CHAPTER 114

BARRIER ISLAND DYNAMICS: OVERWASH PROCESSES AND EOLIAN TRANSPORT

Stephen P. Leatherman[1]

Abstract

The northern 5 miles of shoreline at Assateague Island, Maryland are presently being eroded. During storms, swash surges are able to overtop the most landward (storm) berm as overwash with deposition occurring on the barren flats. Where primary barrier dunes still exist, sediment-charged surges are funneled through breaches in the dune field for deposition of the entrained material on the washover fan.

Sediment budget computations show that there has been a small net loss of material at each washover area, in spite of 7 discrete overwash events during a 26 month time interval. The predominant northwest winds effectively eroded the overwash material, transporting the majority of the sand back to the beach. This analysis indicates that there exists a balance between overwash and eolian processes with wind transport being slightly dominant.

Introduction

The impetus that spurred this research was the sharp debate among coastal investigators concerning the importance of overwash in terms of the sediment budget of a barrier island. Dolan (1972) maintained that construction of large barrier dunes in the 1930's along the Outer Banks of North Carolina has had a significant adverse impact on this shoreline's stability. By preventing overwash, material that would have been deposited on the backdune area will either be lost offshore or carried alongshore. The viewpoint of the Corps of Engineers (Shore Protection Manual, 1974) is that island maintenance by overwash is probably only significant within the context of a geologic time frame. The mechanics of barrier island migration by the overwash process have not been previously established by quantitative studies.

[1] Assistant Professor, Department of Geology, Boston University, Boston, Massachusetts 02215

This investigation was designed to address the question of the short-term sedimentary dynamics of a washover area on Assateague Island.

The concept of a sediment budget was adopted to monitor the amount of sediment transport. The sediment budget is defined for the control volume which includes the washover fan/flats and adjacent barrier dunes, vegetated barrier flats and marsh. The beach is excluded from the control volume since only net changes can be recorded, not the actual quantities and directions of sediment removal, transportation and deposition. Sediment budget calculations should permit determination of the relative importance of overwash as a process shaping the barrier island.

During the past 26 months (February 1973 - April 1975) of continuous study, 7 discrete overwash events were monitored at Assateague Island, Maryland. Field surveying prior to and after an overwash enabled calculation of the total subaerial sediment transport along selected sections of the island. Monthly surveys allowed for the detection of subsequent post-storm reworking and transport of sand on the backdune zone.

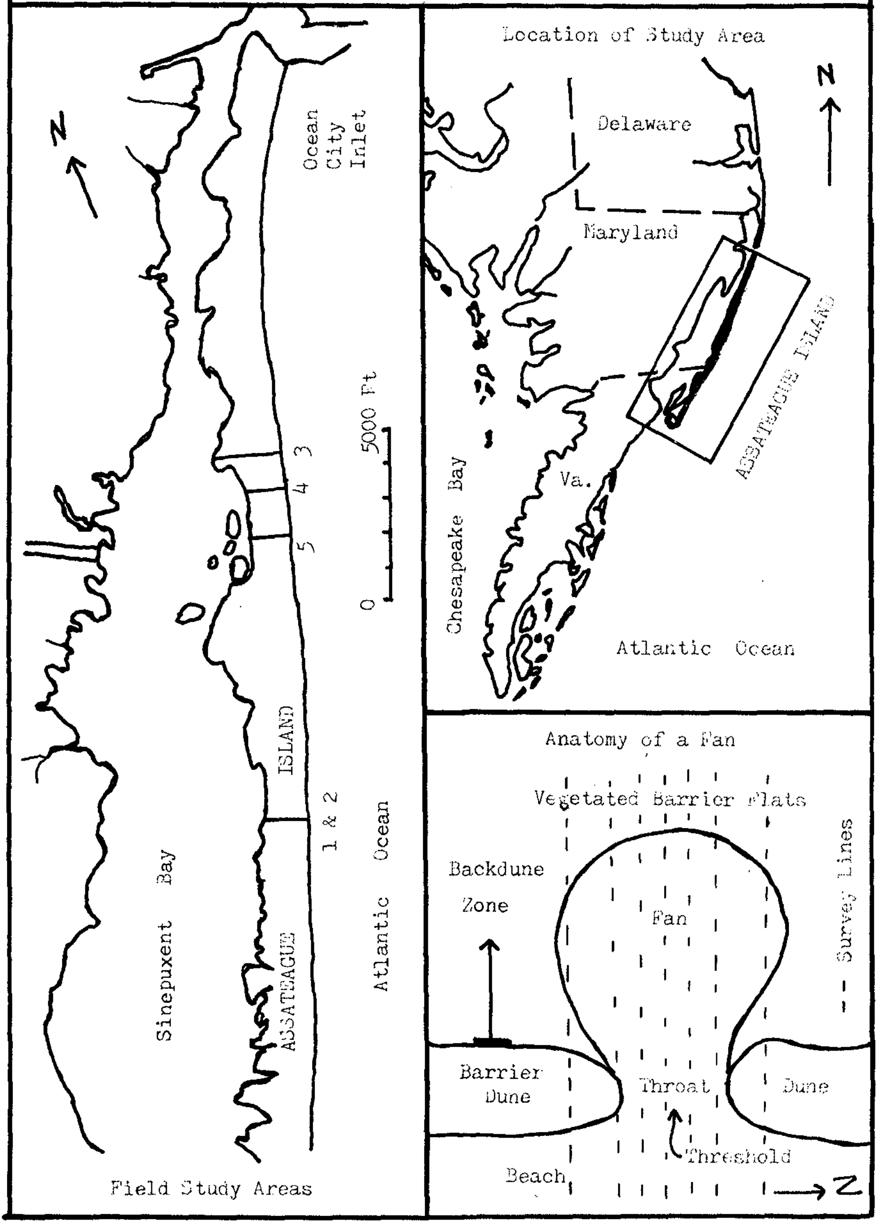
A single washover fan (Site 1) was selected for the initiation of this study (Fig. 1). The dunes are eroded during major storms, and gaps between the dunes force overwash sediments into discrete units enabling study of individual deposits. Site 2 was established in the fan adjacent to that of Site 1 for volumetric comparison on an annual basis. For the final year of field work, 3 additional sites were chosen based on their position along the island and on their physiographic features. Sites 3 and 4 are located in a region of broad washover flats where barrier dunes no longer exist. Site 5 is similar to the primary site (Site 1), except that the dimensions of the fan are much larger.

Previous Research

Overwash has been reported to be a significant process along the Gulf and East Coasts of North America, but little quantitative data is available on its transport potential. In fact, there is a scarcity of data correlating "storm intensity" to the expected amount of shoreline erosion. This type of data has direct application to engineering considerations, but it is difficult to obtain due to the unpredictability of occurrence and magnitude of coastal storms.

Caldwell (1959) compiled data concerning the amount of beach erosion for various storms along the New Jersey shoreline. Everts (1973) and Everts et al. (1974) also used surveying programs to determine the amount of erosion associated with single storms for New Jersey and New York beaches. These data sets, along with original field data on beach erosion and overwash deposition from the North Carolina coast, have been summarized by Schwartz (1975).

Figure 1. Location and Site Maps



Overwash Sediment Transport

Storm parameters and overwash deposition for each event monitored by this investigator as well as Schwartz's (1975) data are given in Table 1. Relative measures of storm surges at Assateague Island were obtained by subtracting the predicted tide (U.S. Dept. of Commerce, NOAA Tide Tables) from the recorded tide (NOAA-NOS) for the Indian River Inlet (Bridge) tide gage, located approximately 20 miles north of Ocean City, Md. Significant deep water wave hindcasts were based on the Bretschneider technique. Surf observations of breaker height and wave period were obtained from the CERC Beach Evaluation Program.

The amount of sediment transport for the first two storms recorded during this study were reported by Fisher, Leatherman and Perry (1974), and these results will not be reviewed. The March and November 1974 northeasters were sedimentologically insignificant. Field observations for both storms showed that overwash surges represented only a small portion of the total swash, as only the leading edge of water was able to traverse the beach face. The April 1975 northeaster also represented a threshold occurrence. Since none of these storms resulted in any appreciable amount of beach erosion or overwash, no further discussion is warranted.

The December 1, 1974 northeaster was the largest storm to attack these shores during the survey interval, and data is available for all survey sites along the island. Figure 2 shows the transect across Site 1 washover fan from the beach to the barrier flats. The fan gained 217 ft^3 of sediment per foot while the first 60 feet of beach seaward of the dune line was eroded 110 ft^3 per foot for a net gain of 107 ft^3/ft. The sand plug level indicated that erosion by the overwash surges was confined to the seaward-most (throat) portion of the fan. The total volume of material transported into this single fan was 9,840 ft^3 which corresponded to an effective transport of 221 ft^3 per foot of throat width.

Sites 3, 4 and 5 were also surveyed so that the amount of beach erosion and overwash deposition along these transverse slices of the island would be available for comparison. At Site 3, the lower beach was apparently not eroded by the December northeaster while the storm berm on the backshore was carved away (Fig. 3). The quantity of sand eroded from the storm berm approximately equaled the amount of overwash, except for a small total line loss of -29 ft^3/ft. The overwash penetration distance was 800 feet, equal to one-half of the island's width at this location, but only 91 ft^3/ft of material was deposited on the flats as overwash.

Site 4, the other line extending across the broad, nonvegetated washover flats, experienced a totally different pattern of sediment redistribution (Fig. 4). The upper beach profile migrated over 80 feet landward with a loss of 64 ft^3/ft for the 80 feet of beach surveyed. The major lens of sedimentation occurred from 200 feet to 600 feet landward of the beach for 153 ft^3 of overwash deposition per

TABLE 1. STORM PARAMETERS AND OVERWASH DEPOSITION

Storm Dates	Ho (ft)	Hb (ft)	Storm Surge/ Tide (ft)	Period (sec)	Overwash Deposition (ft^3/ft)
February 9-11, 1973[1] (Cape Hatteras)	22.5	--	--	--	130
March 22, 1973	17.5	6	1.6/4.3	8-12	50
October 26, 1973	14.0	6	1.3/4.4	10	59
March 30, 1974	10.0	--	no data[2]	--	0
November 8, 1974	10.5	--	1.2/3.6	--	0
December 1, 1974	16.5	9	2.7/5.0	7-8	221
March 19-20, 1975	11.5	5.5	1.0/3.3	8-12	29
April 15-16, 1975	11.0	--	--	--	0

[1] Schwartz (1975)

[2] Gage inoperative

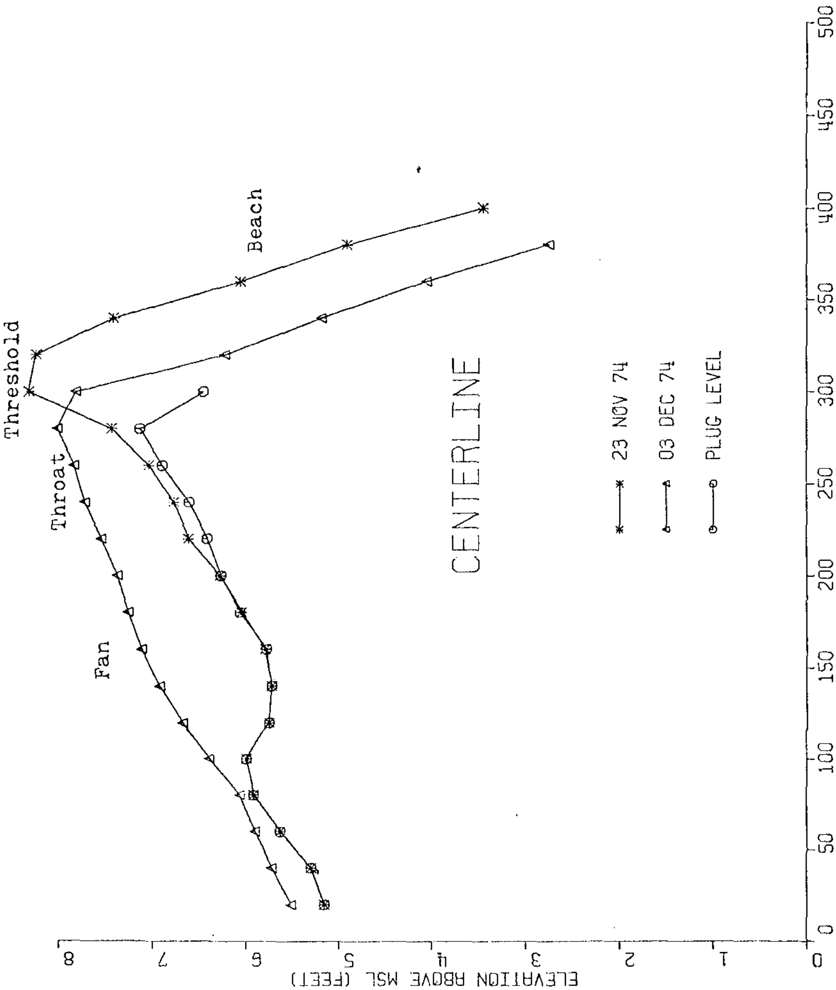


Figure 2. Site 1, Centerline Changes, December 1, 1974 Northeaster

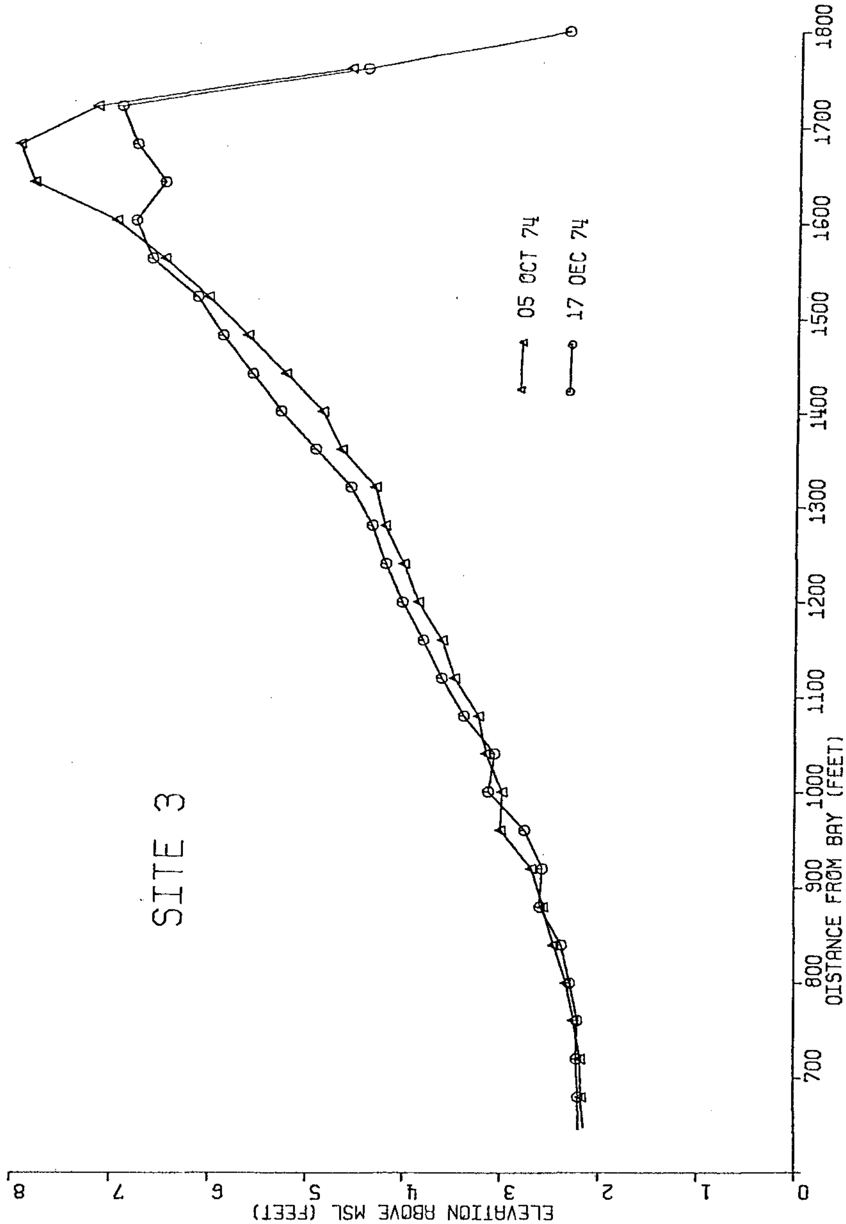


Figure 3. Site 3, December 1, 1974 Storm

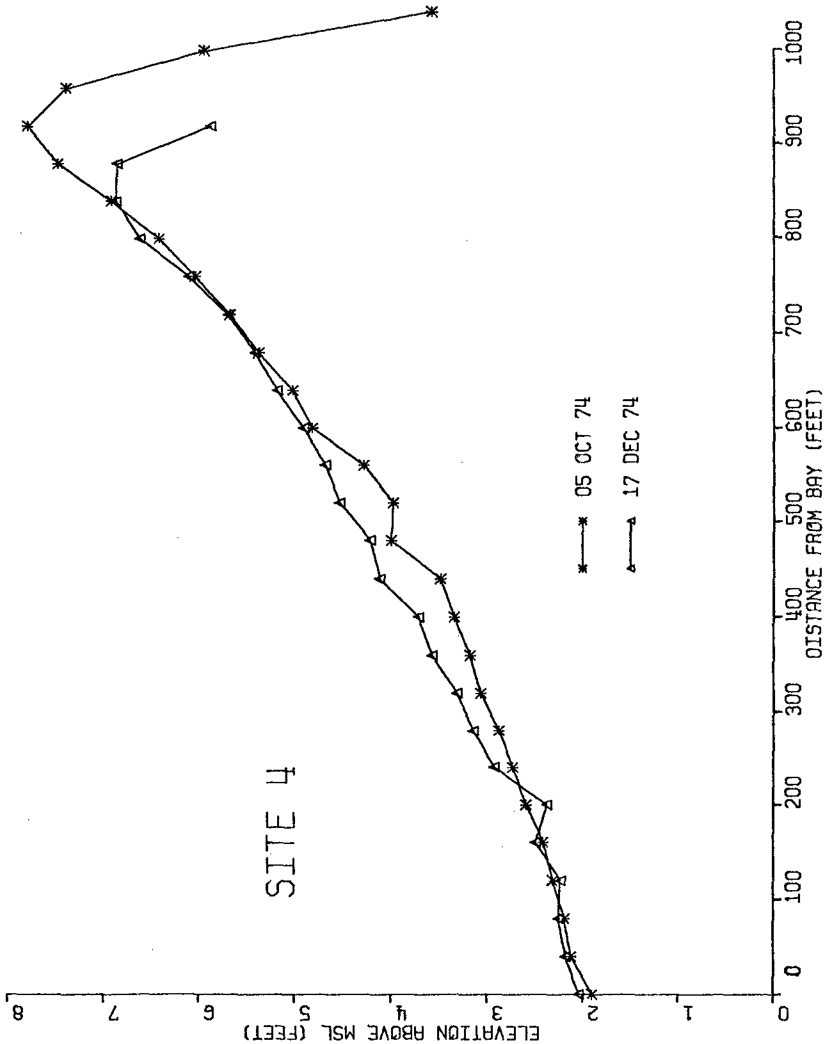


Figure 4. Site 4, December 1, 1974 Storm

foot of beach. Absence of material seaward of this zone of accumulation must be related to the hydraulics of the overwash surges. The overwash surges carried sediment to within 220 feet of the bay where it was deposited as delta foreset beds. Calculations indicate a net gain of seddiment across the profile line (89 ft^3/ft), but only 80 feet of beach was included in the survey.

The final survey site (Site 5) experienced the greatest amount of deposition. Approximately 300 ft^3/ft of new material was deposited along this line as overwash (Fig. 5). As in the previous cases, only the upper backshore of the beach could be surveyed due to high water so that the total amount of beach erosion could not be ascertained. The deposit abruptly terminated at a distance of 250 feet from the bay. The dunes were severely scarped and eroded, but volumetric determinations were not possible at this site.

During the March 1975 northeaster, an electromagnetic current meter was successfuly used to measure the overwash surge velocities during the storm event. The mean of the maximum instantaneous velocities was 5.2 ft/sec at 1.5 inches off the bottom, while the flow depths averaged 6 inches. During the 4 hour and 40 minute time period bracketing high tide, 121 overwash surges were recorded by the magnetic tape data logger. A comparison of profiles taken hours before the storm and on the following day showed that an average of 29 ft^3 of overwash material was deposited per foot of breach. There was actually a small amount of beach accretion (9 ft^3/ft), indicating a net onshore movement of bottom sediment. The barrier dunes were not eroded since the storm tide was quite low (Table 1).

Sediment Budget

Sediment budget calculations indicated the net changes for the washover areas. Overwash was the only significant mechanism of sediment transport to the backdune zone as documented by monthly surveys. Eolian processes were largely ineffective in westward transport, but the strong winter northwest winds resulted in severe deflation of the washover fan/flats between storms.

The net 2 year change at Site 1 has been erosion (Table 2). Survey lines that experienced greatest erosion were the least vegetated along their lengths. Figure 6 shows the net 26 month change along the centerline at this site. The fan elevation has been lowered several feet while the vegetation contact, which appears as a bulge in the survey line, has actually moved seaward during this time interval. The total change for the washover fan and adjacent environs at Site 1 has been a small net loss of material from the fan surface. Slightly over 1000 ft^3 of sand has been lost from the area bounded by the survey grid, not including seaside dune and beach erosion.

The trend for the adjacent washover fan (Site 2) was weighted heavily toward erosion for a net loss of 6,000 ft^3 during this time interval. This fan, however, was sparcely vegetated with an active

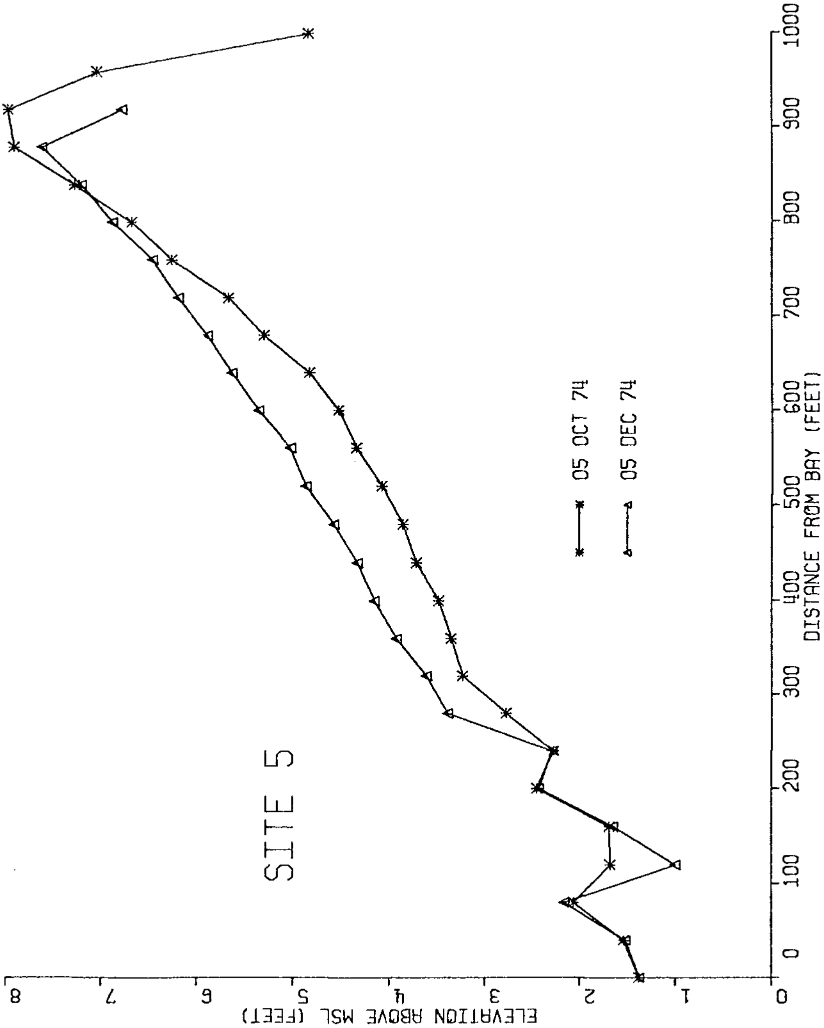


Figure 5. Site 5, December 1, 1974 Storm

TABLE 2. WASHOVER FAN AND BEACH NET CHANGE
(Leatherman, 1976)

Survey Dates	Line	Total Line Change (ft^3/ft)	Washover Fan (ft^3/ft)	Beach Change (ft^3/ft)	Length of Beach Surveyed (ft)
21 Apr 73 - 24 Apr 75	Northline 4 Site 1	+32	-4	+36	100
21 Apr 73 - 24 Apr 75	Northline 2 Site 1	+95	+74	+21	100
6 Apr 73 - 24 Apr 75	Northline 1 Site 1	-187	-86	-101	100
17 Feb 73 - 24 Apr 75	Centerline Site 1	-184	-117	-67	100
6 Apr 73 - 24 Apr 75	Southline 1 Site 1	-263	-122	-141	100
21 Apr 73 - 24 Apr 75	Southline 2 Site 1	-64	+31	-95	100
22 Apr 73 - 24 Apr 75	Southline 4 Site 1	0	+31	-31	60
5 Oct 74 - 24 Apr 75	Site 3	+3	-102	+70	80
5 Oct 74 - 24 Apr 75	Site 4	-67	-45	-50	80
5 Oct 74 - 24 Apr 75	Site 5	-147	-69	-45	80

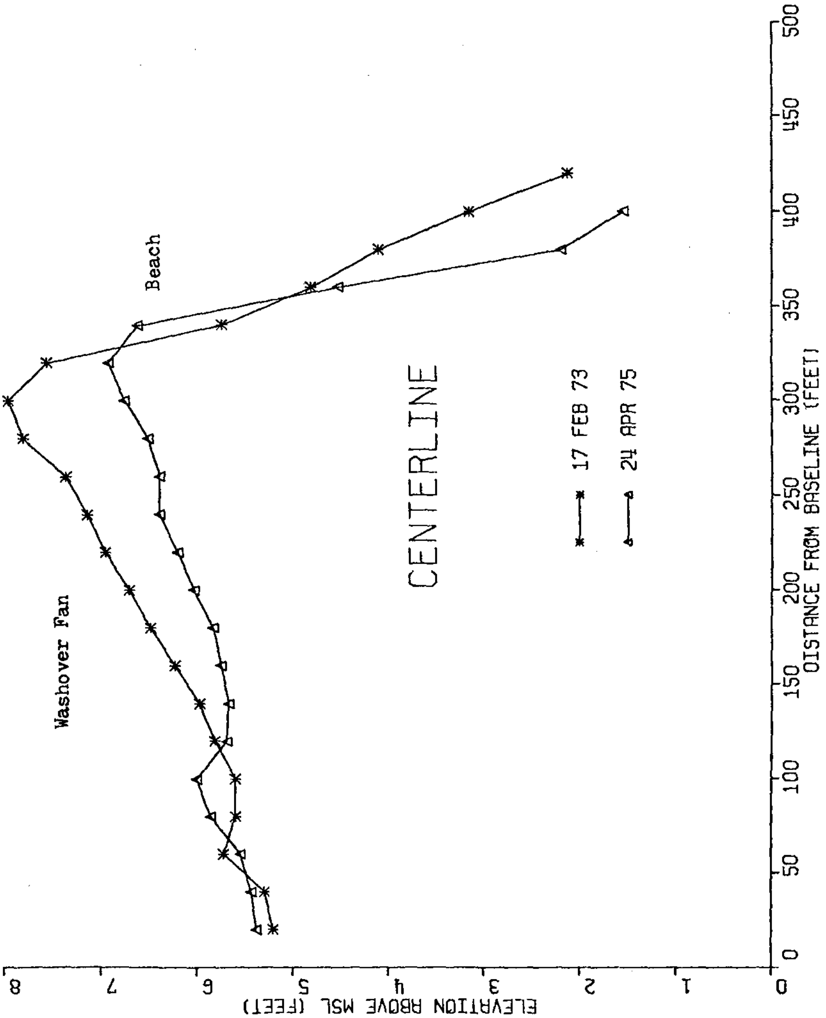


Figure 6. Site 1, Centerline, Net 26 Month Change

blowout on the north dune which flanked the fan. In the absence of any stabilizing agent, the newly-deposited overwash sand was very susceptible to reworking by the predominant northwest winds, resulting in loss of material from the fan surface.

Sites 3, 4 and 5 had similar response patterns during the 1974-75 storm season. In each case there was a zone of eolian action where wind was able to strip away large quantities of sand as shown at Site 4 (Fig. 7) and Table 2. Below an elevation of 4.7 feet, there has been net accretion on all three lines. Sand deposited below this critical elevation will not be reworked. Field observations indicated that this elevation coincided with watertable or semi-saturated conditions.

Discussion

A limiting criterion for the generation of an overwash event can be related to a significant wave hindcast by the Bretschneider method. Deep water waves with heights of 10 to 11 feet represent the minimum conditions necessary for overwash. This condition is generally satisfied by a small northeaster, which generates 24 knot winds for 20 hours or more. For larger events, the deep water wave hindcast is certainly an important index in terms of assessing a storm's impact on the shoreline, but is perhaps not the most important factor.

For this discussion of storm size versus amount of overwash, refer to Table 1. Data for the February 9-11, 1973 northeaster at Cape Hatteras is from Schwartz (1975), and this storm was hindcasted by this investigator for comparative purposes. Unfortunately, other storm parameters, such as amount of surge, are now known. Examination of Table 1 reveals that there is not a clearly definable correlation between storm size, as given by deep water wave height, and amount of deposition. A far more important parameter may be storm surge, in-as-much as the December 1, 1974 northeaster resulted in the largest amount of deposition per breach width, but had the third highest hindcasted deep water wave height. This analysis does not argue against waves as a controlling parameter for overwash but asserts that storm surge may be more important. Large waves and high surge are somewhat coupled systems since both are dependent on some of the same meteorological parameters. Based on this data set, it is suggested that storm surge is the single most important factor in determining the magnitude of an overwash. Since only certain size waves are allowed to reach the shore based on breaking criterion, it is the height of the storm tide that allows the dunes to be directly attacked by storm waves and swash surges to overtop the barrier threshold as overwash.

In attempting to determine if there is a differential amount of sedimentation along the island, only the December 1, 1974 overwash data is available for all survey sites. Sites 3, 4 and 5 showed the greatest amount of variance in deposition (Table 2), but are all con-

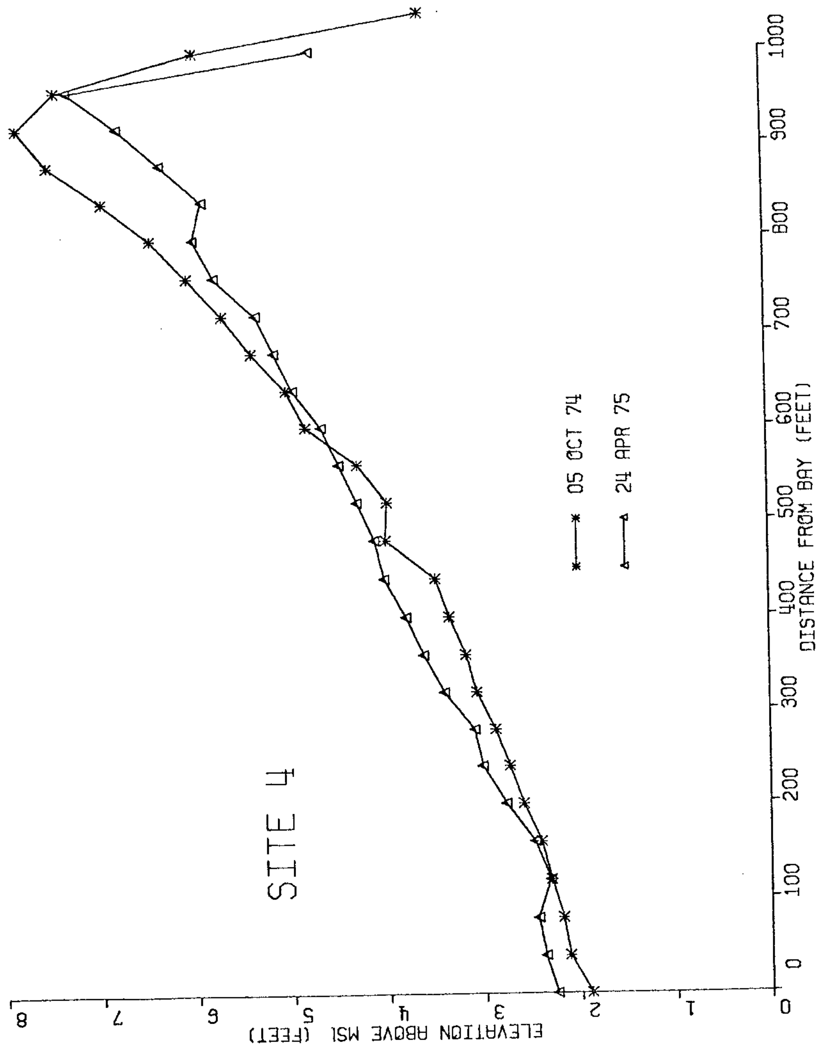


Figure 7. Site 4, Net 1 Year Change

tained within a one-half mile stretch of coast. This differential amount of sedimentation may be linked to local constraints, such as sand availability.

As previously mentioned, overwash deposition at Site 3 almost perfectly matched the amount of storm berm lost plus a small amount of beach erosion. At Site 4, there has been a much greater amount of overwash deposition, and, as reflected by before and after profiles (Fig. 4), probably a greater amount of beach erosion. The length of beach surveyed (80 ft in this case) was a severe limitation in exactly defining this relationship. At Site 5, there was 300 ft^3/ft of overwash deposition, which is over three and almost two times greater than that recorded at Sites 3 and 4, respectively. The corresponding amount of beach erosion at Site 5 was quite small in comparison to the large amount of deposition. It should be noted that Site 5 washover fan is bounded by large dunes on each side of the throat which may act as a source of sand. Post-storm field inspection indicated a large amount of seaside dune face erosion associated with its scarping and landward retreat. This analysis indicates that the chief source of material for the overwash surges is the beach backshore and dunes.

A rough calculation of the amount of overwash as compared to beach and dune erosion can be made by using the December 1974 data set at Site 1. The average amount of beach erosion for the first 60 feet seaward of the dune line was 118 ft^3/ft. Dune erosion rates were quite variable as recorded by the north and south dune profile lines, so an average value of 52 ft^3/ft was used for calculation purposes. The third dimension of the control volume can be defined as half the shoreline distance between fans on each side of the fan monitored. For Site 1 this distance corresponded to 145 feet of dune and 187 feet of beach length as source area or a total of 29,600 ft^3 available for net displacement. Total volume calculations for Site 1 showed that 9,300 ft^3 of material was effectively transported across the threshold which represented 31 percent of that available in this specified zone of change. The majority of sand removed from this zone was probably transported a short distance offshore to become incorporated into the large storm bar. Undefinable amounts of sand are permanently lost offshore, and an imbalance in the longshore transport at any particular point along the shoreline necessitates net erosion or accretion of material.

Conclusions

In spite of contributions from 7 discrete overwash events, there has actually been a small net loss of material from the fan/flats. Sand transport by wind was seen to be of the same order of magnitude as hydraulic transport by overwash. This analysis indicated that there is a balance between overwash and eolian processes with wind transport being slightly dominant. As a result of these two processes, there is a tendency for sediments from different environments of deposition to become homogenized. Since the backshore beach, dune and overwash sand are almost of the same mean grain size (1.70 ø) and standard deviation (0.30 ø), there is only a small loss of material associated with their transport and redeposition. Sand from each area can act equally as a source for the other. This interpretation agrees with the long-held concept that dunes serve as sources of sediment (to the beach) in times of need (during storms).

The above indicates that non-vegetated washover fan/flats serve merely as temporary reservoirs for the eventual redistribution of the sand. Wind reworks the deposit with the bulk of the sand being blown back onto the beach face. The result of this sediment exchange process is dune erosion due to seaside scarping, no change on the fan, flats and marsh, and a stable or eroding beach consistent with upstream littoral drift conditions.

Acknowledgements

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