CHAPTER 256

FUNCTIONING OF GROINS AT WESTHAMPTON BEACH, LONG ISLAND, NEW YORK

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ABSTRACT: An extended field of 15 long rubble stone groins was constructed in two increments of work at Westhampton Beach, New York, in 1965-66 (11 groins) and in 1969-70 (4 groins), as part of a hurricane storm-protection project. A third increment of work completing the protection to a downdrift point of closure was not undertaken due to political decisions. In addition, the dune and beach fill which was to have been placed in the first 10 groin compartments to complete the protection was not accomplished due to local economic problems. No construction work has been undertaken since 1970. During the 26 years following completion of the original 11 groins, substantial portions of the groin field have been filled naturally by trapping of sediment that moves alongshore with a net rate directed to the west. However, the shore area downdrift of the last westerly groin in the unconstructed increment of work has experienced inordinate recession because of insufficient bypassing of sediment to this area. This paper describes the functioning of the groin field, examining both the extreme downdrift recession and the equally dramatic accretion and beach build up in the groin field, drawing lessons on groin functional design from this historic project.

INTRODUCTION

In 1938, the south shore barrier island system along Long Island, New York, was devastated by a hurricane that is the storm of record for this Atlantic coastal area of the United States (Andrews 1938). The barrier islands were greatly eroded and weakened, and erosion was subsequently increased by other extreme hurricanes and extratropical storms that struck the area in 1944, 1950, 1953, 1954, 1958, 1960, and 1962 (USACE 1958, 1963). Since 1962, there have been frequent occurrences of severe extratropical storms, the most

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recent being the October 1991 (Halloween) storm and the winter storm of December 10-12, 1992. Many sections of these east-west oriented barrier islands are in danger of breaching and flooding, and property has been lost or jeopardized by erosion. In 1960, storm-protection plans were authorized by the Federal Government for the coastal area between Fire Island Inlet and Montauk Point. One of the reaches included in the project was the barrier island that extends 24.6 km between Moriches Inlet to the west and Shinnecock Inlet to the east (Fig. 1). As part of the plan, groins were constructed initially on the most vulnerable section of the reach, called Westhampton Beach, with the objective of providing a wide beach and dune as a storm-protection measure.

The original plan provided for construction dunes and fronting protective beaches and 23 groins (if needed) in this reach (USACE 1958). Owing to political and economic considerations (Heikoff 1976), only 11 groins were constructed in 1966 in Section 2A without placement of the dune and beach fill along 3.8 km of shore westerly from a point 10.6 km east of Moriches Inlet, as shown on Fig. 2. This work was supplemented in 1970 with completion of four groins in Section 1A along 1.8 km of shore extending west of the existing groins, together with placement of dune and beach fill in the four westerly compartments (USACE 1969). A third increment of work in Section 1B along 2.9 km of shore to the west providing for six additional groins and accompanying fill was not undertaken due to political decisions (Heikoff 1976).

Because construction was halted before implementation of the third increment of work, the downdrift beaches to the west, which would have been spanned by groins, have eroded significantly, as shown in Figs. 3 and 4. In contrast, a huge dune system and wide beach have developed naturally in the 14 groin compartments, fully realizing the original intent of the storm-protection plan for the sections of reach spanned by the groin field. The net potential longshore sand transport rate on these western, fine-to-medium grain size barrier islands is estimated at 300,000 cu m/year to the west (Panuzio 1968).

In the present study, a large, unpublished data set of beach profile surveys and aerial photography was analyzed to quantify the functioning of the groins at Westhampton Beach. These data provide valuable documentation about the site and extensive coastal process information for understanding the general functioning of groins.

GROIN DESIGN

The project groins, shown in profile in Fig. 5, were designed to reinforce a beach and dune fill intended to provide hurricane and storm protection. The backshore dune had a top width of 7.6 m at elevation +6.1 m National Geodetic Vertical Datum (NGVD), and front and back slopes of 1V:5H. The fronting protective beach had a berm width of 30.5 m at elevation +4.3 m NGVD, with foreshore slopes of 1V:20H from the seaward edge of the berm to elevation -0.6 m, and thence 1V:30H to the existing offshore bottom (USACE 1963).

The groins, which were constructed with quarry stone, have an average spacing of 400 m and are 146.3 m long. The groin design provided a horizontal inshore section 39.6 m long at elevation +4.9 m NGVD, an intermediate section 64.0 m long sloping 1V:15H from the seaward edge of the inshore section to the beginning of a 42.7-m long offshore section at elevation +0.6 m. The groins have side slopes of 1V:2H (USACE 1963). The 15 groins span 5.6 km of shore with the last westerly groin being located 5.0 km east of Moriches Inlet.

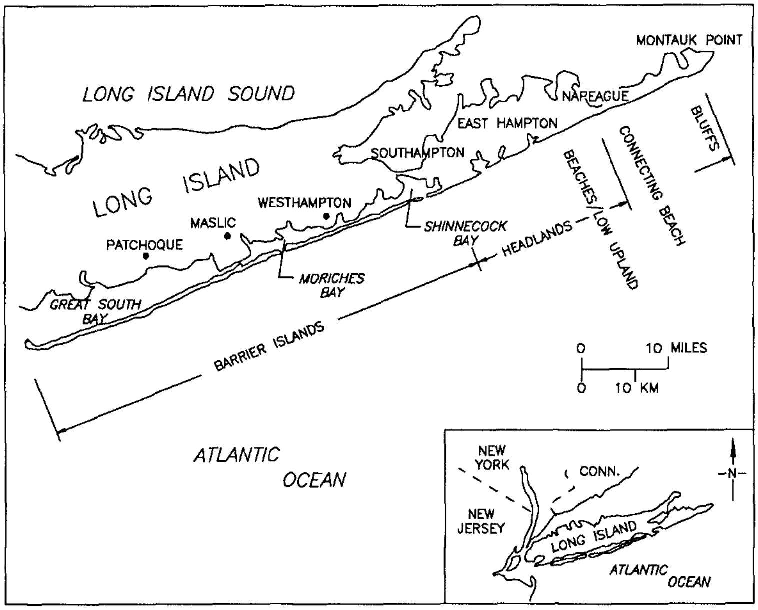

Fig. 1. Site location map for Westhampton Beach, Long Island, New York

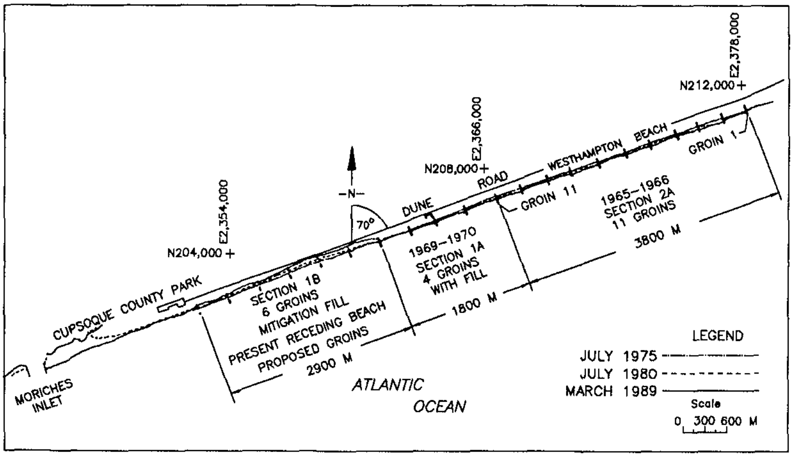

Fig. 2. Construction plan for the Westhampton Beach shore-protection project

Fig. 3. Beach west of Groin 15, Dec. 20, 1983

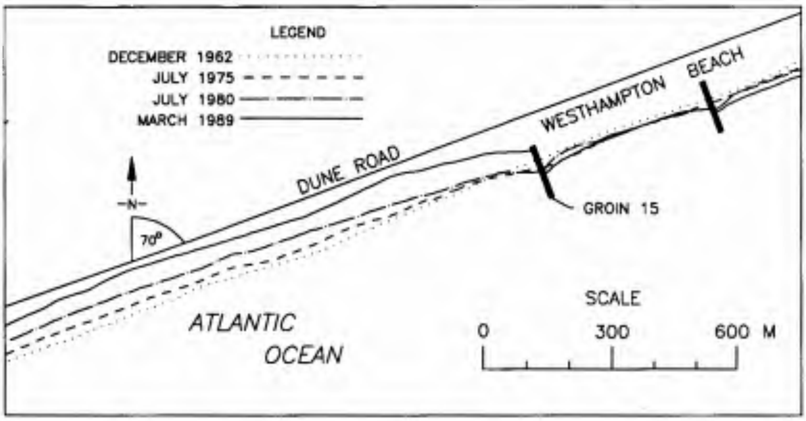

Fig. 4. Shoreline change west of Groin 15, Dec. 1962 - Mar. 1989

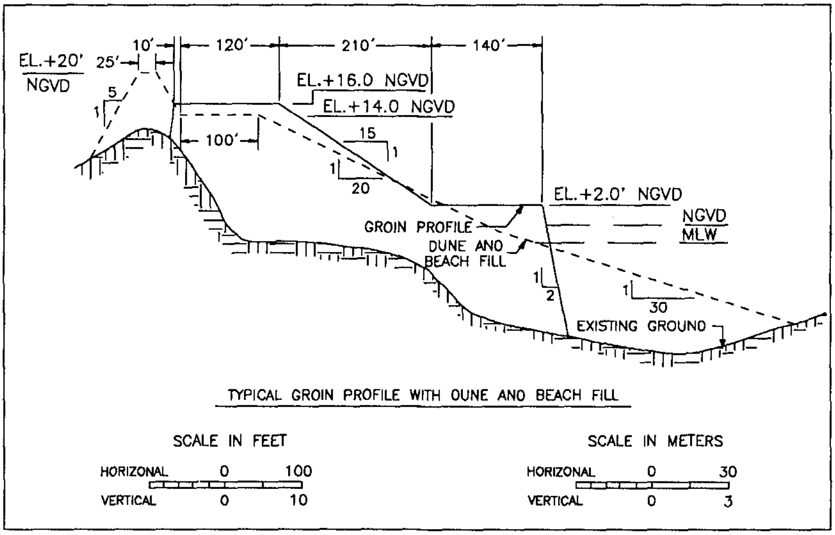

Fig. 5. Cross section view of groin design

OVERVIEW OF SITE

Littoral Factors

The origins of the south shore barriers of Long Island are unknown. It is generally believed that the barriers are formed from glacial outwash sediments from the Pleistocene Epoch and have evolved through the Holocene period with rising sea level. The barriers are composed mainly of quartz sand with some garnetiferous and magnetitic sands and shell fragments (Leatherman and Allen 1985).

Tides in the project area are semi-diurnal and have a mean range of 0.9 m and a spring range of 1.1 m. Mean Low Water (MLW) is estimated to be 0.4 m (NOS 1992a) below NGVD. It is estimated that storm tides of +3.0 m NGVD occurred along the project shore during the 1938 hurricane (USACE 1958). Data from observations of the winds in the vicinity of the project area indicate that the prevailing winds are from the southwest with a duration of almost 25 % and secondarily from the northwest of about 20 %. Over 27 % of the winds in excess of 17 m/sec are from the east, 20 % from the northwest and 6 % from the south. Wind speeds as great as 43 m/sec (September 21, 1938) have been recorded at Westhampton Beach. Wind speeds in excess of 22 m/sec have been recorded more frequently during lesser coastal storms (USACE 1958).

Tidal currents at Moriches Inlet and Shinnecock Inlet vary with the tidal stage reversing in direction about every 6 hr. Published values for the maximum average flood and ebb tides at Shinnecock Inlet are 70 and 76 cm/sec, respectively (NOS 1992b). Tidal currents measured during spring tide conditions by the Corps of Engineers in July 1991 (Chu and Nersesian 1992) at Shinnecock Inlet indicated that the maximum average flood and ebb currents were about 165 cm/sec. For Moriches Inlet the maximum average currents during the same period varied between 243 to 253 cm/sec.

Deep-water heights and return periods in the project area were estimated using a wave climatology study for the South Shore of Long Island, Phase III, Stations 45, 46, 47, and 50. Computed deep-water and breaking wave heights versus return period are shown in Table 1. Breaking wave heights corresponding to the incident wave height were calculated with a refraction coefficient of 1.0 and a flatter post-storm beach slope of 1V:30H. For a 50-year return period, the sea- water level was +3.0 m NGVD, and the wave period was 9 sec. Associated water levels for other wave heights are higher or lower dependent on the return period (USACE 1982, 1986).

Table 1. Wave heights and return periods

Height	Return Period (years)						
	5	10	20	50	100	200	500
H'_o (m)	4.6	4.9	5.3	5.8	6.2	6.3	6.6
H_b (m)	4.8	5.2	5.4	6.4	6.9	7.4	8.2

H'_o is unrefracted deep-water significant wave height; H_b is breaking wave height

Shore History

Examination of prior storm impacts on the shore in the vicinity of the groin field shows that there have been frequent breakthroughs of the barrier beach and dune system as well as creation of new inlets (Andrews 1938, USACE 1963). These impacts, shown in comparative format on Fig. 6, clearly demonstrate that the shore area at Westhampton Beach is susceptible to severe damage by hurricanes and other storms. Of special interest is the shore location about 700 m west of the west bridge at Westhampton Beach where storms created inlets in 1938 and 1962, and a breakthrough in 1958. This location is now bracketed by Groins 5 and 6. Similar repeated impacts can be found in other portions of the project area. The present location of Shinnecock Inlet at the east end of the barrier beach was created by the 1938 hurricane, and later was permanently stabilized by local interests. It was on this basis that the project designers believed there was a definite need to reinforce the dune and beach fill protection with groins.

ANALYSIS OF DATA

Procedure

The data base assembled for this study presently contains 10 beach profile surveys covering the interval 1962-91, seven aerial photographic surveys yielding shoreline positions for the interval 1962-89, and a topometric shoreline mapping survey. The profile surveys typically contain at least three transects per groin compartment and extend from the landward toe of the dune to the 8-m depth. Several aerial surveys extending over the full littoral cell between Moriches Inlet and Shinnecock Inlet enable interpretation of coastal processes through examination of the regional sediment budget, not discussed here. The beach profile and shoreline position data, originally recorded in a variety of formats, were digitized in a controlled georeferenced Geographic Information System for quantitative analysis and visual

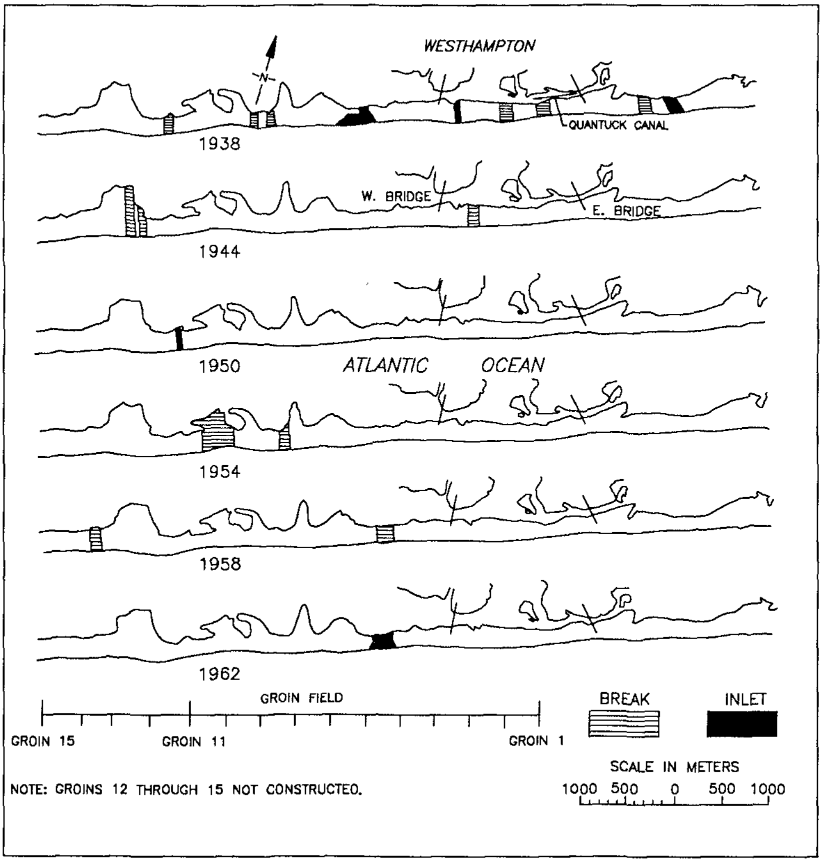

Fig. 6. Locations of historic breaching and inlet creation

interpretation. The first-order analysis included time evolution of shoreline position, volume of the dune and berm complex, and bottom morphology change (not discussed here).

Profile surveys selected for comparison were 12/62, 8/66, 7/75, 12/79, and 12/91. Shoreline position survey data from aerial photography taken in 12/62, 12/79, and 3/89 were integrated in the comparative analyses. The 1962 survey is a base survey which closely approximates the pre-groin construction shore position for the original 11 groins. The 1966 survey approximates the pre-groin construction shore position for the second 4 groins.

Shoreline Positions at Westhampton Beach

Comparative plots of shoreline positions at Westhampton Beach for five profile surveys and one shoreline survey between 1962-89 using all survey transects are shown on Fig. 7. The horizontal axis on this figure represents the baseline origin position for the plotted data. To better display the trends, shoreline positions were smoothed by moving average. Inspection of this figure shows that shoreline position advanced from approximately 100 to 70 m or 3.7 to 2.6 m/year, respectively, from east to west, along 3,800 m of shore. The

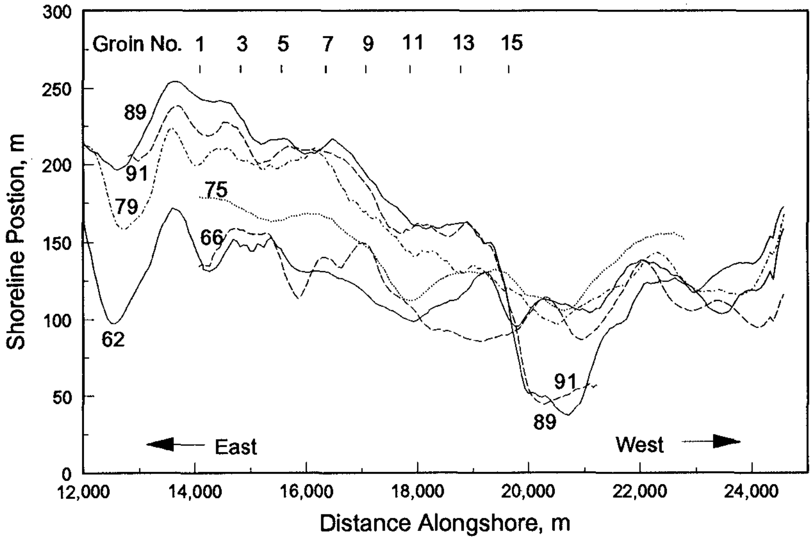

Fig. 7. Smoothed shoreline position in the vicinity of the groin field

general trend of shoreline movement in the first 11 groins during the 1962-89 period was one of continuing advance. From 1989-91 there was minor shoreline recession, which may reflect the impact of the October 1991 storm.

In the shore area encompassed by the second group of 4 groins, shoreline advance over the period 1966-89 was 50 to 55 m, or about 2.3 m/year, and was probably influenced in part by the dune and beach fill that was artificially placed during the second increment of work. In the period 1975-89, there was a shoreline advance of 40 to 20 m or 2.9 to 1.4 m/year, respectively, from east to west, in this area. At a point about 370 m west (downdrift) of Groin 15, the shoreline receded about 6.5 m/year in the period 1975-89. Further westward the rate of recession decreased to about 5.0 m/year. It is noted that the shoreline recession between 1962-75 was 1.9 m/year or less. Accordingly, the rate of recession in the downdrift area tripled following completion of the second increment of work.

Shoreline Positions Near Groins

Shoreline position near the groins is more closely examined in Fig. 8. Filling of the groin compartments has resulted in various shoreline alignments through the groin field. Between Groins 1 and 3, the shoreline shows generally straight alignment about 243 m from the baseline origin on Dune Road. Between Groins 3 and 4, the shoreline moved seaward from 243 m to 214 m, respectively, from the origin. This latter shoreline position generally continues westward to Groin 8. Between Groins 8 and 11, the shoreline moved seaward from 214 m to 164 m, respectively, from the origin. Between Groins 11 and 15, shoreline position moved seaward from 164 m to 154 m, respectively, from the origin. The shoreline positions and alignments within the groin demonstrate the natural filling of groin compartments and the bypassing of littoral sediment to downdrift compartments. Between Groins 1

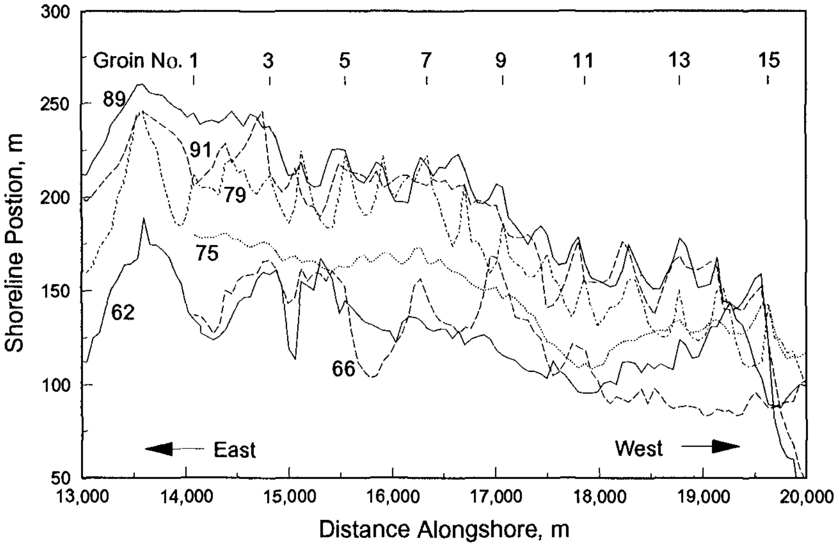

Fig. 8. Shoreline positions in the groin field

and 8, there are two plateaus, indicating that the groin is nearing complete filling in the compartments. It is of interest that the midpoint of the groin field is marked by Groin 8. Comparison of shoreline position between Groins 8 and 11 and between Groins 11 and 15 indicates that filling of the downdrift compartments is proceeding at a much lower rate.

Rate of Shoreline Change by Groin Compartment

Mean shoreline change per groin compartment from December 1962 to December 1989 for Compartments 1, 3, 5, 7, 9, 11, 13, and 14 is shown on Fig. 9. The results confirm filling of the groin compartments in the westerly direction. The mean shoreline change for all compartments is shown in Fig. 10, where it is seen that shoreline position in the groin field is approaching equilibrium after 26 years.

Comparative Profiles in Center Groin Compartments

Comparative profile plots are shown in Fig. 11 for the centers of Compartments 1, 5, 10, 14, and 15, for surveys taken in December 1962, 1979, and 1991. Compartment 15 is actually the westerly downdrift 400 m of shore area adjacent to Groin 15. The plots clearly show the massive dunes created from trapped sand subsequently moved onshore by wind. These dunes contain vegetation and provide habitat for coastal birds and ground animals.

Area and Volume Changes at Westhampton Beach

Computed area extent and volume changes (NGVD intercept to near baseline) in the 14 groin compartments and in the planned, but not constructed downdrift compartments are presented in Figs. 12 and 13. Between 1962-91 the area within the compartments increased by about 75 %. Average compartment area in 1991 was about 27,900 sq m, and, based on an average compartment length of 400 m, the average beach width was about 70 m. The

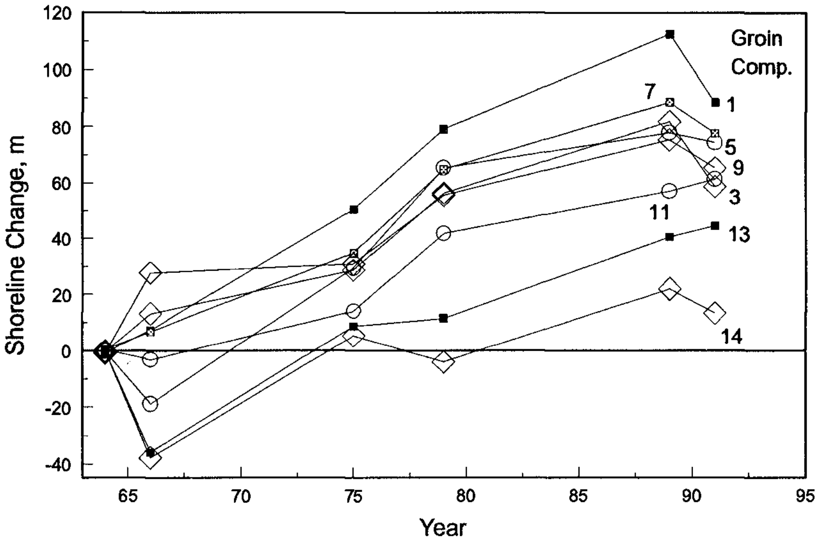

Fig. 9. Mean shoreline change per groin compartment

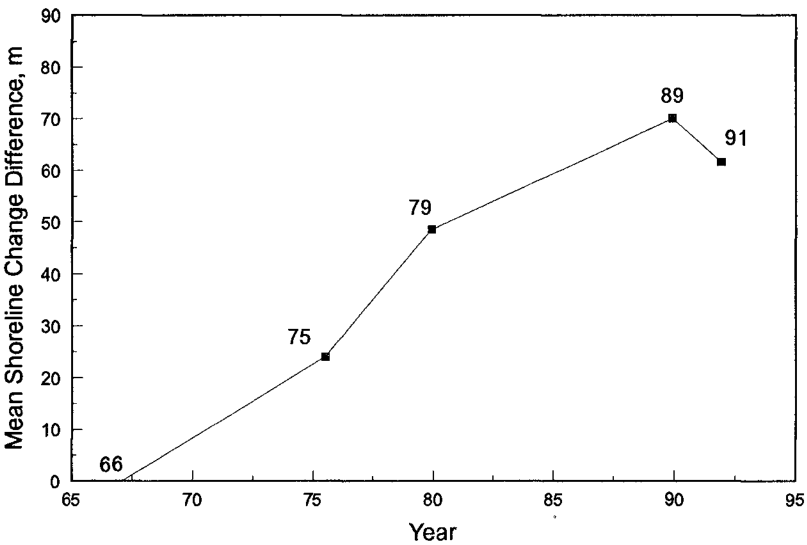

Fig. 10. Mean shoreline change over the groin field

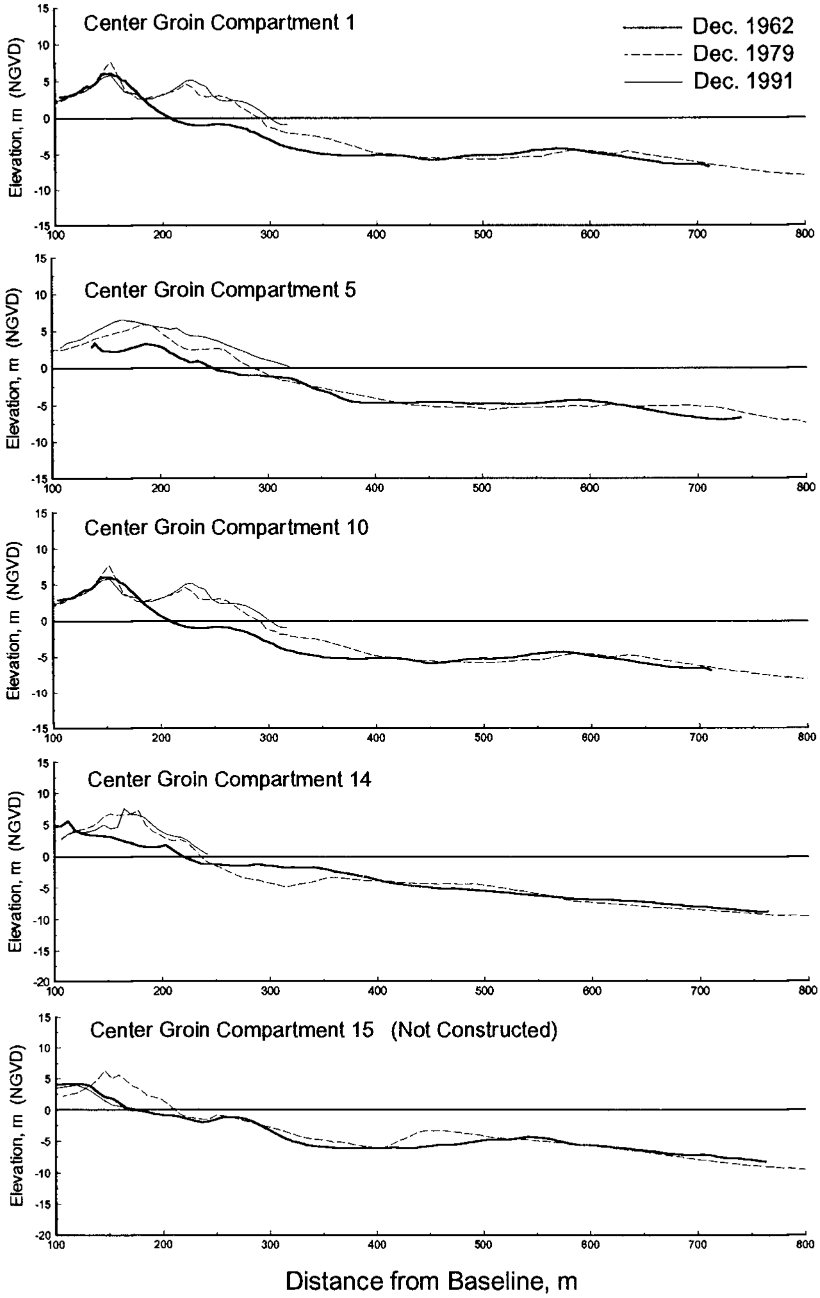

Fig. 11. Selected profile surveys to 800 m from baseline, Dec. 1962 - Dec. 1991

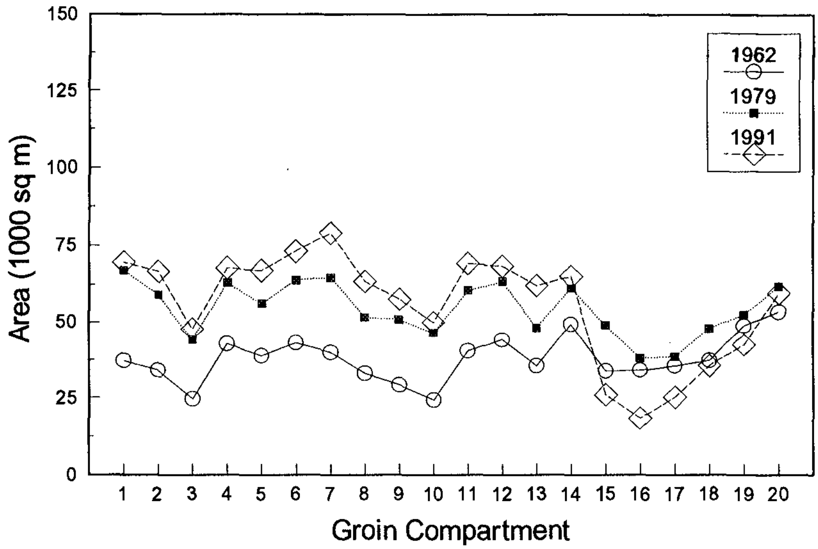

Fig. 12. Area change above NGVD intercept

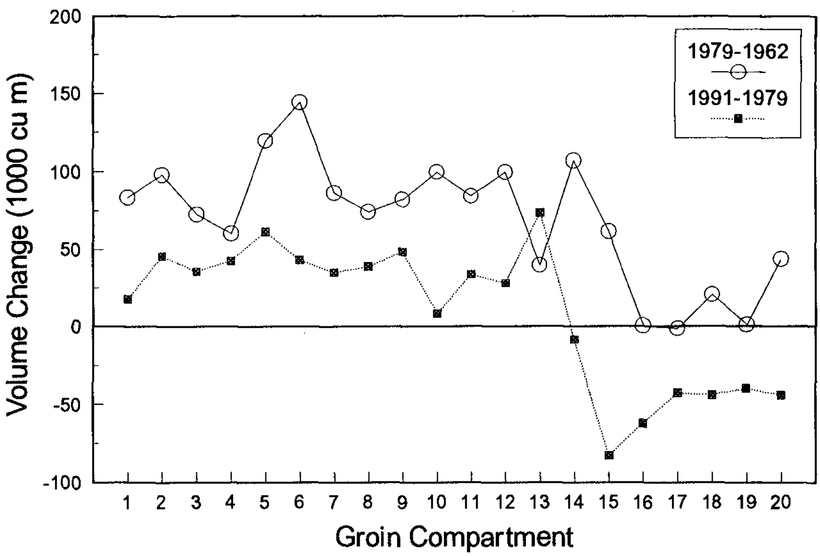

Fig. 13. Volume change above NGVD intercept

greatest increase in area of the groin compartments occurred between 1962-79, and the largest losses occurred downdrift of Groin 15 between 1979-91.

The data for the 14 compartments indicate that, between 1962-91, the average area volume compartment increased on average by 129,000 cu m or by 4,450 cu m/year for a total of 1.8 million cu m trapped by the groin field (above NGVD). The average increase in beach elevation over the period of record was 4.6 m. The greatest increase in volume of the groin compartments occurred between 1962-79, and, as in the case of the area plots, the largest losses, 315,200 cu m, occurred downdrift of Groin 15 between 1979-91. Although not discussed here, the beach profile did not steepen or lose volume seaward of the shoreline.

DISCUSSION AND CONCLUSIONS

Review and analyses of the data strongly demonstrate that introduction of groins at Westhampton Beach has resulted in both adverse and positive impacts. The adverse impact, recession of the shoreline in the area downdrift of the groin field, developed as a result of not completing the project construction as originally intended. The adverse impact, caused by administrative, economic, and political decisions and not engineering miscalculation, has left the barrier island in a weakened condition such that it is still subject to being breached or broken through by storms.

The benefit of the groin field, which typically is not discussed in other analyses of the Westhampton groin field project, is that the groin compartments have been filled naturally or are still being filled from east to west, although taking much longer than the planned method of using artificial fill placement. Compartment filling has been accompanied by formation of high primary backshore dunes and several secondary dunes ridges located seaward of the primary dune. The shore area in the 14 groin compartments has not been significantly affected by storm attack, except for one compartment in 1980. The overall benefit of the groin field bypassing and dune building has been to provide a high level of protection to the barrier island over the area it encompasses

Significant lessons which can be drawn from experience at Westhampton Beach are:

a. COMPLETE PROJECT WITHOUT UNDUE DELAY. The construction of projects involving groins must be completed without significant delay to permit functioning of the system and to minimize impacts on adjacent shores. If there is a question as to whether the work can be conducted in this fashion, then it should not be initiated.

b. PERFORM CASE-BY-CASE EVALUATION. Groins are not universally bad. Use of groins requires the same type of evaluation as is given in consideration of other protective measures to provide a solution for coastal problems on a case-by-case basis.

c. EXAMINE THE NEED FOR SHORE REINFORCEMENT WITH GROINS. Groins may be needed to reinforce or hold protective beach fills, if their need is demonstrated by shore history and storm attack in the area to be protected. Emplacement of groins without concurrent placement of beach fill is strongly discouraged.

d. DEVELOP PROPER DESIGN. The use of groins requires proper design by qualified professionals to ensure their functioning within a shore system. Designers need to be knowledgeable of the littoral forces affecting the area, the longshore sediment budget, and the sensitivity of adjacent shores to changes that groins can precipitate.

e. ENSURE BYPASSING OF LONGSHORE SEDIMENT. Where longshore transport is essential to providing nourishment to downdrift shores, the use of groins must provide for bypassing of sediment to adjacent shorelines without interruption. The groin field should be filled, and, at the downdrift terminus of the project, the groin system should be tapered to meet the unimproved shoreline area in a smooth fashion.

f. PROVIDE LONG-TERM PROTECTION. The 15 groins at Westhampton Beach still continue to function after 26 years to hold and build up the dune and beach in the groin compartments. The life of the groin structure can be extended through proper design, construction, and maintenance. Groins can provide positive and economical long-term protection while blending with the natural surroundings.

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