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Short Term Sediment Dynamics in a Southeastern U.S.A. *Spartina* Marsh

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ABSTRACT

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Suspended sediments in tidal creeks and sediments deposited on the adjacent marsh surface, collected concurrently at Mud Bank (MB) and Sixty Bass (SB) in North Inlet, SC from March, 1991 until February, 1992 were compared. For 8 consecutive days of each lunar month (waxing moon neap tide until full moon spring tide), sediment traps collected daily and water pumped from the adjacent creek at 3.1 hour intervals (mid-flood, high tide, and mid-ebb) were analyzed for inorganic and organic sediment, as well as carbon and nitrogen content. Salinity, sea level, Pee Dee River discharge, rainfall, temperature, wind, and inundation time were examined as forcing functions. SB creek connects to the oceanic inlet, but MB is located near the tidal node where brackish and high salinity waters meet in a sharp halocline. Although the duration of inundation is approximately twice as long at SB (12.5 hr/d : 7.4 hr/d) because of a 27 cm elevation difference, MB averaged more deposition (5.3 mg/d/cm^2 : 4.2 mg/d/cm^2). Neither concentration of sediments in the water column nor duration of inundation were found to be strongly related to sediment deposition ($r^2 < 0.05$). Variability among replicates on sediment traps suggests sediment dynamics at very small scales. High suspended sediment concentrations and deposition rates at MB during August, when Pee Dee River discharge was unseasonably high, indicate direct input of riverine sediments. The importance of bioturbation on sediment dynamics is suggested by the dominance of seasonal rather than spring-neap patterns.

ADDITIONAL INDEX WORDS: *Sedimentation, estuary, wind, bioturbation, Pee Dee River, North Inlet, S.C.*

INTRODUCTION

The ecological importance of salt marshes, which also act as buffers between the ocean and land, justifies study of the processes which affect the stability of these marshes. Sediment accretion, primarily inorganic, is generally keeping up with sea level rise on the South Carolina coast (WOLAVER *et al.*, 1988). Historic maps and aerial photos of North Inlet show that, although the inlet mouth has migrated, the general morphology and apparent elevation of the marsh has remained relatively stable. The source of the sediment and the mechanisms of transport and deposition are less clear. PHILLIPS (1991) estimated that only 4% of the gross eroded sediment from the 47,900 km^2 Pee Dee/Yadkin drainage basin reaches Winyah Bay. Based on daily (10:00 EST) measurements of suspended sediment in North Inlet, GARDNER *et al.* (1989) proposed that sediment is entering the marsh via the ocean inlet rather than from direct intrusions of riverine water into the marsh and that bioturbation is the main source of suspended material in the North Inlet system.

REED (1988), studying eroding marshes on Dengie Peninsula U.K., concluded that sediment recycling within the system accounts for most of the material suspended at any given time, while net import and export are relatively small. This was also observed by JORDAN and VALIELA (1983) at Great Sippewissett Salt Marsh, MA. MCCAVE (1984) noted that sediment dynamics are very complex involving erosion and redeposition due to tidal currents and wind driven wave action, temperature, bioturbation, and stabilization with mucopolysaccharide secretions. The relative con-

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tributions of wave and tidal energy are determined by the physical structure of each individual marsh and salt marsh geomorphology is much more than the net sum of erosion and deposition (PETHICK 1991).

Sediment Transport

Movement of sediments occurs when enough energy is applied to the sediment surface via wind waves, tidal currents, rainfall and runoff, or excavation forces (bioturbation and man-made) to overcome the forces of cohesion and to move the sediment laden water across the system. REED (1988) found that high amplitude spring tides transported more sediment than the neap tides in tidal creeks and on the marsh of Dengie Peninsula U.K. Spring tide total suspended sediment (TSS) concentrations were 2–3 times greater than concentrations during neap tides in the turbidity maximum zone of Charleston Harbor, South Carolina (ALTHAUSEN and KJERFVE, 1992). Sediment budgets, developed by combining sediment concentration with net water flux, have been used to determine net sediment import or export. Creekbank and marsh surface erosion by rainfall during low tide exposure have been shown to be significant in sediment budgets (SETTLEMYRE and GARDNER, 1977). In North Inlet, DAME *et al.* (1986) reported net import of sediment in winter and net export in summer. Water column turbidity in North Inlet has been shown to vary seasonally, spatially, and with tide stage (HUTCHINSON and SKLAR, 1993). The dynamics of sediment transport are very difficult to determine even in controlled flume studies, and the added complexity of turbulence over uneven bottom structure and material in natural systems makes this determination virtually impossible. The effective particle size and density of small cohesive sediment particles, typical in salt marshes, are highly variable in aggregates, further complicating the prediction of particle behavior (MCCAVE, 1984).

Sediment Deposition

As the energy which suspended and transported sediments dissipates, sediments are deposited, either to be resuspended or consolidated as net accretion. The energy of wind waves and storms, found to play major roles in sedimentation patterns (SETTLEMYRE and GARDNER, 1977; LETZSCH and FREY, 1980; JORDAN and VALIELA, 1983; REED, 1989; and CHILDERS and DAY, 1990) is dissipated on the marsh surface, aided by marsh plants (REJMANCK *et al.*, 1988). Several of these studies found that sediment accretion diminished with increasing marsh surface elevation implying that duration of inundation played a key role in sedimentation rates. Long-term measurements of sediment deposition in North Inlet and two other temperate estuaries have demonstrated that variation at the microhabitat scale is important (CHILDERS *et al.*, 1993). Tidal creeks are a response to the tidal energy of flood tides rather than drainage for ebbing tides. This was PETHICK'S (1991) conclusion because the total area of creeks in marshes is related to the size of the inlet and not the area of the marsh. WEST *et al.* (1990) and STODDART *et al.* (1989) point out the need for very extensive and intensive sampling to clarify sedimentation patterns because of the complexity of salt marsh systems.

Hypotheses

An understanding of the sources and dynamics of sediments is required for informed public responses to sea level rise. Watershed management, beach maintenance policies, and land use planning also benefit from clear information regarding accretion, deposition, and erosion processes. Therefore, in this paper we describe the composition and quantity of sediments suspended and deposited at 2 sites in the North Inlet system. Examination of potential forces involved in sediment dynamics provides insight into the rates of accumulation and the sources of sediments to the system. Our hypotheses are as follows: (1) accretion is a function of the concentration of sediments in the water column and the length of time that the surface is submerged; (2) riverine sediments deposited directly onto the marsh are important to the North Inlet system; (3) tidal currents increase suspended sediment concentrations and deposition during maximum tidal amplitudes associated with spring tides.

MATERIALS AND METHODS

Study Site

North Inlet is a 3,400 hectare Holocene transgressive marsh-barrier complex located near Georgetown, SC, U.S.A. (Figure 1). The *Spartina alterniflora* marsh is bordered by maritime forests to the north and west, the Atlantic Ocean to the east, and Winyah Bay to the south. Mean tidal range is about 1.5 m and mean tidal flow of 500 m^3 sec^{-1} through the inlet to the Atlantic Ocean

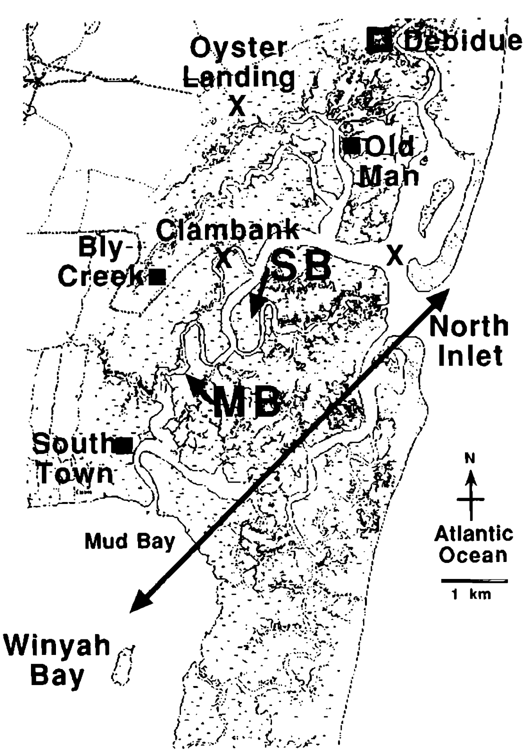

Figure 1. SB and MB sampling sites. X marks daily 10:00 EST water sample sites. Meteorological station is located at Oyster Landing. Boxes mark tide gauges and long-term sedimentation sites. Large arrow illustrates the Northeast–Southwest fetch.

accounts for most water exchanges (GARDNER *et al.*, 1989). Freshwater intrusions from Winyah Bay are normally limited to the extreme southern portion of the North Inlet system with very little mixing because of a tidal node described by SCHWING and KJERFVE (1980). The node area is shallow, with poorly defined channels, low tidal velocities, and a very sharp salinity gradient (*personal observation*). Direct rainfall and runoff from the adjacent maritime forest are very small compared to the volume of the tidal prism. KJERFVE (1986) estimated that the mean freshwater input ranges from 1 to 5 m^3 sec^{-1} and that salinity usually ranges from 30 to 35‰. Periods of lower salinities associated with major rain events and wind driven baywater intrusions are normally short lived because, on average, approximately 40% of the water in the inlet at high tide leaves on the following ebb tide (GARDNER *et al.*, 1989).

Two tidal creeks characterized by inter-tidal oyster reefs along the banks (SB near the ocean inlet and MB just north of the tidal node) were monitored in this study. The SB site is located on the west bank of Sixty Bass Creek which connects to Town Creek and directly to the ocean inlet during mid to high tide. The MB site is located on the east bank on South Town Creek just north of the tidal node. South Town Creek connects to Winyah Bay south of the node in the vicinity of Mud Bay which is very shallow and has a thick layer of fine grained mud on the bottom. A survey of the two sites using a Total Station laser transit found that the MB site was 27 cm higher than the SB site.

Sampling Design

Suspended sediment concentration in the water column and sediment deposition on the marsh surface were measured concurrently at both sites from March 1991 to February 1992. Samples were taken each month, beginning on the neap tide of the waxing moon and continuing until the day of the full moon. In March 1991, water column samples were taken at approximately 6 hour intervals beginning at mid-flood tide to obtain 2 ebb and 2 flood tide samples per day. From April, 1991 through February, 1992 water column samples were taken at 186 minute intervals to obtain 2 samples at low, flood, high, and ebb tides each day. Isco autosamplers, deployed on platforms constructed at the edges of the creeks, were attached to sample intake devices mounted on PVC pipes approximately 7 meters from the bank. The intakes were placed approximately 10 cm above the creek bottom and connected to the samplers with Tygon tubing. Ice was placed in the autosamplers and the samples were collected each day and returned to the lab on ice for processing. All glassware was acid washed, rinsed in deionized water and dried in an oven.

Salinity was measured in each sample, beginning April 1991, with a refractometer. Three subsamples, 50 ml each (except during extremely high sediment loads), were filtered through pre-ashed, pre-weighed 2.5 cm Whatman GF/F glass fiber filters. Filtrate was collected and refrigerated for subsequent dissolved organic carbon (DOC) analysis using a Shimodzu TOC 500 carbon analyzer. The 3 filters were dried for 24 hr at 45 °C and reweighed to determine total suspended sediment concentration. One filter was analyzed for elemental carbon and nitrogen using a Control Equipment Corporation elemental CHN analyzer. The other 2 filters were ashed at 450 °C for 24 hr and reweighed to differentiate organic and inorganic fractions.

On the same day that the autosamplers were deployed, several sediment traps were also placed on the *Spartina* marsh surface alongside a boardwalk attached to the sampling platform. Each trap consisted of 3 pre-ashed, pre-weighed Whatman GF/F 2.5 cm glass filters attached to an aluminum sheet with 2 bobby pins. The plates were secured to the marsh surface with two large nails and small flags were placed in the mud to facilitate retrieval. On the second day, when the first set of water samples was collected, one of the sediment traps at each site was collected and replaced with an identical trap and the time was noted. The filters on the trap were removed from the plate, in the field, placed into numbered petri dishes, transported to the lab, dried for 24 hr at 45 °C, and reweighed to determine total sediment deposited. Two of the filters were then ashed for 24 hr at 450 °C to determine inorganic and organic content. The other filter was scraped to remove a subsample of the deposited sediment, which was weighed and analyzed for elemental carbon and nitrogen using the CHN analyzer. This method was followed on each of the sampling days so that a trap, in place for approximately 24 hr, was collected for each day. In addition a trap which had been in the field since the first day was also collected to yield a cumulative deposition. The filters could not be rinsed without ruin because the sediment was not consolidated. All traps were processed the same way.

From March, 1991 to October, 1991 sampling was done each day from neap tide through spring tide. Sampling was reduced to 2 days beginning at the neap tide and 2 days ending with the spring tide from November, 1991 to February, 1992 (Figure 2). Additional data sets were examined for influence on sediment dynamics. Pee Dee River discharge at Pee Dee, SC, (U.S. Geological Survey Report SC 90-1) was lagged 5 days to account for the time taken by the water at the monitoring station to reach Winyah Bay. Local rainfall, barometric pressure (BP), and wind velocity (WV) and direction were recorded hourly at the Baruch Marine Lab meteorological station at Oyster Landing. Water temperature (WT15), water level (WV15), and secchi depth measurements taken with the Clambank Dock daily water sample at 10:00 EST were averaged on a 15 day running mean to eliminate the tidal variation. Monthly

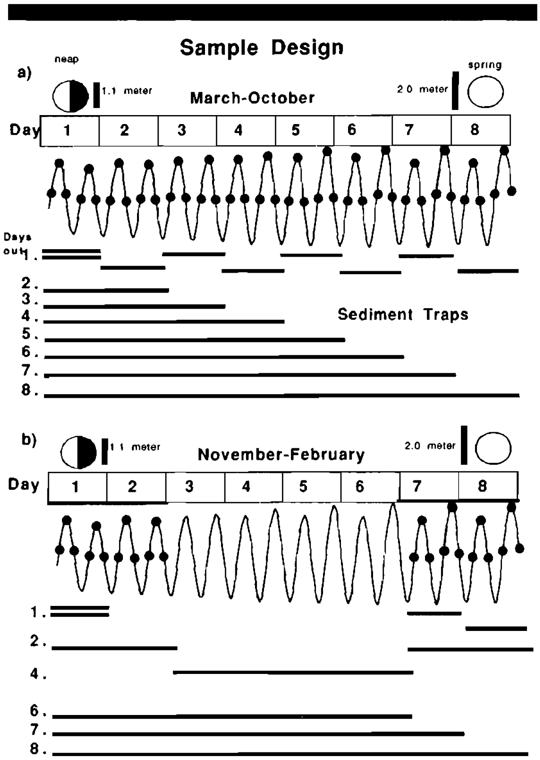

Figure 2. Sample design. (a) A typical tidal pattern from neap to spring tide with dots marking time of water column samples. Horizontal bars indicate traps in the field. (b) Reduced sampling from November 1991–February 1992. Tide ranges are long-term averages.

mean Charleston sea level was obtained from the Ocean Survey Division of NOAA. Daily inundation periods (INUN) for each site were estimated from elevation data and water level measurements made using two Richard's type recording stations located to the north and south of the two sites. These inundation periods were used to estimate whether or not rainfall occurred while the sediment traps were exposed (RAINX). Wind speed and direction were reduced to cumulative daily wind vectors so that regressions could be made. The north–south (NS), east–west (EW), and the northeast–southwest vector (NESW), which approximates the maximum fetch across North Inlet (Figure 1), were examined for their influence on sediment dynamics.

RESULTS

For all tide stages combined, comparison of water column samples at the two sites using paired

Table 1. *Paired t-test and mean values.*

Tide Stage	SB (mean)	MB (mean)	P value (P)	SB (mean)	MB (mean)	P value (P)	SB (mean)	MB (mean)	P value (P)
	TSS (mg/l)			OSS (mg/l)			ISS (mg/l)		
Flood	174.4	159.9	0.00**	32.9	30.0	0.00**	143.6	130.5	0.00**
High	176.2	181.7	0.28	33.1	34.9	0.13	144.1	147.9	0.39
Ebb	157.2	149.8	0.06	29.4	27.5	0.04*	128.2	122.3	0.05*
All tides	169.1	163.5	0.02*	31.8	30.7	0.07	138.4	133.3	0.01**
	Carbon (μg/l)			Nitrogen (μg/l)			Salinity (ppt)		
Flood	3,168.0	2,925.7	0.09	402.9	368.9	0.04*	30.8	27.9	0.00**
High	2,919.3	2,750.6	0.02*	381.2	350.4	0.01**	32.4	31.5	0.00**
Ebb	2,253.7	2,300.9	0.58	293.7	292.8	0.29	32.5	29.5	0.00**
All tides	2,768.1	2,648.8	0.01**	357.8	336.3	0.00**	31.9	29.7	0.00**
Deposition on 1 day traps									
Total sed. (mg/trap)	20.7	26.1	0.02*						
Inorganic (mg/trap)	17.0	23.4	0.01*						
Organic (mg/trap)	3.6	4.4	0.07						
C (μg/trap)	768.0	951.0	0.11						
N (μg/trap)	90.3	100.8	0.46						
C %	3.3	3.2	0.30						
N %	0.4	0.4	0.00**						
C/N	8.9	9.7	0.00*						

*Significant = 0.05
**Highly significant = 0.01

t-tests demonstrates statistically significant ($p < 0.05$) differences in salinity (SAL), TSS, inorganic suspended sediment (ISS), carbon (C), and nitrogen (N), but not organic suspended sediment (OSS) (Table 1). Flood tide site comparisons showed highly significant differences ($p < 0.01$) for salinity, TSS, ISS, and OSS. All suspended constituents had significantly lower concentrations on ebb tide than at high tide or on flood tide. While OSS and ISS at both sites were highest at high tide, C and N were highest on flood tides. Sediment trap samples showed significant differences between sites only for TSS, ISS and N%.

The seasonal pattern of suspended and deposited sediments is illustrated in Figure 3. Maximum values for all parameters at both sites occurred during the summer. Both OSS and ISS were relatively stable compared to suspended C and N and to all parameters of deposited sediment. Suspension and deposition were high at both sites in July, but in August SB had maximum TSS and relatively low TSS. August showed the greatest differences in sediment deposited at the two sites. The amount of sediment deposited on the marsh surface was not strongly related to the amount of sediment suspended in the water column nor to the duration of inundation ($r^2 < 0.05$ in each case). A comparison of monthly mean sedimentation rates (mg/cm^2/hr) for 1 day traps and the combined mean of 6, 7, and 8 traps is made in Figure 4. The hourly rates of deposition were always higher on 1 day traps than multi-day traps at MB. There is a much greater seasonality in rates of the 1-day plates. Rates were more similar and substantially lower at SB. Time of inundation was not closely related to the rate of deposition.

Some time-series of the potential forcing functions which might influence sediment dynamics are plotted in Figure 5. Note that rainfall was frequent and relatively abundant during both July and August. Pee Dee River discharge, reflecting regional rainfall, was unseasonably high during August as well. July and August also showed low secchi depth readings from the daily water sample at Clambank Dock, reflecting a large sediment load in the water column. August had the highest amount of sediment deposition at the MB site while SB had much less deposited.

In Figure 6, illustrating the 24 hr total deposition, both sites show similar patterns. Seasonality is clearly shown but there is no consistent spring-neap pattern. A few extreme events account for much of the variability. Note that maximum deposition at both sites occurred on the same day in July. In August both sites still show the same pattern but total deposition was much higher at MB. Figure 7 provides a detailed look at TSS concentrations for each month. The 2 sites

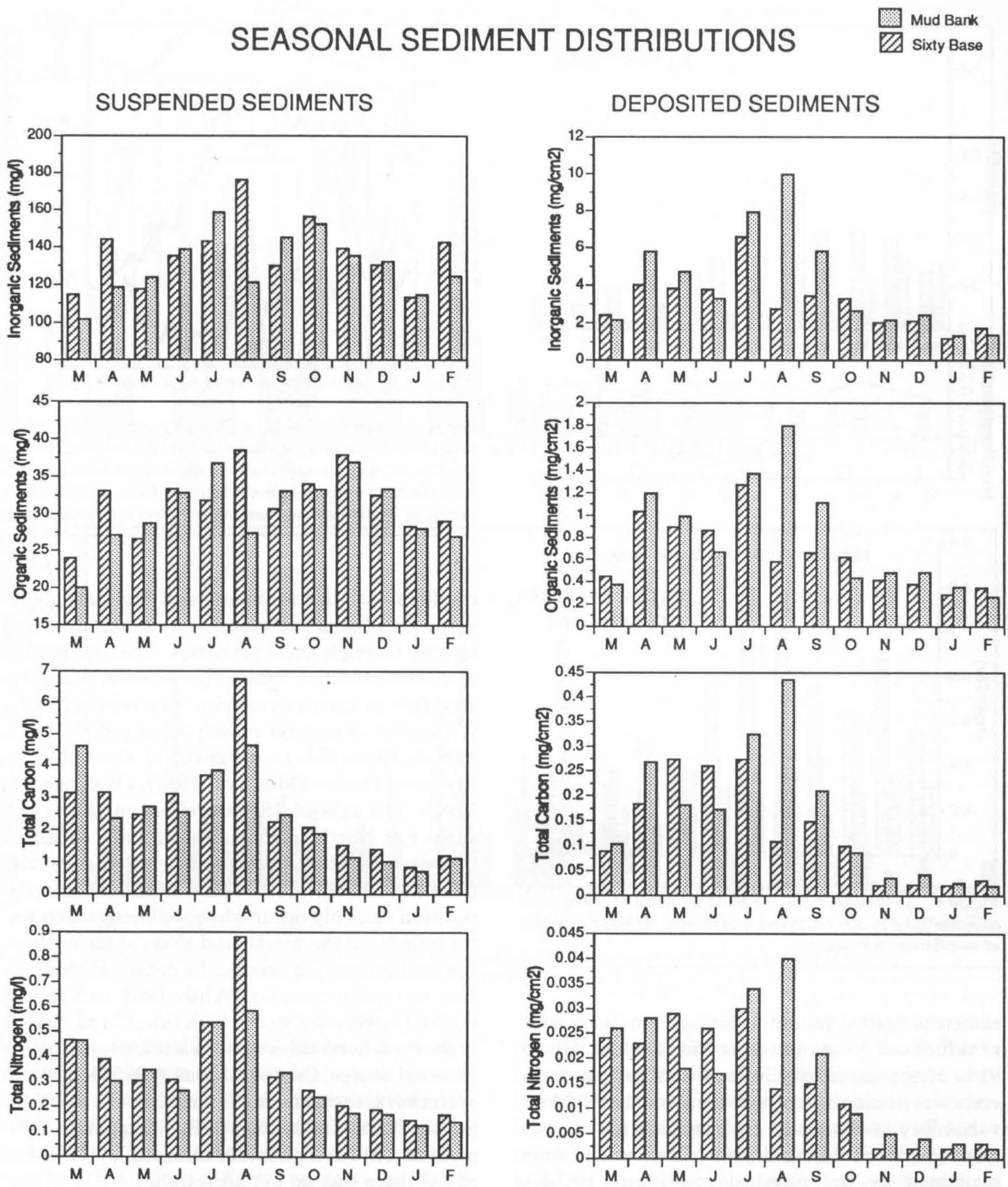

Figure 3. Seasonal patterns of mean monthly suspended (left) and deposited (right) sediment concentrations at both sites.

mostly follow the same pattern with SB slightly higher overall but only consistently higher for the month of April. Some months show a slight increase from neap to spring, but May shows an opposite and significant trend. The period of highest concentration is August and the scale is almost doubled.

Stepwise multiple regressions of sediment pa-

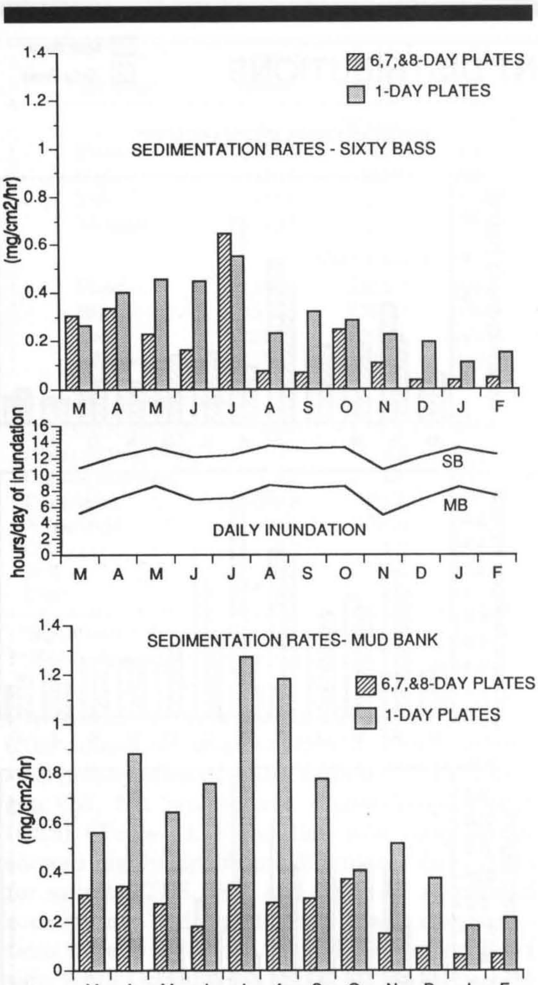

Figure 4. Deposition rates. (a) Monthly mean of 1 day traps and combined mean of 6, 7, and 8 day traps. (b) Mean duration of inundation in hours/day.

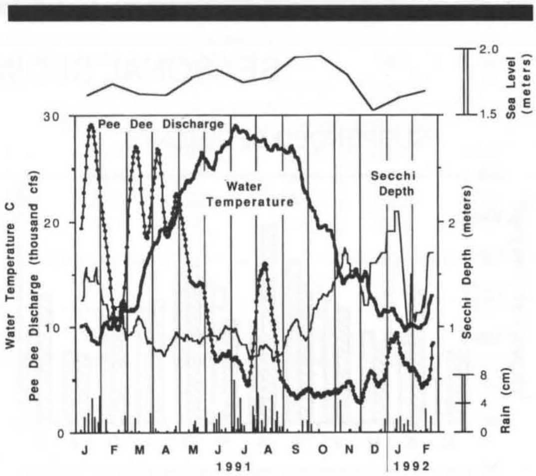

Figure 5. Forcing functions. Monthly mean sea level at Charleston, SC, smoothed discharge data for Pee Dee River at Pee Dee, SC, water temperature and secchi depth measurements from the daily water sample at Clambank Dock, and total daily rainfall at Oyster Landing from January, 1991 to February, 1992.

rameters against potential forcing functions with r^2 values >0.50 are presented in Table 2. Up to 91% of the variability in local sediment parameters was predicted by the forcing functions. More variability in the water column than for deposition, and more variability at MB than SB were explained by the physical conditions. SAL15, WT15, wind, and BP were significant factors for several of the sediment measurements.

DISCUSSION

A host of physical and biological factors figure into overall sediment dynamics. Macro and micro-flora stabilize sediment and facilitate deposition and fauna can stabilize or destabilize sediments through their activities. The interaction of climate and the water column has a multi-faceted role in marsh dynamics. As a result, the development of general principles of sediment dynamics applicable to a variety of environments has been elusive (McCave, 1984), (West *et al.*, 1990). The rate of ISS accretion on the marsh surface at North Inlet was shown to be sufficient to keep up with the present rate of sea level rise (Wolaver *et al.*, 1988). Water born sediment deposition can only occur when sediment laden water inundates the marsh and slows sufficiently so that sedimentation occurs; the details of this process are quite complex. While OSS and ISS at both sites were highest at high tide, C and N were highest on flood tides at both sites, suggesting an external source. Childers *et al.* (1993) long-term accretion measurements found that the marsh at South Town Creek, near MB, was gaining sediment at a much higher rate than sea level rise but at SB there was no net accretion.

The evidence presented here suggests that North Inlet sediment dynamics are more a function of seasonal and climatic conditions than tidal forcing. Although the tidal range is substantially higher than Louisiana, the systems are similar in terms of sediment movements in that tidal effects are secondary (Reed, 1989), (Childers and Day,

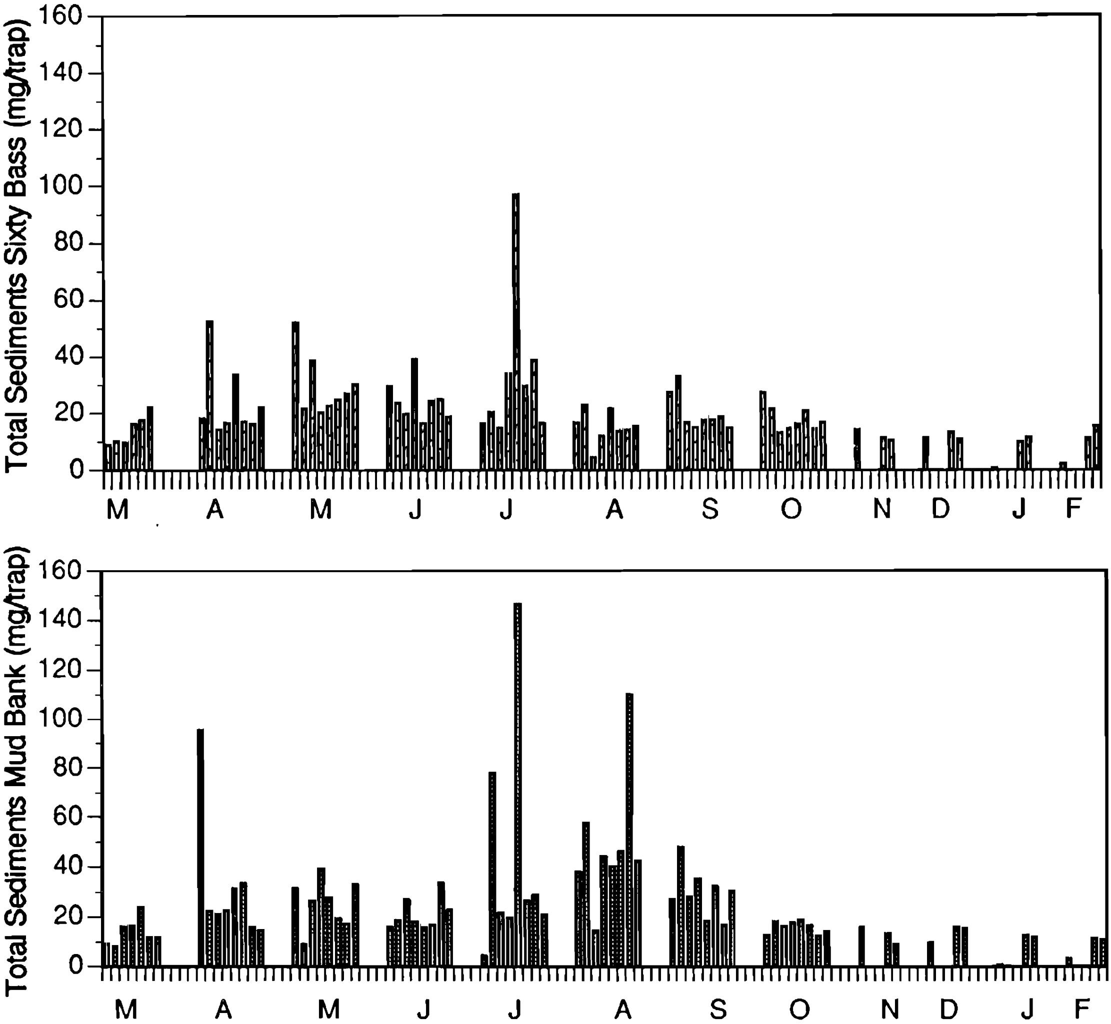

Figure 6. Daily deposition of total sediment (mg/trap). Seasonal pattern is dominant; spring-neap pattern is lacking.

1990). One major difference between these two regions is the season of maximum deposition and transport. Whereas south winds associated with winter storms and frontal passages were found to be important in Louisiana, the multiple regressions indicate quite a different scenario for North Inlet. High water temperature, high barometric pressure, and strong, steady, southwest winds which lower salinity with river water are conditions associated with the Bermuda High; this high dominates summer weather conditions in the southeastern U.S.A. In most Louisiana marshes, south winds increase water level and drive suspended material onto the marsh. In North Inlet, the southwest winds which bring sediment into the system from Winyah Bay also decrease water level in the marsh. High concentration of sediment in the water column was probably not related to deposition because of this interaction. Deposition in North Inlet may be a two step process, with sediment being transported into the system via southwest winds and then moved up onto the marsh during the next northeast wind with sufficient energy to resuspend the sediment and to raise water level above the marsh surface. This would be similar to the process proposed by

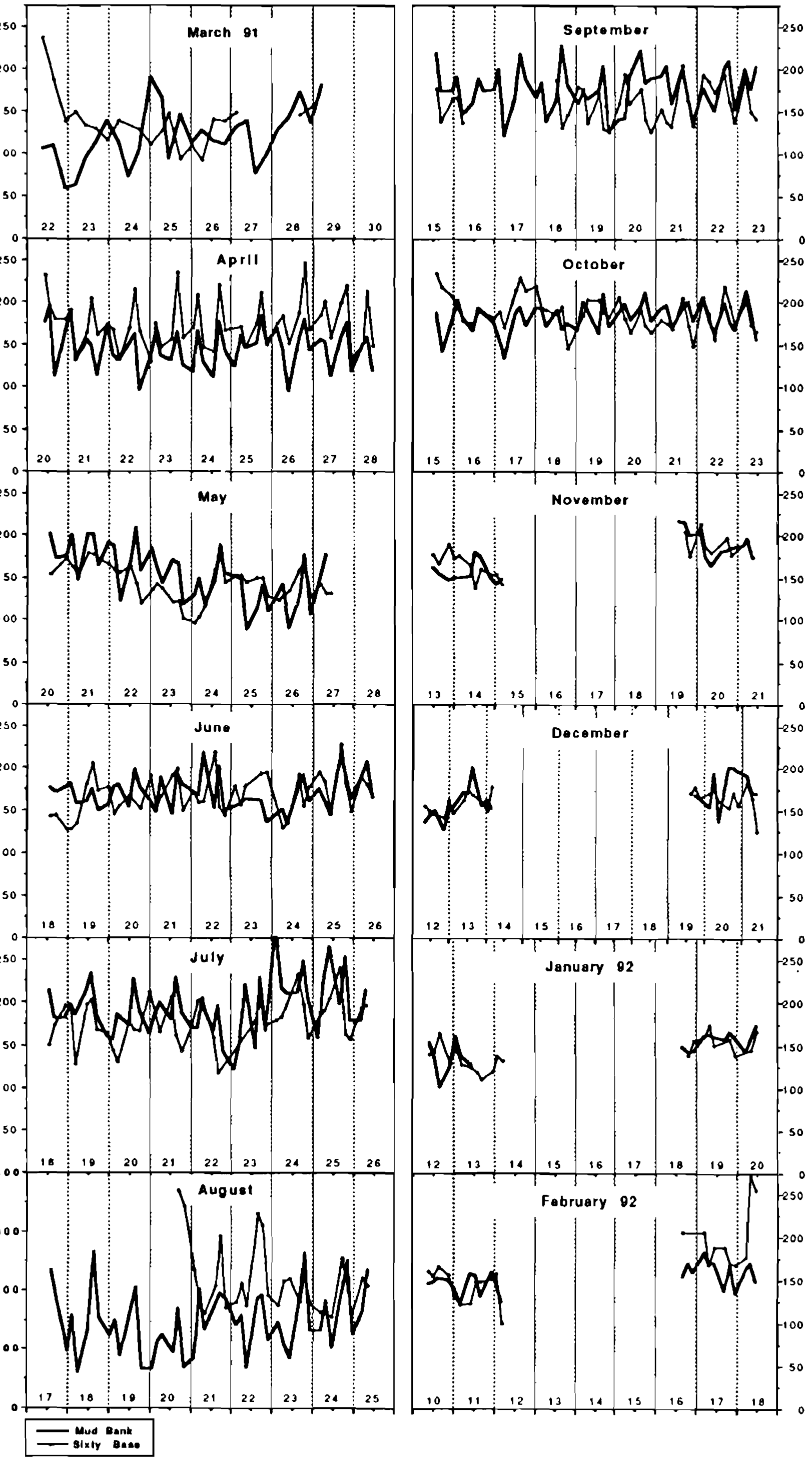

Figure 7. TSS concentrations at 3.1 hour intervals (except low tide) for each month sampled. There is no apparent spring-neap pattern. Note the higher scale in August.

Table 2. *Stepwise regressions with $r^2 > 0.50$.*

MB-Deposited	
$r^2 = 0.56$	C% = −5.5E−3 + 1.4E−3(WT15) + 1.0E−6(PDLAG5)
$r^2 = 0.53$	N% = 9.4E−3 + 5.7E−4(WV) − 1.7E−4(NESW) − 2.6E−4(SAL15)
MB-Suspended	
$r^2 = 0.57$	ISS = −286 + 2.1(WT15) + 3.6(SAL15) + 0.26(BP)
$r^2 = 0.89$	C% = 0.12 + 1.4E−3(WV) − 6.2E−4(NESW) − 2.7E−3(SAL15) − 0.01(WL15) − 0.01(RAINX)
$r^2 = 0.91$	N% = 0.01 + 8.6E−5(WV) − 6.2E−5(NESW) + 5.3E−5(WT15) − 2.5E−4(SAL15) − 9.8E−4(RAINX)
$r^2 = 0.64$	C/N = 18.4 + 0.19(WV) − 2.1(RAINX) − 0.12(SAL15) − 3.4(WL15) + 7.6E−5(PDLAG5)
SB-Suspended	
$r^2 = 0.89$	C% = 4.26E−3 − 6.6E−4(INUN) + 2.1E−5(BP) + 7.0E−4(WT15) − 1.1E−3(SAL15) + 0.01(WL15)
$r^2 = 0.64$	N% = 4.6E−3 + 1.3E−4(WV) − 7.5E−5(NESW) + 8.4E−5(WT15) − 1.5E−4(SAL15)

STODDART *et al.* (1989) in which sediment, accumulated during low velocity neap tides, moved onto the marsh during the subsequent spring tides. Similarly, SETTLEMYRE and GARDNER (1977) found that if wind waves maintained high suspended sediment concentrations through the late flood tide stage, then deposition would occur around high tide. The common element is adequate energy to suspend available material, sustained until water is moved up onto the marsh surface where the energy is dissipated and deposition occurs.

Changes in wind speed and direction can change water level, water velocity, wave energy, and flow patterns within the estuary. These changes alter the energy of suspension, and affect the movements of sediment and the patterns of deposition in the marsh. Waves can cause lateral erosion or scour sediment off the marsh. Wind can also sustain lower water levels and dry recently deposited sediment, facilitating consolidation and long-term accretion. The effects of different wind fetches are quite site specific. Where the same fetch simultaneously results in high suspension and elevated water levels the wind can play a key role in deposition on the marsh surface. In this study, wind had an effect on the quantity and composition of the sediment reflected in the amount of C and N and their percentage of TSS. Southwest winds moved nutrient rich sediments up from Mud Bay into the system, a direct input of riverine sediments into North Inlet. Salinity at MB was significantly lower than SB, and N% and C% of suspended sediment increased at both sites during periods of southwest winds. Although the season of high river discharge and the season of high TSS concentration and deposition do not normally overlap, the highest sediment deposition occurred at MB during the unseasonably high Pee Dee River discharge in August. These observations provide evidence that the Pee Dee River has impacts beyond the tidal node.

In contrast to ALTHAUSEN and KJERFVE (1992), REED (1988), and others, no evidence of increased sediment movement during spring tides was found in this study, although only 3 samples/tide cycle is insufficient for a complete picture. JORDAN and VALIELA (1983) reported that high tidal amplitude only increased suspended sediment concentration in creeks with a high current velocity. Further spatial examination of North Inlet would be needed to test this finding. Instead, seasonal patterns, attributed by GARDNER *et al.* (1989) to bioturbation, were found to be more important in this study. Mucopolysaccharides, which stabilize sediment are reported to break down at about 20 °C, which corresponds to the increase in turbidity found in North Inlet (John Grant, *personal communication*). Fiddler crab burrowing activity and populations of bottom feeding spot, shrimp, and mullet are maximal during summer months. This interaction of physical and biological factors appears to be very important in the observed sediment patterns.

The total sediment accumulated on multi-day plates is less than the sum for the one-day plates exposed during the same period. Erosion forces may be acting on the filters after initial deposition. SETTLEMYRE and GARDNER (1977) reported increased suspended sediment concentrations in creeks as a result of rainfall at low tide. Linear regressions of total rainfall and rainfall while the traps were exposed versus sediment parameters were not significant for the work reported here. However, the day of lowest deposition in August corresponds with a major rain event, possibly as a result of erosion from the trap.

CONCLUSIONS

There was no pattern of increased sediment movement during spring tides. Low deposition from October through February was not explained by duration of inundation or the lack of available suspended sediments. Sediments supplied directly to North Inlet from the Pee Dee River via wind-driven Winyah Bay intrusions were important and should be considered in any sediment budget for the system. More spatially extensive and temporally intensive sampling is necessary to clearly quantify sediment dynamics in temperate estuaries.

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