Chapter 15

SEASONAL CHANGES IN BEACHES OF THE NORTH ATLANTIC COAST OF THE UNITED STATES

By

John M. Darling
Hydraulic Engineer, Research Division
U. S. Army Coastal Engineering Research Center
Corps of Engineers, Washington, D. C.

ABSTRACT

Seasonal changes of eight Atlantic Ocean beaches along the East Coast of the United States from southern New Jersey to Rhode Island have been under study since September 1962. These beaches are surveyed at frequent intervals repeating profile lines perpendicular to the shoreline, spaced to indicate any major changes occurring to the beach shape or dimensions with as much assurance as is reasonably possible. Correlation of changes in beach profile with tide and wave data is being made. Changes in the beach profiles to date indicate variations on a seasonal basis.

INTRODUCTION

The impetus for initiating this study of beaches along the Atlantic Coast stemmed from the disastrous effects of a severe east coast storm which occurred in March 1962. This was an unusual storm because of its great extent and duration. It remained relatively stationary for such a long period that heavy seas battered the coastline at high surge levels through five successive tidal cycles. For this reason this storm has been referred to as "High Five". The wreaking of such extreme havoc along the Atlantic coastline has been attributed to this storm's long duration, which permitted high water and storm waves to reach backshore development after natural and man-made protective features had been swept away.

Protective beaches and dunes were severely eroded along much of the coast from Cape Hatteras, North Carolina to Cape Cod, Massachusetts. This left remaining developments exposed and vulnerable to the damaging forces of storms of lesser magnitude. In order to protect against ordinary storms, emergency restoration of protective features was necessary. Mr. Joseph M. Caldwell of the Coastal Engineering Research Center (formerly Beach Erosion Board) was called upon for advice in this task. An emergency beach and dune section, which became known as the Caldwell section, was designed as protection against a storm of 10-year frequency and was placed along much of the coastline after the storm. This emergency beach section, as shown on Figure 1, has a foreshore slope of 1:20 up to the berm elevation of 10 feet above mean low water, a berm width of 50 feet and a dune slope of 1:5 with a dune crest elevation of 12 feet and width of 20 feet.

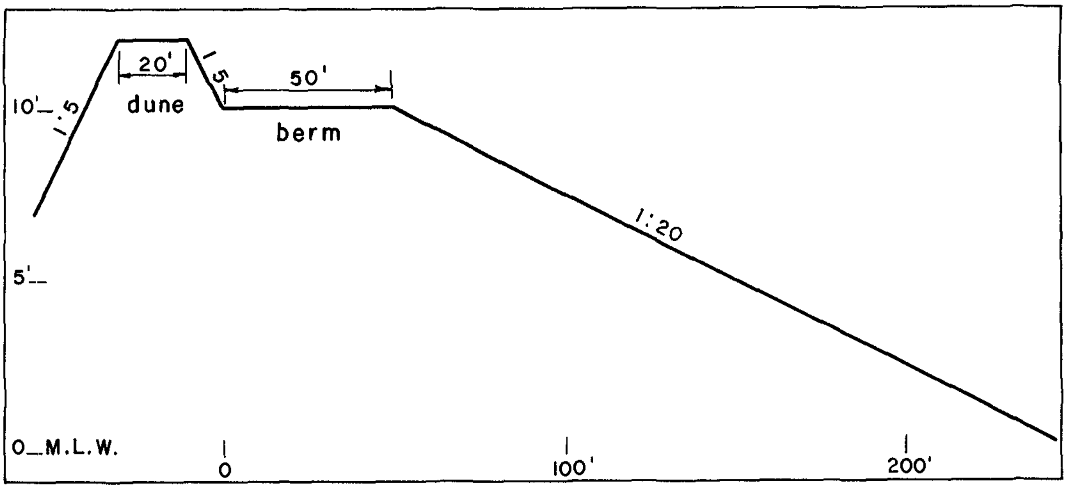

FIGURE 1. EMERGENCY SECTION

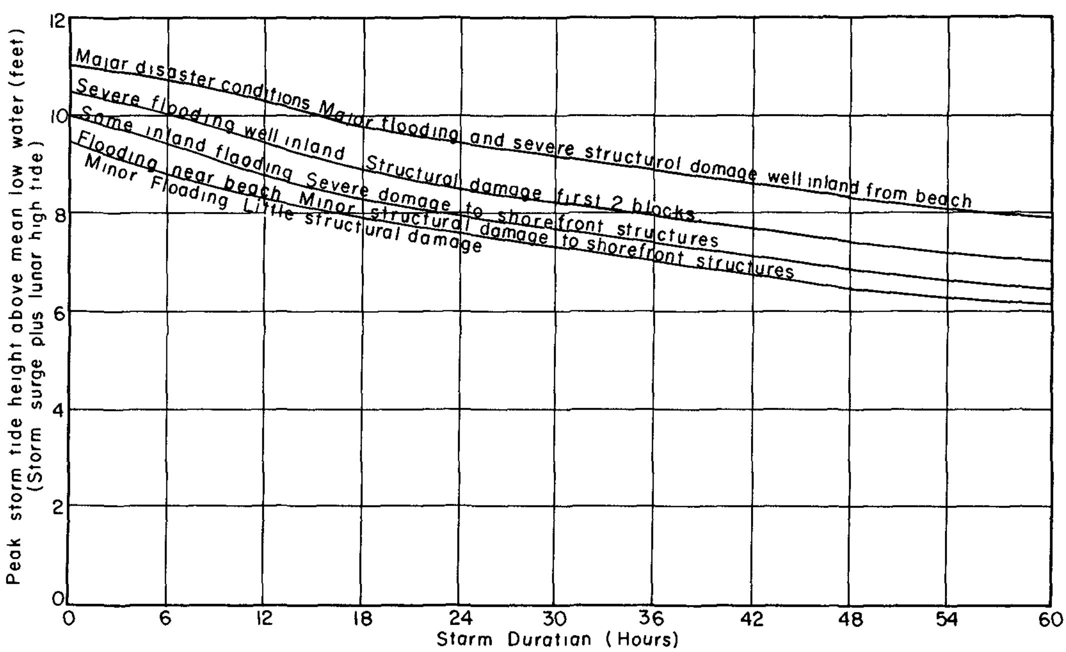

FIGURE 2. VULNERABILTY CONDITION 1 FOR ATLANTIC CITY, N.J.

After the 1962 storm a pilot study was set up to determine the feasibility of a warning system which would forecast effects on the coast for approaching storms through the development of vulnerability curves for individual areas, such as shown in Figure 2. The peak storm tide height above mean low water (storm surge plus astronomical high tide) is plotted along the Y-axis. The storm duration (hours) is plotted along the X-axis. The term storm duration is defined in this case in tidal cycles a particular peak storm tide is present. If a peak storm tide occurs for two successive high tides, this would indicate a storm duration of about 24 hours. These curves are actually limits for determining the extent of damage that might be expected for a particular peak storm tide and storm duration. This set of curves is only applicable for one particular condition of the beach. As the beach condition changes a new set of curves is necessary. The development of the vulnerability curves is being made by correlating beach changes with data on those surge tides and waves responsible for the beach changes. Field surveys for the study are made under the direction of the Division and District offices of the Corps of Engineers in which the pilot beaches are located. Although much of the analysis of data is now being done at the Coastal Engineering Research Center, eventually it will be accomplished in the Division or District offices; the Coastal Engineering Research Center will then act only in an advisory capacity. The seasonal changes in beach conditions along the Atlantic Coast which are discussed in this paper are thus but a part of the continuing study.

STUDY AREA

Eight beaches are under observation for the pilot study located from southern New Jersey to Rhode Island. As shown in Figure 3, three are in New Jersey, two in New York on Long Island, one in Rhode Island, and the other two on Long Island Sound in Connecticut. Although data from all beaches involved in the study are included in this paper, only one or two beaches are discussed in detail.

Tidal and storm surge data are being furnished by the U. S. Weather Bureau and Coast and Geodetic Survey for several places in the study area. Sources of wave information include Fleet Weather Services' charts, surf observations made by the U. S. Coast Guard in cooperation with the Coastal Engineering Research Center, and wave records from stations of the Coastal Engineering Research Center. The tidal records for the following locations are being studied for use in this pilot program: Atlantic City, N. J., Sandy Hook, N. J., Montauk, N. Y., Port Jefferson, N. Y., New London, Conn., and Newport, R.I. Surf observations are available for the following points in the study area: Atlantic City, N. J., Monmouth Beach, N. J., and Point Judith, R. I. These data are subjective in nature as they are actual observations. The Coastal Engineering Research Center has wave gages in the study area at Atlantic City, N. J., and Buzzards Bay, Mass. The wave gage

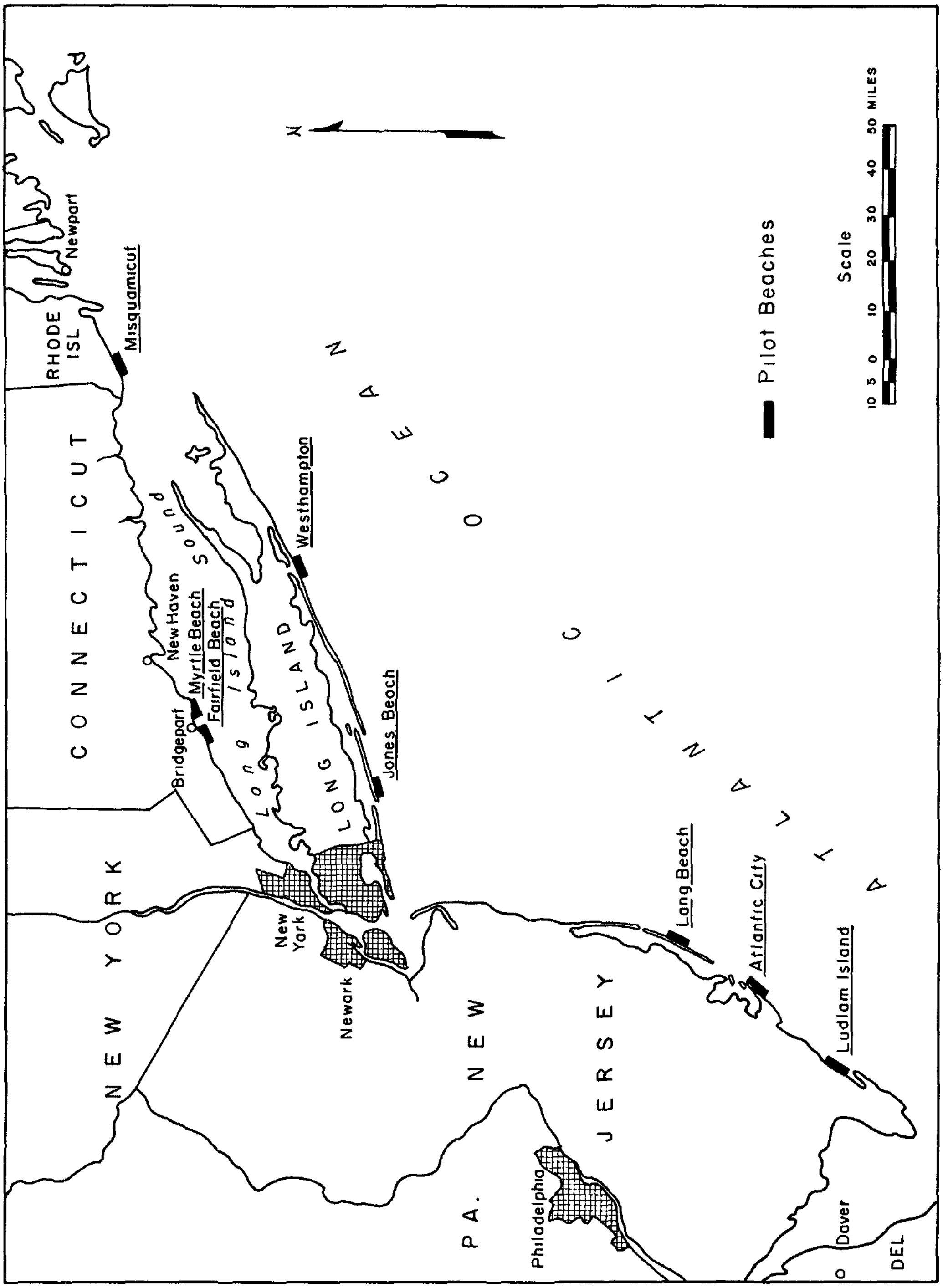

FIGURE 3 LOCATION MAP

at Atlantic City, N. J., is a step-resistance staff located on the seaward end of Steel Pier where the water depth is about 20 feet. Waves at this station are recorded on both paper tape and magnetic tape. The Buzzards Bay recorder is located on the Buzzards Bay light tower operated by the U. S. Coast Guard. The record for this station has been intermittent for various reasons. One is the ice problem in the winter. Originally the only wave gage was a 45-foot step-resistance staff which fouled easily with ice. A pressure-type gage is now in operation which should eliminate the ice problem. These records should be valuable particularly for the pilot study beach at Misquamicut, R. I.

The wave data from Atlantic City for 1963 have been compiled as shown in Table 1. Note that 81% of the waves do not exceed 4 feet in height or rather only 19% are more than 4 feet. During 1963, 46% of the waves had periods between 6-10 seconds and heights of less than 4 feet. High tide elevations at Atlantic City for 1963 relative to MSL were less than +2 feet 35% of the time, 45% were between +2 and +3 feet, 18% between +3 and +4 feet and only 2% above +4 feet. The ordinary mean high tide (astronomical) elevation for Atlantic City is about +2 feet.

The New Jersey beaches under observation are barrier beaches located on the central and southern portions of the New Jersey coast. They are composed of medium to fine sand which is fairly well sorted. Ludlam Island beach, located south of Atlantic City, has a flat foreshore slope of about 1:40 and is quite wide. At Atlantic City, the beach is narrower with a foreshore slope in the order of 1:20. Long Beach is fairly steep, with a foreshore slope of 1:10 to 1:15 with generally a narrow berm.

The study beaches in New York are Jones Beach and Westhampton Beach along the south shore of Long Island. Their characteristics are somewhat different. Jones Beach, located near the west end of Long Island is composed of poorly sorted medium to fine sand. The foreshore slope of the beach, 1:20, is similar to that at Atlantic City, but in general it is accompanied by a wide berm. Westhampton Beach, in the central part of Long Island's southern shore, is fairly steep with a foreshore slope of 1:10 to 1:15. There is little or no berm. Westhampton Beach material is coarse to medium sand, fairly well sorted.

In Connecticut the study areas are Myrtle and Fairfield Beaches, adjacent to Bridgeport Harbor, and Misquamicut Beach in southwest Rhode Island. Myrtle and Fairfield Beaches in Connecticut front on Long Island Sound and are not directly exposed to the Atlantic Ocean. These beaches are fairly flat, foreshore slope of 1:20 to 1:40, and are not exceptionally wide. The materials on these beaches range from medium sand to fine gravel. Misquanicut Beach is relatively narrow and steep with a foreshore slope of 1:10 to 1:15. The beach material consists of coarse to fine sand with some gravel and shingle. Figures 4, 5, and 6 are typical views of beaches in the three major areas under study. They show the general configuration of the beaches in their areas.

Sig. Height (ft)	Calm	2-4	4-6	6-8	8-10	10-12	12-14	14-16	Total %
	SIGNIFICANT WAVE PERIOD (SECONDS)								
0-2	2.7	6.5	6.3	12.0	9.2	2.8	0.5	-	40
2-4	-	3.5	8.6	16.0	9.2	2.6	0.7	-	41
4-6	-	0.3	1.8	4.8	3.2	1.6	0.6	0.1	12
6-8	-	-	0.7	1.3	1.4	0.7	0.2	-	4.3
8-10	-	-	0.2	0.3	0.5	0.2	0.1	-	1.4
10-12	-	-	-	0.1	0.2	0.3	0.05	-	1.4
12-14	-	-	-	-	0.2	0.1	-	-	0.3
14-16	-	-	-	0.05	0.1	-	-	-	0.15
16-18	-	-	-	0.05	-	-	-	-	0.05
18-20	-	-	-	-	-	-	-	-	-
Total (Percent)	2.7	10	18	35	24	8.4	2.2	0.1	

TABLE 1: WAVE STATISTICS FOR ATLANTIC CITY, N. J., 1963 IN PERCENT OCCURRENCE

Sig. Height (ft)	Calm	2-4	4-6	6-8	8-10	10-12	12-14	Total %
	SIGNIFICANT WAVE PERIOD (SECONDS)							
0-2	2.5	5.4	13	15	9.4	4.8	0.4	51
2-4	-	3.6	6.7	6.1	5.0	1.3	0.4	23
4-6	-	0.8	3.3	2.7	2.5	1.7	-	11
6-8	-	-	1.5	3.3	2.7	1.3	0.2	9
8-10	-	-	0.6	2.7	1.1	0.6	-	5
10-12	-	-	-	0.4	0.4	-	-	.8
Total (Percent)	2.5	9.8	25	31	21	9.8	1.0	

TABLE 2: WAVE STATISTICS FOR ATLANTIC CITY, N. J., OCTOBER 1962 to JANUARY 1963 IN PERCENT OCCURRENCE

FIG. 4. MISQUAMICUT, RHODE ISLAND

FIG. 5. WESTHAMPTON, LONG ISLAND

FIG.6. ATLANTIC CITY, NEW JERSEY

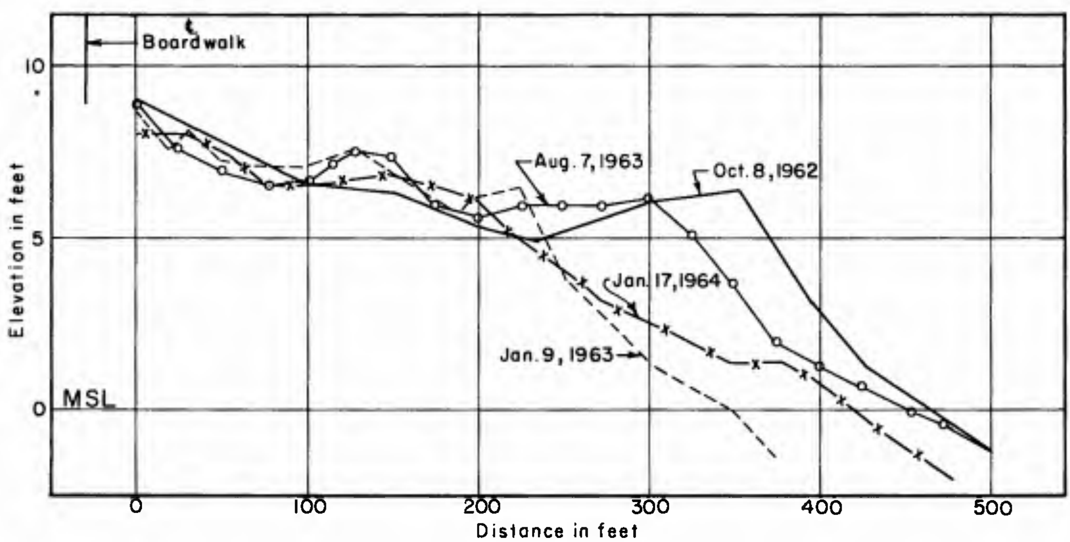

FIGURE 7. PROFILE G - ATLANTIC CITY , N.J.

SEASONAL VARIATIONS VERSUS WAVE AND TIDE STATISTICS

For the purpose of this paper only one beach will be discussed at length. Atlantic City was selected for discussion as wave and tide data are obtained specifically at this point.

At Atlantic City, seven profiles have been surveyed at regular intervals but to simplify matters only one typical profile will be described. It is reasonably representative of conditions at Atlantic City.

The method selected for studying the seasonal changes is a simple one. It is accomplished by recording the distance seaward or landward which certain contours moved from one survey period to the next. Landward movement is an indication of erosion. Similarly, seaward movement should indicate accretion. Mean sea level is used as the reference datum at Atlantic City. This particular study involves only that portion of the beach above mean sea level as very little data were obtained seaward of that shoreline.

Figure 7 shows the changes in the beach shape at Atlantic City at intervals during the period October 1962 through January 1964. Referring to the dates of the actual surveys, between 8 October 1962 and 9 January 1963, contour +3 eroded 134 feet and contour +6 eroded 127 feet. This represents about 27 cubic yards of erosion per linear foot of beach between MSL and +6 feet. In discussing quantity of erosion or accretion, the zone between the MSL and +6-foot contours will be used throughout this paper. The wave characteristics for this period were as shown in Table 2. For this period of erosion 74% of the waves were below 4 feet in height or 26% were above 4 feet. Only 35% had periods between 6-10 seconds and height below 4 feet. The high tides were above +3 feet in elevation 32% of the time for this interval.

The beach accreted between 9 January 1963 and 7 August 1963 to the extent of 96 feet at +3 feet and 75 feet at +6 feet. This is in the order of 19 cubic yards of accretion per linear foot of beach. Concurrent wave characteristics were as shown in Table 3. During this period of accretion 86% of the waves were below 4 feet or only 14% above 4 feet. Fifty-three percent had periods of 6-10 seconds and heights under 4 feet. High tides were above +3 feet elevation for only 17% of the time.

Between 7 August 1963 and 17 January 1964, the beach eroded 84 feet at the +3 level and 104 feet at the +6 level, with erosion amounting to 15.5 cubic yards per linear foot of beach. The wave characteristics were as shown in Table 4. Seventy-two percent of the waves were less than 4 feet, or 28% were greater than 4 feet. Thirty-five percent of the waves had periods from 6 to 10 seconds with heights less than 4 feet. High tides were above +3 feet for 24% of the time.

Sig. Height (ft)	SIGNIFICANT WAVE PERIOD (SECONDS) Calm	2-4	4-6	6-8	8-10	10-12	12-14	Total %
0-2	0.7	6.9	6.3	15	10	3.4	0.8	43
2-4	-	3.6	8.5	20	8.2	1.7	.7	43
4-6	-	.4	1.8	4.7	2.9	.7	.1	11
6-8	-	-	.5	.9	1.0	.2	.1	2.7
8-10	-	-	.1	.4	-	.2	-	.7
Total (Percent	.7	11	17	41	22	6.1	1.7	

TABLE 3: WAVE STATISTICS FOR ATLANTIC CITY, N. J., JANUARY 1963 TO AUGUST 1963 IN PERCENT OCCURRENCE

Sig. Height (ft)	SIGNIFICANT WAVE PERIOD(SECONDS) Calm	2-4	4-6	6-8	8-10	10-12	12-14	14-16	Total %
0-2	5.4	6.7	5.6	6.9	6.9	1.9	0.1	-	34
2-4	-	3.5	9.1	11	10	3.4	0.8	-	38
4-6	-	0.1	2.1	4.4	4.3	2.8	1.0	0.2	15
6-8	-	-	0.9	2.1	2.0	1.5	0.6	-	7.1
8-10	-	-	0.4	1.1	1.0	0.4	0.2	-	3.2
10-12	-	-	-	0.4	0.7	0.9	0.1	-	2.1
12-14	-	-	0.1	0.1	0.7	0.2	-	-	1.1
14-16	-	-	-	0.1	0.2	-	-	-	0.3
16-18	-	-	-	0.1	-	-	-	-	0.1
Total (Percent)	5.4	10	18	26	26	11	2.8	0.2	-

TABLE 4: WAVE STATISTICS FOR ATLANTIC CITY, N. J., AUGUST 1963 TO JANUARY 1964 IN PERCENT OCCURRENCE

Figure 8 depicts the degree of erosion at Atlantic City accompanying the passage of Hurricane Ginny during the latter part of October in 1963. Consecutive surveys were made 28 October and 14 November 1963. One was just before the hurricane passed and the other shortly thereafter. Therefore, the indicated changes were no doubt caused by this storm. Contour +3 eroded 38 feet and +6, 49 feet, or approximately 10.5 cubic yards were removed per linear foot of beach. During the period between surveys the waves were as shown in Table 5. It may be noted that a period of over 24 hours during passage of the hurricane, significant wave height of recorded waves at Atlantic City were of the order of 8 to 10 feet and significant periods were 8 to 10 seconds. Concurrently storm surge levels reached elevations of 3.4 to 3.9 feet above MSL during four consecutive tidal cycles, where ordinary mean high water is about +2 feet.

SUMMARY AND RESULTS

Analysis of the surveys made at Atlantic City from October 1962 to the present, although covering a period of little more than one year, does indicate marked seasonal differences in beach conditions. The beach recedes during the fall or early winter, and recession of the beach seems to have reached a maximum by about January or February. There is a fairly constant beach condition during the remainder of the winter (February and March) once the maximum recession limit is approached. The beach is restored during spring and summer months, reaching its maximum accreted position in July or August; however, the beach is fairly stable during the summer (June through August). It seems significant that during the erosion periods the characteristics of the waves were similar. In both cases 26% to 28% of the significant waves were above 4 feet in height and 17% had 6 to 10-second periods and heights greater than 4 feet. The high tides were above +3 feet for 24% to 32% of the time. During the accretion portion of the cycle only 14% of the significant waves were above 4 feet in height and 10% had periods of 6 to 10 seconds and were above 4 feet. Also, the high tides were above +3 feet only 17% of the time. From the foregoing it will be seen that the waves during the erosion periods were characteristically of greater steepness than those of the accretion period.

The seasonal trend inferred from data for Atlantic City seems to prevail in varying degrees at all the beaches under study, with the possible exception of those fronting on Long Island Sound rather than the Atlantic Ocean. It must be recognized that the actual erosion or accretion does not occur as a continuous pattern, but there are periods which are dominated either by erosion or accretion. These seasonal trends are then the net or resultant behavior pattern.

These observations are based on only a little over one year's record of events, so these are only trends. It is hoped that with additional

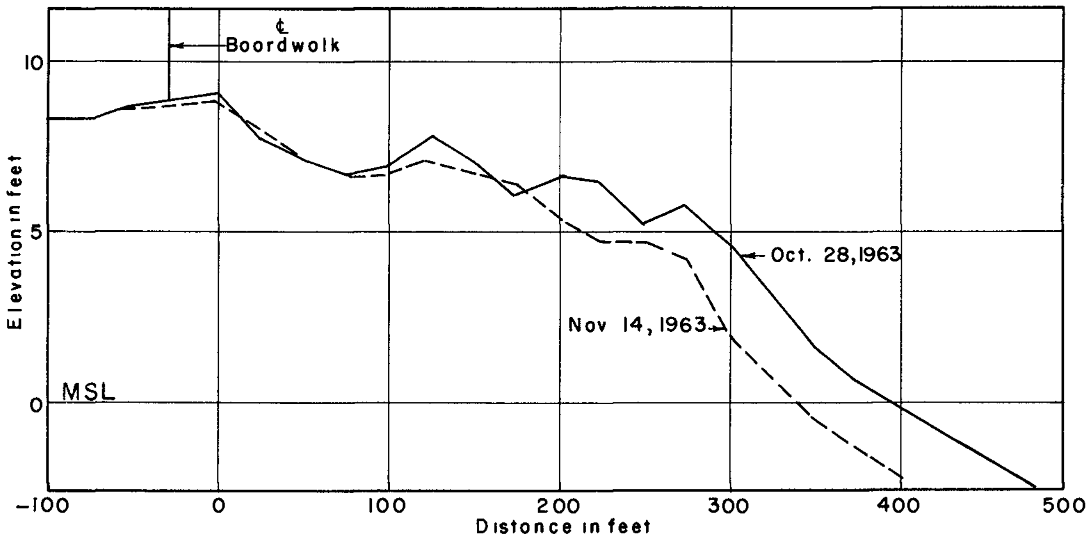

FIGURE 8 PROFILE G-ATLANTIC CITY, N.J.

Sig. Height (ft)	SIGNIFICANT WAVE PERIOD (SECONDS) Calm	2-4	4-6	6-8	8-10	10-12	12-14	Total %
0-2	4	11	-	1.0	5.0	5.0	-	26
2-4	-	2.0	4.0	3.0	12	12	3.0	36
4-6	-	1.0	2.0	4.0	6.0	4.0	5.0	22
6-8	-	-	1.0	3.0	2.0	2.0	-	7.9
8-10	-	-	1.0	1.0	-	-	-	2.0
10-12	-	-	-	1.0	-	2.0	1.0	4.0
12-14	-	-	-	-	2.0	-	-	2.0
14-16	-	-	-	1.0	-	-	-	1.0
Total (Percent)	4.0	14	8.0	14	27	25	9.0	

TABLE 5: WAVE STATISTICS FOR ATLANTIC CITY, OCTOBER 28, 1963 TO NOVEMBER 14, 1963 IN PERCENT OCCURRENCE

years of records we can either confirm or establish the general behavior pattern of this section of coastline, and extend the study to other coastal areas.

ACKNOWLEDGMENTS

The data collected and analysis thereof was made in connection with the general research program of the U. S. Army Coastal Engineering Research Center. Permission of the Chief of Engineers to publish this information is appreciated. Grateful acknowledgment is made to the New England Division, New York and Philadelphis Districts of the Corps of Engineers for their extensive work on this study. Appreciation is extended to those members of the Coastal Engineering Research Center who have been extremely helpful in this study. The conclusions reached and presented herein are those of the author and do not necessarily reflect the policy or views of the Corps of Engineers.

REFERENCES

Taney, N. E. (1961) - Littoral Materials of the South Shore of Long Island, New York: Tech. Memo. No. 129, BEB, Corps of Engineers, Washington, D. C.

U. S. Army Corps of Engineers: South Kingstown & Westerly, Rhode Island, Beach Erosion Control Study, 1958, House Doc. 30, 86th Cong., 1st Sess.

U. S. Army Corps of Engineers: Area 3 - New Haven Harbor to Housatonic River, Connecticut, Beach Erosion Control Study, 1953. House Doc. 203, 83rd Cong. 1st Sess.

U. S. Army Corps of Engineers: South Shore, State of Rhode Island, Beach Erosion Control Study, 1950, House Doc. 490, 81st Cong., 2nd Sess.