CHAPTER 111

OFFSHORE SEDIMENTARY PROCESSES AND RESPONSES NEAR BEACH HAVEN-LITTLE EGG INLETS, NEW JERSEY

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INTRODUCTION

The offshore region in the vicinity of the Beach Haven and Little Egg Inlets of New Jersey is the site of the proposed Atlantic Generating Station, a floating nuclear power plant to be constructed 2.8 n. mi. offshore by Public Service Electric and Gas Company (Figure 1A). In order to assess the impact of this proposed project on the region, a comprehensive study of the nearshore and offshore region was conducted. A complete synopsis of this study is available in PSE&G (1976). This paper presents the results of the investigations into the sedimentary processes operative in the offshore region. The dynamics and coastal evolution of the nearshore region is summarized in DeAlteris et al, (1976; this conference).

The proposed Atlantic Generating Station (AGS) is located offshore of the complex and transient tidal inlet system of Beach Haven and Little Egg Inlets. These inlets are the major hydraulic connections between the Atlantic Ocean and the Great Bay and Little Egg Harbor estuaries. A large, roughly triangular ebb-tidal delta is present at the mouths of and between the two inlet channels. The major offshore bathymetric feature is a broad linear sand ridge, the Beach Haven Ridge, which trends northeast and reaches a maximum elevation of -28 feet (NLW) (Figure 1A). The AGS site is located on the landward flank of the ridge and partially in the adjacent trough in about 40 feet of water. Landward of the wide, northward-deepening trough, the ocean bottom slopes gently up towards the ebb-tidal delta of Beach Haven and Little Egg Inlets. The offshore zone adjacent to the proposed AGS is separated from an extensive tidal marsh lagoon system by a broken chain of barrier islands, from Long Beach Island on the north to Little Beach and Brigantine Islands on the south.

The Beach Haven Ridge is one of a system of sand ridges which occur on the shelf surface. In recent years the origin of these features has been the subject of a number of studies. Duane et al, (1972) studied the sand shoals on the inner portions of the eastern continental shelf of the United States. Swift et al, (1973) review the question of the ridge and trough topography of the Middle Atlantic Bight. A detailed description of the geomorphic elements of the inner New Jersey continental shelf for this region is presented in PSE&G (1975). Duane et al, (1972) suggested that the shoreface-connected ridges originated in a shallow nearshore environment in response to the interaction of south-trending, shore-parallel, wind-driven currents and waves during winter storms. They suggest that as sea level rises, and the shoreface retreats, the shoals are abandoned and isolated as "relict" features on the shelf surface. This concept was proposed in part by Moody (1964) from studies of the ridge system at Bethany Beach, Delaware.

Duane et al, (1972) recognized two categories of shoreface-connected ridges based on their orientation to the shoreline and their inferred response to the coastal hydraulic regime:

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Type I Ridges - Ridges with wide angle to the shoreline (over 30°)

Type II Ridges - Ridges with low angle to the shoreline (less than 30°).

Type I ridges are oriented transverse to the wind-driven storm currents and essentially parallel to the direction of wave attack. The Type II ridges would be oriented nearly parallel to the storm-generated currents and normal to the wave attack. During the initial stages of development, the low angle ridges (II) have the morphologic responses of wave-built bars (Duane et al, 1972; McHone, 1972). Wide angle ridges, such as those studied by Moody (1964), are more responsive to the coast-parallel storm currents and may migrate to the south. Moody's data showed that for a 42-year period, migration rates were about 10 feet per year. These cases of ridge migration were noted for the shallow segments of the shoreface-connected ridges.

Moody (1964) also suggested that considerations of wave refraction indicated that the wave orthognals tended to converge over crests, producing nearbottom residual wave currents which would converge obliquely shoreward toward the crests. The wave refraction patterns may also be an important generating mechanism for the shoal topography (Moody, 1964; Goldsmith and Colonell, 1970). Thus, ridges oriented parallel to the prevailing storm wave attack, would produce consistant patterns of wave convergence on the north side of their connections with the shoreline, causing erosion in this area. The ridges would tend to perpetuate themselves by a feedback mechanism during the retreat of the coastline.

The Beach Haven Ridge cannot be classified as a typical shoreface-connected ridge. Duane et al, (1972) define the shoreface-connected ridges as those ridges outlined by, but landward of the isobath that defines the shoreface (usually the 30 ft isobath). In the study area, the nearshore profile is dominated by the sedimentary buldge of the tidal delta from the double inlet system (Figure 1B). The Beach Haven Ridge is located adjacent to the basal segments of this progradational feature which has been deposited over the shoreward edge of the ridge system (Figure 1B). Thus, the position of the ridge is comparable to the isolated, "relict" linear shoals elsewhere on the inner shelf and its location adjacent to the rising nearshore profile (shoreface) is due to its proximity to the large inlet system. The Beach Haven Ridge forms a low angle with the shoreline and would be comparable to Type II ridge of the shoreface-connected ridges, suggesting a response comparable to a longitudinal bedform in relation to the inferred controlling processes. Thus, its position beyond the upper shoreface and its orientation, parallel to the storm currents (Type II), both suggest a degree of stability of position and a lower sedimentary transport climate. The studies conducted in the offshore zone tend to substantiate these inferences.

GEOLOGIC FRAMEWORK

The geologic studies carried out in conjunction with soil investigations of the AGS site are presented in detail elsewhere (Stahl et al, 1972; PSE&G, 1972). These investigations support previous findings which indicate that the ridges on the inner shelf were formed by nearshore dynamic processes subsequent to the Holocene transgression of the shoreline (Field and Duane, 1976).

In addition, the AGS studies indicate that a backbarrier sand unit is differentially preserved below the sand ridge and that the underlying Holocene lagoonal clay unit below this is locally exposed in the landward trough. The subsurface data thus suggests that during shoreface retreat, the backbarrier unit was differentially eroded from the trough and its residue was deposited in the adjacent ridge (Figure 1B). The preservation of the backbarrier facies below the ridge suggests that, once the ridge formed, it did not migrate substantially and thus protected the underlying backbarrier sandy units from further erosion in this earlier upper shoreface setting. This pattern of long-term stability, suggested from the geologic data, is consistant with the historical analysis of the ridge stability, the studies of short-term stability of the ridge in response to major dynamic events and the assessment of the sediment transport from the monitoring of the hydraulic regime.

SURFICIAL SEDIMENTS

The nearshore area in the vicinity of the AGS site was sampled during the summer of 1974. The location of bottom samples is indicated in Figure 1A. Grain size analysis was conducted on the samples using calibrated 1/4 Phi sieves and where appropriate, hydrometer analysis.

Sieving was conducted on 8-inch diameter sieves using standard techniques as outlined by Folk (1968). Sieves were calibrated with respect to effective openings by using sets of standard glass spheres from the U.S. Bureau of Standards. Calculation of statistical movement measures following Friedman (1961) and plotting of frequency, and cumulative frequency curves was carried out using a computer program.

The grain size parameters which were found most useful in defining the patterns of sediment distribution and dispersal in the nearshore zone were the modal grain size and the percentage of fines (greater than 62 microns). The distribution of these parameters are presented in Figure 2A and Figure 2B.

Previous detailed grain size studies have revealed that in sandy sediments, a central sub-population can be recognized (Moss, 1962, 1963, and 1972; Visher, 1967). This central population is the main component of most sands and appears to represent a saltation population of framework building grains. This central population is a near Phi - normal distribution and is represented by a central parabola when the frequency distribution is plotted on logarithmic scale (Hald, 1954; McKinney and Friedman, 1970). The parabola-like aspects of the distribution can be seen in the frequency plots listed in Figure 3 and 5B. The modal size was determined as the central grain size of this parabola. From Figures 2A and 2B the distribution of sediment patterns can be delineated.

Figure 3 presents the sequence of frequency curves on logarithmic scale across sampling Profile I to illustrate the nature of the systematic variation and tracebility of distinct modal entities and their relationship to the morphologic elements in the nearshore zone.

The modal size shows systematic variation which enables this parameter to be contoured and related to apparent dispersal trends which reflect the transport and depositional processes which resulted in accumulation of these sediments (Figure 2A). The modal size distribution map of primary modes has been constructed using a contour interval of 0.4 Phi units. The following sediment classes of modal sizes have been shaded for additional emphases: a) Modal sizes coarser than 1.0 Phi (includes coarser and very coarse sands). b) Modal sizes 1.0 Phi to 1.8 Phi (medium sand). c) Modal sizes 1.8 Phi to 3.0 Phi (fine sands). d) Modal sizes 3.0 to 3.4 Phi (very fine sands). Note that the boundaries between B and C listed above is not the boundary between medium and fine sands as defined in the Wentworth (1928) classification of grain sizes, but for the purposes of discussion in the context of the contouring of modal sizes discussed above, these subdivisions will be referred to as medium sands and fine sands, respectively. The contoured pattern of modal sizes reveals and outlines three major sedimentary facies:

1. Tidal sand deposits - these sediments are defined by the alternating patterns of fine and medium sand reflecting the onshore-offshore pattern of tidal ebb and flood flow from the double inlet system.

2. The shoreface very fine (and silty) sands.

3. The shelf sand sheet - with modal sizes ranging from coarse to fine sands.

Tidal Sand Facies - Tidal sand facies as mapped by the contours of modal shows a very close relationship to the tidal channel and inlet morphology. Fine sands are deposited on shoal areas between active tidal channels which are characterized by medium sands. Locally, coarse sands characterize the deeper portions of the inlet channels as in the Beach Haven channel system to the north. A general asymmetry to the sizes can be noted within the inlet system with the northern half of the inlet system being characterized by a predominance of medium sand modal sizes, while the southern portion has a greater abundance of fine sand sizes. Charlesworth's (1968) study of sediments and hydraulics of this double inlet system reveal a similar southerly decrease in grain size as defined by trend surface analysis of mean grain sizes of inlet samples. The variation in modal size also shows a systemic pattern of decreasing sizes down the axis of the inlet channels in an offshore direction. This pattern terminates in bulges in the modal size contours of the fine sand lobes on the upper shoreface. This would seem to indicate and reflect the decreasing sediment transport capacity associated with the flow in the tidal channels offshore and the associated deposition. Fine sand seems also to have accumulated in the shadow zone of the ebb flow seaward of Tucker's Island.

The distal portions of the complex ebb delta system is marked by a slope increase illustrated by the 10- to 15-foot contours. Locally, a flattening is noted on the upper segments on this outer delta front, seaward of the Beach Haven Inlet as outlined by the 5-foot contour. These outer flattened margins of the delta complex are characterized by coarser grain sizes. The flat area off of the Beach Haven delta is characterized by modal sizes of 1.2 to 1.3 Phi. The outer edge of the delta front to the south is characterized by an increase of modal sizes to 1.5 Phi above the surrounding suite of modal sizes which range from 1.8 to 2.1 Phi. These patterns apparently reflect the storm-wave reworking of the outer distal portions of the ebb tidal delta.

Most of the tidal sands within this area are characterized by very low percentage of fine material. In general, there is an increase in the percentage of fine materials at the distal edge of the tidal sand facies corresponding with the sediments in the upper portions of the shoreface zone, where percentages of fines increased to 0.5 to 1 percent of the total sediment (Figure 2B). Locally, a few sampels within the tidal sand facies contain percentages of fines greater than 1 percent as is indicated in Figure 2B.

Shoreface Facies - The modal size distribution reflects a systematic decrease in grain size from the sediments which characterize the outer segments of the tidal sand facies as described above, into the sedimentary suite defined as the shoreface sand. These sands are characterized by a definitive pattern of modal grain sizes which occur within the upper portions of the shoreface morphology as defined by the approximate position of the 15-foot contour.

The sediments within the shoreface zone are characterized by a very uniform pattern of modal sizes over the wide area of this zone which range from 2.9 Phi in the upper portions of the shoreface to 3.2 Phi in the lower portions (Figure 2A and 3). In general, this area is characterized by sizes within the very fine sand modal class.

The distribution of these very fine modal sands is best developed in the central and southern portions of the study area. The shoreface area seaward of Long Beach in the northern segment of the study area does not appear to be characterized by a continuous suite of very fine sands. In this region, corresponding with the location of small-scale ridge and swale morphology, the bottom sediments are characterized by coarser grain sizes ranging from fine to medium to coarse sands. The distribution in the occurrence of the very fine modal sand class as outlined in Figure 2A also corresponds with those areas characterized by percentage of fine material which are greater than 1 as indicated in Figure 2B.

Thus, the shoreface sands are located within a definitive morphological setting and are characterized by the well-defined and narrow range of modal sizes and increased percentages of fine silty material. The percentage of fine materials increases locally on the lower portions of the shoreface zone to values in the 30 to 40 percent range (Figure 2B).

The shoreface sands have been identified from textural analysis of samples within cores from subsurface material across this zone. Cores through the shoreface suite are characterized by similar modal sizes of very fine sand and similar percentages of fine silty material. Sedimentary structures within the cores are locally characterized by thin laminations of this very fine silty sand material. Except for the occurrence of one sample in the landward trough of the offshore sand facies to be described below, this destinctive modal suite is present only within the narrowly defined limits of the shoreface zone.

<u>Shelf Sand Facies</u> - Beyond the thin distal edge of the shoreface very fine silty sand facies described above, lies the shelf sand sediments. This facies is characterized by predominance of coarse and medium sands. The contour patterns of modal grain sizes for this offshore suite is characterized by a distinctive coast-parallel orientation in contrast with the coast-perpendicular patterns of contours in the tidal sands and shoreface facies.

The northern portions of the shelf sand facies is characterized by very coarse modal sizes, apparently representing the southern distal edge of the reworked fluvial gravel deposits of Schlee and Platt (1970). Frank and Friedman (1971), also identified these coarse sands in similar depth position immediately to the north of the present study area.

The boundary between the offshore distal edge of the shoreface sand and the shelf sand facies is, in general, a very sharp one as indicated by the contours of modal size (Figure 2A), with modal sizes varying from very fine sands to coarse to medium sands within very short distances. In addition, sediments of the shelf sand facies located adjacent to the distal edge of the shoreface sands are characterized by secondary modes of the very fine sand mode of the shoreface suite (Figure 3).

As with the other facies within the study area, there appears to be a regional fining of the grain sizes within the shelf sand facies from coarse on the north to predominantly finer sizes on the south.

The more detailed variations in the distribution of modal sizes can be described within the context of the ridge and swale topography as outlined in the bathymetric chart of the Atlantic Generating Station area

(Figure 1A). The landward trough of the Beach Haven Ridge is characterized by an underlying framework of medium and coarse sand sizes. This suite forms a thin cover over the Holocene lagoonal clay unit as described in corings and borings (Figure 1B). Locally, the clay is exposed at the surface. In addition, during the sampling period, isolated samples of fine sand and one sample of very fine modal sand were present within the landward trough. The medium and coarse sands above the Holocene clay show the presence of secondary modes of fine and very fine sands as admixtures (Figure 3). Locally, higher values of fine material (Figure 2B) correspond with the presence of the very fine sand admixtures in the landward trough.

Thus, the landward trough is characterized by a thin sedimentary cover which represents an admixture of predominantly coarse and medium modal sizes and local admixtures of suspended fine material and secondary modes of fine and very fine sand which locally represent the predominant modal size. Thus, the sorting within these sediments is relatively poor compared to adjacent areas (Figure 3).

The Beach Haven Ridge itself is characterized by the predominance of medium sand sizes along its axial portions. A decrease of modal sizes occurs from the central axial portions of the ridge down the northward sloping axial portions of the ridge from grain sizes of 1.2 Phi to 1.3 Phi to 1.4 Phi in a northerly direction. A central zone of coarse sand is located along the axial portions of the ridge where the lineation aspect of the ridge is clearly defined. The location of this coarse sand zone along the axis of the ridge correlates with the crossing of caustic rays as indicated in the wave refraction diagrams for storm waves from the northeast (PSE&G, 1975). Further to the south of this area, along the continuation of the ridge trend, grain sizes within the ridge proper decrease. In this region, the ridge morphology is not clearly defined and flattens out with a general southward merging with the shoreface morphology.

This flattening of the ridge crest to the south is outlined by the nature of the 30- to 35- foot contours in this area (Figure 1A). Also noted in the ridge morphology in this region, is a broad delta-like fan which occurs on the upper portions of the seward flank. This is indicated by the outline of the 35- and 40- foot contours. This feature, which occurs opposite a lower area, or swale in the crestal portions of the ridge, is very similar to the fan-like features mapped and discussed by McHone (1972) for a shallow shoreface-connected ridge on the south Virginia coast. The Virginia features are associated with erosional saddles in the ridge crest and have been ascribed to the breaching of the ridge during storms and the deposition of fine sediments in the adjacent sediment lobes on the seaward flanks.

A careful examination of the modal sizes in the area of this fan-like buldge shows that it corresponds to a comparable lobe of finer bottom sizes as indicated by the seaward convexity in the isopleths of modal size that become finer down the axis of the fan. At the base of the fan, immediately seaward of the 35-foot contour, a depocenter of fine sand (modal size 2.2 Phi) is noted.

Superimposed on the general pattern of coarse and medium sands, is the distribution of fine sands in selected areas in the offshore sand facies. A distinctive aerial distribution of such fine sands is encountered on the seaward flank of the Beach Haven Ridge and incorporates the fan-like feature described above.

The modal sizes of the outer shelf fine sands are characterized by a narrow range of modal sizes (2.0 to 2.3 Phi). This is in contrast to the wide range of fine modal sizes noted for the sands of the tidal facies which can be related to the systematic dispersal of sediment from the tidal inlets. The surficial zone of fine sand (2.0 to 2.3 Phi) noted on the seaward flank of Beach Haven Ridge has also been identified from analysis of cores in this area. The core data indicates that the fine sands are 1 to 2 feet thick and overlie medium sands which characterize the core of the ridge. Another ridge-parallel zone of fine sand occurs further seaward of the ridge flank but it is not as clearly defined as the former. To the south, both fine sand units appear to merge to form a broadening zone of fine sand which characterizes the southern inner segments of the shelf sand facies.

The occurrence of the fine sand deposit on the seaward portion of the Beach Haven Ridge also corresponds to a general increase in the percentage of fine material in this area of the offshore facies. Locally, values of percent of fines are greater than 1 and in a few cases very high portions of fine material occur in isolated patches on the outer segments of shelf sand facies (Figure 2B).

BOTTOM STABILITY

An analysis of bathymetric data from 1677, but in detail from 1935 to 1972, reveals the Beach Haven Ridge has maintained its general position for almost 300 years and its overall orientation and shape for at least 35 years, the period when detailed maps were available. Moderate variation in the sea floor over this period are, however, evident.

The landward trough has been the site of alternating periods of infilling and erosion. The periods of infilling can be related to greater influx of sediment from the adjacent inlet system. The correlation of such an event with the passage of Hurricane Agnes in June 1972 suggests that sediment was pumped out of the inlets by the reflux of storm surge that accompanied this event and was deposited at the distal edge of the shoreface. Subsequent remobilization of this fine silty sand during storm events, resulted in the removal of a few feet of this material from the trough surface. At no time, however, did erosion proceed down to and involve the Holocene clay unit which underlies the trough. The overall trend was one characterized by a general erosion of the lower shoreface and the south-trending headward segments of the trough.

The erosive resistance of the Holocene clay which underlies the trough is further documented by a laboratory analysis of the critical shear stress of erosion of this unit that was carried out at the University of

California, Davis (Krone, 1974), samples of cohesive sediment from 20 diver-collected cores were kept moist and shipped immediately to Davis. Testing was accomplished using a rotating cylinder apparatus, modified after Moore and Masch (1962), using both sea water and distilled water. The critical shear stress for surface erosion was found to exceed the capacity of the apparatus, 82 dynes/cm^2. Occasionally, the presence of small sand lenses and concentrations of shell material, resulted in the falling off of "chunks", even though the rest of the surface did not erode.

Accompanying the patterns observed in the landward trough, were the observations of slight depositional trends ranging to a few feet on the seaward flank of the ridge. Subsequent sediment analysis from cores and surface samples indicate that this depositional trend was also characterized by fine sands. Thus, the differential mobility of the fine sands appears to correlate to the minor variations in the ridge and trough morphology over the measuring period.

A program to evaluate short-term changes in and around the ridge was conducted from the summer of 1973 to the summer of 1974. Bottom elevations were measured by divers on a bi-monthly schedule. Measurements were made with reference to a series of stakes at each field (Figure 4A). The results indicate that there was no significant scour or accumulation at any of the stake fields at any time during the measuring period. Variations noted were on the order of magnitude of the wave ripple heights.

In addition to bottom elevation measurements, the stake field study enabled divers to collect bottom samples over the monitoring period for an analysis of the temporal variations in bottom sediment texture. The statistical parameters for a particular stake field were remarkably consistent during the measuring period. This consistency is reflected in the plots of the size distributions which fall into tight envelopes as plotted on the Phi-probability scale (Figure 4B). The small variations noted may easily reflect the variations expected due to the combined sampling, splitting and analysis operations and/or the variations related to position on a ripple crest or trough. Stake field 5 samples showed the most variability within the stake field and with time for a particular stake. The slight variability at stake field 5 occurs in the fine sand portion of the distributions.

Storm Hydraulics and Effects of December, 1974 Storm - The long-term cumulative effects of erosion and deposition are intergrated and reflected by the changes in the historical bathymetry. Such patterns are responses to the coastal circulation system.

The dynamic aspects of the coastal circulation at the AGS site have been monitored for over two years (E.G.&G. 1974, 1975). This area is characterized by the interaction of tidal current outflow from the inlets and the general pattern of coast-parallel, coastal current circulation. Like other segments of the Middle Atlantic Bight, this coastal region displays a geostrophic coastal current which is driven by the density patterns associated with lighter nearshore waters due to the freshening influence of river runoff and results in a general net south-westerly drift, measured at the site as 5 cm/sec. Although the net and predominant drift is to the south, during winter months, due to the low runoff and extreme cooling for the inner shelf waters, the density gradients are reversed and the drift can be reversed, to a northeasterly direction. Superimposed on this coastal drift, is a weak (1.5 cm/sec.) quasi-estuarine onshore-offshore circulation; offshore in the surface waters and onshore along the bottom.

The dominant process operative in the offshore area with the potential for differential sediment transport, is the wind-driven circulation associated with major storms. The intensity and directional aspect of the bottom flow regime is directly related to the wind intensity and direction; reversals in the wind direction are accompanied by reversals in the bottom current circulation patterns. The wind patterns associated with storm events generally resulted in coast-parallel circulation particularly to the southwest or downcoast direction in response to "Northeaster" storms which characterize this area. Currents in this direction tended to be characterized by somewhat greater values and were of slightly longer duration than the upcoast bottom currents associated with continental storms. This can be related to the superposition of the downcoast wind-driven circulation with the southwesterly geostrophic drift which characterizes the coastal circulation. However, the data indicates that upcoast storm-driven bottom circulation does occur in response to continental storms and must be considered in the evaluation of the sedimentary processes for the offshore area. This upcoast transport is increasingly important for winter months when the tendency for a northeasterly drift is increased.

The current data (obtained from Savonius Rotor instruments) as summarized for the year 1972, shows that the percentage of occurrence of current values with a potential for bottom transport (velocities greater than 40 cm/sec. near the bottom) was about 3 percent and was associated with the wind-driven circulation from these storm events, mostly in a downcoast direction.

On December 1 and 2nd, 1974, a major northeaster storm passed the site, resulting in strong winds out of the east with unlimited fetch. A maximum observed wave height of 5.6 meters and a maximum significant height of 4.4 meters, recorded on December 1st were the most severe to be encountered during the two year measuring period. This storm was the most damaging coastal storm for the eastern seaboard since the major storm of 1962. Peak flow in the lower meters had an hourly average speed of 62 cm/sec, while the upper flow speeds reached 85 and 95 cm/sec, directed in the downcoast direction. In order to assess the impact of this storm on the bottom configuration and sediment texture of the ridge, a series of bathymetric profiles across the ridge system were measured shortly after the storm (Figure 4A). In addition, stake fields 2 and 5 were measured and bottom sediment samples were collected to compare with earlier data. Comparisons of the pre- and post-storm profiles are presented in Figure 5A. The results indicate that the ridge system was essentially unchanged by the storm. Measurements at stake fields 2 and 5 were unchanged also from the previous measuring period. The post-storm bathymetric profiles do indicate that one to two feet of sediment was eroded from the lower portion of the shoreface and some from the landward trough. There is also the suggestion of a slight zone of accretion on the seaward flank of the ridge in places. The sediment analysis of the post-storm samples did show an interesting variation at stake field 5; stake field 2 sediments were unchanged. The comparison between a representative size distribution for stake field 5 sediments prior to the December, 1974 storm and the post-storm sediment distribution is presented in Figure 5B. The storm resulted in the addition or admixture of a distinct very fine sand modal component to the earlier sediment distribution. The very fine sand population apparently is derived from the erosion and remobilization of the very fine silty sands of the lower shoreface and landward trough. The storm transport has apparently moved this material from the lower shoreface and trough up onto the landward flank as a thin textural admixture. The process has also enabled the separation of the silty fraction from the shoreface sands as the very fine sand moved offshore as bottom sediment while the fines (< 62 microns) were suspended and apparently travelled further downcoast.

DISCUSSION AND CONCLUSIONS

The distribution of the sediments in the study area and the aerial variations in their compositional and their textural parameters provide insight into the nature and degree of sediment transport processes that have been operative in this region. The modern active processes of sediment transport and deposition are most active in the double-inlet system in the nearshore zones. Here, tidal currents are largely responsible for the sediment patterns observed. The decreasing pattern of grain sizes and increased proportion of fine suspension material of the shoreface zone, represents the distal portions of the modern zone of nearshore sedimentation. The origin of the basic coarse pattern of the sediment distribution and character of the offshore shelf sands cannot be attributed to modern processes. Their general pattern can be related to the reworking of fluvial deposits to the north and the differential erosion of backbarrier Holocene sediments by coast-parallel processes at lower sea levels.

The nature and degree of modern sediment transport in and around the offshore ridge system can be closely related to the distribution of fine sand and suspended material as primary and secondary modal entities in the offshore sands. The landward trough is the distal depo-center for modern very fine sand and silt derived from the nearshore zone. When the influx of this fine silty sand material is high, as perhaps during major storm events which produce a flushing of the inlet system, the trough floor is covered with these fine silty sands over the thin coarser sands which cap the Holocene clay within the trough. Subsequent coast-parallel storm transport, especially by northeasters, may flush out the fine sands from the trough. This appears to reflect the ongoing balance of accretion from, and progradation of, the distal portions of the shoreface zone and the subsequent reworking of these loose silty sands by storms.

The remobilization of the fine sands in this setting at the headward portions of the trough, may thus pass to the south and over the flattened crestal parts of the ridge. Such migration of the mobile fine sand fraction would explain deposition of the fine sands which characterize the gentle seaward flank of the ridge. This sand has accumulated here in the "lee" of the ridge as a thin coating and relates to data from the historical bathymetry analysis which indicates accretional events in these seaward flanks over various measuring periods.

The base level of the landward trough reworking is clearly the erosion-resistant Holocene clay foundation and its coarse sand capping.

It is the coming and going of the fine silty sands which have characterized the modern sediment transport in and around the ridge system. Elsewhere, away from the main source of this modern fine material, the coarser sediments of the offshore shelf facies only display this finer material as subordinate bimodal admixtures.

The well sorted and unimodal medium to coarse sands of the Beach Haven Ridge crestal zone are an exception. Here storm-wave agitation has apparently kept these transient fine fraction admixtures from accumulating within the crestal ridge sands.

The suggestion that the only significant transport of sediment in the offshore zone, is the fine sands which form the thin and disconnected admixtures into the coarse sands of the offshore shelf facies, is substantiated by sediment analysis of the stake fields. In particular, the post-storm (December, 1974) sediment comparisons for stake field 5 clearly indicated that it is this fine sand only, which has been differentially moved and deposited on the ridge's landward flank.

It is concluded that the Beach Haven Ridge, originated during an earlier sea level stand by an active differential erosion on the upper shoreface. Due to sea level rise, the ridge system is now located out of the zone of active shoreface erosion and within the zone of nearshore deposition. The outflux of sediment in the nearshore zone from the double inlet system is of considerable magnitude and has been capable of covering the shelf sand facies (Figure 1B). This depositional zone thins to a distal edge over the shelf sands to the north, apparently due to the net effect of the transport of the shoreface sands to the southwest in response to the net coastal currents in that direction.

A differential battle at the offshore distal edge of the shoreface depositional zone, between the progradation of this edge, due to the greater sediment influx into this zone, and the regression of the distal edge by the reworking currents and low sediment supply to the offshore zone, appears to characterize the sediment regime in the offshore area. In this battle, fine sands are transported over the ridge system out onto the shelf in a step-like fashion, as a thin coating over the older coarser shelf sediments. The long range pattern, if sea level continues to rise, would be one of the translation of the nearshore shoreface depo-center shoreward, further isolating the ridge system as the distal edge as the shoreface migrates landward.

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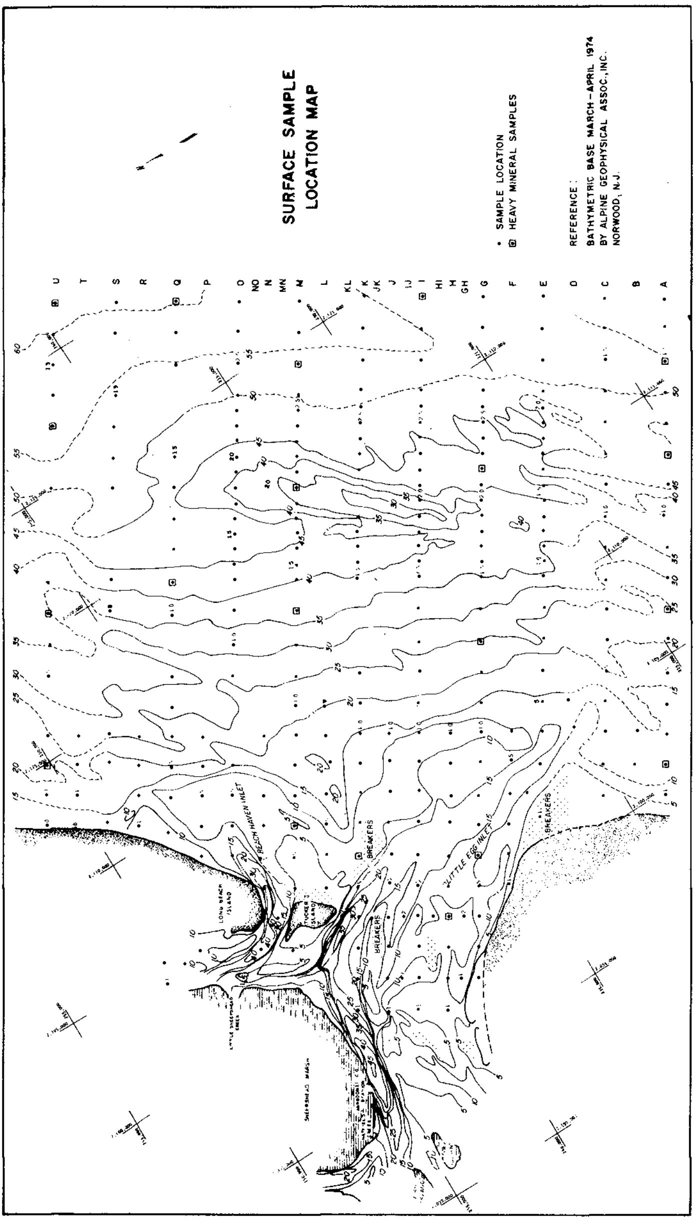
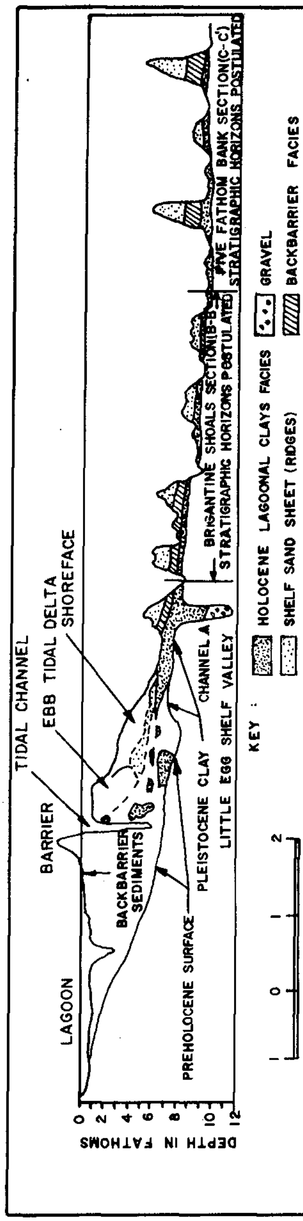

SURFACE SAMPLE
LOCATION MAP
• SAMPLE LOCATION
⊡ HEAVY MINERAL SAMPLES
REFERENCE:
BATHYMETRIC BASE MARCH–APRIL 1974
BY ALPINE GEOPHYSICAL ASSOC., INC.
NORWOOD, N.J.
BEACH HAVEN INLET
LITTLE EGG INLET
BREAKERS
LONG BEACH ISLAND
TUCKER ISLAND

FIGURE 1A



COMPOSITE GEOLOGIC PROFILE OF INNER NEW JERSEY SHELF (SCHEMATIC)

FIGURE 1B

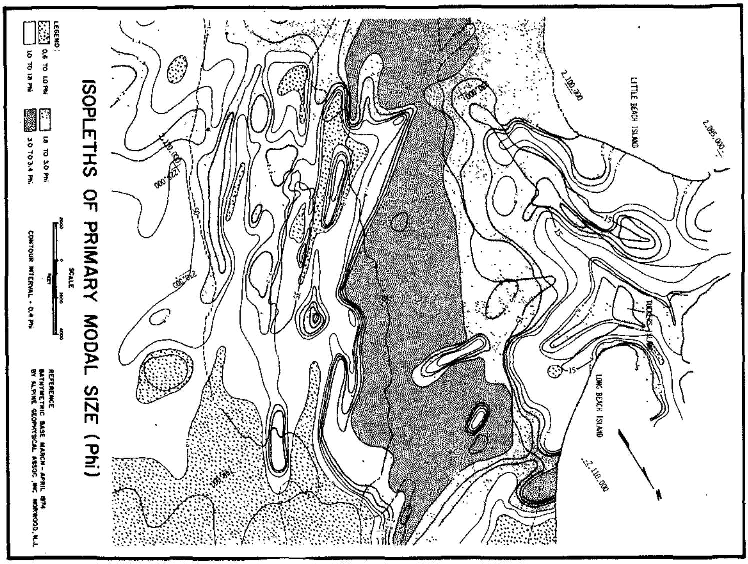


FIGURE 2A

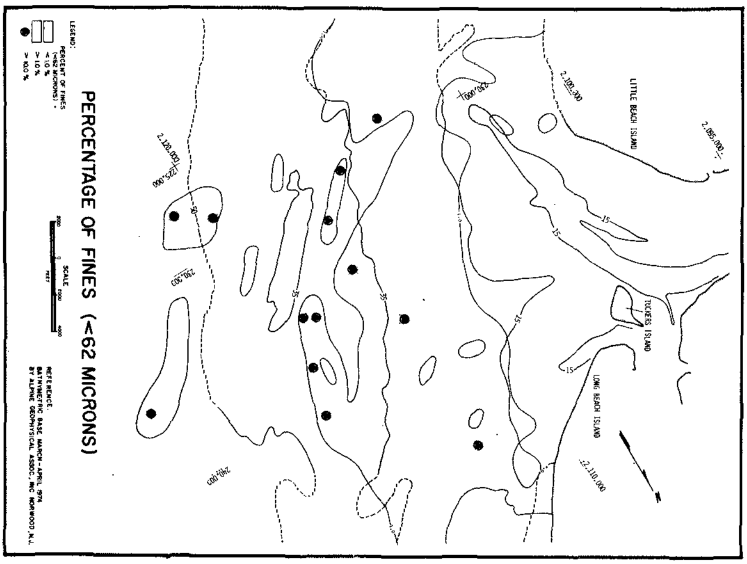


FIGURE 2B

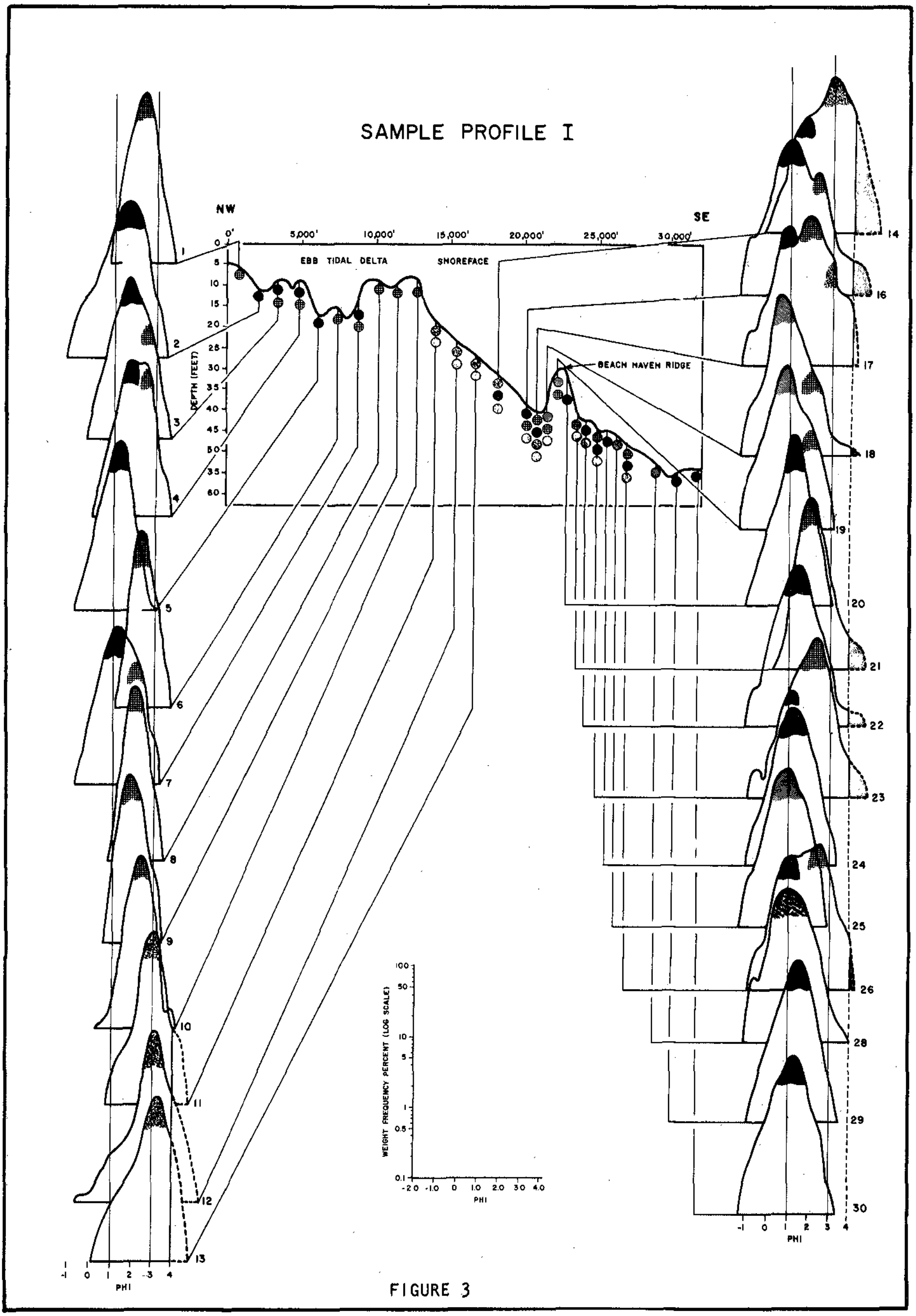

SAMPLE PROFILE I
NW
SE
0'
5,000'
10,000'
15,000'
20,000'
25,000'
30,000'
EBB TIDAL DELTA
SHOREFACE
BEACH HAVEN RIDGE
DEPTH (FEET)
WEIGHT FREQUENCY PERCENT (LOG SCALE)
PHI

FIGURE 3

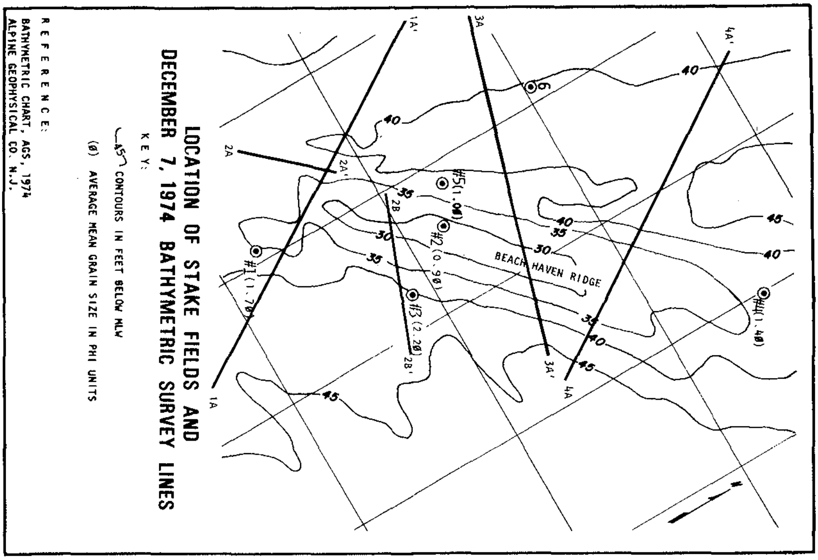


FIGURE 4A

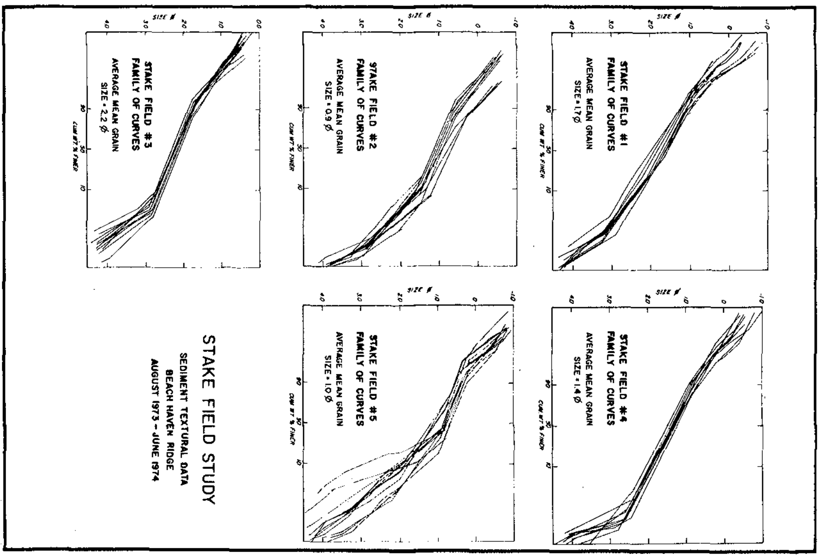


FIGURE 4B

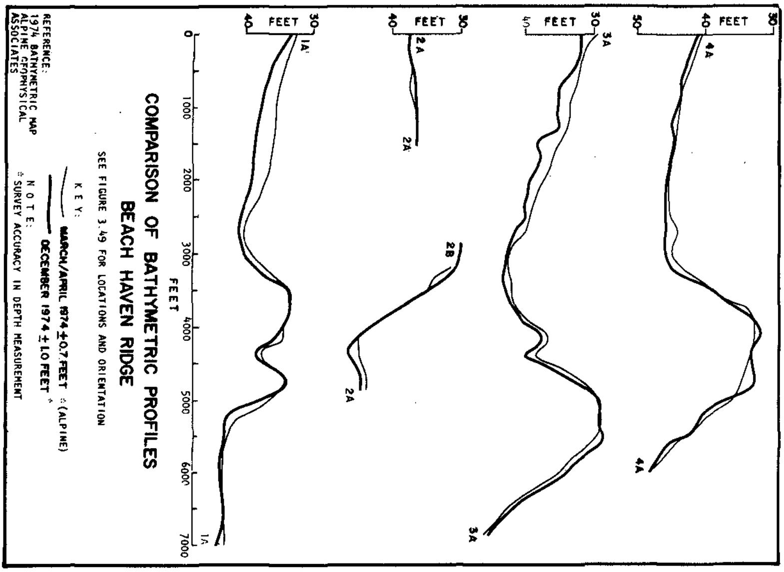


FIGURE 5A

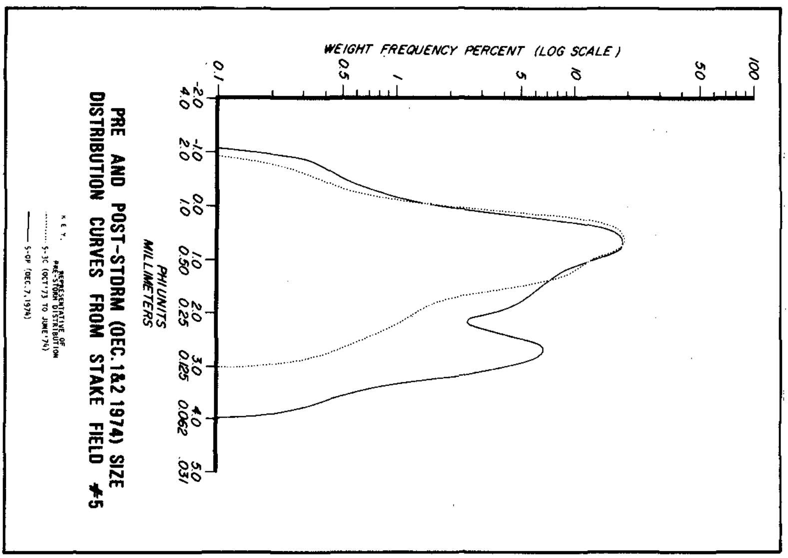


FIGURE 5B