CHAPTER 33

HISTORY OF NEW JERSEY COASTLINE

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INTRODUCTION

The New Jersey coast probably is the most important recreational asset in the nation. This is due in part to the nearby densely populated metropolitan areas that experience unpleasantly hot and humid weather during the summer months. New York and its satellite communities, having a combined population of approximately 13 million, is only 50 miles from the nearest and 160 miles from the most remote of the 57 resort towns that dot the 125-mile length of New Jersey seashore. The Philadelphia metropolitan area, with a population of approximately 4 million, lies 60 miles from the nearest resort and only 86 miles from the farthest. Fig. 1 shows the geographic setting of the seashore area.

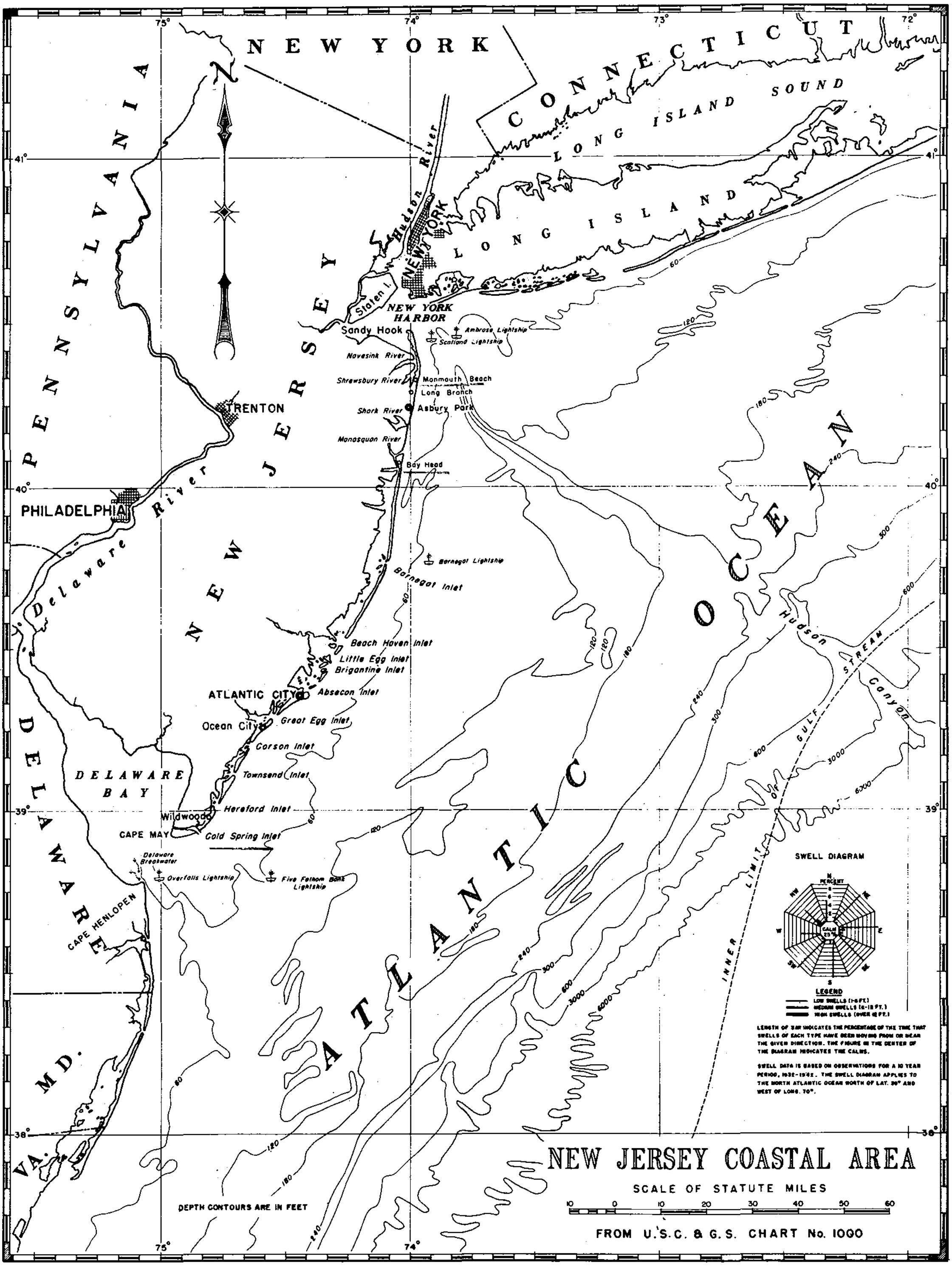
But it is not merely geographic proximity to large numbers of people and the compulsion of uncomfortable weather at home that attracts 4 million vacationers and a great many one-day excursionists to the New Jersey seashore resorts each year. Nearly all of the 125 miles of shoreline is a satisfactory sandy bathing beach, and about 80% of it is open to the public at no charge. The ocean is not polluted, its temperature is approximately 70° throughout the summer months, and its surf is not dangerous. The 57 resort communities collectively offer a great variety of accommodations ranging from luxurious hotels to modest boarding houses and tourist camps, and the surroundings include highly developed areas, as at Atlantic City, as well as localities remaining in a natural condition.

The development of this shoreline as a recreational resource began nearly two hundred years ago, at Cape May. By 1801, there was evidently at least one establishment there that was large enough to be considered a hotel. The following advertisement appeared that year in a Philadelphia newspaper:

> "The public are respectfully informed that the subscriber has prepared himself for entertaining company who use sea bathing, and he is accommodated with extensive houseroom, with fish, oysters, crabs and good liquors. Care will be taken of gentlemen's horses.
>
> "The situation is beautiful, just at the confluence of Delaware Bay with the Ocean, in sight of the Lighthouse and affords a view of shipping which enters and leaves the Delaware; Carriages may be driven along the margin of the ocean for miles, and the wheels will scarcely make an impression upon the sand; the slope of the shore is so regular that persons may wade a great distance. It is the most delightful spot the citizens can retire to in the hot season.
>
> "A stage starts from Cooper's Ferry on Thursday in every week, and arrives at Cape Island on Friday; it starts from Cape Island on Friday and Tuesday in each week, and arrives in Philadelphia the following day."

A large and fashionable clientele was built up by 1855, many coming from the southern states. The accommodations available included a huge structure, even by 1950 standards. It contained 482 rooms, each with a private bath, and a dining room seating 3,000.

Long Branch and Atlantic City began to attract visitors in 1819 and 1854 respectively, and the smaller resorts gradually came into being. Fewer work hours for most people, budgets permitting larger expenditures for recreation, and the family automobile inevitably resulted in the growth of these recreational communities along the seashore to the extent that now it is estimated that 800,000 visitors can be housed at one time. At many of the resorts, boardwalk promenades are located close to the beach fronts. Along the landward side of these popular


NEW YORK
CONNECTICUT
LONG ISLAND SOUND
LONG ISLAND
PENNSYLVANIA
NEW JERSEY
DELAWARE
MD.
VA.
ATLANTIC OCEAN
Hudson River
NEW YORK
Staten I.
NEW YORK HARBOR
Sandy Hook
Ambrose Lightship
Scotland Lightship
Navesink River
Shrewsbury River
Monmouth Beach
Long Branch
Shark River
Asbury Park
Manasquan River
Bay Head
TRENTON
PHILADELPHIA
Delaware River
Barnegat Lightship
Barnegat Inlet
Beach Haven Inlet
Little Egg Inlet
Brigantine Inlet
ATLANTIC CITY
Absecon Inlet
Ocean City
Great Egg Inlet
Corson Inlet
Townsend Inlet
Hereford Inlet
Wildwood
CAPE MAY
Cold Spring Inlet
DELAWARE BAY
Delaware Breakwater
Overfalls Lightship
Five Fathom Bank Lightship
CAPE HENLOPEN
Hudson Canyon
INNER LIMIT OF GULF STREAM
75°
74°
73°
72°
41°
40°
39°
38°
60
120
180
240
300
600
3000
6000
DEPTH CONTOURS ARE IN FEET
SWELL DIAGRAM
N.
PERCENT
8
6
4
2
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E
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CALM 25%
LEGEND
LOW SWELLS (1-6 FT.)
MEDIUM SWELLS (6-12 FT.)
HIGH SWELLS (OVER 12 FT.)
LENGTH OF BAR INDICATES THE PERCENTAGE OF THE TIME THAT SWELLS OF EACH TYPE HAVE BEEN MOVING FROM OR NEAR THE GIVEN DIRECTION. THE FIGURE IN THE CENTER OF THE DIAGRAM INDICATES THE CALMS.
SWELL DATA IS BASED ON OBSERVATIONS FOR A 10 YEAR PERIOD, 1932-1942. THE SWELL DIAGRAM APPLIES TO THE NORTH ATLANTIC OCEAN NORTH OF LAT. 30° AND WEST OF LONG. 70°.
NEW JERSEY COASTAL AREA
SCALE OF STATUTE MILES
10
0
10
20
30
40
50
60
FROM U.S.C. & G.S. CHART No. 1000

Fig. 1

features are located shops, restaurants and amusement places presenting a varied array of attractions. The larger resorts have piers extending out over the ocean, featuring convention halls, commercial exhibits, theaters, concert halls, and other attractions. Other piers provide facilities for sport fishing.

The social and economic significance of this unique seashore recreational area is enormous. It has become part of the pattern of life for thousands of people living as far as 400 miles from its center of gravity, Atlantic City. Families look forward to their vacations at the seashore as the bright spot of the year, and to their brief, week-end sojourns there as respites from their daily routine. The seashore provides the facility that translates their available leisure time and their financial latitude for expenditures beyond bare necessities to wholesome recreation. Likewise, it provides a livelihood for a great many people who furnish the facilities and cater to the needs and desires of the visitors. Their business has been valued at one billion dollars annually, making it the largest in the State of New Jersey.

Unfortunately, nature does not recognize the social and economic need for beach stability along the New Jersey shoreline. Changes are occurring presently that threaten the very existence of some of the resorts by destruction of their beaches and their shore front developments. In many cases, it is a matter of record that the shoreline location has varied over a wide band, including the present heart of the community, prior to its having reached the present state of development. These facts were forgotten in the excitement of building for ever-increasing numbers of visitors, and the beach line at the moment was accepted as the point where it was expected to remain. Minor variations occurring subsequent to such optimistic appraisals greatly reduce the beach areas available for bathing and sunning; overcrowding results, and soon the city fathers either are driven to taking steps to restore the beach or accepting the inevitable loss of patronage.

Some of the resorts for years have been fighting a losing battle with erosion, or merely worrying over the condition, while others have enjoyed some measure of success in their efforts to maintain reasonably stable beaches. It is the purpose of this paper to appraise the overall, general situation, and certain specific problem areas.

GEOLOGY

The 125 miles of ocean shoreline in New Jersey represents three geomorphic types: A sand spit about 5 miles in length at the northern extremity; 24 miles of headland beach; and 96 miles of barrier beach. The sand spit at the north end of the State, known as Sandy Hook, projects northward and westward into Lower New York Bay in continuation of a barrier beach which extends northward about 5 miles from the headland at Monmouth Beach. This spit cuts off the direct entrance of Shrewsbury River and Navesink River into the ocean. They enter the ocean to the north, back of Sandy Hook.

Southward from Monmouth Beach to Bay Head, a distance of approximately 19 miles, the upland terrain, with elevations at 15 ft. to 25 ft. above sea level, extends oceanward to the general line of the beaches where it terminates in an abrupt drop to the ocean strand, the width of which generally is about 50 ft. As the southern limit of the upland frontage is approached from the north, the terrain elevations decrease and the width of strand increases to about 200 ft. Emerging through the upland frontage, Shark River and Manasquan River enter the ocean at distances of 20 and 26 miles, respectively, south of Sandy Hook. Both of these rivers have been improved for navigation and their channel entrances are now protected by jetties. Several other water courses that once drained the upland now exist as lakes with their outlets to the ocean controlled by works installed for the purpose of regulating the levels of the impounded waters.

From Bay Head southward to Cold Spring Inlet, a distance of approximately 91 miles, the formation is a barrier beach lying from 2 to 5 miles off the mainland and varying in width from 550 ft. to 1 mile. Sand dunes ranging from a few feet to as much as 30 ft. in height are found along a few sections of this reach. At Cape May the mainland extends to the ocean front for a short distance.

The continuity of the barrier beach is broken by ten inlets which afford tidal connection between the ocean and the bays and sounds lying between the beach and the mainland. Three of these inlets have been improved for navigation; at Barnegat and Cold Spring, jetties have been built, while the third, Absecon Inlet, is improved only in the sense that the entrance channel is periodically dredged.

Since the earliest recorded observations there have been numerous inlets along the New Jersey coast, all of which have been generally unstable as to both location and cross-sectional area. A number of inlets which once existed have closed, leaving no physical trace of their existence. The general trend of the inlets through the barrier beach south of Bay Head is to migrate southward. Records indicate that some have shifted as much as 1 mile. From Absecon Inlet south, the southward migration of the inlets is generally accompanied by a seaward building of south shore. This has resulted in the south side of the inlets off-setting the north side; at Absecon Inlet, the south side extends a mile farther seaward than the north.

The formations along the New Jersey coast are of the cretaceous and more modern ages, and are composed of practically level unconsolidated strata of gravel, sand, silt and clay. They are flat sheets which slope gently to the southeast, extending out under the ocean, and presumably crop out on its bottom at the edge of the continental shelf. The total thickness of the strata is great near the shoreline. A well driven at Atlantic City to a depth of 2,305 ft. did not reach the ancient surface of hard rock underlying the oldest deposits.

The offshore hydrography is not complex. The formation resembles a plateau extending seaward 80 to 90 miles from the shoreline and gently sloping to 300 ft. below sea level in this distance. Beyond here, the depths increase in a precipitous manner, attaining 6,000 ft. approximately 100 miles from the shore. In general this description applies to the area extending from Cape Cod to the Virginia Capes, the outer "bluff" line curving to generally parallel the Long Island-New Jersey-Delmarva Peninsula shoreline. The plateau is cut by several submarine canyons, however all but one are so insignificant on this enormous stage as to have little bearing on shoreline processes in New Jersey. The exception to this generalization is the Hudson Canyon, which dissects the plateau in a northwest-southeast direction beginning at the entrance to New York Bay. It is as much as 100 ft. deeper than the adjacent plateau in its inner reaches, and near its outer extremity it plunges to depths 2,000 to 3,000 ft. below the surrounding ocean floor. It appears reasonable to suppose that so mighty a gash as this plays a significant part in the processes operating along the New Jersey shoreline.

As stated previously, the shoreline and presumably the offshore plateau is devoid of rock formations for great depths below the surface. Likewise, the New Jersey hinterland southeast of a line extending between Trenton and Staten Island (the Fall Line) almost entirely consists of unconsolidated sediments extending to great depths. This area, part of the Coastal Plain, is seen to include all of the ocean shoreline. The deposits are largely the result of erosion of the upland now included in the Appalachian Mountain terrain, which once was much higher than it is presently. Some of the material is marine in origin, as it is commonly accepted that the Coastal Plain has experienced several cycles of uplift and submergence; and a smaller portion of the sedimentary deposits were derived from the glacial moraines, the southernmost of which is found just north of the Fall Line. The latter class of material evidently is found mostly in portions of the Plain adjacent to the Delaware estuary.

It appears that the material composing the New Jersey ocean beaches is derived from the deposits found in the portions of the Coastal Plain adjacent to the beaches. Neither the beaches nor that part of the Plain contain the minerals associated with the morainal deposits, which were derived from the ancient crystalline rocks of New England. On the other hand, both contain cretaceous and tertiary sediments with paralleling mineral compositions. The predominant mineral is quartz.

The particle size on the beach as reflected by various criteria increases rather progressively from Sandy Hook to Manasquan River, then decreased from the latter point to Cape May. The median diameters at these places are 0.37 mm, 0.78mm respectively, and the percentages held on the number 28 sieve are approximately 30, 73 and zero.

THE SHORELINE REGIMEN

General description of shoreline changes. The earliest reliable survey of the New Jersey coast is that made by the Coast Survey in 1839-42. In the more than a century of record accumulated since then, it is found that the net change represents a loss of beach, but the differences along the shore between the earliest and the latest surveys of record are very irregular. In some places, there have been extensive accretions, in others the beach has been essentially stable, and at some localities the losses have been great. The record also shows that the beach frontage does not change between surveys in the same way in all its parts, nor is the rate or even the direction of change constant at any given point during the period of record. For example, the northern extremity lost heavily between 1839 and 1873 while the middle section and parts of the southern generally were accreting. There are instances of erosion and accretion occurring simultaneously in adjoining sections of a unit barrier beach (i.e., one lying between two inlets) during the period between two record surveys, followed by the diametric opposite in the next period for which comparisons of shoreline locations are possible. Where there was erosion in one section between two surveys, there is accretion between the next two surveys; in the neighboring section, gains were experienced in the first period and losses in the second.

Thus, while the overall result in the more than a century of record has been erosion, checking with the geologists' concept that nature is working to extend the continental shelf at the expense of the land mass, it appears that in the process an erratic or perhaps a cyclic shifting of masses of material takes place on the beach. There is also a possibility that the pattern of net losses to the sea is not a steady or even unidirectional process.

There is reason to believe that the present pattern of shoreline processes in New Jersey has existed for a long time, perhaps throughout the entire period during which geologic conditions similar to those that now obtain have prevailed. That it has been erosive in the net is evidenced by the existence of ancient marsh formations on the sea face of eroding barrier beaches at several points along the coast. Such formations were most certainly not laid down in the open sea; they must have been established during a period when the areas they occupy were protected by barriers much farther seaward than the present beaches. It is also known that inlets have closed and reopened prior to the earliest reliable survey. This indicates that the variableness that is characteristic of the present shoreline changes must have existed prior to 1839 also. Inlets exist as a result of a balance between the supply of materials moving along the adjacent beaches and the inflow and outflow of their tidal prisms. An increase in the supply may choke the entrance with eventual complete closure; a decreased supply may result in such serious erosion that a storm will reopen an inlet that can cope with the existing littoral drift.

Principal factors. The New Jersey shoreline regimen is a function of the supply of New Jersey beach material, and the waves, currents, tides and winds that shift it about, and the inlets, jetties, groins and other features that affect the processes.

Supply of beach-building material. It has already been stated that materials typical of morainal deposits are not present on the New Jersey beaches. As such minerals are present on the Long Island beaches, it is probable that these beaches do not constitute a source supply of material for the New Jersey beaches. The Hudson River and its deep canyon doubtless are effective barriers to such a movement, and the direction of drift in northern New Jersey is towards, not away from New York Bay, as evidenced by Sandy Hook. Likewise, the New Jersey beaches are effectively isolated from the Delaware beaches by the Delaware estuary, which debouches into the Atlantic through an entrance 12 miles in width. While it spreads its currents fanwise before its entrance, the materials discharged by the Delaware evidently are not carried eastward up the Cape May Ocean frontage. Groins and jetties here do not trap material on their westward sides, and the beach material is quite different from the sands composing the bottom of Delaware Bay.

The beaches receive little nourishment from stream detritus. Excluding drainage to New York Bay and Delaware Bay, the area discharging into the Atlantic or its coastal bays and sounds amounts to only 1,700 square miles approximately; of this total, only 121 square miles are drained directly into the ocean. The approximately 40-in. annual rainfall is well-distributed throughout the year, the terrain does not exceed 100 ft. in altitude, and there are numerous swampy areas. As a result, the water-courses are sluggish and carry little sediment. It is emphasized that 93% of the coastal drainage is discharged into the bays and sounds. Even if the streams carried much detritus, it would be trapped in these bodies of water and not become available for beach nourishment.

Thus, the New Jersey beaches probably receive no material from the shorelines to the north and south of the state, and little or no contribution from the New Jersey hinterland. Also, material brought down by the Hudson and the Delaware is not made available to nourish the beaches. It follows that the New Jersey ocean beaches as an entity have no source of supply of beach-building material unless the ocean floor itself constitutes a source. In the face of the record surveys obtained at intervals since 1839 indicating a net loss of beach, it must be concluded that the ocean does not supply as much material as it receives, and consequently does not qualify as a source of supply.

It is clear, if this concept is sound, that sand in littoral transport on the New Jersey beaches consists of a redistribution of the volume on the beaches. In the process, the sea exacts a charge for its services as the principal transporting medium, as does the wind for its work, with the result that there is generally a smaller volume moving along the beach than was eroded from some updrift location.

It is considered that beaches like those along the New Jersey coast are rarely static, although the shoreline may not be changing in a given period of time. A stable beach probably is experiencing an exchange of sand, the supply equalling the losses. Where a beach is accreting, the supply is in excess of the quantity carried away, and conversely, an eroding beach is losing more sand than is fed to it. The forces that effect this movement of sand to and fro are the waves, tides, currents, and winds. They may, and frequently do, act in concert, to produce the observed result.

Waves. The waves are doubtless the principal tool in nature's hands for molding and remolding the sands that comprise these New Jersey beaches. In general, it may be said that their action is less violent on this coast, where the sea floor slopes gently for a considerable distance, than in localities where greater depths exist close to the shore.

Observations by the Beach Erosion Board at Long Branch during the 20-month period extending from April 1948 to October 1949, reveal that 71% of all the waves are two feet in height, or lower. 94% are four feet in height or lower, and 98% are six feet or lower. The highest wave observed was about 12 feet; waves in this range occurred during only 1/10 of one percent of the observation period, or about 12 hours.

Observations by the Philadelphia District, Corps of Engineers, at Atlantic City during a 19-month period in 1935-1937 disclosed that 65% of the waves there are two feet in height, or lower, 90% four feet or lower, and 97% six feet or lower. The greatest wave observed measured about 13 ft. from crest to trough. It is apparent that the wave experience at Atlantic City is similar to that at Long Branch; these data, supplemented by less extensive observations at Ocean City, Wildwood, and Cape May, lead to the conclusion that in general the waves all along the New Jersey coast are generally similar in their height characteristics. This is probably true only for fairly long periods of observations. The waves on a given day may be quite different at one locality than those occurring at another.

Methodical observations of wave directions are available only for Atlantic City, Ocean City, Wildwood and Cape May. The data show that waves approach these beaches from directions north of normal to the general set of the shoreline much more often than from points south of the normal. Considering the swell data shown on Fig. 1 and the configuration of the shoreline, this condition is to be expected. Swells from the northeast, east, and southeast, accounting for 43% of all the observations north of latitude 39° and west of longitude 70° approach New Jersey south of Barnegat Inlet in such directions that their impingement on the beach are from directions north of the normal lines.

It may be inferred that the northeast swell is considerably reduced in significance in northern New Jersey due to the lee provided by Long Island, also that the southeast swell is likely to impinge on the beach at an angle to the south of normal to the northern New Jersey shoreline. The pronounced change in shoreline orientation north of Barnegat Inlet is clearly shown on Fig. 1. Accordingly, it is inferred, with support from casual observations, that the most common direction of wave approach at points along the shore north of Barnegat Inlet is south of normal.

Currents. It is generally believed that waves approaching a beach at an angle generate a longshore current away from the angularity. Thus, the more oblique approaches produce the higher longshore, or littoral, current velocities. Waves hitting a beach normal to its alignment would not produce a littoral current under this concept. Applying this to the New Jersey coast, it is seen that a wave-induced littoral current flowing towards New York Harbor is likely to be encountered north of Barnegat Inlet, and that a similar current setting towards Delaware Bay should exist south of Barnegat Inlet. Direct observations covering a considerable period are available at Atlantic City, where a recording current velocity and direction apparatus was maintained in operation for about two years. The data obtained showed the existence of a non-tidal current generally flowing towards Cape May. This current attained a velocity of nearly three miles per hour on one occasion.

Other currents existing in the locality that are, or may be, factors in the changes occurring on the New Jersey beaches include those generated by the discharges and inflows of New York Harbor and Delaware Bay, also the coastal inlets and tidal entrances; oceanic currents other than tidal; and tidal oceanic currents.

For a distance of at least a mile south of the tip of Sandy Hook, the normal ebb flow from New York Harbor generates a current of nearly 2 miles per hour velocity generally paralleling the ocean shore and setting away from the Harbor. During the normal inflow to New York Harbor, the current along Sandy Hook attains approximately the same velocity as is found during the ebb, but flows toward the Harbor. Information as to the distance south of the tip of Sandy Hook that a reversing current is experienced is not available, but it seems reasonable to expect that currents as strong as those encountered a mile from the tip would not disappear in less than five miles. At the entrance to Delaware Bay, reversing currents have been found as far as Wildwood, seven miles above the tip of Cape May, and at a point sixteen miles south of Cape Henlopen on the opposite shore of the bay. These currents had strengths of about 1.5 miles per hour, increasing to about 2.5 miles per hour closer to the entrance. It is important to bear in mind that these are normal velocities; during times when extraordinary ranges of tide are occurring, the tidal prisms of estuaries are proportionately larger, as are the current velocities throughout the current pattern. Without doubt, the Delaware estuary and the New York Harbor tidal complex are significant factors in the New Jersey ocean shoreline regimens within their respective zones of influence.

The ten tidal inlets and the two tidal rivers encountered along the shoreline are minor estuaries with effects on currents similar to those at New York Harbor and Delaware Bay just discussed, but obviously their areas of influence are much smaller. As an example, a carefully analyzed long series of observations at a point less than a mile from Absecon Inlet revealed a very feeble reversing current -- so feeble, in fact, that there are grounds for skepticism that such a current exists. Current velocities in the entrances, and through their typical bar channels, are on the other hand frequently quite strong. At Barnegat Inlet, currents having a velocity of nearly 4 miles per hour have been observed. Such currents without question are very important factors in shoreline development along the inlet shores.

While the general statement is true that the 12 coastal tidal entrances do not generate currents over large zones, it is important to remember that their bar channels sometimes are found close to the downdrift ocean beach. When this condition exists, the ocean shoreline may be subjected to swift main-thread inlet currents for as much as a half-mile. It is usually found that this section of shoreline is subject to violent changes, indicating clearly that the inlet currents are the principal factor in the regimen of the locality.

The non-tidal oceanic currents, other than those generated by waves, include the northeastward-flowing Gulf Stream, the inner edge of which is 140 miles off Atlantic City and 175 miles off Sandy Hook, a slow counter-current extending from the 20 fathom contour nearly out to the Gulf Stream, and wind generated currents. The Gulf Stream seems too remote from the shoreline to be a factor; the counter-current is extremely feeble, and also can be discounted; only the wind-generated currents merit further discussion.

From a long series of observations made by the U.S.C. & G.S. at the five lightships near the New Jersey Coast, it is found that the current velocity in knots generated by wind is 1.3% of the wind velocity in miles per hour. A 50-mile per hour wind velocity evidently would cause a 0.65 knot current (1.1 ft. per sec.). The data also show that the current would set about 13 degrees to the right of the direction towards which the wind is blowing. Currents of this order of magnitude acting alone would be of little significance in the New Jersey beach regimen. However, acting in concert with the waves and wave generated currents, their significance becomes real. It is generally accepted that detritus possessing given characteristics will begin to move when subjected to a certain current velocity. Under some conditions, that velocity will not be attained by wave-induced currents alone, but when these currents are reinforced by the wind-driven current, the marginal velocity may be reached and sand movement will begin.

Ocean tidal currents (the so-called rotary current) exist off the New Jersey coast but doubtless have no significance in its shoreline processes. The velocity at strength of flow is reported to be about 0.5 ft. per sec. at the Lightships; analyses by the Beach Erosion Board of current observations off Long Branch, and by the Philadelphia District off Atlantic City resulted in much lower values closer to the shore.

Tide. The tide in the locality is of the semi-diurnal type; that is, morning and afternoon tides resemble each other closely. The tide-defining data are tabulated below:

	Mean Range	Time of Tide* H.W.	Time of Tide* L.W.
Sandy Hook	4.6 ft.	12.74 hrs.	6.68 hrs.
Atlantic City	4.1 "	12.24 "	6.12 "
Delaware Breakwater	4.2 "	13.45 "	7.13 "

*Referred to upper and lower transits of the moon at Greenwich.

Mean ranges are often greatly exceeded; meteorological disturbances have raised the ocean to as much as 5.4 ft. above mean high water and lowered it to 3.5 ft. below mean low water at Atlantic City and presumably elsewhere along the New Jersey coast. The extreme high stages are usually accompanied by strong winds and great waves. Due to the increased depth of water over the shallow off-shore areas, the waves deliver more energy at their impact on the beach, and affect portions thereof normally free from the effect of waves.

Another characteristic of the tides that possibly is of significance in considering their relationship to shoreline changes is the variation in mean range that occurs over a 19-year period due to astronomical factors. At Atlantic City, the range of tide in 1933, the low point of the cycle, was 3.9 ft.; in 1940, the peak of the cycle, the range was 4.3 ft. A variation of only 0.4 ft. might seem inconsequential, but on the gently sloping beaches that characterize most of the New Jersey shoreline, the mean high water line would vary from eight to ten feet without any change in absolute elevations of the beach. It must also be borne in mind that every factor in shoreline processes, excepting the direct effect of the wind, would vary somewhat in effectiveness in consonance with the variation in tide. In the case of a beach in a delicate state of equilibrium during the low point of the 19-year cycle, it is conceivable that the high water mark would be advanced shoreward at the high point of the cycle far more than the 8 or 10 ft. referred to above.

While variations in sea level are not due to astronomical factors, it is germane to the general subject of tides to refer to the rising elevations that have been noticed in recent years. Whether this is due to a subsidence of the land mass or a gain in the volume of water present in the ocean is not important in these considerations; the bare fact that sea level relative to the land is now about 0.5 ft. higher than it was in 1925 is important, however. This change in sea level has moved both the mean high water and the mean low water lines landward about 20 ft. on a 1 on 40 sloping beach without the assistance of any accompanying erosion. Obviously, such a change increases the effectiveness, even though possibly very little, of the factors in shoreline processes. Again, a small increase in their strength may be sufficient to produce a significant change in the overall regimen.

Inlets. The existence of ten inlets and two tidal rivers on the ocean shoreline of New Jersey has been mentioned previously. These tidal entrances are very important factors in the shoreline regimen, much more so than would be their role if they were mere generators of coastal currents. Some students of sandy coasts conceive them to be barriers to the orderly movement of the littoral drift. They divert part of the drift far seaward, perhaps beyond recovery, carry another part into their interior lagoon system, and temporarily store the remainder in outer bar formations.

As the bar develops in the direction of the littoral drift, springing out from the windward beach, the channel is forced towards the leeward beach, which then suffers erosion unless it is strongly protected. Unstabilized inlets migrate in this manner, and numerous fine examples of such movements exist in the history of the New Jersey coast, the best being the shift of Barnegat Inlet to the south amounting to a mile in about 100 years. Finally, the bar channel is forced into so unfavorable a position that a natural tendency exists for it to seek a more direct route to the ocean. With the help of a storm, or perhaps an unusually powerful ebb discharge, the bar is breeched, and a deep channel develops with the consequent rapid deterioration of the former location of the channel close to the beach. A section of the bar, perhaps containing hundreds of thousands of cubic yards of sand, then is detached from the main stem and is no longer barred from the leeward beach by swift inlet currents. The material thus freed gradually moves to that beach, repairing the erosion caused by the inlet channel when it was close at hand, and in some recorded instances producing a very considerable accretion. The beach immediately south of Barnegat Inlet was very lean in 1932, so much so that stabilization measures taken by the State a few years earlier to save the historic lighthouse there were threatened with an outflanking maneuver in the inlet's effort to resume its migration southward. The channel had been forced far towards the leeward beach, and an extensive bar formation was dangling like a ripe fruit. By 1937, it was clear that the inlet and its vicinity had passed through a particularly interesting phase of its development. The channel had shifted to the east, and the formerly lean leeward beach had experienced an accretion amounting to several hundred feet. Such events doubtless have occurred at the other inlets, fairly certainly at Absecon Inlet and Great Egg Inlet. Close study of the recorded changes in the ocean shoreline of the State reveals that the greatest erosion or accretion has occurred adjacent to the inlets and tidal rivers.

Shark and Manasquan Rivers, also Barnegat and Cold Spring Inlets, presently have jettied entrances. Absecon Inlet has a strongly protected shoreline on its down drift side, and an entrance channel 20 ft. in depth that is maintained by dredging; without maintenance, this channel would shoal to about 8 ft. over the bar.

The south jetties at Shark River and Manasquan River accumulated fillets of beach material extending to their outer ends years ago, and it is believed that the littoral drift is now by-passing these entrances, in part naturally and in part as a result of the direct deposit on the north beaches of material dredged from the channels. The north beaches suffered erosion in the early years of the existence of the jetties, but they are apparently relatively stable now. The Barnegat Inlet jetties have not had a well-defined effect on the adjacent beaches as yet, although they have been in existence for ten years. Apparently, there is a tendency at this inlet for fillets to accumulate north of the north jetty and south of the south, although it is considered certain that the long-term prevailing direction of littoral drift is from north to south.

some of the structures were of no value as protective devices but their removal was not considered justifiable or expedient. In the case of others, it is conceivable that the structures were initially successful but that complacency, budget problems, and short memories combined to prevent routine maintenance until the structures had lost their effectiveness.

If the concept that the sandy beaches of New Jersey are not static is sound, then it follows that a stable beach exists only where the rate of movement of sand away from that beach is balanced by the rate of arrival of other sand there. Thus, if works can be designed to reduce sufficiently the rate of loss at a beach where an unsatisfactory balance exists, erosion will be supplanted by stability. Obviously, such works will not preserve a beach when there is no supply of sand, unless they have succeeded in reducing the loss rate to zero, an unattainable goal. Even more obviously, they will not build a beach when no beach-building materials are furnished.

This simple, rational concept is widely accepted; yet, when beach protective works are being considered, it is sometimes either forgotten, or it is assumed that an adequate supply of material is reaching the problem beach when in fact this assumption is unsound. The alternative in such circumstances would consist of increasing the supply rate artificially. When the net loss rate is low, the economical solution to the problem might be this measure alone; beach protective works, which are always unsightly, might not earn their way. When the net loss rate is high and the cost of an artificial increase in the supply rate is great, it might be sound to include beach protective works in the project. Another important reason for careful consideration of the artificial nourishment type of project for the eroding beaches lies in the great variations in the supply volume. Artificial nourishment of a beach having such a history would carry it through an erosive cycle perhaps far more economically and certainly more successfully than a project for beach protective works alone. These principles will be discussed further in the presentation of the four outstanding problem areas that exist now.

Long Branch and Vicinity. Long Branch occupies the northerly portion of a 19-mile section of mainland ocean frontage. The littoral drift is northward, as evidenced by the accumulations at the numerous groins, but it is of negligible volume at Long Branch presently. This is due in part to the vigorous efforts of communities to the south to retard their erosion, thereby reducing the supply for Long Branch, and in part, in all probability, to a naturally small supply throughout this section of shoreline. The resorts to the south appear to be nearer to the kitchen, so to speak, and they seek as great a portion of the available supply as their groins can retain. The shoreline north of Manasquan River is entirely utilized, and there are few sections free of groins. It may be concluded that the supply, after running the gamut of so many structures designed to trap it, has become quite thin before the needs of Long Branch and its neighbors to the north can be met.

In addition to loss of beach, the locality in recent years has suffered loss of slices of headlands, which are composed of unconsolidated sediments. The headlands are occupied by pretentious mansions, and real estate values are extremely high. The problem has been attacked by the construction of strong bulkheads, fronted by heavy revetments of stone at their toes, together with high groins. Some of the groins have offshore breakwaters extending upcoast and downcoast perpendicular to the groin, making a structure resembling a capital T. The bulkheads have been successful in eliminating further erosion of the shoreline, but the groins, as may be expected, have not built much beach to serve either for bathing or as a buffer to protect the bulkhead. Where the T groins were built, the offshore breakwater serves the latter purpose, and there have been small accumulations of sand adjacent to their stems, paradoxically to a greater extent on the downdrift than on the updrift sides. Survey data are not available on which to premise an explanation of the results of these T groins, but it is reasoned that the accumulations are either the result of a redistribution of the ocean bottom enclosed by the adjacent Ts, or is material scoured from the bottom at the sea face of the offshore portions and carried through the gaps left between adjacent Ts. The sand that is thus trapped is native to the immediate locality. Its mineral composition includes much glauconite, giving it a darker appearance than the sands on the beaches to the south and the north of the T groins. Evidently, the sand trapped by the Ts is not the material in general littoral transport in the locality.

The Beach Erosion Board, in cooperation with the New York District, has recently completed a study of the use of dredged material deposited offshore by a hopper dredge to nourish the beaches of Long Branch and the resorts to the north. The material, removed from New York Harbor entrance channels, was placed during the summer of 1948 in a ridge about 1/2 mile from shore in 38 ft. of water. The volume deposited amounted to approximately 600,000 cubic yards. Careful surveys were made of the beach and offshore areas before, during, and after the dumping, the last survey being made 14 months after the last load was deposited. Tide and wave observations were made continuously throughout the experiment.

The data show that the shoreline receded during the study. In the last 12 months of observation, three of the four sections into which the beach was divided for convenient reference eroded 14 ft.; the fourth section, nearest to the stockpile, receded 43 ft. The area shoreward of the 18-ft. depth contour lost 222,000 cubic yards of material during the 12-month period, while the stockpile gained 39,000 cubic yards. The area seaward of the 18-ft. contour, excluding the stockpile, gained 182,000 cubic yards, indicating that the entire study area experienced a very close balance of gain and loss. The conclusion is inescapable that the offshore stockpile did not nourish the beach. It could not have been placed closer to the beach without endangering the dredge.

As stated previously this section of the New Jersey coast evidently does not enjoy an adequate littoral drift volume. Beach protective works cannot be expected to stabilize or build beaches without benefit of such a supply. Offshore deposits do not appear to solve the problem, leaving no alternative but the artificial placement of sand directly along the shore if an adequate bathing and protective beach is to exist there. This work could be accomplished by a hydraulic dredge pumping from Shark River, three miles to the south of the southern limit of the critical area, or from Shrewsbury River, seven miles to the north of the same point. It would be costly sand, but probably commensurate with the value placed on this frontage. It is reported that the existing, relatively new, beach protective works in some areas have cost approximately $1,000,000 a mile.

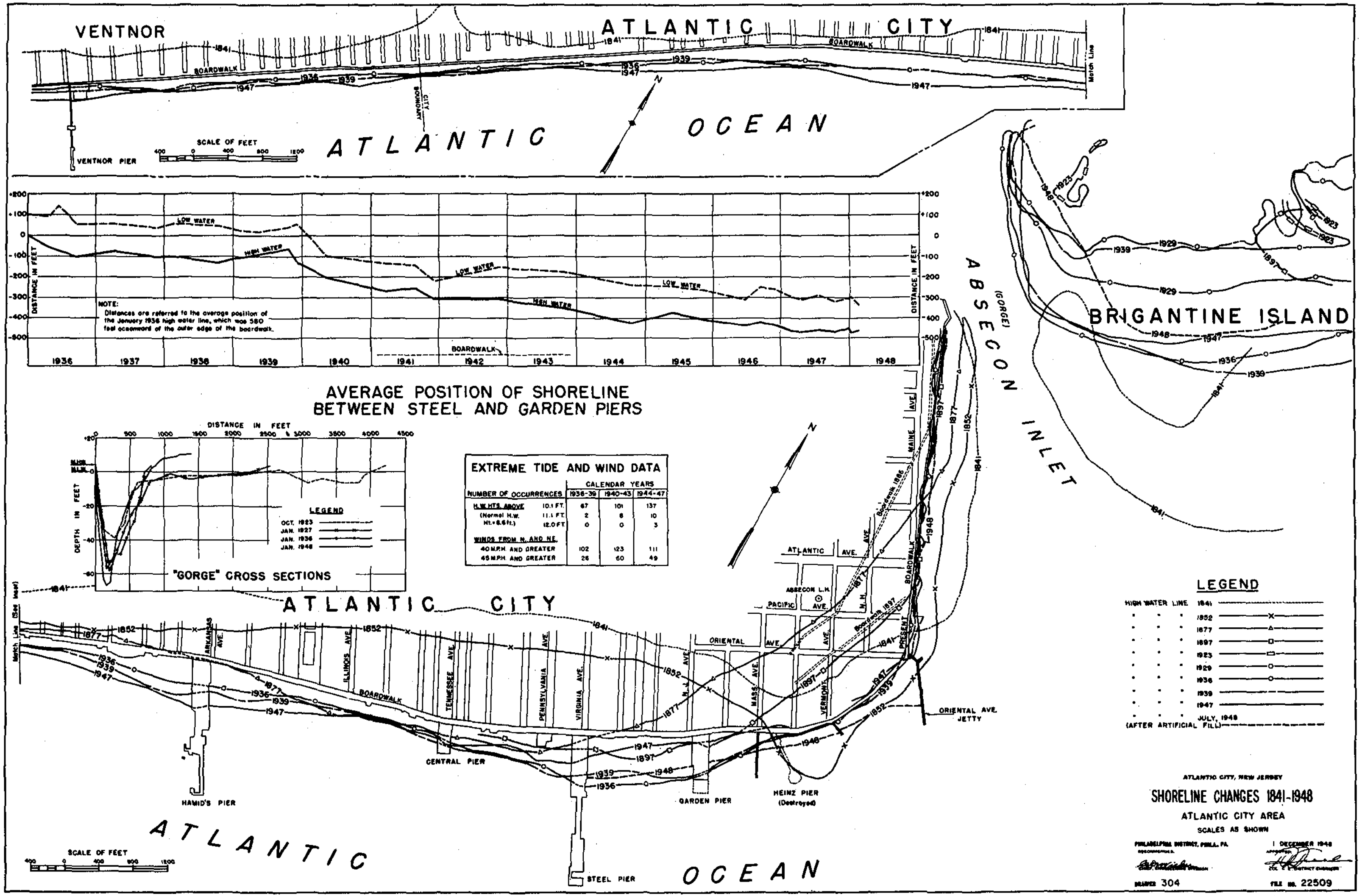
Atlantic City. Conditions at Atlantic City are quite different from those at Long Branch. This section of the shoreline is near the middle of the belt of barrier beach, which is composed of islands of various lengths separated from each other by inlets connecting the ocean with tidal lagoons lying between the mainland and the barrier beach.

Atlantic City occupies the northern 3-1/2 miles of Absecon Island, which extends eight miles from Absecon Inlet on the north to Great Egg Inlet on the south. Absecon Inlet, which is very important to the economy of Atlantic City, has been under improvement by the Federal Government since 1910. The existing project provides for a channel 20 ft. deep and 400 ft. wide. It is maintained by dredging alone; there are no jetties to assist in the stabilization of the entrance.

Fig. 2 shows that shoreline changes at this most important resort have been dramatic during the long period of record, although only those subsequent to about 1854 have been of much economic interest. Prior to this date, the island warranted the historian's pronouncement that "the undisturbed isolation of the island must have made it an attractive spot for refugees from war or justice." Fortunately for the growing resort, it appears that the first reliable survey recorded the deepest invasion of the sea. Between that survey, made in 1841, and about 1925, Atlantic City experienced a net accretion, although it was not a steady gain nor is this general statement true along the entire frontage. The inlet shoreline, for example, was farther seaward in 1841 than at any subsequent date, and there are areas that have experienced alternating gains and losses.

According to local people, the 1925 shoreline was quite similar to that existing in 1939, and it is also their belief that the intervening years were not marked by any notable changes. This happy condition was of course extremely important to the resort, which has grown to a resident population of about 50,000, and an assessed valuation of nearly $100,000,000.

Fig. 2



EXTREME TIDE AND WIND DATA

NUMBER OF OCCURRENCES		CALENDAR YEARS 1936-39	1940-43	1944-47
H.W. HTS. ABOVE	10.1 FT.	67	101	137
(Normal H.W.	11.1 FT.	2	8	10
Ht.=6.6 ft.)	12.0 FT.	0	0	3
WINDS FROM N. AND NE.				
40 M.P.H. AND GREATER		102	123	111
45 M.P.H. AND GREATER		26	60	49

The bulk of this wealth is concentrated close to the shoreline along the famous boardwalk, and provided a setting for the most important asset of the resort, its beach. Any recession of that beach would result in overcrowding; the city plays host to 13,000,000 visitors each year, and the beach area is barely adequate for peak days. It was indeed a precarious situation in view of the recorded violent shifts of the shoreline.

In 1939, a new phase in the cycle of shoreline events was evidently entered. Beginning that year, perhaps even a few years earlier, the beach began to shrink steadily along the northward 1-1/4 miles, the heart of the frontage. By 1947, nearly 500 ft. of width had been lost leaving a mere 100 ft. for the thousands who had become accustomed to bathing in this particular locality. In the south portion of the city and along the frontages occupied by its sister resorts of Ventnor, Margate and Longport, accretions were occurring simultaneously that matched the losses in northern Atlantic City volumetrically.

The City's officials and its influential citizens prior to 1947 evidently appraised the situation as an unpleasant transitory condition that soon would be supplanted by the recuperative phase. However, they prudently took steps to reinforce the inlet shoreline to prevent a recurrence of the severe recession of the ocean shoreline that occurred between 1852 and 1877, in which action the inlet was doubtless an active participant.

In 1947, when it was evident that no further loss of the main ocean frontage could be accepted without suffering irreparable damage, the City fathers reacted with vigor. They sought the views of every individual and organization qualified to give advice on the matter at hand, and entered into a cooperative study with the Corps of Engineers. In 1948, they concluded a contract with a dredging company to pump approximately 1,250,000 cubic yards on the affected beach. This work restored the strand to a satisfactory width, and provided time to continue the appraisal of the problem.

A great quantity of information on the basic factors that enter into the shoreline processes at Atlantic City was available prior to the initiation of the Corps of Engineers cooperative study, and additional observations were made during its course. These data show that the basic difficulty was not a reduction in the rate of supply of beach-building material, but an increase in the rate of loss along this particular section of the island. It has already been stated that the occurrence of northeasterly storms does not follow a regular pattern of frequency of occurrence. Studies of the records revealed that such storms, during the period of erosion beginning in 1939, were much more frequent than during the years when a stable beach existed in this northeasterly salient of the island. Evidently, they are particularly effective here, a concept that is reinforced by reference to the historical changes. It also appears that the salient beaches on the downdrift sides of other inlets experience cycles of great accretion and great loss. It is probable that these beaches wax when nature is in a "routine" mood, and wane during periods of unusual frequency of occurrence of violent northeasters. Examination of the table on Fig. 2 entitled "Extreme tide and wind data" shows that the erosive period certainly could be characterized as stormy in comparison with the preceding period of stable beaches. While the condition doubtlessly was a transitory phase, there was no basis for a prediction as to when it would terminate. It was also clear that it continued throughout the course of the cooperative study, as the artificially placed beach also was eroding. Accordingly, the basic remedy prescribed in the report, which has been accepted by the city, consisted of measures to reduce the rate of loss supplemented by such repetition of the artificial nourishment procedure as is found necessary to counterbalance the remaining loss. Five new groins were recommended for the ocean frontage in addition to the existing two effective structures. It was further recommended that one of these be extended to fit into the resultant pattern of beach protective works. As the inlet is the important factor in the shoreline, additional works to stabilize it were recommended also.

Ocean City. Absecon Island's neighbor on the south, across Great Egg Inlet, is occupied by Ocean City. This resort, while not so populous as Atlantic City, has grown rapidly in recent years, attracting a clientele which prefers its quieter atmosphere to that of Atlantic City. One of its characteristics is the large number of well-maintained, attractive cottages that are occupied by their owners during the entire summer, or are available for leasing. The greater part of the community has developed on the northern portion of the island.

As Absecon Inlet is of great significance in the shoreline development at the northern end of Absecon Island, so Great Egg Inlet, which is larger than Absecon Inlet, plays an important role in the changes in configuration of Ocean City's island. Unlike Absecon Inlet, it has not been subject to improvement for navigation at any time, and until a year ago, its Ocean City shoreline has not been effectively stabilized.

Scrutiny of general maps of the locality leads to the concept that Great Egg Inlet has not always passed the tidal prism of the bays behind southern Absecon Island as well as those behind Ocean City. The lagoon pattern behind the southern half of Absecon Island suggests that there was an inlet about a mile north of the present southern end of Absecon Island which subsequently migrated southward eventually to merge with Great Egg Inlet. Fig. 3 shows that a large middle ground in Great Egg Inlet existed in 1842; the unnamed inlet to the north was evidently about ready to merge. The next survey shows that the tip of Absecon Island had extended southward to incorporate the middle ground in its land mass, forcing the entire flow of the merged inlets against the north end of Ocean City. This condition was found in the 1886 survey, when much of the present-day area of Ocean City was under the waters of the inlet. During the next 38 years, the inlet migrated to the north, against the apparent littoral drift, tearing off a large area of southern Absecon Island to the accompaniment of accretion of the northern end of Ocean City. Evidently the inlet was reorientating itself to serve as the single entrance for two systems of tidal lagoons; the time seized by it as opportune for this effort must have been one of relatively small littoral drift at the southern end of Absecon Island. The remainder of that island was accreting rapidly, probably utilizing most of the drift in the process.

In 1920, Longport secured its rear face and short inlet shoreline, and built a massive groin at its southern tip. Great Egg Inlet's migration to the north was at least temporarily thwarted, but apparently the south tip of the inlet continued to stretch itself northward for 20 years more. Part of this growth is credited to material once included in the bar formations within the inlet that was made available for beach-building as the inlet bar channels readjusted themselves to the changing regimen. It also happens that during this period, which was one of particularly rapid development of the resort, the area was filled by hydraulic dredging and dunes were leveled, perhaps making more material available for the development of the shoreline. After 1944, evidently the favorable balance between supply and loss was replaced by a serious deficit, and the erosion that resulted by 1949 carried the shoreline back to where it had been 30 years earlier. Unfortunately, there had been considerable construction on this land in the intervening years.

As the tip of the island accreted from 1886 to 1944, so did the important northerly two miles of the ocean frontage from 1886 to 1928. The commercial development of the resort kept pace with the accretion; new structures were erected on the gains, always leaving adequate beach, however. Subsequent to 1928, the erosive phase quickly eliminated much of the gain along the ocean frontage, leaving no beach in the heart of the resort. The middle 3 miles of the island generally have enjoyed continuing accretion.

In about 1935, a system of groins perpendicular to the shoreline were built along the eroding ocean frontage; they were rebuilt a few years later to incorporate a curving outer end. These structures have accumulated very small fillets of beach on their northerly sides.

With the arrival of the erosive phase at the tip of the island in 1944, the construction of a system of groins, some of which are anchored to a stout revetment, was undertaken; at the present time, this work is still in progress. The system was started at the southern end of theproblem area and as the work progressed northward, increasingly grave erosion problems preceded it. Due to the draw of the inlet and the set of the shoreline with respect to the wave direction, the littoral drift is toward the inlet, and the groins accumulated fillets on

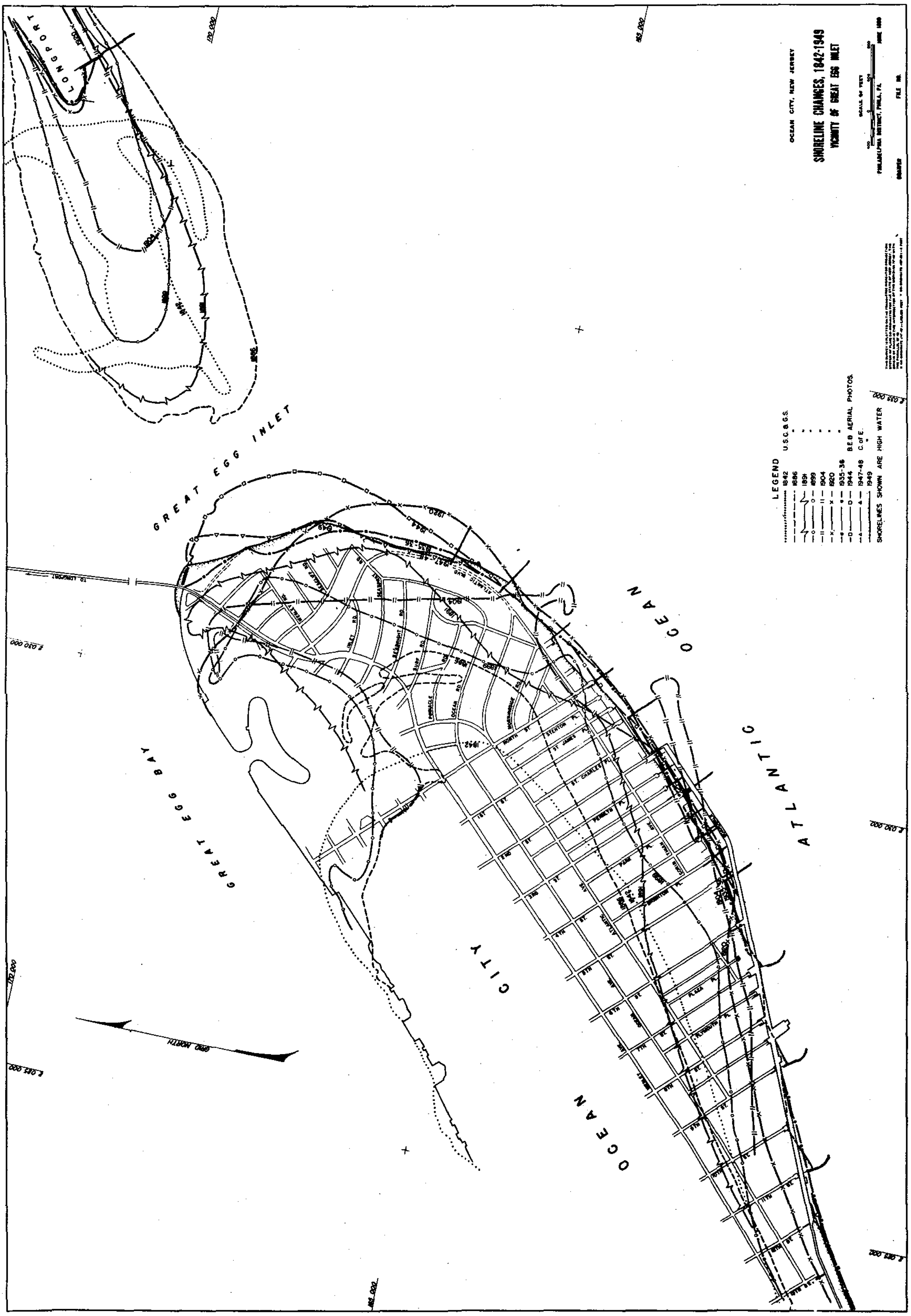

OCEAN CITY, NEW JERSEY
SHORELINE CHANGES, 1842-1949
VICINITY OF GREAT EGG INLET
SCALE OF FEET
PHILADELPHIA DISTRICT, PHILA., PA.
FILE NO.
LEGEND
1842
1886
1891
1899
1904
1920
1935-36
1944
1947-48
1949
U.S.C.&G.S.
B.E.B. AERIAL PHOTOS
C. of E.
SHORELINES SHOWN ARE HIGH WATER
LONGPORT
GREAT EGG INLET
GREAT EGG BAY
ATLANTIC OCEAN
OCEAN CITY
GRID NORTH

Fig. 3

their southern sides. It remains to be seen whether these works will eventually aid in the establishment of a stable regimen in the vicinity.

Ocean City had no shoreline problem at its northern end until 1928. Its history during its growth as a resort had, until that date, been one of continuous accretion. The source of the later accretions clearly was the great mass of sand that had been taken progressively from the southern end of Absecon Island from 1886 to 1920. The accretions prior to 1886 can only be explained as the result of a greatly increased rate of supply in the general locality. Not only at Ocean City, but also along Absecon Island, was there an advance seaward of the shoreline between 1841 and 1886. The year 1920 saw the stabilization of the north shore of the inlet and also the beginning of a period of stability along Absecon Island. The advanced Ocean City shoreline no longer was receiving the large supply of sand necessary for its maintenance, and in only a few years the long, happy period of accretion was ended and serious erosion had taken its place. Beyond a reasonable doubt, Ocean City owed its accretions to an extremely favorable rate of supply, and its present-day erosion problem to such a decreased supply that the shoreline cannot maintain itself. The only visible supply is the present general littoral drift in the locality extending from at least Absecon Inlet to Great Egg Inlet, as erosion at one point of the present shoreline of Absecon Island is balanced by accretion elsewhere. Absecon Island thus is not presently serving to enrich the volume of littoral drift reaching Ocean City.

Under this new condition, maintenance of a beach at Ocean City at the locations desired by the city fathers evidently cannot be attained by beach protective works alone. Such works, which reasonably can be expected only to reduce the rate of loss, must be supplemented by an increased supply of sand. This can be secured by artificial means only, so long as the present shoreline regimen exists. The prudent engineer would proceed in the expectation that existing conditions might last at least as long as the resorts to the north strive to maintain their beaches in their present states.

Cape May. Fig. 4 shows what has happened at Cape May since the earliest survey of record, that of 1842. As may be expected at a community which was a going concern as early as 1801, the survey data can be supplemented to carry the story to an earlier date with reasonable assurance. The evidence indicates that the shoreline in 1804 in the midsection of the Cape, about half-way between Cold Spring Inlet and Delaware Bay, was about midway between the shoreline of 1842 and 1948. Erosion continued from 1804 to 1850, cutting back into what is now Cape May City to a point beyond the mapped location of the 1842 shoreline. Evidently the erosion in this section ceased in 1850, and for 29 years, there was accretion. Simultaneously, there was erosion to the east and west of the midsection, and by 1879 nature had produced a shoreline devoid of salients and embayments, curving gently from Cold Spring Inlet to Delaware Bay. This adjustment was merely a minor activity in the shoreline development in the locality; the net result throughout the period of record has been a loss of beach in all the mapped area of the Cape west of Cold Spring Inlet.

The littoral drift in the locality moves to the west, which is a continuance of the general movement towards Delaware Bay from the nodal area between Manasquan and Barnegat Inlet. The evidence to support this statement is the accumulation of material east of the east jetty of Cold Spring Inlet, the migration of the inlet before it was stabilized, also the accumulations at the numerous groins that exist at Cape May City and at Cape May Point. The fillet at Alexander Avenue in Cape May Point, on the Bay frontage, emphasizes this statement. This leads to the positive conclusion that has already been made; Delaware Bay does not constitute a source of supply for either the New Jersey beaches in general, or for Cape May in particular. Other evidence bearing on this point includes the character of the sand on the Cape May frontage. It is mineralogically similar to that on the beaches to the east and north, and its size suggests a progressive sorting of the same source to the end product observed. It is also quite different from the coarse, sharp sands of Delaware Bay.

The Bay is a powerful factor in the symphony of forces that act on the Cape May beaches. It has a tidal prism approximating 2 million acre feet, which

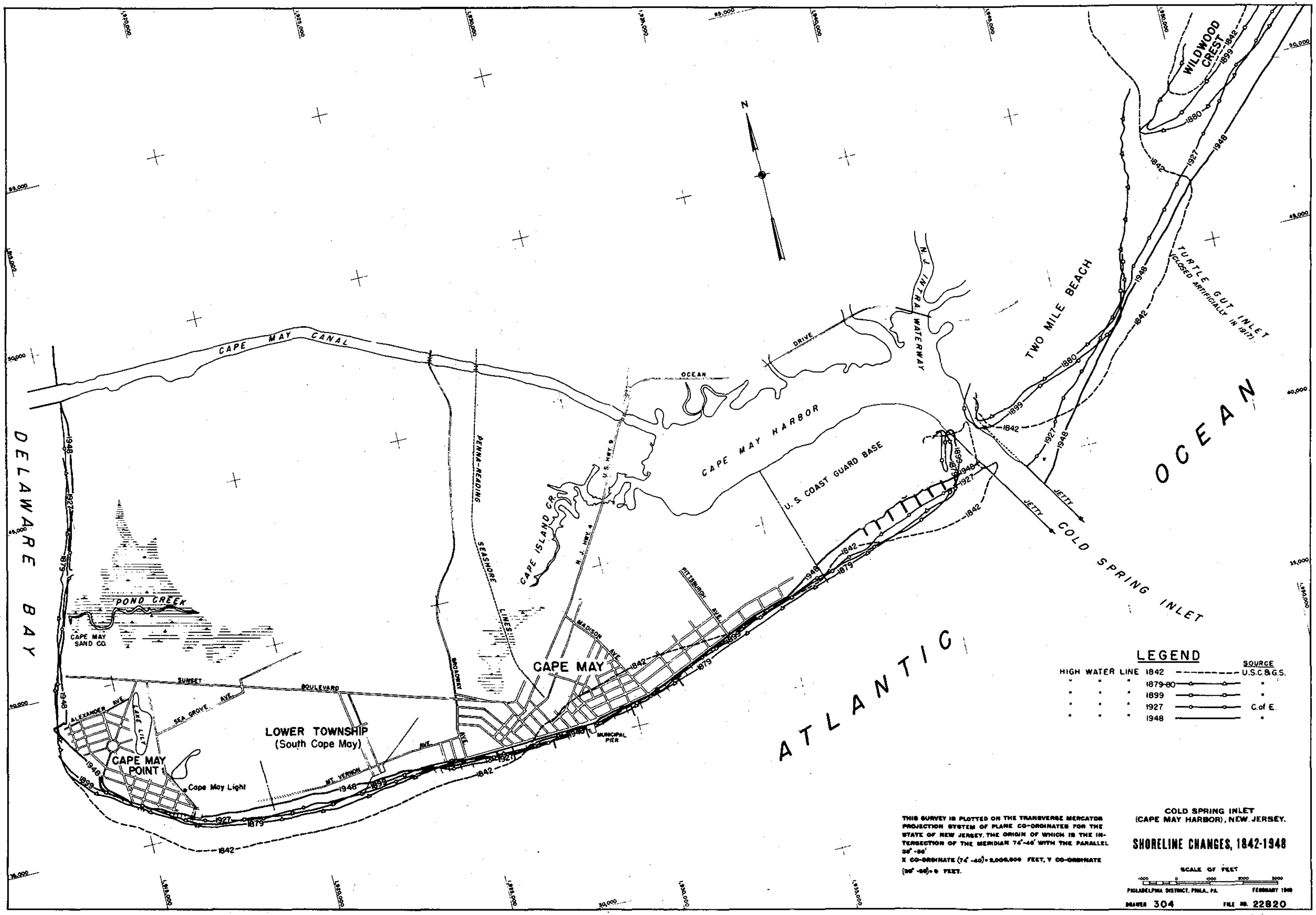

N
CAPE MAY CANAL
DELAWARE BAY
ATLANTIC OCEAN
WILDWOOD CREST
TWO MILE BEACH
TURTLE GUT INLET (CLOSED ARTIFICIALLY IN 1917)
N. J. INTRA WATERWAY
OCEAN DRIVE
CAPE MAY HARBOR
U. S. COAST GUARD BASE
JETTY
JETTY
COLD SPRING INLET
CAPE ISLAND CR.
U. S. HWY. 9
N. J. HWY. 4
PENNA-READING SEASHORE LINES
POND CREEK
CAPE MAY SAND CO.
SUNSET BOULEVARD
SEA GROVE AVE.
ALEXANDER AVE.
LAKE LILY
CAPE MAY POINT
Cape May Light
LOWER TOWNSHIP (South Cape May)
MT. VERNON AVE.
BROADWAY AVE.
CAPE MAY
MADISON AVE.
PITTSBURGH AVE.
MUNICIPAL PIER
1842
1879
1899
1927
1948
1880
LEGEND
HIGH WATER LINE 1842 — U.S.C.&G.S.
1879-80
1899
1927 — C. of E.
1948
SOURCE
THIS SURVEY IS PLOTTED ON THE TRANSVERSE MERCATOR PROJECTION SYSTEM OF PLANE CO-ORDINATES FOR THE STATE OF NEW JERSEY. THE ORIGIN OF WHICH IS THE INTERSECTION OF THE MERIDIAN 74°-40' WITH THE PARALLEL 38°-50'
X CO-ORDINATE (74°-40')=2,000,000 FEET, Y CO-ORDINATE (38°-50')=0 FEET.
COLD SPRING INLET
(CAPE MAY HARBOR), NEW JERSEY.
SHORELINE CHANGES, 1842-1948
SCALE OF FEET
1000 0 1000 2000 3000
PHILADELPHIA DISTRICT, PHILA., PA.
FEBRUARY
DRAWER 304
FILE NO. 22820

Fig. 4

generates reversing currents throughout a fan shaped area centering about its mouth. As far upcoast as eight miles, such currents are known to exist. Along the Cape May frontage, they attain normal peak velocities of more than three feet per second, and under abnormal conditions of tide and weather, they are doubtless even stronger.

As stated before, the direction of the littoral drift is towards the Bay despite the reversing current that is characteristic of the current pattern developed by the Bay. This is evidently brought about by the work of the waves, observations at Cape May City revealing that about 90% of them approach the shoreline there in a direction that generates westerly currents. This overwhelmingly predominate angularity evidently offsets the easterly bay-generated current, and strongly reinforces the westerly bay current.

Cold Spring Inlet in its unimproved state apparently was as important in the regimen of shoreline development as Great Egg Inlet and the other inlets along the New Jersey shoreline are of great significance in the changes adjacent to them. The variations that occurred prior to its stabilization in 1907-11 are quite similar to those found near other unstabilized inlets. It can easily be conjectured, based upon known variations at other inlets, that the bulging west lip of the inlet in 1842 was of recent origin. Perhaps its accumulation required so much of the littoral supply that the beach at the mid-section of the Cape was deprived of the quantity of nourishment it evidently required for a balanced regimen between 1804 and 1850. When the lip subsequently receded to the shoreline of 1879, the released material restored the eroded mid-section.

Since the stabilization of the inlet in 1907-11 as part of a Federal navigation improvement project, the east jetty has trapped a large quantity of material. In the first few years following the construction, the rate of accumulation amounted to 100,000 cubic yards per year. Later, the rate decreased greatly, and in recent years, it appears that very little, if any, material is accumulating. Evidently the capacity of the jetty has been reached, or to express it differently, the shoreline to the east has reached a condition reflecting a state of equilibrium between the rates of supply and loss.

While the east jetty was trapping the supply, clearly the beaches to the west were being deprived of an equivalent volume of their nourishment. However, after the jetties were constructed, sand derived from the initial dredging and subsequent maintenance operations in the amount of 1,300,000 cubic yards was deposited directly on the west beaches. Clearly, artificial nourishment furnished the equivalent of more than 13 years of accumulation; the accumulation proceeded at the 100,000 cubic yards per year rate for only a few years, then decreased to approximately zero at present. Despite this nourishment, the Cape May beaches continued to erode, the rate being 4.2 ft. per year from 1899 to 1948 as compared with 4.1 ft. per year from 1842 to 1899. There was no general survey between 1899 and 1911 to separate the periods of before and after construction of the jetties exactly, but it is considered unlikely that conditions during the 12-year period 1899 to 1911 were greatly different from the years preceding and following. Evidently, the effect of the Cold Spring Inlet jetties was balanced out by the stockpiling in the earlier years of their history, and they are presently being by-passed by the supply from the east. The present regimen on the west beaches is unsatisfactory immediately to the west of the jetties, along the frontage owned by the Coast Guard, probably due to the "shadow" of the jetties; one of reasonable stability in the mid-section due to the arrival of the littoral supply to the east of this area and the existence of groins there; and an unfavorable balance of supply and loss from Cape May City westward around Cape May Point. Scant comfort can be taken from the fact that the erosion rate here was 12.3 ft. per year from 1842 to 1899 and only 3.7 ft. per year from 1899 to date. However, much of this beach is undeveloped and unused, and the consequences of the continuing erosion are not of great importance economically.

RESUME

The writer concludes that the New Jersey shoreline has no natural source of supply in the long-term sense. It may, and probably does, receive contributions from the sea, but these are more than offset by the takings; there is no upland supply of detritus, nor does New Jersey receive a supply from the shorelines of its neighboring States of New York and Delaware due to the existence of New York Harbor and the Hudson Canyon to the north and the Delaware estuary to the south.

The situation in detail has been exceedingly complex. The beaches gain and lose sand apparently whimsically. The sudden and sometimes dramatic changes are due to the pattern of occurrence of storms and the effects of inlets. They have lead to disappointing or even financially disastrous consequences, as resorts built structures and produced a high state of development of advanced shorelines on the assumption that the happy, temporarily accreted condition was permanent.

Maintenance of many of the beaches with reasonable stability is possible only by means of artificial nourishment. A few areas troubled with erosion problems have success with measures designed to reduce the rate of loss to a quantity commensurate with the rate of supply then current. As more beaches endeavor to solve their problems in this manner, more areas will be confronted with erosion. Inevitably, the task will become one of balancing the net long time average annual loss of material to the sea with an equivalent volume of artificially deposited sand.

NOTE: The opinions and conclusion expressed by the author are not necessarily those of the Corps of Engineers.

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