SEDIMENT ACCRETION AND COMPOSITION IN FOUR MARSHES OF THE CHESAPEAKE BAY

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HPEL Data Report #

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1. INTRODUCTION

1.1 Project Description

Funding was provided by NOAA in 1993 to investigate the nutrient recycling times of marsh systems. Short turnover times and dynamic fluxes are expected in the flooding water, while plant biomass is expected to delay nutrient uptake and release over the course of a year. The longest time scale of nutrient removal from the system is incorporation into the sediments of the marsh. Sediment generation through the burial of both organic matter from the marsh plants and inorganic matter from flooding waters results in vertical accretion of the marsh surface. Nutrients within this matrix are permanently removed from the estuary. Here we present the data gathered which was used to estimate long term nutrient retention by four Chesapeake Bay marsh systems.

1.2 Tidal Marshes and Water Quality

The importance of coastal marshes in estuarine nutrient cycles remains an issue for debate among mangers and scientists alike. The role of tidal marshes in the nutrient budgets of the Chesapeake Bay remains unknown. With approximately one million acres of wetlands surrounding it (Field et al. 1991), the Chesapeake Bay has the potential to be strongly impacted by any marsh-water interactions within the system. Tidal flux studies which examine the exchange of dissolved nutrients between marshes and the Chesapeake Bay have been completed in several Chesapeake subestuaries (Jordan et al. 1983, Stevenson et al. 1977). Detailed accretion studies in the Chesapeake Bay marshes have not examined nutrient burial, but have instead focussed on slowly accreting marshes which are being converted to open water systems (Stevenson et al. 1985, Kearney & Ward 1986, Stevenson et al. 1988).

The first step in understanding the role of the tidal marshes in permanent nutrient retention is to find their rate of sedimentation.

Sedimentation is a combination of the burial of both allochthonous and autochthonous material and can remove unknown quantities of nutrients and contaminants (DeLaune 1981, Puckett et al. 1993). Burial of nutrients in the sediments removes them from the estuarine system (Libes 1992, Nixon 1980) and without physical disturbances, may be permanently retained. Removal of nutrients from the surrounding estuarine system reduces the potential for eutrophication (Nixon 1980).

1.3 Site Selection

Four systems of the Chesapeake Bay were investigated (Figure 1a). Brackish sites along the Choptank River were sampled, with plant communities dominated by *Spartina alterniflora*, *S. patens*, and *Typha* spp. (Figure 1b). Sampling sites in Monie Bay National Estuarine Research Reserve were found in plant communities dominated by *Spartina alterniflora*, with *S. cynosuroides* and *Juncus romerianus* also present (Figure 1c). All sites sampled in Monie Bay were brackish, with salinity always greater than ~2 psu. Cores were also collected from the Monie Bay sites with known rates of vertical accretion, previously determined by Ward et al. (1988). Tidal freshwater marshes were sampled on Otter Creek and the Patuxent River. Vegetation in the sampled reaches consisted of *Spartina alterniflora*, *S. patens*, *S. cynosuroides*, *Peltandra virginica*, *Nuphar advena*, *Arrow arum*, *Typha* spp., *Scirpus americanus*, *Hibiscus* spp., *Impatiens capensis*, and *Zizania aquatica*. Three cores were collected from Otter Creek National Estuarine Research Reserve, on the Bush River at the north tip of the Chesapeake Bay (Figure 1d). Brackish and tidal fresh marshes fringing the Patuxent River on the western shore of Chesapeake Bay were sampled, including Jug Bay National Estuarine Research Reserve (Figure 1e). Salinity was generally less than 1.0 ppt.

2. SAMPLING TECHNIQUES AND ANALYSIS

2.1 Sample Collection

During the summers of 1993 and 1994 cores were collected to a meter in depth. A McAuley corer was used to reduce compaction of the cores (Bricker 1989). The cores were sectioned into 3, 5 and 10 cm sections in the field, stored on ice, and returned to the lab for analysis.

2.2 Physical Properties

Samples were weighed and volume was determined by displacement of water to calculate wet bulk density for each sample. After drying and reweighing, samples were ground with a mortar and pestle, and dry density was determined for each sample by dividing the dry weight by the original sample volume. Loss on ignition was calculated as the percent of weight lost in a sample following the ignition of a subsample in a 550°C muffle furnace for 2.5 hours.

2.3 Analysis of ^{210}Pb

Polonium-210, assumed to be in secular equilibrium with ^{210}Pb, was analyzed using a hot acid digestion. A known quantity of polonium tracer was added to 1 g of sample. Analysis of each core was carried out using either ^{208}Po or ^{209}Po for all of the selected sections. Polonium-210 was extracted from the samples using an acid digestion with concentrated HNO_3 and HCl at 80-90°C (Sugai 1990). Centrifugation removed particulates from the solution, which was repeatedly evaporated and diluted with 6 N HCl to replace nitrates which interfere with plating. A weak acid solution (0.10 N HCl) was used to increase the volume and create the plating solution. Iron interference was reduced by the addition of ascorbic acid. Both polonium isotopes were plated on silver and counted on an alpha counting system. Uncertainty associated with the counting system was always less than $\pm$10%. Measured ^{208}Po or ^{209}Po activity was used to calculate ^{210}Po activity originating from the sediment sample by comparison of integrated peak values. Results from the two tracers were not significantly different (ANOVA F-test, alpha = 0.05). A linear regression of unsupported ^{210}Pb activity against depth produced rates of vertical accretion. Regressions of unsupported ^{210}Pb activity with cumulative bulk density produced rates of mass sediment deposited per sqare meter of marsh.

2.4 Nutrient Analysis

Phosphorus (total and inorganic) was analyzed from 1 N HCl extractions of ashed and unashed samples (Aspila et al. 1976) using the molybdenum blue technique of Parsons et al. (1984). Organic P was calculated as the difference between total and inorganic P. Repeated measurements were within $\pm$5%. Nitrogen analysis was carried out using a Control Instruments CHN analyzer with a precision better than 5% for both elements. Iron and manganese were analyzed on the 1 N HCl extractions using a Flame Atomic Absorption Spectrophotometer (Flame AAS). Nutrient and metals concentrations are expressed in mg per gram sediment on a dry weight basis. A representative core was selected from each ecosystem to discuss intersystem variability in this data report.

3. SEDIMENT COMPOSITION AND ACCRETION

3.1 Physical characteristics

General sediment composition changed with each marsh system examined in this study. Water content of 50-90% was observed, with small decreases with depth. All locations showed similar values (Figure 2). Organic content, represented by percent weight lost on ignition, was most variable in the Patuxent River and Monie Bay cores (Figure 2). Patuxent sediments exhibited high surface organic matter content, while Monie Bay's highest values were found in the deep sections. Otter Creek and Choptank River sediments maintained constant organic content through depth, with more organic matter in the Choptank River sites. The percent lost on ignition ranged between 10 and 70%, with the highest values from the Patuxent River and Monie Bay systems. Dry density of the marsh sediments reached values of 1.0 g cm^{-1} in the Otter Creek cores, with lower densities in the other systems (Figure 2). Dry density was essentially constant with depth in both the Choptank River and Monie Bay cores. Cores from Otter Creek and the Patuxent River were variable with depth.

3.2 Nutrient concentrations

The form of phosphorus buried changed with each marsh system. The Patuxent River marsh sediments contained more phosphorus than the other sites (Figure 3), though concentrations exhibited high variability with depth (Table 1). Burial was predominantly as inorganic phosphorus. The marshes of Monie Bay retained primarily organic forms of phosphorus (Tables 2 and 3). Otter Creek and the Choptank River marshes showed little variability with depth and buried mostly inorganic phosphorus (Tables 4 and 5), with larger contributions of organic phosphorus than the Patuxent River.

Carbon concentrations were constant with depth in both the Otter Creek and Choptank

River cores (Figure 4). Otter Creek consistently contained less carbon in the sediments than the other sites (Table 4). The Patuxent River cores were more variable with depth, and surface maxima were noted in most of the cores.

Nitrogen concentrations followed patterns similar to carbon. Otter Creek concentrations were low. In most systems nitrogen concentrations were not variable with depth (Figure 4). The exception to this was the Patuxent River with high surficial nitrogen concentrations.

Surface sediment layers generally contained the most iron in all systems (Figure 2). High concentrations were found in the Patuxent River cores, with sharp declines in deeper sections (Table 1). Low concentrations were found in Monie Bay (Tables 2 and 3) and the Choptank River (Table 5). Otter Creek sediments were between the two extremes (Table 4).

3.3 Vertical accretion

Exponential decay of ^{210}Po with depth was found at most cores within all four systems (Figure 5). Vertical accretion rates ranged between 0.11 and 2.54 cm y^{-1} (Table 6). Sediment deposition reached values of 0.86 g cm^{-2} y^{-1}. Disturbance of ^{210}Pb profiles was mimimal in the cores collected from Otter Creek (Table 4). Monie Bay and Otter Creek consistently had the lowest rates of accretion. Deposition rates were highest in the Patuxent River marshes. Transect data collected in the Patuxent River reveals changes in sedimentation rates across the surface of the marsh. The lowest accretion rates in the transect were found away from the edge of the river.

4. CONTRAST OF FOUR CHESAPEAKE BAY MARSH SYSTEMS

4.1 Sediment Development

Sediment characteristics change with each tidal marsh ecosystem sampled within the Chesapeake Bay. Both physical and chemical properties changed with source material, hydrology and native flora.

4.2 Choptank River

The brackish marshes of the Choptank River can keep pace with the rising sea level by accreting at rates of 0.61-1.09 cm y^{-1}. Low bulk density and iron concentrations indicate limited quantities of mineral sedimentation. This suggests that carbon fixed within the marsh may provide a large portion of the sediment matrix. Chemical profiles indicate little change in sediment composition with age, suggesting diagenesis occurs directly at the sediment surface, and the marsh system is a stable feature of the landscape.

4.3 Monie Bay

Rates of vertical accretion in the Monie Bay marshes (0.26-1.01 cm y^{-1}) suggest that the marshes can just about maintain themselves in the face of sea level rise (0.3 cm y^{-1}). High inputs of organic matter contribute most of the sedimentary material for the system. This is perhaps one of the "sediment starved" marsh systems described by Stevenson et al. (1988). Low mineral concentrations indicate very little sediment input from the surrounding watershed. This lack of sediment supply is likely to be responsible for the slow rates of vertical accretion. As a result, phosphorus is retained as organic material, and nutrient burial rates are relatively slow.

4.4 Otter Creek

With a bulk density approaching that of sand (1.2 g cm^{-3}) and low organic matter, carbon, and nitrogen concentrations, it appears that Otter Creek marshes are almost totally dependent upon external sources for mineral sediment supply to maintain surface elevation. This has no apparent effect on relative burial of total phosphorus. Inorganic retention dominates nutrient burial and maintains rates similar to those found in other systems. Rates of vertical accretion are between 0.21 and 1.02 cm y^{-1}.

4.5 Patuxent River

Extremely high sedimentation rates (0.21-2.54 cm y^{-1}) appear to be dependent upon both high quantities of organic matter input and high sediment loading rates. Dynamic organic matter and bulk density profiles indicate large changes in sediment composition with age. This is indicative of the past century of rapid change within the watershed and early marsh development. These early stages of marsh development my partially explain the relatively high rates of nutrient retention found in the Patuxent River marshes.

Figure Legends

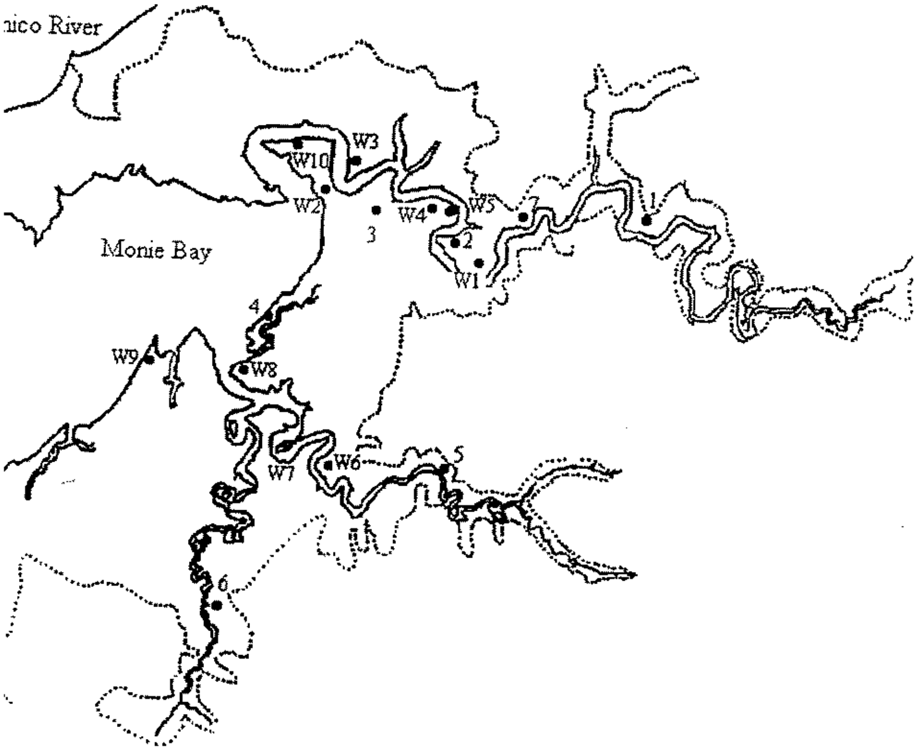
Figure 1. Locations of sample collection (a) Chespeake Bay with National Estuarine Research Reserve Sites indicated, (b) Choptank River, (c) Monie Bay, 'W' indicates location sampled by Ward et al. (1988), (d) Otter Creek, (e) Patuxent River.

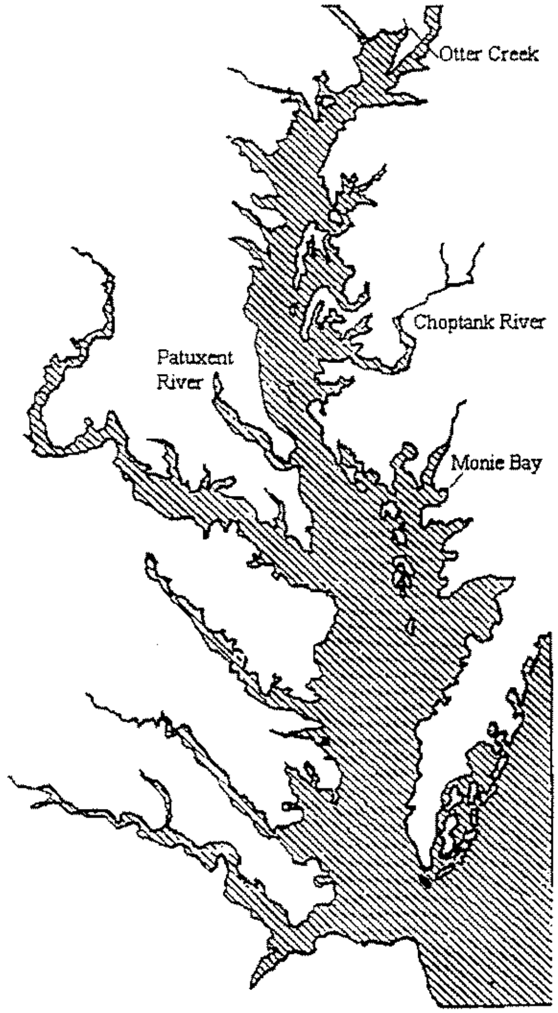
Figure 2. Profiles sediment characteristics of representative cores from four Chesapeake Bay marsh systems. (a) percent sediment as water, (b) percent weight lost after combustion (550°C), (c) sediment dry bulk density, (d) iron concentration.

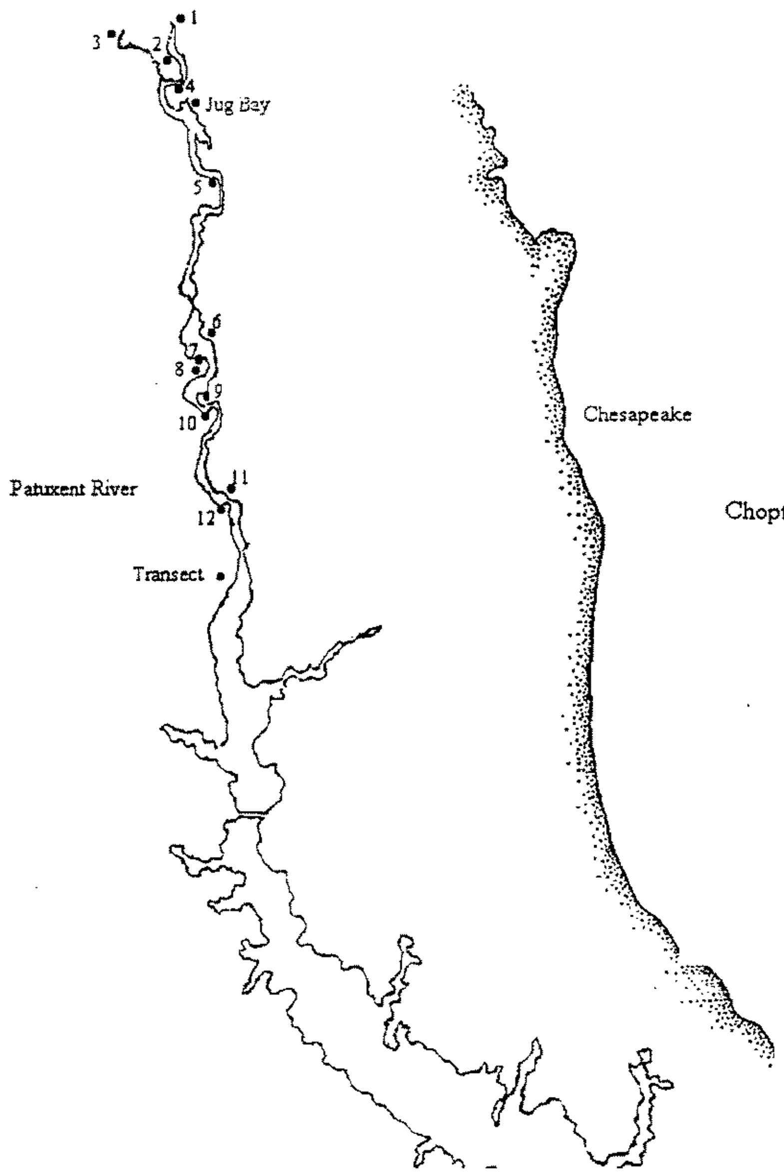
Figure 3. Profiles of representative sediment cores from three Chesapeake Bay marsh systems (a) percent carbon, and (b) percent nitrogen content.

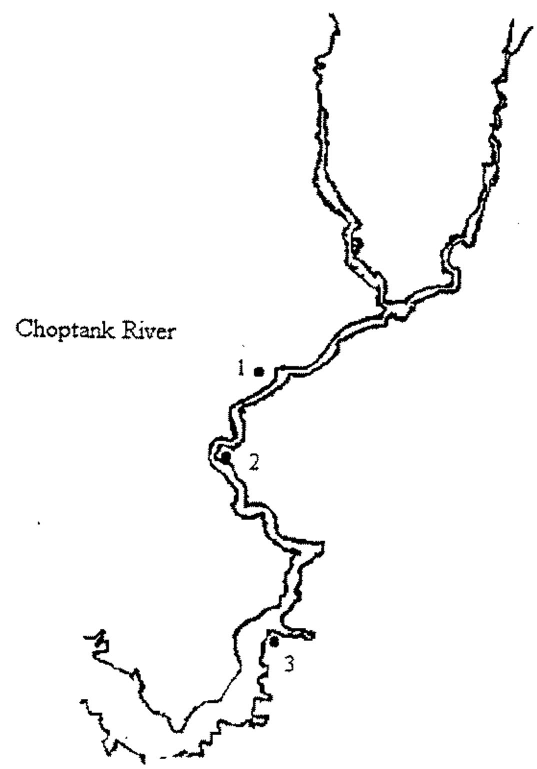
Figure 4. Total and inorganic phosphorus profiles of four Chesapeake Bay marsh sediment cores. Organic phosphorus is assumed to be the difference between total and inorganic phosphorus. Concentrations are expressed as mg P per gram sediment.

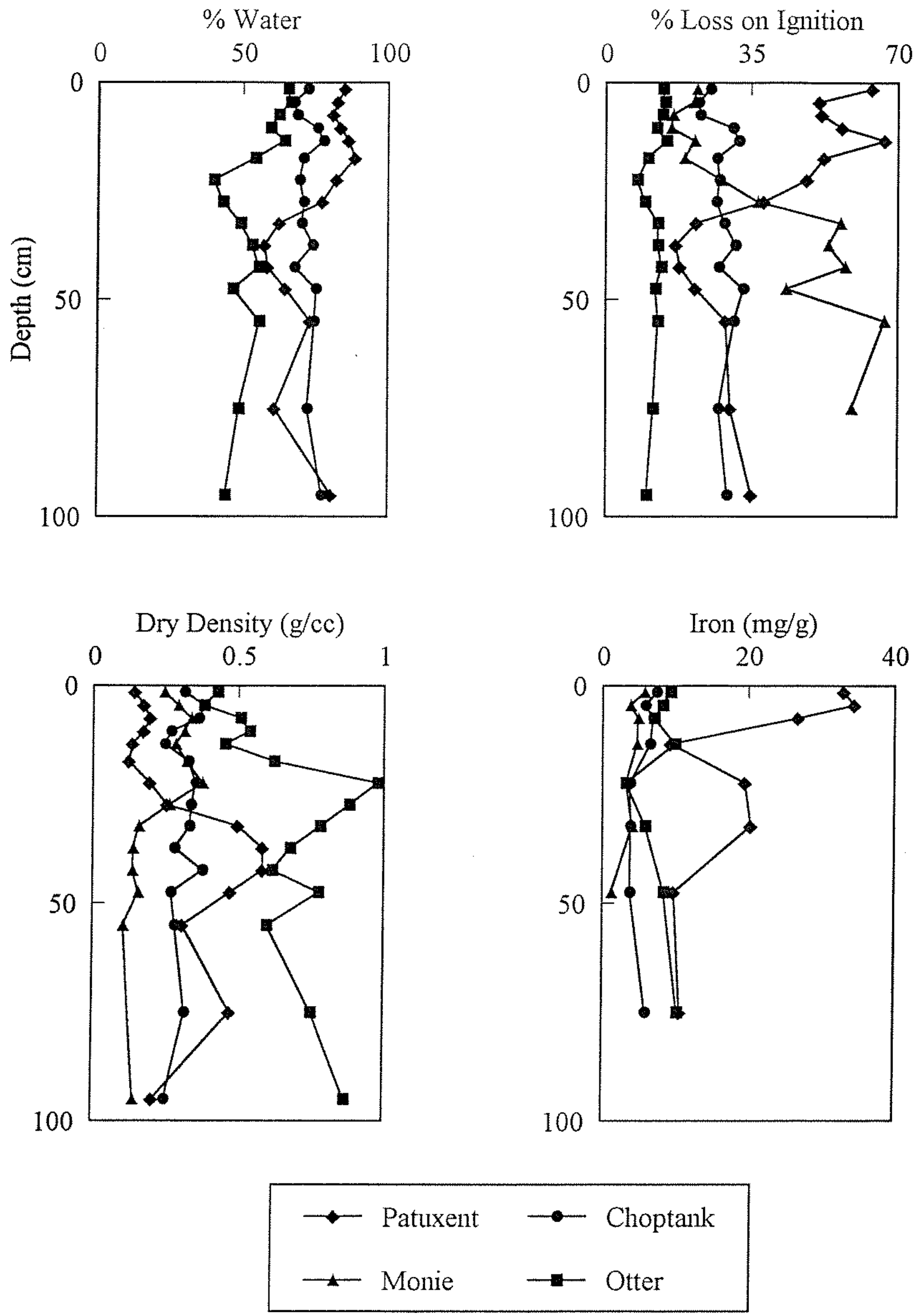
Figure 5. Sediment profiles of total ^{210}Po activity from four Chesapeake Bay marsh systems.


nico River
Monie Bay
W3
W10
W2
3
W4
W5
2
W1
7
1
4
W9
W8
W7
W6
5
1
6
1


Otter Creek
Choptank River
Patuxent
River
Monie Bay


1
3
2
4
Jug Bay
5
6
7
8
9
10
Patuxent River
11
12
Transect
Chesapeake


Choptank River
1
2
3


% Water
0
50
100
0
50
100
Depth (cm)
% Loss on Ignition
0
35
70
0
50
100
Dry Density (g/cc)
0
0.5
1
0
50
100
Iron (mg/g)
0
20
40
0
50
100
Patuxent
Choptank
Monie
Otter

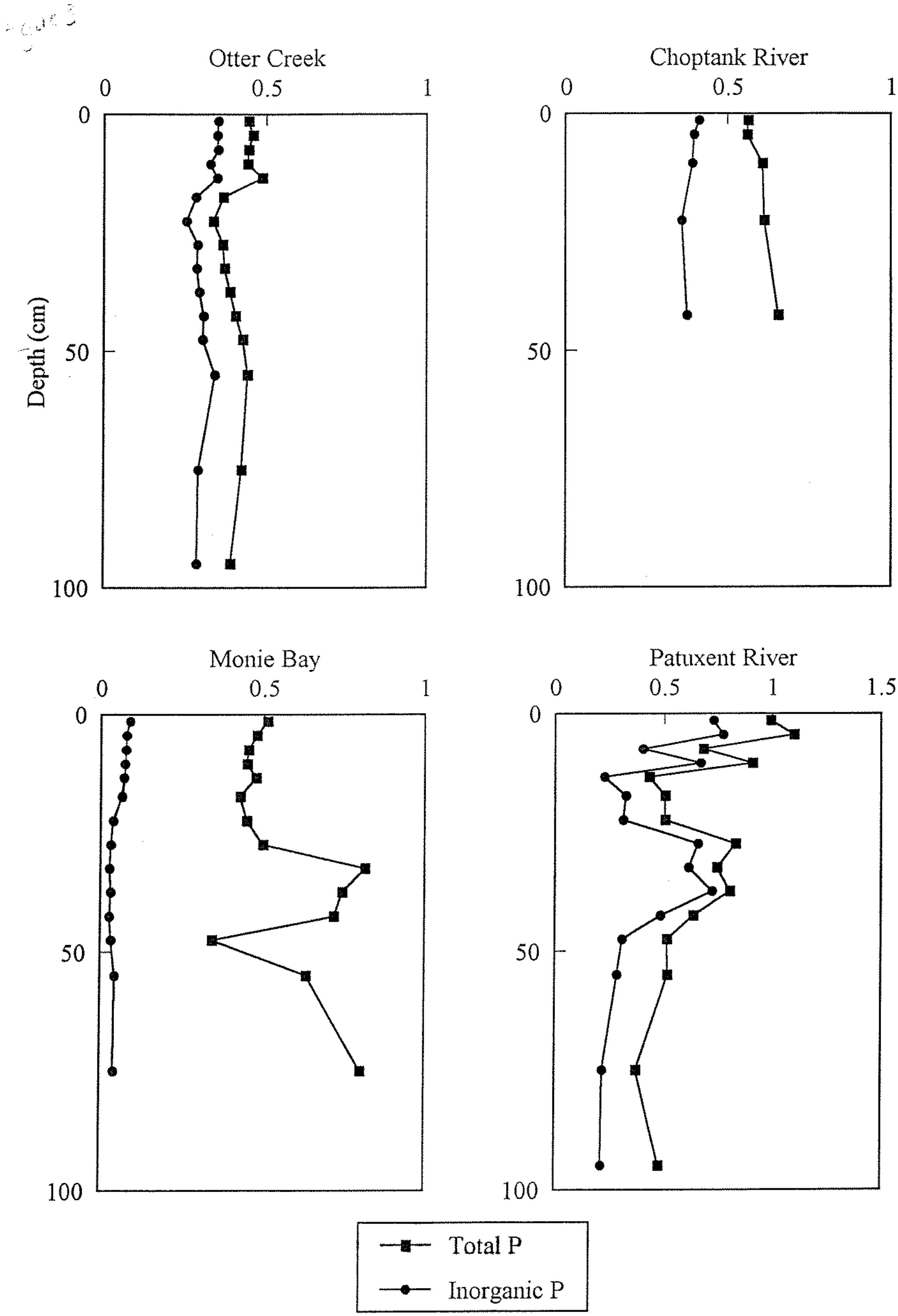
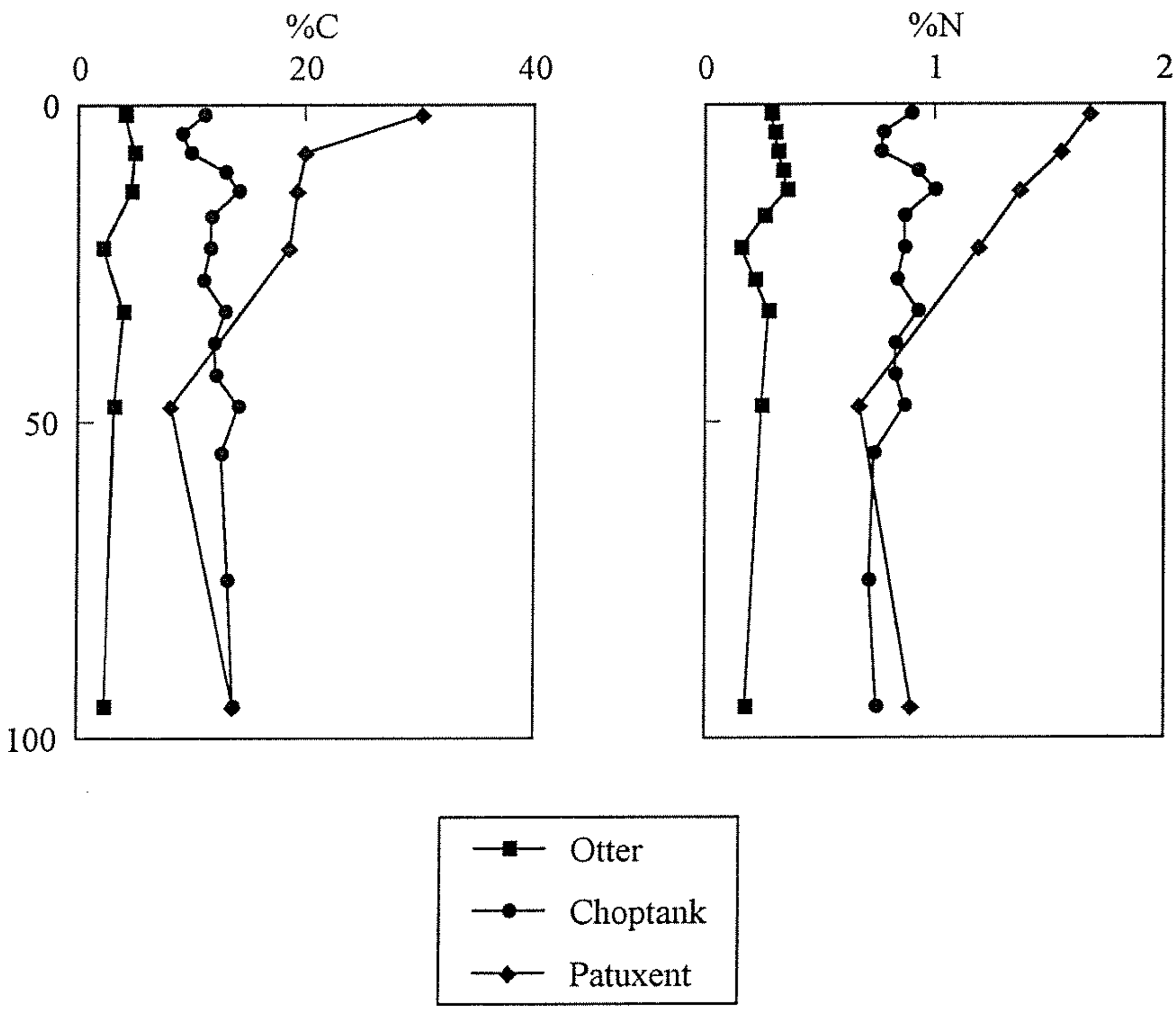


Figure 3
Otter Creek
Choptank River
Monie Bay
Patuxent River
Depth (cm)
0
0.5
1
1.5
50
100
Total P
Inorganic P



%C
0
20
40
0
50
100
%N
0
1
2
Otter
Choptank
Patuxent

Figure 5

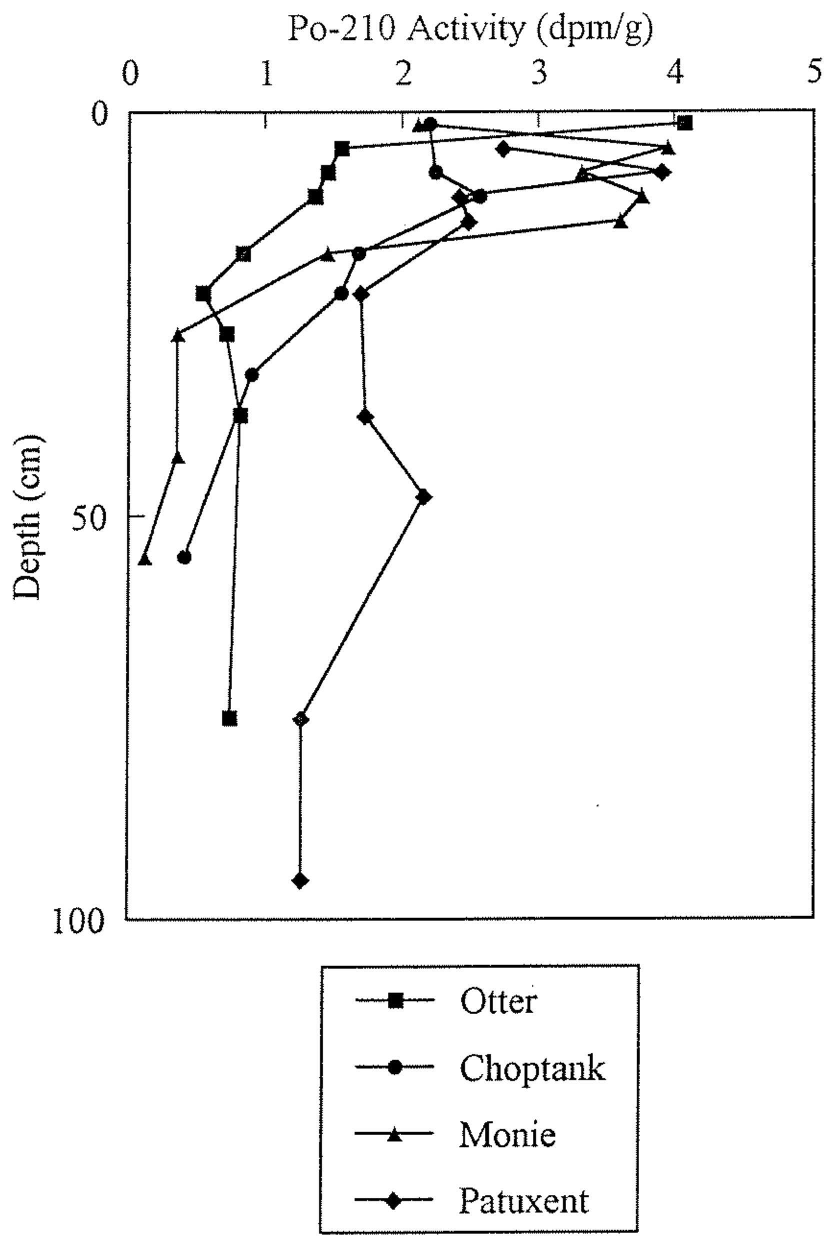

Po-210 Activity (dpm/g)
0
1
2
3
4
5
0
50
100
Depth (cm)
Otter
Choptank
Monie
Patuxent

Table 2. Monie Bay marsh sediment characteristics. Samples were collected in July 1993, and locations correspond to Fig. 1c. Concentrations below detectable limits are indicated with 'bd'. See text for complete description.

Site 1 Section (cm)	Dry Sample Density (g/cc)	% Loss on Ignition	Total P (mg/g)	Inorganic P (mg/g)	Organic P (mg/g)	%C	%N	Metals Conc. Fe (mg/g)	Mn (mg/g)	Po-210 Activity (dpm/g)
0-3	0.189	27.2	0.476	0.254	0.222	10.62	0.88	3.256	0.025	
3-6	0.191	28.1	0.437	0.225	0.212	10.54	0.81	2.960	0.031	4.38
6-9	0.199	26.7	0.415	0.212	0.203			2.629	0.035	
9-12	0.192	29.6	0.401	0.204	0.198	11.6	0.8			2.83
12-15	0.194	29.7	0.366	0.173	0.193			2.620	0.056	1.84
15-20	0.259	23.8	0.330	0.163	0.167	8.32	0.63			
20-25	0.234	24.7	0.331	0.165	0.166			4.148	0.108	
25-30	0.285	22.7	0.330	0.173	0.157					
30-35	0.302	22.4	0.303	0.166	0.137	8.88	0.62	2.675	0.072	1.39
35-40	0.272	24.9	0.302	0.161	0.140					
40-45	0.262	26.0	0.299	0.155	0.144					0.85
45-50	0.116	57.4	0.337	0.144	0.193	13.19	0.8	2.559	0.121	
60-65	0.132	53.0	0.300	bd	0.299					0.30
90-95	0.209	38.3	0.291	0.143	0.148	13.44	0.81	8.542	0.114	

Site 2 Section (cm)	Dry Sample Density (g/cc)	% Loss on Ignition	Total P (mg/g)	Inorganic P (mg/g)	Organic P (mg/g)	Metals Conc. Fe (mg/g)	Mn (mg/g)	Po-210 Activity (dpm/g)
0-3	0.204	28.6	0.575	0.318	0.257	10.478	0.400	3.44
3-6	0.243	26.1	0.445	0.198	0.247	3.150	0.244	
6-9	0.302	23.3	0.381	0.161	0.220	2.075	0.146	2.88
9-12	0.302	23.1	0.358	0.148	0.211			5.25
12-15	0.322	23.3	0.324	0.150	0.173	5.962	0.121	2.30
15-20	0.324	21.3	0.318	0.146	0.173			
20-25	0.275	23.9	0.332	0.140	0.192	3.157	0.126	
25-30	0.227	27.7	0.346	0.140	0.206			
30-35	0.215	30.2	0.356	0.144	0.212	2.321	0.196	1.75
35-40	0.180	34.0	0.365	0.143	0.222			
40-45	0.146	45.9	0.375	0.139	0.235			0.98
45-50	0.107	62.1	0.398	0.131	0.267	3.748	-	
60-65	0.347	18.0	0.230	0.120	0.109			0.13
90-95	1.385	4.7	0.151	0.122	0.030	0.875	-	

Table 2 cont'd. Monie Bay marsh sediment characteristics.

Site 3

Section (cm)	Dry Sample Density (g/cc)	% Loss on Ignition	Total P (mg/g)	Inorganic P (mg/g)	Organic P (mg/g)	Metals Conc. Fe (mg/g)	Mn (mg/g)	Po-21 Activit (dpm/
0-3	0.197	35.2	0.501	0.228	0.273	-	0.469	
3-6	0.212	35.5	0.488	0.188	0.300	7.715	0.098	2.48
6-9	0.188	39.7	0.387	0.064	0.323	6.154	0.033	
9-12	0.171	41.9	0.415	0.049	0.366			2.00
12-15	0.162	50.2	0.359	0.045	0.314	2.389	0.009	
15-20	0.133	70.7	0.204	0.023	0.181			
20-25	0.116	74.9	0.195	0.023	0.172	-	0.020	
25-30	0.124	72.5	0.418	0.160	0.258			1.21
30-35	0.179	64.2	0.369	0.037	0.332	5.427	0.016	
35-40	0.374	38.2	0.558	0.300	0.258			
40-45	0.796	14.4	0.153	0.063	0.091			0.61
45-50	1.136	4.0	0.111	0.058	0.053	0.760	-	

Site 4

Section (cm)	Dry Sample Density (g/cc)	% Loss on Ignition	Total P (mg/g)	Inorganic P (mg/g)	Organic P (mg/g)	Metals Conc. Fe (mg/g)	Mn (mg/g)	Po-21 Activit (dpm/
0-3	0.348	17.3	0.295	0.060	0.234	5.790	0.027	
3-6	0.383	21.2	0.238	0.040	0.197	3.210	0.021	2.47
6-9	0.350	20.4	0.214	0.037	0.178	2.530	0.008	
9-12	0.179	41.2	0.301	0.043	0.258			1.29
12-15	0.220	30.7	0.231	0.026	0.205	1.910	-	
15-20	0.325	22.0	0.219	0.023	0.196			
20-25	0.301	15.9	0.216	0.018	0.198	4.440	0.004	0.85
25-30	0.290	19.4	0.372	0.014	0.357			
30-35	0.205	37.4	0.450	0.014	0.435	3.300	0.006	0.42
35-40	0.171	43.5	0.535	0.013	0.521			
40-45	0.166	49.4	0.621	0.022	0.599			
45-50	0.163	52.3	0.689	0.019	0.670	5.250	-	0.14

Table 2 cont'd. Monie Bay marsh sediment characteristics.

Site 5

Section (cm)	Dry Sample Density (g/cc)	% Loss on Ignition	Total P (mg/g)	Inorganic P (mg/g)	Organic P (mg/g)	Metals Conc. Fe (mg/g)	Mn (mg/g)	Po-210 Activity (dpm/g)
0-3	0.245	22.0	0.510	0.090	0.420	5.760	0.015	2.11
3-6	0.293	21.2	0.479	0.079	0.399	3.850	0.001	3.95
6-9	0.338	16.3	0.452	0.078	0.374	4.930	0.013	3.31
9-12	0.314	15.8	0.449	0.076	0.374			3.76
12-15	0.284	21.4	0.475	0.073	0.402	4.800	0.024	3.60
15-20	0.323	19.0	0.427	0.066	0.361			1.45
20-25	0.378	27.9	0.448	0.039	0.408	3.210	0.017	
25-30	0.264	36.6	0.497	0.032	0.465			0.36
30-35	0.160	56.2	0.814	0.029	0.785	4.110	0.084	
35-40	0.140	53.3	0.743	0.033	0.710			
40-45	0.138	57.4	0.718	0.029	0.690			0.36
45-50	0.157	43.2	0.342	0.034	0.307	1.260	0.042	
60-65	0.106	66.8	0.632	0.046	0.586			0.12
90-95	0.144	58.9	0.800	0.044	0.756	-	0.059	

Site 6

Section (cm)	Dry Sample Density (g/cc)	% Loss on Ignition	Total P (mg/g)	Inorganic P (mg/g)	Organic P (mg/g)	Metals Conc. Fe (mg/g)	Mn (mg/g)	Po-210 Activity (dpm/g)
0-3	0.259	30.4	0.513	0.203	0.310	-	7.330	8.41
3-6	0.287	29.0	0.494	0.043	0.451	-	12.974	1.21
6-9	0.314	24.3	0.400	0.099	0.301	-	2.905	6.89
9-12	0.316	28.0	0.346	0.060	0.286			
12-15	0.345	24.1	0.285	0.047	0.237	7.089	0.219	2.01
15-20	0.300	39.6	0.237	0.044	0.193			
20-25	0.310	26.7	0.265	0.047	0.218	9.664	0.137	1.29
25-30	0.323	23.5	0.419	0.036	0.383			
30-35	0.297	29.0	0.337	0.026	0.311	6.100	0.091	0.55
35-40	0.285	22.1	0.195	0.025	0.170			
40-45	0.310	26.4	0.290	0.046	0.244			0.59
45-50	0.300	25.7	0.342	0.048	0.294	3.357	0.102	
65-70	0.159	55.7	0.692	0.109	0.583			0.43
90-95	0.411	17.5	0.311	0.029	0.282	1.372	0.044	

Table 2 cont'd. Monie Bay marsh sediment characteristics.

Section (cm)	Dry Sample Density (g/cc)	% Loss on Ignition	Total P (mg/g)	Inorganic P (mg/g)	Organic P (mg/g)	Metals Conc. Fe (mg/g)	Mn (mg/g)	Po-210 Activity (dpm/g)
Site 7								
0-5	0.277	23.2	0.202	0.044	0.158	bd	bd	3.87
5-10	0.359	17.9	0.160	0.041	0.119	bd	bd	2.43
10-15	0.333	19.0	0.167	0.038	0.129	bd	bd	2.15
15-20	0.307	22.4	0.163	0.030	0.134			0.70
20-25	0.257	29.7	0.154	0.031	0.123	bd	bd	
25-30	0.252	29.7	0.122	0.024	0.099			0.24
30-35	0.199	38.0	0.153	0.038	0.115	-	bd	
35-40	0.209	-	0.170	0.052	0.118			
40-45	0.253	33.1	0.180	0.041	0.138			
45-50	0.239	35.0	0.186	0.042	0.144	bd	bd	0.48

Table 3. Monie Bay marsh sediment characteristics. Duplicate cores were collected in July 1993, and locations correspond to sites indicated with 'W' in Fig. 1c. See text for complete description. Concentr below detectable limits are indicated with 'bd'.

	Section (cm)	%H2O	% Loss on Ignition	Total P (mg/g)	Inorganic P (mg/g)	Organic P (mg/g)	%C	%N	Fe (mg/g)	Mn (mg/g)
W1	0-3	70.7	-	0.297	0.157	0.14			18.728	0.586
	12-15	66.0	20.06	0.271	0.136	0.136			10.032	0.142
	45-50	60.4	17.17	0.124	0.029	0.095	5.97	0.46	2.435	0.051
	0-3	73.0	22.08	0.267	0.112	0.155			6.598	0.104
	12-15	67.2	20.78	0.174	0.037	0.137			3.601	0.087
	45-50	75.6	29.36	0.162	0.034	0.128	10.62	0.7	4.351	0.086
W3	0-3	74.5	30.69	0.337	0.089	0.247			8.059	0.126
	12-15	76.3	43.63	0.207	0.017	0.190			3.121	0.085
	45-50	88.4	49.82	0.003	0.009	-0.006	15.63	1.15	1.944	0.045
	0-3	77.4	28.39	0.249	0.067	0.183			5.696	0.112
	12-15	71.3	24.11	0.238	0.035	0.203			3.869	0.103
	45-50	89.3	54.21	0.198	0.024	0.174	18.25	1.53	6.689	0.098
W4	0-3	66.9	18.26	0.233	0.109	0.123			17.188	0.432
	12-15	59.7	15.56	0.157	0.038	0.118			3.176	0.063
	45-50	69.3	21.57	0.123	0.011	0.111	8.503	0.553	3.041	0.054
	0-3	70.6	20.44	0.280	0.093	0.187			9.877	0.135
	12-15	69.0	20.78	0.138	0.025	0.112			2.412	0.064
	45-50	83.5	38.17	0.125	0.007	0.119	13.26	0.81	6.484	0.066
W5	0-3	80.5	34.02	0.317	0.067	0.250			6.848	0.496
	12-15	79.3	31.76	0.167	0.017	0.150			4.132	0.069
	45-50	68.2	22.21	0.143	0.024	0.119	8.64	0.59	5.497	0.064
	0-3	79.6	28.70	0.445	0.164	0.281			15.143	0.954
	12-15	65.6	-	0.182	0.019	0.162			3.815	0.079
	45-50	71.8	22.17	0.158	0.022	0.136	8.23	0.64	2.799	0.050

Table 6. Accretion rates in four Chespeake Bay tidal marsh systems. Rates were determined using ^{210}Pb analysis.

	cm y^{-1}	g cm^{-2} y^{-1}
Otter Creek		
Site 1	1.02	0.53
Site 2	0.21	0.12
Site 3	0.27	0.24
Choptank River		
Site 1	0.61	0.24
Site 2	1.09	0.41
Site 3	1.07	0.28
Monie Bay		
Site 1	0.68	0.18
Site 2	0.38	0.12
Site 3	1.01	0.26
Site 4	0.63	0.09
Site 5	0.44	0.12
Site 6	0.26	0.07
Site 7	0.45	0.17

	cm y^{-1}	g cm^{-2} y^{-1}
Patuxent River		
Jug Bay 1	2.19	052
Jug Bay 3	0.54	0.21
Riverbank	0.62	0.31
30 m	0.11	0.01
60 m	0.20	0.03
90 m	0.21	0.03
Site 1	0.76	0.51
Site 2	0.23	0.14
Site 3	0.66	0.40
Site 4	0.31	0.15
Site 5	2.54	0.86
Site 6	1.34	0.42
Site 7	0.78	0.37
Site 8	1.28	0.69
Site 9	0.85	0.17
Site 11	0.42	0.20
Site 12	0.77	0.32