*acuminata*		M/B																		2													
Nitzschia	*bilobata*		M/B																			1												
Nitzschia	*compressa*		M/B																	2		1					2							
Nitzschia	*constricta*		M/B																	1	1		1			2	7	2		1	4	1		
Nitzschia	*granulata*		M/B																6	11	2	2	1		2		3	2	3	3				
Nitzschia	*lanceola*		M/B																															
Nitzschia	*obtusa*		M/B																															
Nitzschia	*punctata*		M/B																															
Opephora	*pacifica*		M/B																						1									
Opephora	*parva*		M/B													1	2		1	1	4	5	3	2	2			9	6	8	2	8	3	
Paralia	*sulcata*		M/B														1		11	1		3			1		4	8	15	1			1	2
Plagiogramma	*staurophorum*		M/B																															
Rhabdonema	*arcuatum*		M/B																															

				C17		Core 16					Core 15						C13	Core7		Core 8						Core 7								Core6
Genus	Species	Variety	**Salinity**	59	63	64	65	66	67	68	70	71	72	73	77	78	87	106	107	108	109	110	111	112	113	115	116	117	118	119	120	121	122	125
Rhaphoneis	*amphiceros*		M/B																															
Rhaphoneis	*psammicola*		M/B																									4	2					
Rhaphoneis	*surirella*		M/B																								1							
Scoliopleura	*tumida*		M/B																															
Surirella	*fastuosa*		M/B																															
Thalassiosira	*discepens*		M/B																			1												
Thalassiosira	*lacustris*		M/B																															
Total				0	0	0	2	2	2	1	1	0	0	0	0	1	4	0	25	46	17	22	13	7	8	6	37	45	61	61	23	32	15	2
% of Slide Total				0	0	0	4.2	4.8	25	50	11	0	0	0	0	1.2	4.4	0	19	27	14	12	6.4	6.6	5.3	4.9	21	28	42	41	16	27	13	14.3
Amphora	*angusta*		M																															
Amphora	*granulata*		M																															
Bidduluphia	*aurita*		M																															
Calonesis	*brevis*		M																															
Coscinodiscus	*radiatus*	*f. obscurus*	M																															
Cyclotella	*styrolum*		M																															
Diploneis	*smithii*	*rhombica*	M																															
Endictya	*sp.1*		M																								1							
Nitzschia	*compressa*	*vexans*	M																								4		1					
Odontella	*obtusa*		M																									1						
Opephora	*marina*		M																											13				
Rhaphoneis	*margaritalimbata*		M																								2							
Thalassionema	*nitzschioides*		M																	1								1	2	2				
Thalassiosira	*eccentrica*		M																									1			1	1	1	
Thalassiosira	*pacifica*		M																	3			1				8	9	4	4	3	3	2	
Trachyneis	*aspera*		M																															
Trachysphenia	*australis*		M																															0
Actinoptychus	*vulgaris*		M																															
Nitzschia	*coarctata*		M																															
Total				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	15	12	7	19	4	4	3	0
% of Slide Total				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0.5	0	0	0	8.6	7.5	4.8	13	2.7	3.4	2.5	0
Navicula	*capitata*		E													1									1		1							
Navicula	*capitata*	*hungarica*	E																			1	1	1										
Navicula	*cryptocephala*		E													1	2		1					1				2					4	
Tabellaria	*flocculosa*		E																															
Total				0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	1	0	0	1	1	2	1	0	1	2	0	0	0	0	4	0
% of Slide Total				0	0	0	0	0	0	0	0	0	0	0	0	2.4	2.2	0	0.8	0	0	0.5	0.5	1.9	0.7	0	0.6	1.3	0	0	0	0	3.4	0
Achnanthes	*spp.*		Unknown																															
Amphora	*spp.*		Unknown																															
Calonesis	*spp.*		Unknown																															
Cocconeis	*klamathensis*		Unknown																													1		
Cocconeis	*spp.*		Unknown			3																												
Cyclotella	*caspia*		Unknown																															
Cyclotella	*spp.*		Unknown																											1			1	
Cymbella	*spp.*		Unknown																														1	
Diploneis	*spp.*		Unknown																															
Epithemia	*spp.*		Unknown		1						1	1		2				4																2
Fragilaria	*spp.*		Unknown														1																	
Gomphonema	*bipunctum*		Unknown			1																		1										
Gomphonema	*spp.*		Unknown													1																		
Gyrosigma	*spp.*		Unknown																						1									
Hantzschia	*spp.*		Unknown																															
Mastogloia	*spp.*		Unknown																															
Melosira	*spp.*		Unknown																															
Navicula	*lapidosa*		Unknown																															
Navicula	*stroemii*		Unknown																															
Navicula	*sublucidula*		Unknown																											1				

				C17		Core 16					Core 15						C13	Core7		Core 8						Core 7								Core6
Genus	Species	Variety	**Salinity**	59	63	64	65	66	67	68	70	71	72	73	77	78	87	106	107	108	109	110	111	112	113	115	116	117	118	119	120	121	122	125
Navicula	*spp.*		Unknown																															
Nedium	*spp.*		Unknown																															
Nitzschia	*palustris*		Unknown																															
Nitzschia	*spp.*		Unknown																															
Pinnularia	*spp.*		Unknown													5		2																
Pleurosigma	*spp.*		Unknown																															
Rhopalodia	*spp.*		Unknown																															
Stauroneis	*spp.*		Unknown																															
Surirella	*spp.*		Unknown																															
Synedra	*spp.*		Unknown	1		2			1	1	1	1			4	1		5																
Tabellaria	*spp.*		Unknown													1																		
Thalassiosira	*spp.*		Unknown		1																									1				
Total				1	2	6	0	0	1	1	2	2	0	2	4	8	1	11	0	0	0	0	0	1	1	0	0	0	0	3	0	1	2	2
% of Slide Total				100	20	35	0	0	13	50	22	100	0	100	100	9.6	1.1	42	0	0	0	0	0	0.9	0.7	0	0	0	0	2	0	0.9	1.7	14.3
Total # of valves counted on slide				1	10	17	48	42	8	2	9	2	1	2	4	83	91	26	131	170	122	184	204	106	152	122	175	160	145	148	146	117	118	14
.																																		

Appendix B: Diatom Counts

				Core 5			Core 4		Core 3			Core 2									C 1	
Genus	Species	Variety	**Salinity**	126	127	128	129	130	131	132	28	27	26	25	24	23	22	21	20	19	18	TOTAL
Achnanthes	*coarctata*		F																			1
Achnanthes	*suchlandtii*		F																			1
Cymbella	*similis*		F																			1
Cymbella	*tumidula*	*lancettula*	F															1				0
Diatoma	*anceps*		F																			3
Eunotia	*flexuosa*		F					2	1		1										1	5
Eunotia	*incisa*		F																			2
Eunotia	*maior*		F			1					13			3							5	4
Eunotia	*monodon*		F								1	2		1		1						4
Eunotia	*naegelii*		F												1							0
Eunotia	*parallela*		F								1										1	0
Eunotia	*pectinalis*		F					11	1		15		1	1	3	66	15	21	16	14	34	21
Eunotia	*praerupta*	*bidens*	F								2		1	1								6
Eunotia	*van heurckii*		F													2						0
Eunotia	*van heurckii*	*intermedia*	F													5						1
Eunotia	*valida*		F																			0
Eunotia	*spp.*		F			2		5							9	12	2		1	1	2	20
Fragilaria	*exigua*		F										1									0
Frustulia	*rhomboids*		F																			1
Gomphonema	*truncatum*		F								1											0
Navicula	*digitulus*		F			1																4
Navicula	*leptostriata*		F																			4
Navicula	*pupula*	*elliptica*	F																			0
Nedium	*hercynicum*		F																			1
Nedium	*iridis*	*iridis*	F					1									1			1		1
Nitzschia	*angustulata*		F																			2
Opephora	*martyii*		F																			1
Pinnularia	*acrosphaeria*		F					1			6			1			1		1		1	3
Pinnularia	*bogotensis*		F																			0
Pinnularia	*divergentissima*		F								1											0
Pinnularia	*gibba*	*linearis*	F					4			2								1			8
Pinnularia	*krockii*		F					1	1													4
Pinnularia	*maior*		F								3											0
Pinnularia	*microstauron*		F																			1
Pinnularia	*nodosa*		F					1			2		1				1			2	3	1
Pinnularia	*stomataphora*		F					1								2						2
Pinnularia	*subcapitata*	*paucistriata*	F							1			3									1
Pinnularia	*subgibba*		F																			3
Stauroneis	*phoenicenteron*	*brunii*	F								1											0
Stauroneis	*smithii*	*incisa*	F														1		1			1
Synedra	*rumpens*		F										1						1			2
Total				0	0	4	0	27	3	1	49	2	8	7	13	88	21	22	21	18	47	
% of Slide Total				0	0	7.5	0	20	2.3	5.6	37	67	6.3	30	12	73	15	18	19	17	43	
Achnanthes	*hustedtii*		F/B					4	4		1		1		1		8	2	5	2		11
Achnanthes	*lanceolata*	*dubia*	F/B												2	1		2	2			7
Achnanthes	*lanceolata*	*ssp.*	F/B																			1
Achnanthes	*lanceolata*	*lanceolata*	F/B					12	2		1				4		6	2	6	2		70
Achnanthes	*minutissima*		F/B																			22
Amphora	*coffeiformis*		F/B																			4
Amphora	*ovalis*		F/B								2											0
Amphora	*ovalis*	*affinis*	F/B														2					4
Amphora	*perpusilla*		F/B																			1
Aulacosira	*granulata*		F/B					5														26
Aulacosira	*islandica*		F/B					2			7											54

				Core 5			Core 4		Core 3			Core 2									C 1	
Genus	Species	Variety	**Salinity**	126	127	128	129	130	131	132	28	27	26	25	24	23	22	21	20	19	18	TOTAL
Aulacosira	*italica*		F/B																			7
Calonesis	*bacillum*		F/B		2		1	1	6	1												41
Cocconeis	*diminuta*		F/B						1													16
Cocconeis	*placentula*		F/B		1										1		2	6				29
Cocconeis	*placentula*	*euglypta*	F/B							1	1		1	1			2				1	76
Cyclotella	*meneghiniana*		F/B																			0
Cyclotella	*compta*		F/B																			1
Cyclotella	*ocellata*		F/B																			0
Cyclotella	*stelligera*		F/B																			3
Cymbella	*aspera*		F/B														2	1			1	0
Cymbella	*cistula*		F/B																		1	1
Cymbella	*minuta*		F/B		1			2				1	1		1	1					2	6
Cymbella	*sinuata*		F/B														1		1			22
Cymbella	*tumida*		F/B																			0
Diatoma	*mesodon*		F/B												1		2		1			9
Diploneis	*pseudovalis*		F/B						2				1									12
Epithemia	*sorex*		F/B	1														1				11
Epithemia	*turgida*		F/B							2				5								14
Epithemia	*turgida*	*westermannii*	F/B		1		4			2			1	3								41
Epithemia	*zebra*		F/B					1		1							1		1			6
Eunotia	*pectinalis*	*minor*	F/B													3						0
Fragilaria	*brevistriata*		F/B																			6
Fragilaria	*capucina*	*vaucheriae*	F/B																			1
Fragilaria	*construens*		F/B														1					3
Fragilaria	*construens*	*pumila*	F/B										1		1		1		1			7
Fragilaria	*construens*	*venter*	F/B						1				6		1	1	1		1	1		12
Fragilaria	*leptostauron*		F/B																			5
Fragilaria	*parasitica*		F/B										1							2		8
Fragilaria	*pinnata*		F/B																			9
Fragilaria	*virescens*		F/B																			2
Frustulia	*vulgaris*		F/B					1	1													13
Gomphoneis	*herculeana*		F/B			1																2
Gomphonema	*acutiusculum*		F/B													2		1				0
Gomphonema	*angustatum*		F/B					10		1	8				6	1	2	4	10	1	7	11
Gomphonema	*gracile*		F/B					4			2					1	3	2	1	2	3	7
Gomphonema	*parvulum*		F/B					28	4		19		2		18	13	36	35	22	35	7	59
Hantzschia	*amphioxys*		F/B											2								9
Melosira	*roeseana*		F/B																			8
Meridion	*circulare*	*constricta*	F/B																			3
Navicula	*accomoda*		F/B																			1
Navicula	*cari*		F/B																			2
Navicula	*contenta*		F/B														6	2	3	2	3	24
Navicula	*cryptotenella*		F/B	1																		7
Navicula	*elegans*		F/B		9		1		3					1								19
Navicula	*elginensis*		F/B																			1
Navicula	*elginensis*	*cuneata*	F/B								1				2	1				1		2
Navicula	*gallica*	*perpusilla*	F/B														1		2	1		6
Navicula	*lanceolata*		F/B																			3
Navicula	*minima*		F/B										4							1		3
Navicula	*mutica*		F/B		10	3	2	1	5				8				1	2				346
Navicula	*mutica*	*undulata*	F/B																			1
Navicula	*muticoides*		F/B				1															6
Navicula	*placentula*		F/B															1		2		0
Navicula	*pupula*		F/B					2							1			1	1	1		6
Navicula	*pusilla*		F/B		50	17	15	2	28	3			10		1							408
Navicula	*pusilla*	*1*	F/B						1													8
Navicula	*radiosa*		F/B																			3
Navicula	*stankovicii*		F/B																			4
Navicula	*tenelloides*		F/B																			3

				Core 5			Core 4		Core 3			Core 2									C 1	
Genus	Species	Variety	**Salinity**	126	127	128	129	130	131	132	28	27	26	25	24	23	22	21	20	19	18	TOTAL
Navicula	*tripuctata*		F/B																			3
Nitzschia	*brevissima*		F/B		4																	7
Nitzschia	*capitellata*		F/B										1		1							0
Nitzschia	*commutata*		F/B																			28
Nitzschia	*dissipata*		F/B																			4
Nitzschia	*inconspicua*		F/B																			10
Nitzschia	*nana*		F/B			1											1					46
Nitzschia	*palea*		F/B								1		3		1		1		1	3		27
Nitzschia	*parvula*		F/B																			1
Nitzschia	*pellucida*		F/B																			9
Nitzschia	*perminuta*		F/B																			3
Nitzschia	*pusilla*		F/B														1					17
Nitzschia	*scapelliformis*		F/B																			20
Nitzschia	*terrestris*		F/B					2									2				1	5
Nitzschia	*trybilonella*		F/B																			0
Pinnularia	*appendiculata*		F/B																			1
Pinnularia	*borealis*		F/B				1						1									22
Pinnularia	*intermedia*		F/B								1									1		14
Pinnularia	*lagerstedtii*		F/B		21	6	1	2	3	1			30		1							107
Pinnularia	*similiformis*		F/B		1			1			1					2	2		1	4	1	16
Pinnularia	*subcapitata*		F/B					1			8						7					9
Pinnularia	*viridis*		F/B		1			8			13			1	5	2	2					14
Pinnularia	*viridis*	*minor*	F/B		1			3			3					1		3			4	5
Rhoicosphenia	*curvata*		F/B		1	3				2					2		1		3	1		58
Rhopalodia	*gibba*		F/B														1					6
Rhopalodia	*gibberula*		F/B						1													8
Stauroneis	*anceps*		F/B																			7
Stauroneis	*kriegerii*		F/B					1			3		6		2	2	2			1		3
Stauroneis	*phoenicenteron*		F/B					1			2						2			1	1	5
Stephanodiscus	*astrea*		F/B																			1
Surirella	*brebissonii*		F/B																			2
Synedra	*ulna*		F/B										3									84
Tabellaria	*fenestrata*		F/B			1												1	1	1		18
Thalassiosira	*westflogii*		F/B																			1
Total				2	103	32	26	94	62	14	74	1	81	13	52	31	100	66	63	65	32	
% of Slide Total				50	82	60	81	70	47	78	56	33	64	57	50	26	70	54	57	60	29	
Achnanthes	*brevipes*		B																			2
Achnanthes	*brevipes*	*intermedia*	B					1														11
Achnanthes	*exigua*		B																			2
Achnanthes	*hauckina*		B					2	1				13		12		10	15	11	12	2	42
Achnanthes	*hauckina*	*rostrata*	B																			125
Amphora	*mexicana*		B																		1	0
Amphora	*ovalis*	*pediculus*	B																	1		7
Calonesis	*westii*		B					2	2		2											28
Cocconeis	*disculus*		B			1			1													32
Cyclotella	*striata*		B			1																5
Denticula	*subtilis*		B																			11
Diploneis	*didyma*		B																			1
Diploneis	*interrupta*		B						3													7
Diploneis	*ovalis*		B						8													9
Frustulia	*linkei*		B																			0
Gomphonema	*pseudexigum*		B																			2
Gyrosigma	*balticum*		B																			12
Gyrosigma	*eximium*		B																			52
Mastogloia	*exigua*		B																			2
Melosira	*nummuloides*		B																			1
Navicula	*cincta*		B		3				2		1										1	148
Navicula	*cryptolyra*		B																			0

				Core 5			Core 4		Core 3			Core 2									C 1	
Genus	Species	Variety	**Salinity**	126	127	128	129	130	131	132	28	27	26	25	24	23	22	21	20	19	18	TOTAL
Navicula	*peregrina*		B					1					5				1	4	3	5	1	12
Navicula	*pygmaea*		B																			8
Navicula	*salinarum*		B																			2
Nitzschia	*aerophila*		B																			2
Nitzschia	*debilis*		B																			7
Nitzschia	*fasciculata*		B																			2
Nitzschia	*levidensis*		B																			1
Nitzschia	*levidensis*	*victoriae*	B																			1
Nitzschia	*littoralis*		B																			2
Nitzschia	*longissima*		B																			0
Nitzschia	*navicularis*		B																			1
Nitzschia	*plana*		B																			0
Nitzschia	*sigma*		B						3													50
Nitzschia	*vitrea*		B																			1
Rhopalodia	*musculus*		B						1				2									12
Synedra	*fasciculata*		B				1		2				1									41
Synedra	*gaillonii*		B																			0
Total				0	3	2	1	6	23	0	3	0	21	0	12	0	11	19	14	18	5	
% of Slide Total				0	2.4	3.8	3.1	4.4	18	0	2.3	0	17	0	11	0	7.7	16	13	17	4.5	
Achnanthes	*delicatula*		M/B	1																		73
Actinocyclus	*spp.*		M/B																			1
Actinoptychus	*senarius*		M/B						3													3
Amphora	*proteus*		M/B																			4
Amphora	*ventricosa*		M/B						1													6
Bacillaria	*paradoxa*		M/B																			0
Camplyodiscus	*echineis*		M/B																			2
Catentula	*adherens*		M/B																			5
Ârerataulus	*turgidus*		M/B																			1
Cocconeis	*scutellum*		M/B																			21
Cocconeis	*scutellum*	*parva*	M/B																			20
Delphineis	*surirella*		M/B		1				4													88
Dimeregramma	*minor*		M/B																			25
Diploneis	*smithii*		M/B																			2
Grammatophora	*oceanica*		M/B																			1
Gyrosigma	*spencerii*		M/B																			1
Hantzschia	*virgata*		M/B		1								1				1					1
Hyalodiscus	*scoticus*		M/B																			0
Melosira	*moniliformis*		M/B																			0
Navicula	*digitoradiata*		M/B										2		1							4
Navicula	*granulata*		M/B																			0
Navicula	*lyra*		M/B																			0
Navicula	*lyra*	*elliptica*	M/B																			1
Navicula	*perminuta*		M/B																			1
Navicula	*phyllepta*		M/B																			18
Navicula	*rhyncocephala*		M/B						3								4					22
Nitzschia	*acuminata*		M/B																			3
Nitzschia	*bilobata*		M/B																			1
Nitzschia	*compressa*		M/B																			6
Nitzschia	*constricta*		M/B																	1		22
Nitzschia	*granulata*		M/B		1	1	1	1	2													43
Nitzschia	*lanceola*		M/B																			0
Nitzschia	*obtusa*		M/B																			2
Nitzschia	*punctata*		M/B																			0
Opephora	*pacifica*		M/B																			1
Opephora	*parva*		M/B																			63
Paralia	*sulcata*		M/B		16	13	3	7	24	3	5											128
Plagiogramma	*staurophorum*		M/B																			0
Rhabdonema	*arcuatum*		M/B																			0

				Core 5			Core 4		Core 3			Core 2									C 1	
Genus	Species	Variety	**Salinity**	126	127	128	129	130	131	132	28	27	26	25	24	23	22	21	20	19	18	TOTAL
Rhaphoneis	*amphiceros*		M/B						1													1
Rhaphoneis	*psammicola*		M/B																			7
Rhaphoneis	*surirella*		M/B																			2
Scoliopleura	*tumida*		M/B																			0
Surirella	*fastuosa*		M/B																			0
Thalassiosira	*discepens*		M/B																			2
Thalassiosira	*lacustris*		M/B																			2
Total				1	19	14	4	8	38	3	5	0	3	0	1	0	5	0	0	1	0	
% of Slide Total				25	15	26	13	5.9	29	17	3.8	0	2.4	0	1	0	3.5	0	0	0.9	0	
Amphora	*angusta*		M																			0
Amphora	*granulata*		M																			1
Bidduluphia	*aurita*		M																			0
Calonesis	*brevis*		M																			0
Coscinodiscus	*radiatus*	*f. obscurus*	M																			0
Cyclotella	*styrolum*		M																			0
Diploneis	*smithii*	*rhombica*	M																			1
Endictya	*sp.1*		M																			1
Nitzschia	*compressa*	*vexans*	M						1													7
Odontella	*obtusa*		M																			1
Opephora	*marina*		M																			13
Rhaphoneis	*margaritalimbata*		M																			2
Thalassionema	*nitzschioides*		M																			6
Thalassiosira	*eccentrica*		M						3													7
Thalassiosira	*pacifica*		M				1		1													40
Trachyneis	*aspera*		M																			0
Trachysphenia	*australis*		M																			0
Actinoptychus	*vulgaris*		M																			1
Nitzschia	*coarctata*		M																			0
Total				0	0	0	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	
% of Slide Total				0	0	0	3.1	0	3.8	0	0	0	0	0	0	0	0	0	0	0	0	
Navicula	*capitata*		E																			4
Navicula	*capitata*	*hungarica*	E																			3
Navicula	*cryptocephala*		E																			16
Tabellaria	*flocculosa*		E																1		1	0
Total				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
% of Slide Total				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0.9	
Achnanthes	*spp.*		Unknown												2				1			0
Amphora	*spp.*		Unknown																			2
Calonesis	*spp.*		Unknown																			1
Cocconeis	*klamathensis*		Unknown																			1
Cocconeis	*spp.*		Unknown																3			8
Cyclotella	*caspia*		Unknown																			0
Cyclotella	*spp.*		Unknown																			2
Cymbella	*spp.*		Unknown																		1	3
Diploneis	*spp.*		Unknown																		1	3
Epithemia	*spp.*		Unknown	1		1									1	1		1		1		37
Fragilaria	*spp.*		Unknown											1								1
Gomphonema	*bipunctum*		Unknown															1				2
Gomphonema	*spp.*		Unknown																1		4	2
Gyrosigma	*spp.*		Unknown																			1
Hantzschia	*spp.*		Unknown												1							0
Mastogloia	*spp.*		Unknown																			0
Melosira	*spp.*		Unknown																			0
Navicula	*lapidosa*		Unknown										1						1			0
Navicula	*stroemii*		Unknown																1			0
Navicula	*sublucidula*		Unknown																			1

				Core 5			Core 4		Core 3			Core 2									C 1	
Genus	Species	Variety	**Salinity**	126	127	128	129	130	131	132	28	27	26	25	24	23	22	21	20	19	18	TOTAL
Navicula	*spp.*		Unknown										1		2			2		1	2	3
Nedium	*spp.*		Unknown																		1	0
Nitzschia	*palustris*		Unknown										1									0
Nitzschia	*spp.*		Unknown										5	1	3	1		2	3	2	1	22
Pinnularia	*spp.*		Unknown										3	1	16		2	2	1	1	12	12
Pleurosigma	*spp.*		Unknown																			0
Rhopalodia	*spp.*		Unknown																			0
Stauroneis	*spp.*		Unknown														1		1			7
Surirella	*spp.*		Unknown												1		3	1		2	2	0
Synedra	*spp.*		Unknown										3		1			4				44
Tabellaria	*spp.*		Unknown															2			1	2
Thalassiosira	*spp.*		Unknown																			5
Total				1	0	1	0	0	0	0	0	0	14	3	27	2	6	15	12	7	25	
% of Slide Total				25	0	1.9	0	0	0	0	0	0	11	13	26	1.7	4.2	12	11	6.4	23	
Total # of valves counted on slide				4	125	53	32	135	131	18	131	3	127	23	105	121	143	122	111	109	110	
.																						

APPENDIX C. INTERTIDAL SETTING INTERPRETATIONS

Note: Species counts that do not add up to 100% are due to diatoms not identified to species level and/or lacking salinity preference data.

CORE 4: Diatom Analysis

Sample: 18 Core section: 1
Depth below land surface: 0.6m (4.95 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Eunotia pectinalis, Eunotia maior, Gomphonema angustatum, Gomphonema parvulum, Pinnularia viridis* var. *minor, Achnanthes hauckina*
Environment: Probably freshwater wetland
Special notes: Preservation very good. Many intact diatoms present.
Species counts: Freshwater 43%; Fresh/Brackish 29%; Brackish 4.5%; Euryhaline 1%

Sample: 19 Core section: 2
Sediment description: silt/clay
Depth below land surface: 1.25m (4.30 m NGVD)
Pertinent diatom species: *Eunotia pectinalis, Achnanthes lanceolata, Gomphonema parvulum, Nitzschia palea, Pinnularia similiformis, Achnanthes hauckina* var. *rostrata, Navicula peregrina*
Environment: Probably freshwater wetland or brackish high marsh
Special notes: Preservation very good. Many intact diatoms present.
Species counts: Freshwater 16.5%; Fresh/Brackish 60%; Brackish 16.5%; Brackish/Marine 1%

Sample: 20 Core section: 2 (Just after submergence? Event A)
Depth below land surface: 1.29m (4.26 m NGVD)
Sediment description: clay/silt; sharp lower boundary (~3mm)
Pertinent diatom species: *Eunotia pectinalis, Achnanthes hustedtii, Achnanthes lanceolata, Gomphonema angustatum, Gomphonema parvulum, Rhoicosphenia curvata, Achnanthes hauckina* var. *rostrata, Navicula peregrina*
Environment: Probably brackish high marsh
Special notes: Preservation good. Many intact diatoms present. Assemblage similar to Sample 21, but more unidentified fresh/brackish to brackish *Nitzschia* spp. present.
Species counts: Freshwater 19%; Fresh/Brackish 57%; Brackish 13%; Euryhaline 1%

Sample: 21 Core section: 2 (Just before submergence? Event A)
Depth below land surface: 1.35m (4.20 m NGVD)
Sediment description: fine peaty mud; sharp lower boundary (~3mm)
Pertinent diatom species: *Eunotia pectinalis, Cocconeis placentula*, *Gomphonema angustatum, Gomphonema parvulum, Pinnularia viridis* var. *minor; Achnanthes hauckina; Navicula peregrina*; *Synedra spp.*
Environment: Probably brackish high marsh
Special notes: Preservation good. Many intact diatoms present. Similar to assemblage from Sample 20, but many of the unidentified valves are freshwater *Eunotia* and *Synedra* spp.
Species counts: Freshwater 18%; Fresh/Brackish 54%; Brackish 16%

Sample: 22 Core section: 2 (Just after submergence. Event B)
Depth below land surface: 1.365m (4.18 m NGVD)
Sediment description: silt/clay; sharp lower boundary (<2mm)

Pertinent diatom species: *Eunotia pectinalis, Eunotia spp., Achnanthes hustedtii, Achnanthes lanceolata, Cocconeis placentula, Gomphonema gracile, Gomphonema parvulum, Navicula contenta, Pinnularia subcapitata, Achnanthes hauckina, Hantzschia virgata, Navicula rhyncocephala*
Environment: Brackish high to low marsh
Special notes: Preservation moderate. A mixture of *in situ* freshwater and brackish diatoms. Many heavily and non-heavily silicified valves present, but most of both types are highly fragmented, perhaps indicating transport?
Species counts: Freshwater 15%; Fresh/Brackish 70%; Brackish 7.7%; Brackish/Marine 3.5%

Sample: 23 Core section: 2 (Just before submergence. Event B)
Depth below land surface: 1.39m (4.16 m NGVD)
Sediment description: silt/clay with detrital herbaceous organics (70%)
Pertinent diatom species: *Eunotia pectinalis, Eunotia* var. *heurkii, Eunotia spp.,Gomphonema parvulum*
Environment: Freshwater wetland
Special notes: Preservation very good. Assemblage dominated by freshwater *Eunotia spp*.
Species counts: Freshwater 73%; Fresh/Brackish 26%

Sample: 24 Core section: 2 (Just after submergence. Event C)
Depth below land surface: 1.48m (4.07 m NGVD)
Sediment description: silt/clay; sharp lower boundary (~3mm)
Pertinent diatom species: *Eunotia pectinalis, Eunotia spp., Achnanthes lanceolata, Gomphonema angustatum, Gomphonema parvulum, Pinnularia viridis, Achnanthese hauckina, Navicula digitoradiata*
Environment: Brackish low marsh
Special notes: Preservation moderate. Many fragmented diatoms, perhaps indicative of allochthonous diatom transport and deposition. Mixture of freshwater species with brackish species indicates probable rapid inundation, perhaps associated with a submergence event.
Species counts: Freshwater 12%; Fresh/Brackish 50%; Brackish 11%; Brackish/Marine 1%

Sample: 154 Core section: 2 (Just before submergence. Event C)
Depth below land surface: 1.51m (4.03 m NGVD)
Sediment description: silt/clay; 20% fibrous organics
Pertinent diatom species: *Pinnularia gibba, Stauroneis smithii, Achnanthes hustedtii, Achnanthes lanceolata, Gomphonema angustatum, Gomphonema parvulum*
Environment: Freshwater wetland
Special notes: Preservation good.
Species counts: Freshwater 16%; Fresh/Brackish 81%; Brackish/Marine 2.5%

Sample: 25 Core section: 2
Depth below land surface: 1.56m (3.99 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Eunotia maior, other large Eunotia spp., Epithemia turgida, Epithemia turgida* var. *westermanii, Hantzschia amphioxys*
Environment: Freshwater wetland
Special notes: Preservation good. However, only a few large, heavily silicified species present in assemblage.
Species counts: Freshwater 30%; Fresh/Brackish 57%

Sample: 155 Core section: 2 (Just after submergence. Event D)
Depth below land surface: 1.58m (3.96 m NGVD)
Sediment description: silt/clay and very fine sand; sharp lower boundary (~3mm)

Pertinent diatom species: *Eunotia pectinalis, Fragilaria construens, Gomphonema parvulum, Nitzschia linearis, Nitzschia pellucida, Pinnularia obscura*
Environment: Brackish low marsh
Special notes: Preservation good. Many fragmented valves, especially the Brackish and F/B species. May indicate transport of more brackish-tolerant species. While many Fresh and F/B species are present, the most dominant species, *Fragilaria construens* and *Gomphonema parvulum,* are often associated with lower brackish marsh or channel bank localities (Hemphill-Haley 1993). This, and the marked difference in assemblage composition from the assemblage 1cm below, implies a distinct change in depositional setting.

Species counts: Freshwater 19%; Fresh/Brackish 74%; Brackish/Marine 6%

Sample: 26   Core section: 2 (Just before submergence. Event D)
Depth below land surface: 1.60m (3.95 m NGVD)
Sediment description: silt/clay; 20% organic fibers
Pertinent diatom species: *Pinnularia subcapita* var. *paucistriata, Fragilaria construens* var. *venter, Navicula minima, Navicula mutica, Navicula pusilla, Nitzschia palea, Pinnularia lagerstedtii, Stauroneis kriegerii, Synedra ulna, Achnanthes hauckina, Navicula peregrina, Navicula digitoradiata*
Environment: Brackish high marsh
Special notes: Preservation very good. According to Kelsey et al. 2002 (Appendix DR1), although the species *Navicula mutica, Navicula pusilla*, and *Pinnularia lagerstedtii* are individually found in freshwater wetlands, when found in assemblages together they are indicative of brackish high marshes (salt marshes above mean higher high water). Following this, all succeeding sample interpretations will take groupings of these species into account.
Species counts: Freshwater 6%; Fresh/Brackish 64%; Brackish 17%; Brackish/Marine 2%

Sample: 156   Core section: 2 (Just after submergence. Event E)
Depth below land surface: 1.63m (3.91 m NGVD)
Sediment description: silt/clay; sharp lower boundary (~2mm)
Pertinent diatom species: *Navicula mutica, Navicula pusilla, Nitzschia palea, Pinnularia lagerstedtii, Navicula peregrina, Nitzschia debelis, Nitzschia plana, Nitzschia sigma, Navicula digitoradiata*; *Synedra fasciculata, Thalassiosira* spp.
Environment: Brackish low marsh
Special notes: Preservation good. Many fragmented valves.
Species counts: Freshwater 1%; Fresh/Brackish 60%; Brackish 22%; Brackish/Marine 13%

Sample: 157   Core section: 2 (Just before submergence. Event E)
Depth below land surface: 1.64m (3.90 m NGVD)
Sediment description: silt/clay; 10% organic fibers
Pertinent diatom species: *Eunotia* spp., *Pinnularia acrosphaeria, Pinnularia nodosa*, *Gomphonema angustatum, Gomphonema parvulum, Pinnularia viridis, Pinnularia phoenicenteron, Navicula peregrina, Navicula rhyncocephala,*
Environment: Brackish high marsh
Special notes: Preservation good. Many robust forms present, with fewer fragile forms noted. Some dissolution of valves evident. Assemblage may be suspect. Smaller forms that are preserved are primarily freshwater (*Navicula contenta, Fragilaria* spp.), implying a freshwater skew to the original, unaltered assemblage.
Species counts: Freshwater 13%; Fresh/Brackish 62%; Brackish 16%; Brackish/Marine 9%

Sample: 27   Core section: 2
Depth below land surface: 1.83m (3.72 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Eunotia monodon, Cymbella minuta*

Environment: Freshwater wetland
Special notes: Preservation poor. Very few diatoms present.
Species counts: Freshwater 67%; Fresh/Brackish 33%

Sample: 158 Core section: 2 (Just after submergence. Event F)
Depth below land surface: 1.99m (3.55 m NGVD)
Sediment description: silt/clay and very fine sand
Pertinent diatom species: *Navicula cari, Achnanthes hauckina, Caloneis westii, Nitzschia constricta, Opephora parva, Paralia sulcata, Thalassiosira* spp.
Environment: Intertidal flat
Special notes: Preservation excellent. Many small and large forms present. Small brackish to marine epipsammic and planktonic species may indicate tsunami transport and deposition of valves.
Species counts: Freshwater 3%; Fresh/Brackish 6%; Brackish 17%; Brackish/Marine 71%; Marine 3%

Sample: 28 Core section: 2 (Just before submergence. Event F)
Depth below land surface: 2.01m (3.54 m NGVD)
Sediment description: organic silt/clay with some fine (1-5mm), sharply delineated laminae of silt to fine sand; sharp lower boundary (~3mm)
Pertinent diatom species: *Eunotia maior, Eunotia pectinalis, Pinnularia acrosphaeria, Aulacosira italica, Gomphonema angustatum, Gomphonema parvulum, Pinnularia subcapitata, Pinnularia viridis, Caloneis westii, Paralia sulcata*
Environment: Brackish high marsh
Special notes: Preservation good. Assemblage a mixture of *in situ* freshwater species and brackish tidal flat species, consistent with tsunami deposit. However, because no sample was analyzed from just below this sample the earthquake hypothesis is unsubstantiated.
Species counts: Freshwater 37%; Fresh/Brackish 57%; Brackish 2%; Brackish/Marine 4%

Sample: 132 Core section: 3
Depth below land surface: 2.64m (2.91 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Epithemia turgida, Epithemia turgida* var. *westermannii, Navicula pusilla, Rhoicosphenia curvata, Paralia sulcata*
Environment: Probably brackish high marsh
Special notes: Preservation moderately poor. Whole diatoms rare and when present are largely robust species.
Species counts: Freshwater 6%; Fresh/Brackish 78%; Brackish/Marine 16.7%

Sample: 131 Core section: 3
Depth below land surface: 2.84m (2.71 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Achnanthes hustedtii,, Caloneis bacillum, Gomphonema parvulum, Navicula elegans, Navicula mutica, Navicula pusilla, Pinnularia lagerstedtii, Diploneis interrupta, Diploneis ovalis, Nitzschia sigma*
Environment: Probably brackish low marsh, or transition from brackish low to high marsh
Special notes: Preservation very good. Many well-preserved diatoms present.
Species counts: Freshwater 2%; Fresh/Brackish 45%; Brackish 18%; Brackish/Marine 29%; Marine 4%; Euryhaline 3%

Sample: 130 Core section: 4
Depth below land surface: 3.7m (1.85 m NGVD)
Sediment description: silt/clay

Pertinent diatom species: *Eunotia pectinalis, Eunotia spp., Pinnularia gibba* var. *linearis, Achnanthes hustedtii, Achnanthes lanceolata, Aulacosira granulata, Gomphonema angustatum, Gomphonema gracile, Gomphonema parvulum, Pinnularia viridis, Achnanthes hauckina, Caloneis westii, Paralia sulcata*
Environment: Brackish high marsh
Special notes: Preservation very good. Many well-preserved diatoms present.
Species counts: Freshwater 20%; Fresh/Brackish 70%; Brackish 4%; Brackish/Marine 6%

Sample: 129 Core section: 4
Depth below land surface: 3.96m (1.59 m NGVD)
Sediment description: silt/clay, some fine (<2mm) silt laminae
Pertinent diatom species: *Epithemia turgida* var. *westermanii, Navicula mutica, Navicula pusilla, Nitzschia granulata, Paralia sulcata, Thalassiosira pacifica,*
Environment: Brackish high marsh
Special notes: Preservation moderately poor. Some diatoms present, but primarily robust forms. Integrity of assemblage suspect.
Species counts: Fresh/Brackish 81%; Brackish 3%; Brackish/Marine 13%; Marine 3%

Sample: 128 Core section: 5
Depth below land surface: 5.13m (0.42 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Eunotia spp., Navicula mutica, Navicula pusilla, Pinnularia lagerstedtii, Rhoicosphenia curvata, Cocconeis disculus, Cyclotella striata, Paralia sulcata*
Environment: Brackish high marsh
Special notes: Preservation moderate. Many diatoms fragmented or dissolved. Assemblage dominated by brackish high-marsh species *Navicula mutica, Navicula pusilla,* and *Pinnularia lagerstedtii* and brackish-marine *Paralia sulcata*.
Species counts: Freshwater 8%; Fresh/Brackish 60%; Brackish 4%; Brackish/Marine 26%

Sample: 127 Core section: 5
Depth below land surface: 5.42m (0.13 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Navicula elegans*, *Navicula mutica, Navicula pusilla, Nitzschia brevissima, Pinnularia lagerstedtii, Navicula cincta, Paralia sulcata*
Environment: Brackish high marsh
Special notes: Preservation good. Assemblage dominated by brackish high-marsh species *Navicula mutica, Navicula pusilla,* and *Pinnularia lagerstedtii* and brackish-marine *Paralia sulcata*
Species counts: Fresh/Brackish 82%; Brackish 2%; Brackish/Marine 15%

Sample: 126 Core section: 5
Depth below land surface: 5.74 (-0.19 m NGVD)
Sediment description: silt/clay and very fine sand
Pertinent diatom species: *Epithemia sorex, Epithemia spp., Navicula cryptonella*
Environment: Brackish high marsh?
Special notes: Preservation very poor. Very few diatoms present, all highly fragmented.
Species counts: Fresh/Brackish 50%; Brackish/Marine 25%

Sample: 125 Core section: 6
Depth below land surface: 6.3m (-0.75 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Cocconeis placentula, Hantzschia amphioxys, Navicula pusilla, Nitzschia brevissima, Paralia sulcata*

Environment: Brackish high marsh
Special notes: Preservation poor. Few diatoms present, all highly fragmented.
Species counts: Fresh/Brackish 71%; Brackish/Marine 14.3%

Sample: 122 Core section: 7
Depth below land surface: 7.52m (-1.97 m NGVD)
Sediment description: clay/silt to very fine sand
Pertinent diatom species: *Achnanthes lanceolata, Achnanthes minutissima, Cocconeis placentula, Cocconeis placentula* var. *euglypta, Navicula mutica, Nitzschia pusilla, Rhoicosphenia curvata, Achnanthes hauckina* var. *rostrata, Cocconeis disculus, Denticula subtilis, Navicula cincta, Synedra fasciculata, Achnanthes delicatula, Opephora parva, Navicula cryptocephala*
Environment: Brackish low marsh or estuarine tidal flat
Special notes: Preservation moderately poor. Many diatoms present, but most are highly fragmented.
Species counts: Freshwater 3%; Fresh/Brackish 45%; Brackish 31%; Brackish/Marine 13%; Marine 3%; Euryhaline 3%

Sample: 121 Core section: 7 (just after submergence. Event G)
Depth below land surface: 7.65m (-2.10 m NGVD)
Sediment description: very fine sandy loam with some clay/silt masses (soft-sediment rip-up clasts?); sharp lower boundary (<2mm)
Pertinent diatom species: *Achnanthes lanceolata, Achnanthes minutissima, Pinnularia intermedia, Achnanthes hauckina* var. *rostrata, Navicula cincta, Achnanthes delicatula, Navicula phyllepta, Navicula rhyncocephala, Opephora parva, Thalassiosira pacifica*
Environment: Mixture of brackish low marsh species with some sandy brackish tidal-flat species. Tsunami deposit?
Special notes: Preservation moderately good. Diatoms fewer in number and more fragmented than in lower deposits. Assemblage dominated by small epispammic diatoms such as *Achnanthes hauckina* var. *rostrata,* and *Opephora parva.* Differences between sample assemblages 121 and 120 are minor, with greater percentages of epipsammic diatoms in the overlying deposit.
Species counts: Fresh/Brackish 44%; Brackish 24%; Brackish/Marine 27%; Marine 3%

Sample: 120 Core section: 7 (just before submergence. Event G)
Depth below land surface: 7.70m (-2.15 m NGVD)
Sediment description: silt/clay with fine (<2mm) organic-rich laminae
Pertinent diatom species: *Navicula leptostriata, Pinnularia krockii, Achnanthes lanceolata*, *Cocconeis placentula, Cocconeis placentula* var. *euglypta, Diatoma mesodon, Epithemia turgida, Gomphonema parvulum, Navicula cryptonella, Navicula tenelloides, Nitzschia inconspicua, Rhoicosphenia curvata, Synedra ulna, Cocconeis disculus, Navicula cincta, Navicula phyllepta, Nitzschia granulata, Thalassiosira pacifica*
Environment: Brackish low to high marsh?
Special notes: Preservation good. Diatom assemblage highly mixed, not indicative of any one specific environment
Species counts: Freshwater 7.5%; Fresh/Brackish 60%; Brackish 14%; Brackish/Marine 16%; Marine 3%

Sample: 119 Core section: 7
Depth below land surface: 7.77m (-2.22 m NGVD)
Sediment description: fine sand and silt
Pertinent diatom species: *Achnanthes lanceolata, Amphora coffeiformis, Cocconeis placentula* var. *euglypta, Nitzschia perminuta, Achnanthes hauckina* var. *rostrata, Navicula cincta, Achnanthes delicatula, Nitzschia granulata, Opephora parva, Opephora marina*
Environment: Sandy, estuarine tidal flat

Special notes: Preservation good. Assemblage dominated by small, epipsammic diatoms such as *Achnanthes hauckina* var. *rostrata, Achnanthes delicatula,* and *Opephora parva*
Species counts: Fresh/Brackish 13%; Brackish 31%; Brackish/Marine 41%; Marine 13%

Sample: 118 Core section: 7
Depth below land surface: 7.92m (-2.37 m NGVD)
Sediment description: silt/clay with organic inclusions (root casts?)
Pertinent diatom species: *Navicula mutica, Navicula pusilla, Nitzschia commutata, Navicula cincta, Delphineis surirella, Dimeregramma minor, Opephora parva, Paralia sulcata, Thalassiosira pacifica*
Environment: Probably low marsh or estuarine tidal flat
Special notes: Preservation moderately good. Many diatoms present, but some fragmentation of valves. Mixed assemblage of brackish high marsh species and brackish marine diatoms. Perhaps indicative of recent rapid rise in sea level
Species counts: Freshwater 1%; Fresh/Brackish 43%; Brackish 10%; Brackish/Marine 42%; Marine 5%

Sample: 117 Core section: 7 (just after submergence. Event H)
Depth below land surface: 8.04m (-2.49 m NGVD)
Sediment description: Normally graded fine sand to silt, abrupt lower boundary (~1mm)
Pertinent diatom species: *Achnanthes lanceolata, Achnanthes minutissima, Achnanthes hauckina, Achnanthes hauckina* var. *rostrata, Catentula adherens, Delphineis surirella, Dimeregramma minor, Opephora parva, Paralia sulcata, Rhaphoneis psammicola, Thalassiosira pacifica*
Environment: brackish-marine (tsunami deposit?)
Special notes: Preservation good. Assemblage dominated by *Achnanthes hauckina* var. *rostrata* and other brackish, epipsammic diatoms. Possible inundation of area by tidal flat deposits following sudden submergence.
Species counts: Freshwater 1%; Fresh/Brackish 7.5%; Brackish 55%; Brackish/Marine 28%; Marine 7.5%; Euryhaline 1%

Sample: 116 Core section: 7 (just before submergence. Event H)
Depth below land surface: 8.06m (-2.51 m NGVD)
Sediment description: silt/clay with many fine (<2mm) organic-rich laminae
Pertinent diatom species: *Achnanthes minutissima, Caloneis bacillum, Navicula mutica, Navicula muticoides, Navicula pusilla, Achnanthes brevipes* var. *intermedia, Caloneis westii, Gyrosigma eximium, Navicula cincta, Nitzschia debilis, Nitzschia sigma, Delphineis surirella, Nitzschia constricta, Nitzschia granulata, Paralia sulcata, Nitzscia compressa var. vexans, Thalassiosira pacifica*
Environment: Mixed fresh/brackish and brackish/marine deposits (low marsh?)
Special notes: Preservation good. Assemblage a mixture of *in situ* brackish to fresh-water diatoms and brackish water species.
Species counts: Freshwater 1%; Fresh/Brackish 47%; Brackish 22%; Brackish/Marine 21%; Marine 9%; Euryhaline 1%

Sample: 115 Core section: 7
Depth below land surface: 8.22m (-2.67 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Frustulia vulgaris; Navicula contenta; Navicula mutica, Navicula pusilla, Nitzschia nana, Pinnularia lagerstedtii, Gyrosigma eximium, Navicula cincta, Navicula pygmaea*
Environment: Brackish high marsh
Special notes: Preservation good. Assemblage dominated by *Navicula mutica, Navicula pusilla,* and *Pinnularia lagerstedtii* group
Species counts: Fresh/Brackish 73%; Brackish 22%; Brackish/Marine 5%

Sample: 113 Core section: 8
Depth below land surface: 8.90m (-3.35 m NGVD)
Sediment description: silt/clay to very fine sands with thick (~2cm) laminae of more highly organic silt to very fine sand
Pertinent diatom species: *Caloneis bacillum*, *Navicula mutica, Navicula pusilla, Nitzschia commutata, Nitzschia nana, Nitzschia palea, Pinnularia lagerstedtii, Gyrosigma eximium, Navicula cincta, Synedra fasciculata*
Environment: Brackish high marsh
Special notes: Preservation good. Assemblage dominated by *Navicula mutica, Navicula pusilla, Navicula cincta* and *Pinnularia lagerstedtii*
Species counts: Fresh/Brackish 62%; Brackish 30%; Brackish/Marine 5%; Euryhaline 2%

Sample: 112 Core section: 8
Depth below land surface: 9.13m (-3.58 m NGVD)
Sediment description: silt/clay with thick (~2cm) laminae of silt
Pertinent diatom species: *Epithemia turgida, Gomphonema parvulum, Navicula pusilla, Pinnularia lagerstedtii, Rhoicosphenia curvata, Navicula cincta, Navicula phyllepta*
Environment: Brackish high marsh
Special notes: Preservation good.
Species counts: Freshwater 6%; Fresh/Brackish 72%; Brackish 13%; Brackish/Marine 7%; Euryhaline 2%

Sample: 111 Core section: 8
Depth below land surface: 9.22m (-3.67 m NGVD)
Sediment description: silt/clay to very fine sand with thick (~2cm) laminae of more highly organic silt to very fine sand
Pertinent diatom species: *Diploneis pseudovalis*, *Navicula mutica, Navicula pusilla, Navicula pusilla* var.*1, Nitzschia nana, Pinnularia lagerstedtii, Cocconeis disculus, Navicula cincta, Synedra fasciculata, Dimeregramma minor*
Environment: Brackish high marsh
Special notes: Preservation good. Assemblage dominated by *Navicula mutica, Navicula pusilla, Navicula cincta* and *Pinnularia lagerstedtii.*
Species counts: Fresh/Brackish 78%; Brackish 14%; Brackish/Marine 6%

Sample: 110 Core section: 8
Depth below land surface: 9.34m (-3.79 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Caloneis bacillum, Navicula mutica, Navicula pusilla, Achnanthes hauckina, Caloneis westii, Nitzschia nana, Pinnularia lagerstedtii, Navicula cincta, Nitzschia sigma, Cocconies scutellum var. parva, Opephora parva*
Environment: Brackish low marsh?
Special notes: Preservation good. Mixture of brackish high marsh species with intertidal or tidal flat diatoms
Species counts: Freshwater 2%; Fresh/Brackish 66%; Brackish 20%; Brackish/Marine 12%;

Sample: 109 Core section: 8
Depth below land surface: 9.46m (-3.91 m NGVD)
Sediment description: silt to very fine sand
Pertinent diatom species: *Eunotia* spp., *Achnanthes lanceolata, Cocconeis placentula* var. *euglypta, Epithemia turgida* var. *westermanii, Navicula mutica, Navicula pusilla, Nitzschia nana, Pinnularia borealis, Pinnularia similiformis, Rhoicosphenia curvata, Synedra ulna, Gyrosigma eximium, Navicula cincta, Nitzschia sigma, Rhopalodia musculus, Cocconeis scutellum var. parva, Opephora parva*
Environment: Brackish high or low marsh?

Special notes: Preservation good. Mixture of fresh to brackish high marsh species with intertidal or tidal flat diatoms.
Species counts: Freshwater 2%; Fresh/Brackish 69%; Brackish 15%; Brackish/Marine 14%;

Sample: 108 Core section: 8
Depth below land surface: 9.48m (-3.93 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Navicula mutica, Navicula pusilla, Nitzschia commutata, Nitzschia palea, Nitzschia scapelliformis, Caloneis westii, Gyrosigma balticum, Gyrosigma eximium, Navicula cincta, Nitzschia sigma, Rhopalodia musculus, Synedra fasciculata, Delphineis surirella, Nitzschia granulata, Thalassiosira pacifica*
Environment: Brackish low marsh
Special notes: Preservation good. Assemblage dominated by low marsh species
Species counts: Fresh/Brackish 29%; Brackish 42%; Brackish/Marine 27%; Marine 2%

Sample: 107 Core section: 9 (just after submergence. Event I)
Depth below land surface: 9.88m (-4.33 m NGVD)
Sediment description: coarse to fine sand; sharp lower boundary (<3mm)
Pertinent diatom species: *Navicula mutica, Navicula pusilla, Nitzschia scapelliformis, Pinnularia lagerstedtii, Achnanthes hauckina, Cocconeis disculus, Navicula cincta, Synedra fasciculata, Nitzschia granulata, Paralia sulcata*
Environment: Intertidal flat or subtidal channel
Special notes: Preservation good. Mixture of *in situ* high marsh species with tidal flat species is consistent sudden subsidence
Species counts: Freshwater 1%; Fresh/Brackish 59%; Brackish 21%; Brackish/Marine 19%; Euryhaline 1%

Sample: 106 Core section: 9 (just before submergence. Event I)
Depth below land surface: 10.04m (-4.49 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Cocconeis placentula* var. *euglypta, Epithemia turgida, Hantzschia amphioxys, Pinnularia borealis*
Environment: Brackish high marsh
Special notes: Preservation poor. Diatoms highly fragmented. Much of the assemblage consists of unidentified *Synedra, Epithemia,* and *Pinnularia* spp., which are commonly associated with freshwater or fresh-brackish deposits.
Species counts: Freshwater 4%; Fresh/Brackish 54%

Sample: 87 Core section: 13
Depth below land surface: 15.16m (-9.61 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Aulocosira granulata, Aulocosira islandica, Fragilaria* spp.*, Navicula mutica, Tabellaria fenestrata*
Environment: Brackish high marsh or freshwater wetland
Special notes: Preservation moderate. Many diatoms partially dissolved. Assemblage dominated by *Fragilaria* and the planktonic *Aulocosira* species, which may indicate freshwater ponding.
Species counts: Freshwater 4%; Fresh/Brackish 87%; Brackish 1%; Brackish/Marine 4%; Euryhaline 2%

Sample: 78 Core section: 15 (just after submergence. Event J)
Depth below land surface: 17.165m (-11.62 m NGVD)
Sediment description: fine sand; sharp lower boundary (<2mm)
Pertinent diatom species: *Aulocosira spp., Fragilaria* spp.*, Melosira roeseana, Stauroneis anceps, Tabellaria fenestrata, Achnanthes exigua*

Environment: Brackish high marsh- ponding? Or transport from a lower, channel bank locality?
Special notes: Preservation moderate. Assemblage dominated by freshwater to fresh-brackish species often associated with standing water. May be indicative of a wetter, ponded brackish high marsh or the assemblage may indicate planktonic transport from a channel-fringing low marsh.
Species counts: Freshwater 7%; Fresh/Brackish 63%; Brackish 5%; Brackish/Marine 2%; Euryhaline 5%

Sample: 77 Core section: 15 (just before submergence. Event J)
Depth below land surface: 17.19m (-11.64 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Synedra* spp.
Environment: Freshwater wetland?
Special notes: Highly fragmented, very few in number; 100% of diatoms are *Synedra* spp.
Species counts:

Sample: 73 Core section: 15
Depth below land surface: 17.70m (-12.15 m NGVD)
Sediment description: silt/clay
Pertinent diatom species:
Environment: Freshwater wetland?
Special notes: Preservation very poor. Only unidentified *Epithemia* spp. present.
Species counts:

Sample: 72 Core section: 15
Depth below land surface: 17.75m (-12.20 m NGVD)
Sediment description: medium to fine sand
Pertinent diatom species: Only species present is *Nitzschia brevissima*
Environment: Freshwater wetland? Brackish high marsh?
Special notes: Preservation very poor. Almost no diatoms present.
Species counts: Fresh/Brackish 100%

Sample: 71 Core section: 15
Depth below land surface: 17.80m (-12.25 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species:
Environment: Freshwater wetland? Brackish high marsh?
Special notes: Preservation very poor. Few diatoms, most highly fragmented. Only unidentified *Epithemia* and *Synedra* spp. present
Species counts:

Sample: 70 Core section: 15
Depth below land surface: 18.00m (-12.45 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Cymbella sinuata, Navicula mutica, Pinnularia borealis, Synedra ulna, Cocconeis scutellum* var. *parva*
Environment: Brackish high marsh?
Special notes: Preservation very poor. Few diatoms, most highly fragmented. Assemblage dominated by *Synedra* species.
Species counts: Fresh/Brackish 67%; Brackish/Marine 11%

Sample: 68 Core section: 16

Depth below land surface: 18.6m (-13.05 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Cocconeis scutellum* var. *parva*
Environment: Brackish low or high marsh?
Special notes: Preservation very poor. Few diatoms, most highly fragmented and/or dissolved. Only *Cocconeis scutellum* var. *parva* identifiable.
Species counts: Brackish/Marine 50%

Sample: 67   Core section: 16
Depth below land surface: 18.95m (-13.40 m NGVD)
Sediment description: silt/clay and fine to medium sand
Pertinent diatom species: *Navicula mutica, Stauroneis anceps, Synedra ulna, Cocconeis scutellum, Cocconeis scutellum* var. *parva*
Environment: Brackish low marsh?
Special notes: Preservation very poor. Few diatoms, most highly fragmented and/or dissolved.
Species counts: Fresh/Brackish 63%; Brackish/Marine 25%

Sample: 66   Core section: 16
Depth below land surface: 19.37m (-13.82 m NGVD)
Sediment description: medium to fine sand
Pertinent diatom species: *Achnanthes lanceolata, Cocconeis placentula, Cocconeis placentula* var. *euglypta, Cymbella sinuata, Navicula mutica, Rhopalodia gibba, Synedra ulna, Navicula rhyncocephala*
Environment: Brackish high marsh?
Special notes: Preservation moderately good, but few valves present.
Species counts: Freshwater 5%; Fresh/Brackish 90%; Brackish/Marine 5%

Sample: 65   Core section: 16
Depth below land surface: 19.39m (-13.84 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Achnanthes lanceolata, Cocconeis diminuta, Cocconeis placentula* var. *euglypta, Cymbella sinuata, Epithemia sorex, Epithemia turgida var. westermannii, Gomphonema parvulum, Rhoicosphenia curvata, Rhopalodia gibba, Synedra ulna, Amphora ovalis* var. *pediculus, Diploneis smithii*

Environment: Brackish high marsh?
Special notes: Preservation moderately poor. Few diatoms, many highly fragmented.
Species counts: Freshwater 2%; Fresh/Brackish 85%; Brackish 8%; Brackish/Marine 4%

Sample: 64   Core section: 16
Depth below land surface: 19.45m (-13.90 m NGVD)
Sediment description: fine sand to silt
Pertinent diatom species: *Cocconeis placentula* var. *euglypta, Rhoicosphenia curvata, Navicula cincta, Cocconeis spp.*
Environment: Brackish high marsh?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Fresh/Brackish 53%; Brackish 12%

Sample: 63   Core section: 17
Depth below land surface: 19.77m (-14.22 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Eunotia monodon, Gomphonema parvulum, Navicula contenta, Navicula mutica, Synedra ulna*

Environment: Brackish high marsh? Freshwater wetland?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Freshwater 10%; Fresh/Brackish 70%

Sample: 57 Core section: 18
Depth below land surface: 20.86m (-15.31 m NGVD)
Sediment description: silt/clay to medium sand
Pertinent diatom species: *Gomphonema parvulum, Synedra ulna, Synedra* spp.
Environment: Brackish high marsh? Freshwater wetland?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Fresh/Brackish 50%

Sample: 56 Core section: 18
Depth below land surface: 21.02m (-15.47 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Cocconeis placentula* var. *euglypta, Epithemia turgida* var. *westermannii, Epithemia zebra, Fragilaria capuchina var. vaucherie, Gomphonema parvulum, Navicula mutica,Cocconeis disculus, Navicula cincta*
Environment: Brackish high marsh?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Fresh/Brackish 67%; Brackish 22%

Sample: 55 Core section: 18
Depth below land surface: 21.10m (-15.55 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Cocconeis diminuta, Cocconeis placentula* var. *euglypta, Navicula gallica var. perpusilla, Stauroneis anceps, Epithemia* spp.
Environment: Brackish high marsh? Freshwater wetland?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Fresh/Brackish 46%

Sample: 54 Core section: 18
Depth below land surface: 21.21m (-15.66 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Achnanthes lanceolata*, *Cocconeis placentula, Cocconeis placentula* var. *euglypta, Epithemia turgida* var. *westermannii, Nitzschia palea, Stauroneis phoenicenteron, Epithemia* spp., *Nitzschia* spp.
Environment: Brackish high marsh? Freshwater wetland?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Fresh/Brackish 58%

Sample: 53 Core section: 18
Depth below land surface: 21.59m (-16.04 m NGVD)
Sediment description: silt/clay to medium sand
Pertinent diatom species: *Eunotia pectinalis, Nedium hercynicum, Cocconeis placentula, Cocconeis placentula* var. *euglypta, Epithemia turgida* var. *westermannii, Meridion circulare* var. *constricta, Navicula mutica, Synedra ulna, Navicula cincta*
Environment: Brackish high or low marsh?
Special notes: Preservation very poor. Few diatoms, most highly fragmented and dissolved.
Species counts: Freshwater 10%; Fresh/Brackish 45%; Brackish 15%

Sample: 52 Core section: 18 (Just after submergence. Event K)
Depth below land surface: 21.77m (-16.22 m NGVD)
Sediment description: silt/clay to medium sand
Pertinent diatom species: *Achnanthes lanceolata*, *Cocconeis placentula, Cocconeis placentula* var. *euglypta, Epithemia turgida* var. *westermanii, Hantzschia amphioxys, Navicula mutica, Pinnularia borealis, Synedra ulna, Amphora proteus, Navicula perminuta*
Environment: Brackish high to low marsh?
Special notes: Preservation moderately poor. Few diatoms, most highly fragmented. Mixture of fresh and brackish diatoms may indicate sudden salinity change.
Species counts: Freshwater 3.6%; Fresh/Brackish 89%; Brackish 1.8%; Marine/Brackish 3.6%

Sample: 51 Core section: 18 (Just before submergence. Event K)
Depth below land surface: 21.83m (-16.28 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Diatoma anceps*, *Eunotia pectinalis, Epithemia sorex, Navicula mutica, Rhoicosphenia curvata, Synedra* spp.
Environment: Brackish high marsh? Freshwater wetland?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Freshwater 14%; Fresh/Brackish 50%

Sample: 50 Core section: 19
Depth below land surface: 22.03m (-16.48 m NGVD)
Sediment description: silt/clay to coarse sand, some pebbles
Pertinent diatom species: *Aulacosira islandica*, *Cocconeis placentula* var. *euglypta*
Environment: Freshwater wetland?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Fresh/Brackish 75%

Sample: 49 Core section: 19
Depth below land surface: 22.24m (-16.69 m NGVD)
Sediment description: silt/clay to medium sand
Pertinent diatom species: *Cocconeis placentula* var. *euglypta, Navicula pusilla, Diploneis interrpta, Navicula cincta, Nitzschiza constricta, Navicula granulata, Paralia sulcata*
Environment: Brackish high marsh?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Fresh/Brackish 20%; Brackish 20%; Brackish/Marine 30%

Sample: 48 Core section: 19
Depth below land surface: 22.35m (-16.80 m NGVD)
Sediment description: silt/clay to medium sand
Pertinent diatom species: *Navicula mutica, Diploneis* spp., *Nitzschia* spp.
Environment: Brackish high marsh?
Special notes: Preservation very poor. Few diatoms, most highly fragmented.
Species counts: Fresh/Brackish 33%

Sample: 47 Core section: 19
Depth below land surface: 22.43m (-16.88 m NGVD)
Sediment description: medium to fine sand
Pertinent diatom species: *Cocconeis diminuta, Pinnularia similiformis, Diploneis* spp.*, Nitzschia* spp.*, Synedra* spp.

Environment: Brackish high marsh?
Special notes: Preservation very poor. Few diatoms, mostly fragmented
Species counts: Fresh/Brackish 40%

Sample: 46 Core section: 19
Depth below land surface: 22.56m (-17.01 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Amphora ovalis* var. *affinis*, *Cocconeis placentula* var. *euglypta, Navicula mutica, Rhoicosphenia curvata, Synedra ulna, Epithemia* spp.
Environment: Brackish high marsh? Freshwater wetland?
Special notes: Preservation moderately poor. Very few diatoms present.
Species counts: Fresh/Brackish 63%

Sample: 45 Core section: 19
Depth below land surface: 22.73m (-17.18 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Eunotia spp., Pinnularia gibba* var. *linearis, Cocconeis placentula* var. *euglypta, Cymbella sinuata, Epithemia sorex, Epithemia zebra, Fragilaria brevistriata, Navicula mutica, Pinnularia borealis, Rhoicosphenia curvata, Synedra ulna, Nitzschia* spp., *Synedra* spp.
Environment: Brackish high marsh
Special notes: Preservation moderate.
Species counts: Freshwater 6%; Fresh/Brackish 67%

Sample: 44 Core section: 19
Depth below land surface: 23.05m (-17.50 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Cocconeis placentula* var. *euglypta, Navicula lanceolata, Navicula mutica, Nitzschia terrestris, Pinnularia borealis, Synedra ulna, Fragilaria* spp.
Environment: Brackish high marsh? Freshwater area?
Special notes: Preservation poor.
Species counts: Fresh/Brackish 50%

Sample: 43 Core section: 20
Depth below land surface: 23.24m (-17.69 m NGVD)
Sediment description: silt/clay to very fine sand
Pertinent diatom species: *Cocconeis placentula* var. *euglypta, Navicula mutica, Pinnularia borealis, Cocconeis spp., Synedra* spp.
Environment: Brackish high marsh? Freshwater area?
Special notes: Preservation very poor.
Species counts: Fresh/Brackish 60%

Sample: 41 Core section: 20 (Just after submergence. Event L)
Depth below land surface: 23.48m (-17.93 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Eunotia* spp., *Cocconeis placentula* var. *euglypta, Nitzschia commutata, Pinnularia subcapitata, Pinnularia viridis, Rhoicosphenia curvata, Stauroneis anceps, Stauroneis spp., Synedra ulna, Achnanthes brevipes* var. *intermedia, Synedra fasciculata, Cocconeis scutellum*
Environment: Brackish low marsh or intertidal zone
Special notes: Preservation moderately poor. Many valves broken/dissolved. Assemblage a mix of *in situ* freshwater diatoms and intertidal species, possibly indicative of a rapid rise in relative sea level
Species counts: Freshwater 6%; Fresh/Brackish 58%; Brackish 8%; Brackish/Marine 19%

Sample: 40 Core section: 20 (Just before submergence. Event L)
Depth below land surface: 23.5m (-17.95 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Eunotia* spp., *Synedra rumpens, Cocconeis placentula* var. *euglypta, Cymbella sinuata, Diatoma mesodon, Navicula contenta, Navicula gallica* var. *perpusilla, Pinnularia subcapitata, Rhoicosphenia curvata, Synedra ulna*
Environment: Brackish high marsh
Special notes: Preservation moderately poor. Assemblage dominated by freshwater to fresh/brackish species.
Species counts: Freshwater 14%; Fresh/Brackish 76%; Brackish 3%; Marine 3%

Sample: 39 Core section: 20
Depth below land surface: 23.68m (-18.13 m NGVD)
Sediment description: fine sand
Pertinent diatom species: *Gomphonema parvulum, Cybella sinuata, Epithemia sorex, Navicula mutica, Synedra ulna, Stauroneis* spp*., Synedra* spp.
Environment: Brackish high marsh
Special notes: Preservation poor.
Species counts: Fresh/Brackish 75%

Sample: 38 Core section: 20
Depth below land surface: 23.83m (-18.28 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Eunotia* spp., *Cocconeis placentula* var. *euglypta, Epithemia turgida* var. *westermannii, Synedra ulna, Epithemia* spp*., Synedra* spp.
Environment: Freshwater wetland? Brackish high marsh?
Special notes: Preservation poor. Very few diatoms present, many valves partially dissolved. Assemblage dominated by *Eunotia, Epithemia*, and *Synedra* species
Species counts: Freshwater 29%; Fresh/Brackish 41%

Sample: 37 Core section: 20
Depth below land surface: 23.92m (-18.37 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Cocconeis placentula* var. *euglypta, Synedra* spp.
Environment: Freshwater wetland? Brackish high marsh?
Special notes: Preservation very poor. Very few diatoms present.
Species counts: Fresh/Brackish 25%

Sample: 35 Core section: 20
Depth below land surface: 23.98m (-18.43 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Pinnularia borealis, Stauroneis kriegerii, Synedra ulna*
Environment: Freshwater wetland? Brackish high marsh?
Special notes: Preservation very poor. Very few diatoms present.
Species counts: Fresh/Brackish 75%

Sample: 31-34 Core section: 20
Depth below land surface: 24.13 to 24.22m (-18.58 to –18.67 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Synedra spp.*

Environment: Freshwater wetland? Brackish high marsh?
Special notes: Preservation very poor. Only highly fragmented *Synedra* spp. present
Species counts: Fresh/Brackish 100%

Sample: 17 Core section: 21
Depth below land surface: 24.46m (-18.91 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Achnanthes lanceolata, Aulacosira islandica, Cocconeis placentula* var. *euglypta, Navicula contenta, Navicula gallica* var. *perpusilla, Pinnularia borealis, Synedra ulna*
Environment: Freshwater wetland? Brackish high marsh?
Special notes: Preservation poor. Very few diatoms present, predominantly fragmented.
Species counts: Fresh/Brackish 91%

Sample: 16 Core section: 21
Depth below land surface: 24.56m (-19.01 m NGVD)
Sediment description: silt/clay to fine sand
Pertinent diatom species: *Epithemia turgida, Synedra ulna, Cocconeis scutellum, Thalassiosira discepens*
Environment: Brackish high marsh? Brackish low marsh?
Special notes: Preservation very poor. Very few diatoms present, mostly fragmented.
Species counts: Fresh/Brackish 62.5%; Brackish/Marine 25%

Sample: 15 Core section: 21
Depth below land surface: 24.79m (-19.24 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Eunotia maior, Aulacosira granulata, Cocconeis diminuta, Cymbella cistula, Synedra ulna, Cocconeis scutellum var. parva, Gyrosigma eximium, Epithemia* spp.
Environment: Brackish high marsh? Brackish low marsh?
Special notes: Preservation poor. Very few diatoms present, but fragile forms (ex. *Gyrosigma eximium)* found relatively whole.
Species counts: Freshwater 10%; Fresh/Brackish 50%; Brackish 10%; Brackish/Marine 10%

Sample: 14 Core section: 21
Depth below land surface: 25.00m (-19.45 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Achnanthes coarctata, Diatoma anceps, Aulacosira granulata, Pinnularia similiformis, Synedra ulna, Achnanthes brevipes* var. *intermedia, Nitzschia compressa, Thalassiosira lacustris*
Environment: Brackish high marsh? Brackish low marsh?
Special notes: Preservation very poor. Very few diatoms present, all fragmented.
Species counts: Freshwater 14%; Fresh/Brackish 43%; Brackish 7%; Brackish/Marine 21%

Sample: 13 Core section: 21
Depth below land surface: 25.18m (-19.63 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Cocconeis placentula* var. *euglypta, Synedra ulna*
Environment: Brackish high marsh? Freshwater wetland?
Special notes: Preservation very poor. Very few diatoms present, all fragmented.
Species counts: Fresh/Brackish 100%

Sample: 12 Core section: 21

Depth below land surface: 25.28m (-19.73 m NGVD)
Sediment description: silt/clay to very fine sand
Pertinent diatom species: *Synedra ulna, Tabellaria* spp.
Environment: Brackish high marsh? Freshwater wetland?
Special notes: Preservation very poor. Very few diatoms present.
Species counts: Fresh/Brackish 50%

Sample: 11 Core section: 21
Depth below land surface: 25.39m (-19.84 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Aulacosira granulata, Cocconeis disculus*
Environment: Brackish high marsh?
Special notes: Preservation very poor. Very few diatoms present.
Species counts: Fresh/Brackish 50%; Brackish 50%

Sample: 10 Core section: 21
Depth below land surface: 25.46m (-19.91 m NGVD)
Sediment description: silt/clay to very fine sand
Pertinent diatom species: *Aulacosira granulata, Nitzschia nana, Synedra ulna, Paralia sucata*
Environment: Brackish high marsh?
Special notes: Preservation very poor. Very few diatoms present.
Species counts: Fresh/Brackish 80%; Brackish/Marine 20%

Sample: 8 Core section: 22
Depth below land surface: 25.68m (-20.13 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Pinnularia subgibba, Caloneis bacillum, Navicula mutica, Navicula pusilla, Nitzschia scapelliformis, Pinnularia lagerstedtii, Achnanthes hauckina, Navicula cincta, Navicula peregrina, Synedra fasciculata, Delphineis surirella, Paralia sulcata, Actinoptychus vulgaris, Navicula cryptocephala*
Environment: Brackish low marsh
Special notes: Preservation moderately good. Assemblage dominated by the *Navicula mutica, Navicula pusilla, Pinnularia lagerstedtii* group and *Delphineis surirella,* a marine tychoplankton.
Species counts: Freshwater 3%; Fresh/Brackish 51%; Brackish 15%; Brackish/Marine 17%; Marine 2%; Euryhaline 2%

Sample: 7 Core section: 22
Depth below land surface: 25.47m (-20.19 m NGVD)
Sediment description: silt/clay
Pertinent diatom species: *Dimeregramma minor, Paralia sulcata*
Environment: Brackish low marsh? Estuarine tidal flat or channel?
Special notes: Preservation very poor. Very few diatoms present.
Species counts: Brackish/Marine 100%

Sample: 4 Core section: 22
Depth below land surface: 26.168m (-20.62 m NGVD)
Sediment description: silt/clay to very fine sand
Pertinent diatom species: *Achnanthes hustedtii, Achnanthes lanceolata, Navicula contenta, Navicula mutica, Navicula pusilla, Nitzschia palea, Achnanthes hauckina, Navicula cincta, Synedra fasciculata, Cocconeis scutellum, Dimeregramma minor, Nitzschia obtusa, Opephora parva, Paralia sulcata, Navicula cryptocephala, Nitzschia* spp.
Environment: Estuarine tidal flat or channel

Special notes: Preservation moderately poor. Many diatoms present, but very fragmented. Fresh/brackish portion of assemblage dominated by *Navicula mutica*. Small, brackish epipsammic diatoms common.
Species counts: Freshwater 3%; Fresh/Brackish 47%; Brackish 19%; Brackish/Marine 18%; Marine 2%; Euryhaline 3%

CORE 6: Diatom Analysis

Sample: 6-21 Core section: 9 (Just after submergence. Event G)
Depth below land surface: 9.82m (-4.36 m NGVD)
Sediment description: silt to coarse sand and pebbles
Pertinent diatom species: *Cocconeis delicatula, Navicula mutica, Nitzschia nana, Achnanthes haukina, Rhopalodia muscalus, Achnanthes delicatula, Cocconeis scutellum* var. *parva, Delphineis surirella, Opephora parva, Paralia sulcata, Thalassiosira*
Environment: Estuarine tidal flat or channel
Special notes: Preservation good. Many diatoms present, some fragmentation. Fresh/brackish portion of assemblage dominated by *Navicula mutica*. Small, brackish epipsammic diatoms common.
Species counts: Freshwater 1%; Fresh/Brackish 33%; Brackish 29%; Brackish/Marine 28%; Marine 5%; Euryhaline 2%

Sample: 6-20 Core section: 9 (Just before submergence. Event G)
Depth below land surface: 9.86m (-4.40 m NGVD)
Sediment description: silt/clay to very fine sand
Pertinent diatom species: *Caloneis bacillum, Diploneis pseudovalis, Navicula mutica, Navicula pusilla, Pinnularia lagerstedtii, Navicula tenelloides, Nitzschia nana, Gyrosigma eximium, Navicula cincta, Nitzschia debilis, Navicula phyllepta, Nitzschia constricta*
Environment: High to low brackish marsh
Special notes: Preservation good. Dominant species *Navicula mutica, Navicula pusilla,* and *Pinnularia lagerstedtii* imply brackish high marsh, but many low marsh species imply more of a transitional zone between high and low region.
Species counts: Freshwater 1%; Fresh/Brackish 66%; Brackish 23%; Brackish/Marine 11%

Sample: 6-18 Core section: 9
Depth below land surface: 10.24m (-4.78 m NGVD)
Sediment description: upward fining fine sand to silt
Pertinent diatom species: *Navicula mutica, Nitzschia nana, Nitzschia palea, Cocconeis disculus, Navicula gregaria,* numerous marine/brackish, epipelic *Nitzschia* spp.
Environment: Intertidal mud flat, channel bank, or low brackish marsh
Special notes: Preservation excellent. Many fragile epipelic species occur as whole valves. Dominant fresh/brackish species is *Navicula mutica*, a species commonly found in low marshes. Other dominant group includes intertidal mud flat *Nitzschia* spp.
Species counts: Freshwater 3%; Fresh/Brackish 58%; Brackish 26%; Brackish/Marine 11%; Maine 1%; Euryhaline 1%

Sample: 6-17 Core section: 9
Depth below land surface: 10.26m (-4.80 m NGVD)
Sediment description: silt/clay to very fine sand
Pertinent diatom species: *Nitzschia angustulata, Navicula mutica,* numerous fresh/brackish, brackish, and marine/brackish epipelic *Nitzschia* spp., *Cocconeis disculus*, *Opephora parva*
Environment: Intertidal mud/sand flat
Special notes: Preservation good, many fragile valves present and intact. Many epipsammic or epipelic brackish species indicates intertidal flat.

Species counts: Freshwater 3%; Fresh/Brackish 54%; Brackish 21%; Brackish/Marine 20%; Marine 1%

Sample: 6-16 Core section: 9 (Just after submergence. Event H)
Depth below land surface: 10.36m (-4.90 m NGVD)
Sediment description: silt/clay with very fine laminae of silt to fine sand
Pertinent diatom species: *Nitzschia angustulata,* numerous fresh/brackish, brackish, and marine/brackish epipelic *Nitzschia* spp,,*Denticula subtilis, Gyrosigma eximium, Navicula cincta, Navicula pygmaea*
Environment: Intertidal mud flat
Special notes: Preservation good. Intertidal epipelic species most common
Species counts: Freshwater 3%; Fresh/Brackish 33%; Brackish 38%; Brackish/Marine 23%; Marine 3%; Euryhaline 1%

Sample: 6-15 Core section: 9 (Just before submergence. Event H)
Depth below land surface: 10.42m (-4.96 m NGVD)
Sediment description: silt/clay; highly organic
Pertinent diatom species: *Eunotia* spp., *Aulocosira* spp., *Tabellaria* spp., *Cymbella minuta, Cymbella pusilla, Fragilaria* spp.*, Nitzschia compressa, Nitzschia constricta*
Environment: Freshwater wetland to high brackish marsh
Special notes: Preservation excellent. Most common forms are *Aulocosira* and *Tabellaria* spp., which imply standing freshwater
Species counts: Freshwater 4%; Fresh/Brackish 67%; Brackish 4%; Brackish/Marine 7%; Euryhaline 17%

Sample: 6-14 Core section: 9
Depth below land surface: 10.70m (-5.74 m NGVD)
Sediment description: silt/clay, organic laminae
Pertinent diatom species: *Eunotia* spp., *Stauroneis smithii, Achnanthes lanceolata, Cyclotella meneghiniana, Gomphonema parvulum, Tabellaria fenestrata*
Environment: Frashwater wetland
Special notes: Preservation excellent. Most common species is *Tabellaria fenestrata,* often indicate standing freshwater
Species counts: Freshwater 18%; Fresh/Brackish 80%; Brackish/Marine 2%

Sample: 6-13 Core section: 9
Depth below land surface: 10.80m (-5.34 m NGVD)
Sediment description: silt/clay to very fine sand
Pertinent diatom species: *Eunotia* spp., *Cyclotella meneghiniana, Diatoma tenue, Rhopalodia gibba, Tabellaria fenestrata*
Environment: Freshwater wetland to high brackish marsh
Special notes: Preservation good. Fresh to fresh/brackish forms most common.
Species counts: Freshwater 10%; Fresh/Brackish 82%; Brackish 2%; Brackish/Marine 6%

Sample: 6-12 Core section: 9
Depth below land surface: 10.82m (-5.36 m NGVD)
Sediment description: silt/clay to very fine sand
Pertinent diatom species: *Eunotia* spp., *Cyclotella meneghiniana, Diatoma mesodon, Diatoma tenue, Gomphonema angustulum, Gomphonema parvulum, Navicula mutica*
Environment: Freshwater wetland to high brackish marsh
Special notes: Preservation good. Fresh to fresh/brackish forms most common.
Species counts: Freshwater 30%; Fresh/Brackish 59%; Brackish 1%; Marine 3%; Euryhaline 7%