A.M. ENVIRONMENTAL GEOLOGY OF DEMOCRAT POINT, FIRE ISLAND, N. Y., AND INFLUENCES ON ADJACENT BARRIER ISLANDS - Manfred P. (Fred) Wolff, pp. A-5-AM 1 through A-5-AM 16.

P.M. ENVIRONMENTAL GEOLOGY OF THE JONES BEACH BARRIER ISLAND - Coordinator: Peter J. R. Buttner; Lecturers: Richard A. Brady, Francis A. Hyland, Robert Johnson, Manfred P. (Fred) Wolff, pp. A-5-PM 1 through A-5-PM 10.

Cumulative Miles	Miles from last stop	Description
0.0	0.0	Assembly point: Hofstra University. Head East on Hempstead Turnpike toward Meadowbrook Parkway.
0.5	0.5	Cross California Avenue.
1.5	1.0	Junction with Meadowbrook Parkway (Southbound) to Southern State Parkway, bear right onto Meadowbrook.
4.0	2.5	Pass over junctions with Southern State Parkway - continue on Meadowbrook - follows signs to Jones Beach.
9.9	5.9	Tool booth at entrance to Jones Beach State Park.
10.9	1.0	Leave Jones Island and cross Jones Inlet and State Boat Channel to Jones Beach State Park.
11.8	0.9	Bear left - follow signs to Jones Beach Parking Fields 1, 2, 6 (not West End!)
12.8	1.0	Pass Parking Field #2 (Jones Beach water tower in distance) on Ocean Parkway.
13.4	0.6	Pass half way about traffic circle at tower - follow signs to Field #6 and Theatre.
14.1	0.7	Pass Field #6 - follow signs to town beaches, Field #9 and Robert Moses State Park (i.e. remain on Ocean Parkway).
26.6	12.5	Junction to Robert Moses State Park - bear right.
27.0	0.4	Cross bridge over Fire Island Inlet.
27.8	0.8	Bear right at traffic circle (Fire Island water tower) - follow signs to Parking Field #2.
28.9	1.1	Circle about loop at end of road.
29.1	0.2	Enter Parking Field #2, park in SW (right diagonal) corner near beach.

STOP #1 - Robert Moses State Park
(Trucks will transport you along the beach for one mile to the jetty at Democrat Point. Walking time is about 35 minutes.)

INTRODUCTION

This area, located at the federal jetty on the western end of Fire Island (and Robert Moses State Park) has been mapped since 1825 when it was located at the tip of the Fire Island Lighthouse - 4.6 miles (7.4 km.) east of its present position. The growth rate now averages 212 feet (71 meters) per year (Figure 1).

The purpose of this stop is to view the effects of the accretionary processes of spit formation from littoral drift and wave refraction associated with a laterally migrating barrier island. A more detailed analysis of the features, processes, and history of this migration is presented in article B-3 of this guidebook.

Because of the necessity for beach nourishment and inlet stabilization, the area is now dredged once every 2-3 years and the accumulated sands transferred to an adjacent feeder beach (Cedar Island and Gilgo beaches) on the west side of Fire Island Inlet. It is unfortunate, that this trip follows shortly after such a period, when only a few features are present. However, participants are invited to return at other intervals during the next few years when all of the characteristic sediment features will again reappear. You are now seeing the initial growth stages of a new intertidal

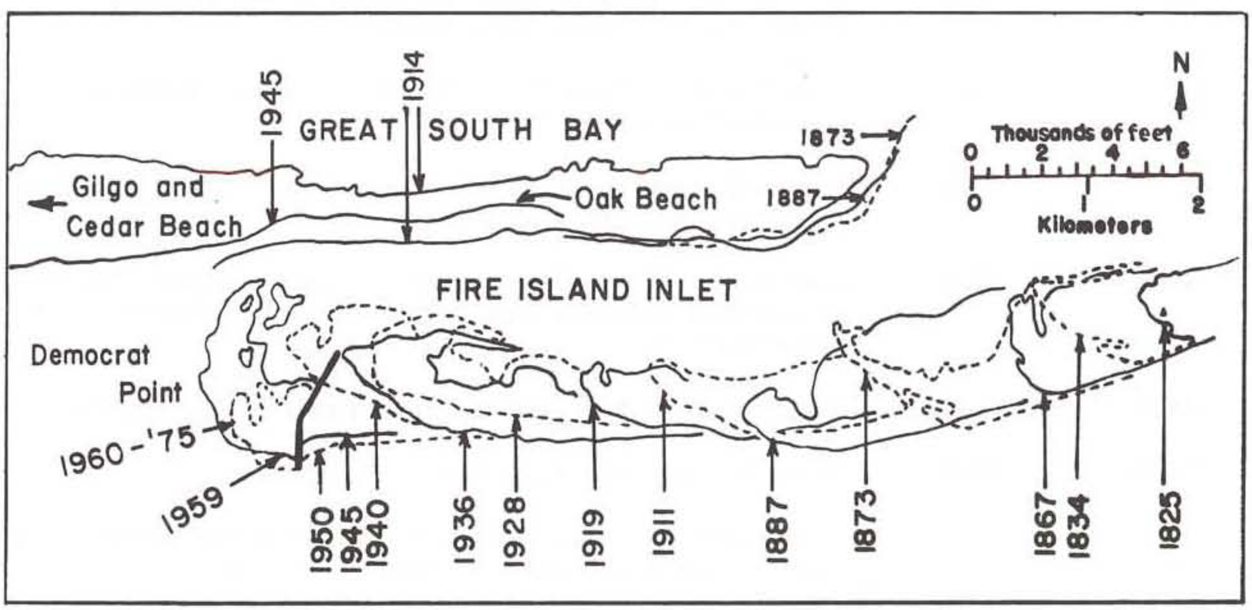

Figure 1. Progressive growth of Democrat Point (1825-1975) between Fire Island Lighthouse and federal jetty.

spit platform, but the development of the extensive primary and modified spits and their migration across embayments and lagoons will not reappear until the subtidal spit platform has been built seaward - as was the case once before (Wolff, 1972).

OCEANOGRAPHIC DATA

Tides

Fire Island Inlet is characterized by short-range, semidiurnal tides with a mean range of 4.1 feet (maximum storm surges of 9.4 feet). The ranges are 1-2 feet in the inlet and 0.6-0.8 feet in the Great South Bay. Flood tides sweep sand around Democrat Point into the S-shaped inlet while strong ebb currents dominate near the revetted sand dike at Oak Beach on the opposite side (Figure 1). The volume of water transferred through the inlet at each tidal cycle is 2 billion cubic feet, but the amount of "new" water is negligible (House Document #115, 1965). The short tidal range allows wave energy to be concentrated in a narrow swash zone, causing the vertical development of the major accretionary features just beyond the plunge point of the breaking waves.

Winds

Most of the south shore is characterized by summer winds from the southwest (April-October) or winter winds from the west (November-December) or northwest (January-March). The most dynamic changes occur during the periodic extratropical "northeasters" or during hurricanes. Hurricane frequency averages 3/100 years; moderate-strong "northeasters" average 30/100 years (House Document #191, 1967). While not a principal erosional factor, the frequency of such storms is increasing (Ruzyla, 1973).

Waves

Surf height is usually 0-4 feet with 4-10 feet waves during storms. Wave period averages 7 seconds with ranges from 12 (maximum) to 3.5 (minimum). Spilling or plunging waves are both common. Most waves approach from the southeast or southwest (81% of the time) with some increment from the south (17%) and east (2%) (House Document #411, 1957). The refraction of these wind waves establishes the characteristic pattern of littoral drift which moves toward the west two-thirds of the time and toward the east the other 33%. Most of the deep and shallow water wave energy also comes from the east-northeast, and east.

Currents

On the lower beachface steep refracted waves in the surf zone laterally transport sand as westward pulsating currents. On the upper beachface flat waves, refracted from the swash zone, transport sediments by zigzag beach drifting and by lateral transport and erosion. Tidal currents in the inlet have surface velocities of 4-6 feet/second with a maximum of 8 feet/second in the gorge near Oak Beach on the opposite side of the inlet (the velocity increases as the channel becomes constricted). At depth, inlet velocities average 2-2.5 feet/second (House Document #411, 1957).

Sand Supply

Seasonal changes in wave frequency along the south shore provide for onshore sand transport and berm accretion in the late spring and summer, and offshore movement with berm erosion in the fall and winter. At Democrat Point accretion dominates in the spring and summer while spit migration and refraction are more characteristic during the fall and winter. Analysis of the -6, -12 and -18 submarine contours near the inlet indicate an average westward migration of 197 feet (66 meters) a year (House Document #115, 1965). There is a landward movement of these contours in areas of berm accretion and a seaward movement in areas characterized by erosion.

Most of this sand is supplied by the littoral drift from the eastern end of Long Island (the opening of Moriches Inlet in 1930-34 produced no net accumulation of sand at Democrat Point - the only such "gap" in its recorded history of nearly 150 years). Besides the erosion of cliffs along the Montauk Peninsula, which can only supply part of the sand to the littoral drift, another possible source comes from the storm generated wave surges to the south and west, but this sand may not reach the breaker zone and remain offshore (Taney, 1961). The only other source of sand for littoral drift is on the existing beaches, and this accounts for the present extensive beach erosion.

ACCRETIONARY FEATURES

After the construction of the federal jetty in 1940 sands continued to be trapped behind it until 1950 when littoral bypassing began (Figure 1). By 1959 sediment accumulation was again closing the inlet. Since then, periodic dredging has removed the sand from the jetty and transferred it to the beaches on the other side of the inlet. Detailed studies of this region were initiated by Sanders, Friedman and Kumar (1972) and Kumar (1973) particularly for the channel, subtidal platform and offshore areas of Fire Island Inlet. Monthly mapping of the intertidal spit platform (spit of Kumar, 1973) was initiated shortly thereafter (Wolff, 1972) and this led to the recognition of a migration pattern of the refracted overlapping spits (Figure 2), and the development of distinct spit features and sub-environments (Figure 3).

The effects of tides, littoral currents, and refracted waves initially produce a subtidal spit platform as sands spread northwestward across the previous dredge site. Within a few months, a series of small spits develop and extend west of the jetty into the inlet. Tidal inlet currents prevent extensive lateral migration, but the small swash bars and spits continue to develop and coalesce against the remaining beachface and berm of the old spit platform, as is the case at present (Figure 4).

Once the sediment on the subtidal spit platform reaches wave base, the breaker zone becomes more extensive, and littoral sands begin to develop more extensive spits within the intertidal zone. Wave refraction also causes refraction of the spits, and the pattern of barrier island growth, based on maps from earlier years, is initiated (Figure 5A and 5B).

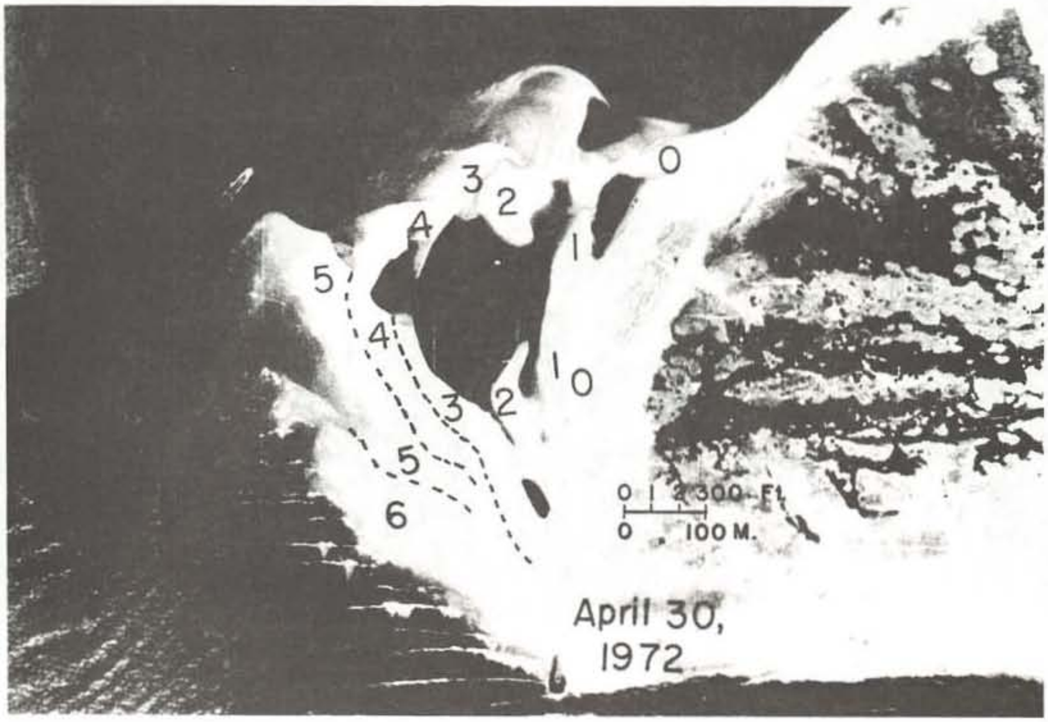

Figure 2. Progressive development of refracted spits across the intertidal spit platform between 1970 and 1972.

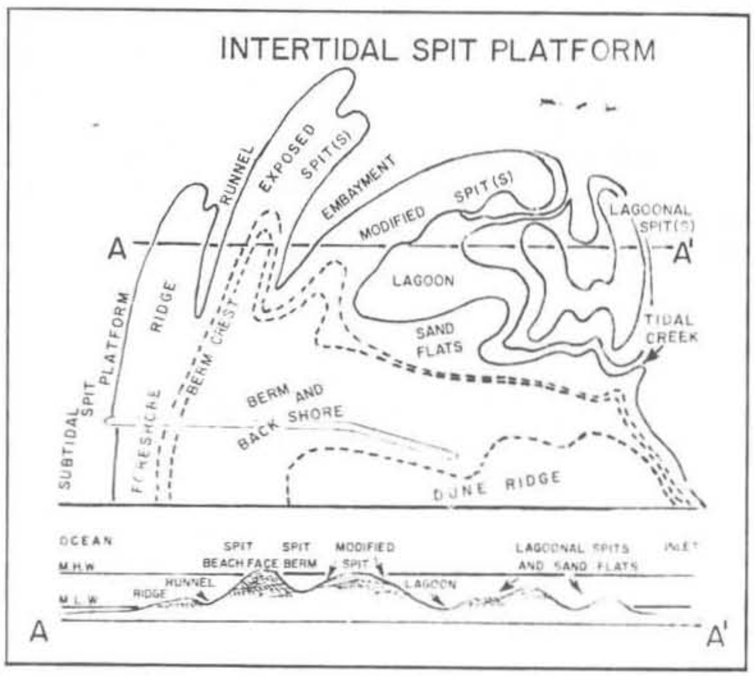

Figure 3. Schematic plan view and cross-profile of features formed on a well-developed intertidal spit platform.

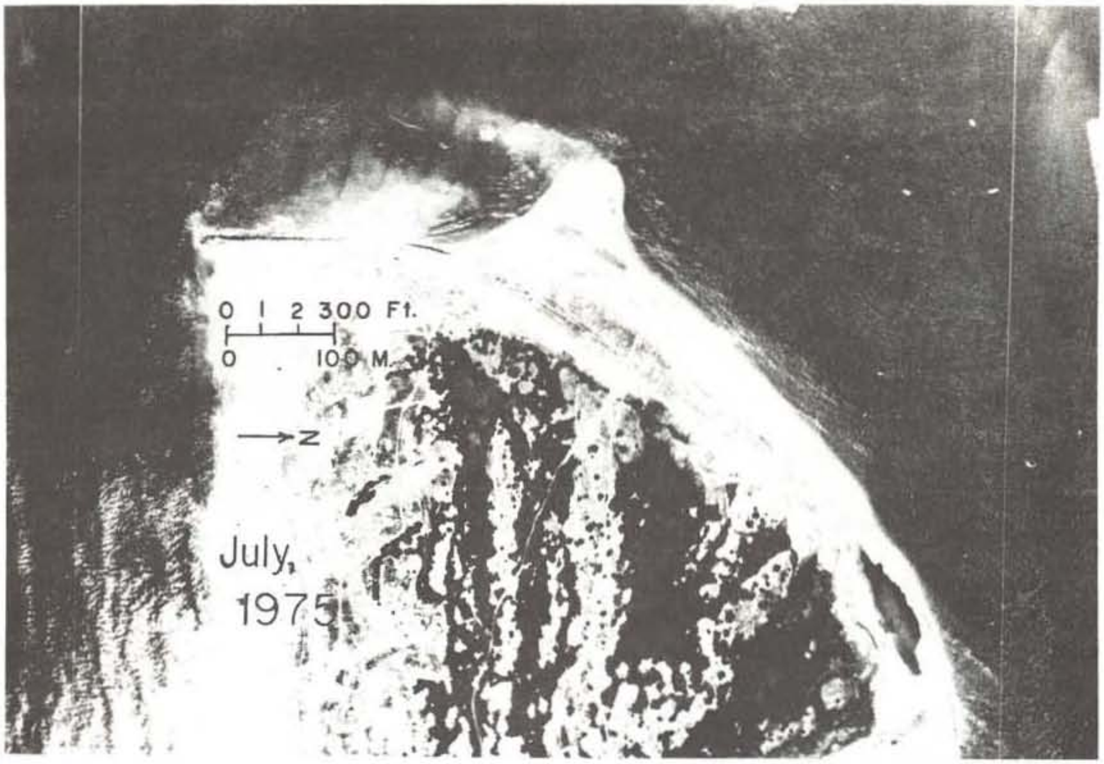

Figure 4. Initial growth of spit at Democrat Point after a period of extensive dredging (July, 1975).

The initial swash bars or ridges continue to accrete on the beachface of the spit until there has been enough refractive transport across the intertidal zone to cause a temporary separation. This could be due to storms, spring tides, or fluctuations in the amount of sand brought in by littoral drift. The result is a runnel or trough between ridges, or on a larger scale, the development of embayments between major spits. The spit noses continue to sweep over the platform and gradually becoming flattened, distended, or separated by washovers, as they close off the embayments into a series of ponds or lagoons (Figure 5C and 5D).

While vertical accretion is rapid near the jetty, lateral migration (up to 100 feet or 33 meters/week) dominates along the outer edge of the area when the spits, swept across the platform, accrete against the inlet edge of the barrier island, and continue to be modified by tides and currents to produce a series of lagoonal spits and tidal creeks (Figure 6A and 6B).

Once the modified and lagoonal spits have formed an effective barrier on the inlet side of the platform, extension of the exposed spit continues, and the process of northwestward and then eastward accretion of spits and enclosure of ponds and lagoons continues - unless removed by dredging (Figure 6C and 6D).

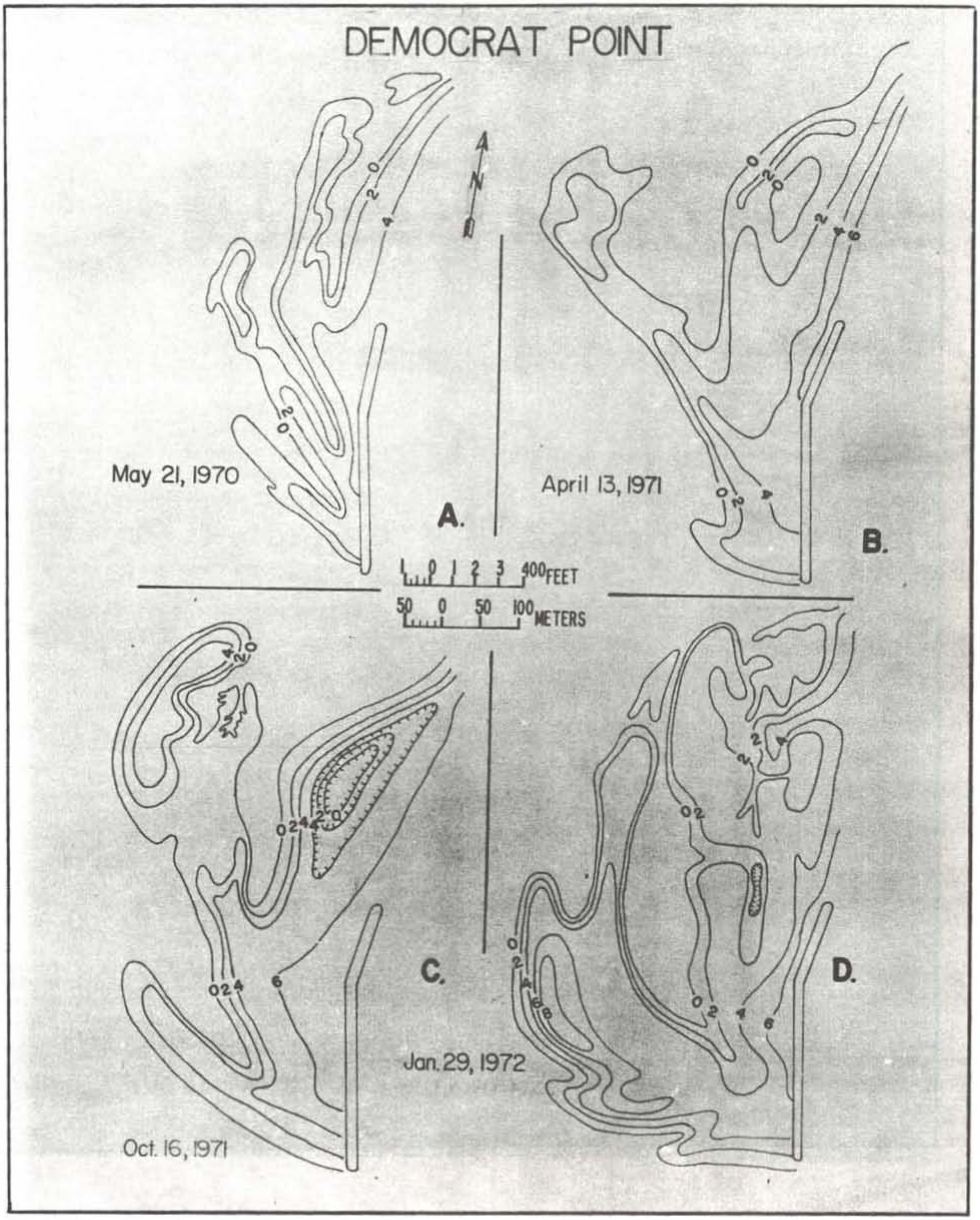

Figure 5A, B, C, D. Position of intertidal spit platform features at periodic intervals (1970-72). Contour interval 2 feet; datum mean low tide.

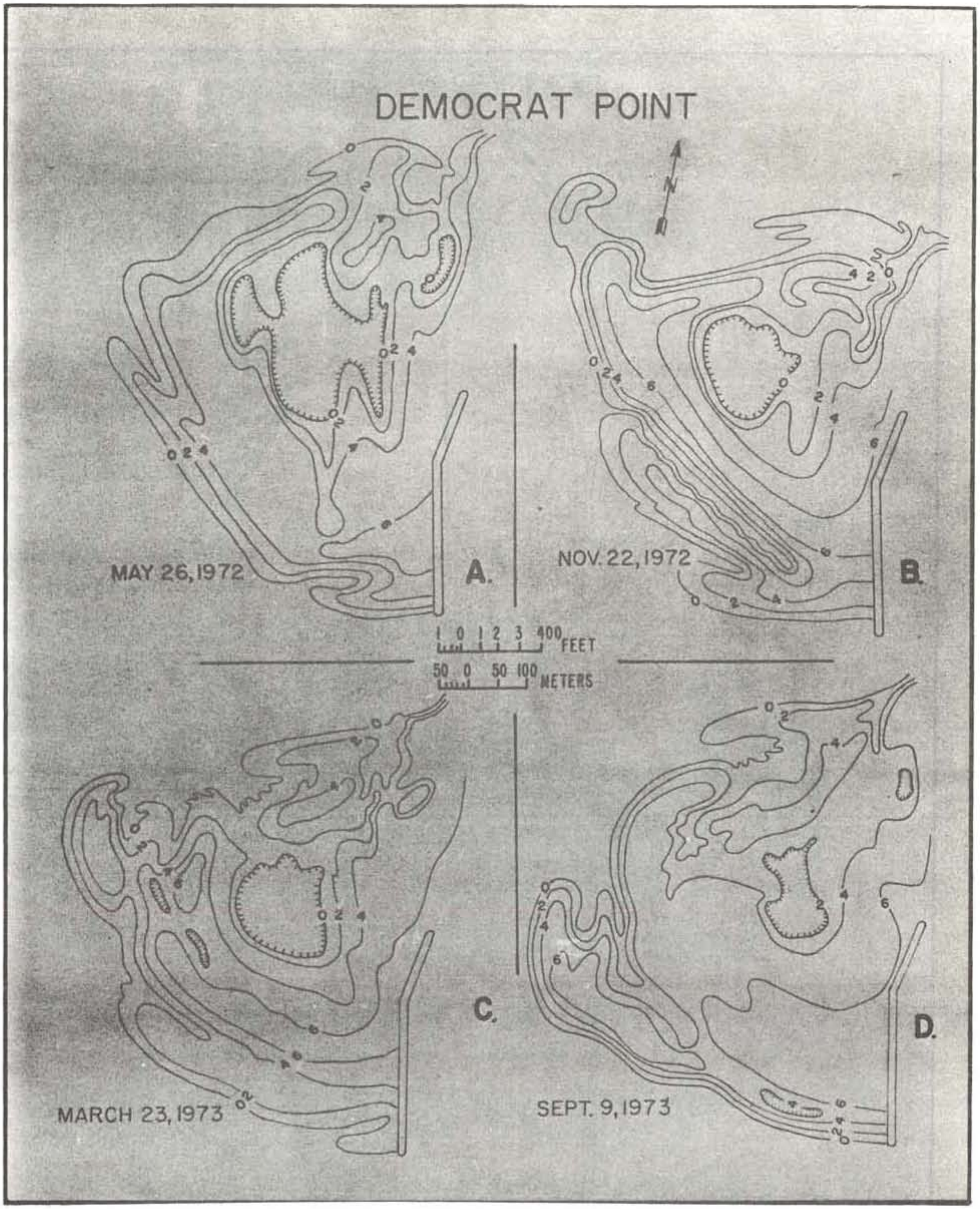

Figure 6A, B, C, D. Position of intertidal spit platform features at periodic intervals (1972-73). Contour interval 2 feet; datum mean low tide.

INLET MANAGEMENT AND STABILIZATION

Several projects proposed by the U. S. Army Corps of Engineers for stabilization and navigation improvement of the inlet along with control of beach erosion include (Bobb & Boland, 1969):

1) a 3000 ft. revetted sand dike (completed).
2) a 1000 ft. extension of the federal jetty (probably not needed).
3) a littoral reservoir directly west of the jetty with a capacity of 1.2 million cubic yards of sand.
4) a rehandling basin or depositional reservoir in the mouth of the inlet with a capacity of 2 million cubic yards.
5) a connecting navigational channel between the reservoir and depositional basin.

Dredging would be two-fold - first, hopper dredging from the littoral trap into the rehandling basin and finally a hydraulic pipeline dredge would pump this sand onto the adjacent feeder beaches (Figure 7). These last three items have never been constructed because of the expense involved (especially for the double-handling of the sediment) and because of the lack of a hopper dredge and its accessory equipment.

Sand bypassing by periodic dredging has been carried out since 1959. About 2 million cubic yards have been transferred from Democrat Point to the adjacent feeder beaches in 1959, '64, '70, and '73-'75. The most recent sediment bypassing was completed on April 18, 1975, and the depositional features present indicate the "new" growth since then.

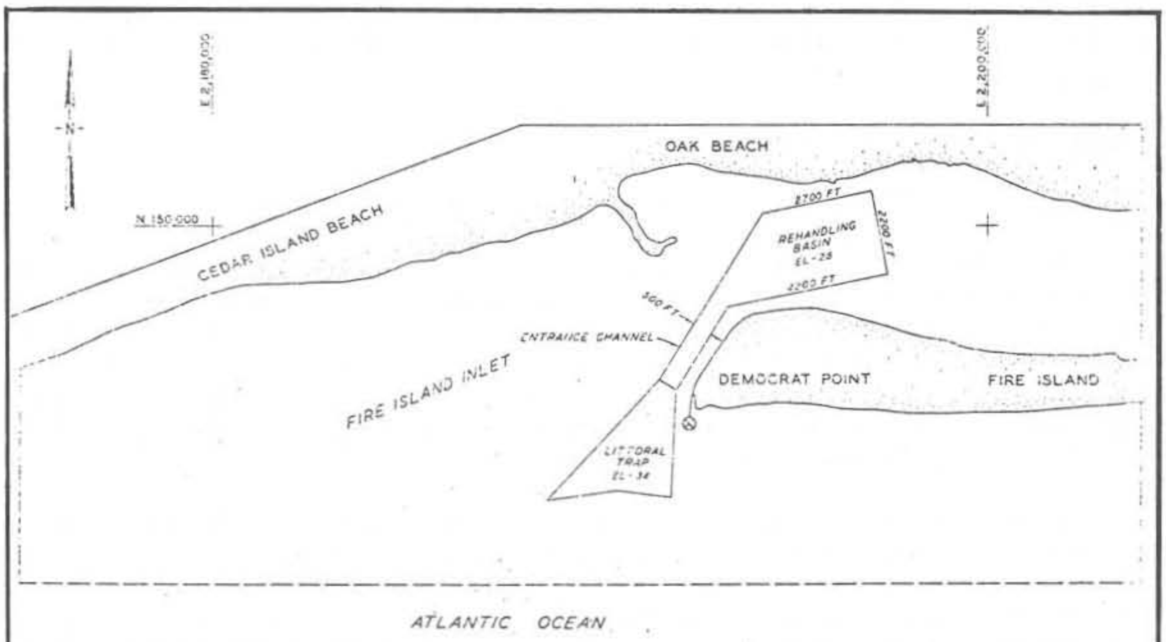

Figure 7. Proposed littoral reservoir, connecting channel, and rehandling basin (from Bobb and Boland, 1969).

While stabilization of the inlet and beach nourishment through sand bypassing are vital to the economy and recreation of Long Island residents, they are also expensive. The most recent project averaging \$2.20 per cubic yard of dredging or \$2 million per mile (\$1.2 million per kilometer) for feeding - with prices expected to almost double by the time the next bypass operation becomes necessary. Beach nourishment at Fire Island Inlet may now be initiated once every three years to replace the sand continually lost from the western feeder beaches. Loses now average 600,000 cubic yards annually (Everets, 1973). However, inlet stabilization does not imply barrier island stabilization, and the present horizontal rates of erosion, averaging 2-3 feet (.8-1.0 m.) per year will also continue. The only remaining source of sand is in the offshore zone, seaward of the 30 foot (10 m.) depth contour, but at present the associated costs make this resource prohibitive.

While inlet stabilization and sand bypassing is a reliable and successful engineering accomplishment, it demonstrates the economic futility of short-term goals for long range problems. Any man-made "permanent" alteration emphasizing stability of natural geologic features, particularly in the coastal zone, may be unsuccessful when viewed through the span of one generation. The progressive growth at Democrat Point and its importance as a sand reservoir to the western barrier islands cannot be overemphasized - but this will occur at the expense of further erosion of Fire Island and areas to the east. What is needed is a long range (25-50 year) master plan, for the barrier islands, that could even include the (man-made) opening and closing of inlets. However because of all the diverse interests and investments, this is no longer probable since no solution would be acceptable to any majority. Since the natural closing of the inlet has more deleterious consequences than its present stabilization, it will remain stabilized until there is an acceptable alternate solution.

BEACH MANAGEMENT AND STABILIZATION

Natural Versus Man-made Processes on the Barrier Beaches

The history of Fire Island Inlet, and, on a smaller scale, even the present accretion-migration patterns at Democrat Point demonstrate progressive lateral and vertical changes of barrier island features. Democrat Point, and indeed all of Fire Island, provides an example of lateral extension of a barrier by spit accretion (Hoyt, 1967). However, a rising (or stable) sea also has an effect on the vertical or shoreward migration of the barrier island (Sanders & Kumar, 1975).

If a large sand supply is available, even with a stable sea level, storm effects will produce a shoreface retreat of the barrier island (Johnson, 1919). As the island migrates landward the dune and overwash deposits will override the lagoonal deposits, decrease the size of the lagoon, and shift the barrier toward the mainland (Figure 8A and 8B). If sea level rises, and the rate of barrier accretion by onshore-offshore or longshore transport remains higher than the amount of sand lost to the offshore zone by storms and the rising sea, the barrier island still migrates landward. But the lagoon remains of constant width since it migrates with the barrier (Fischer, 1961). In either case, lagoonal

If the sand supply is small, a rising sea will cause the shoaling of the barrier, the creation of extensive washovers, low dunes, and more tidal marshes and inlets. The result is an in-place "drowning" of the original barrier island and the creation of a new one nearer the mainland by jumping of the surf zone (Figure 8C and 8D - after Gilbert (1885)). Now nearshore massive sediments will overlie and preserve the backbarrier lagoonal deposits.

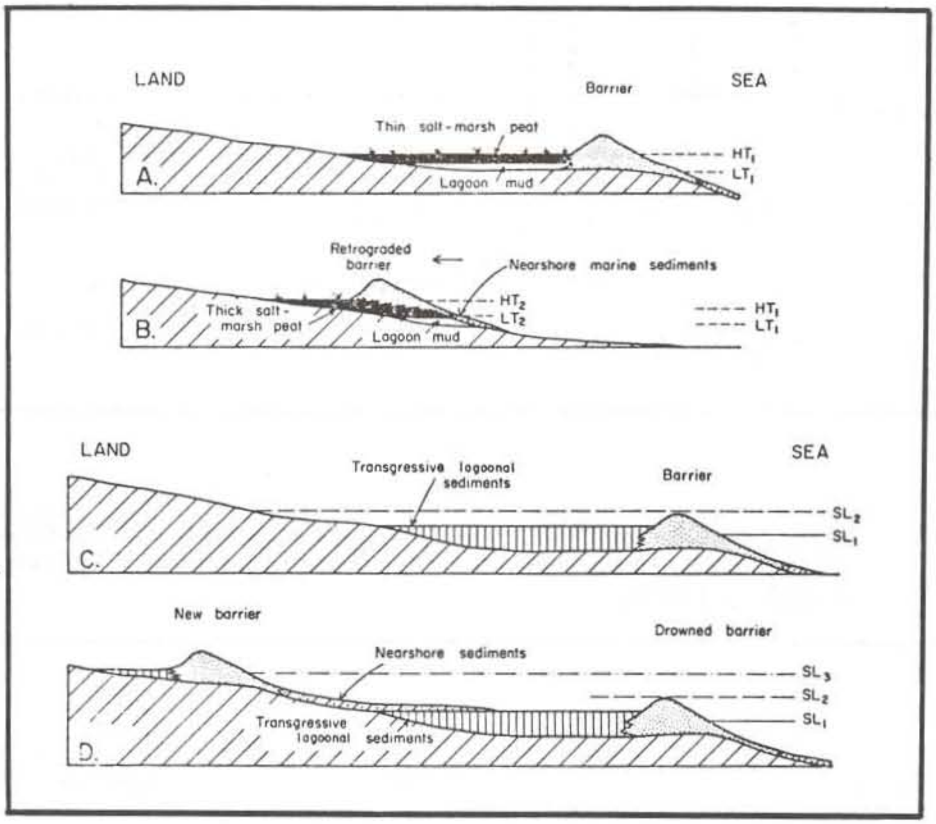

Figure 8A, B. Johnson's (1919) concept of barrier shoreface retreat during a rising sea (level 1 to level 2) as barrier overrides lagoonal sediments (HT=high tide; LT=low tide).
8C, D. Gilbert's (1885) concept of in-place "drowning" during a rising sea (level 1 through 3) causing a "transgression" on the landward side of the lagoon (after Sanders & Kumar, 1975).

Recently, evidence from cores on the continental shelf (Sanders & Kumar, 1975) indicate that Fire Island has undergone both drowning and migration (Figure 9). During the change from sea level I to II 8,500 years ago, in place drowning with surf zone jumping took place. For the past 7,500 years there has been shoreface retreat through landward migration. This pattern should persist into the future (200 years) and even distant future (500 years) as the bay and barrier islands continue to migrate landward (Figure 10) - but only if a continued reservoir of sand from the offshore zone or eastern Long Island remains available.

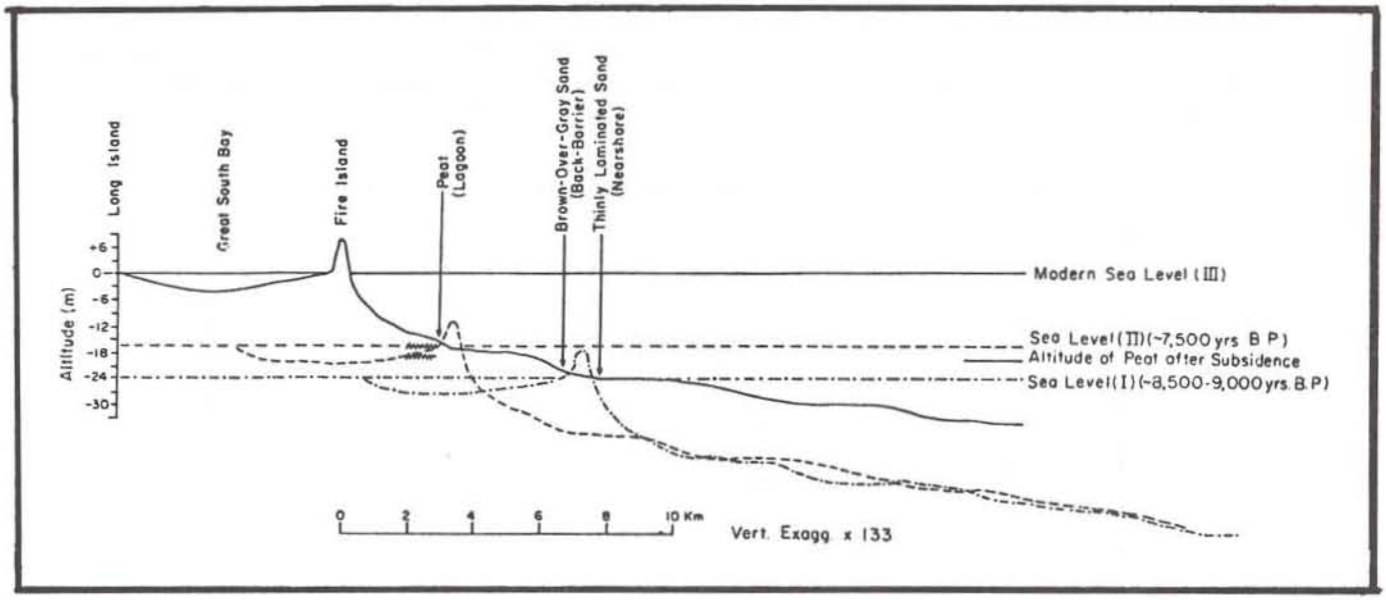

Figure 9. Effects of submergence on the former positions of Fire Island on the continental shelf. Explanation in text (after Sanders & Kumar, 1975).

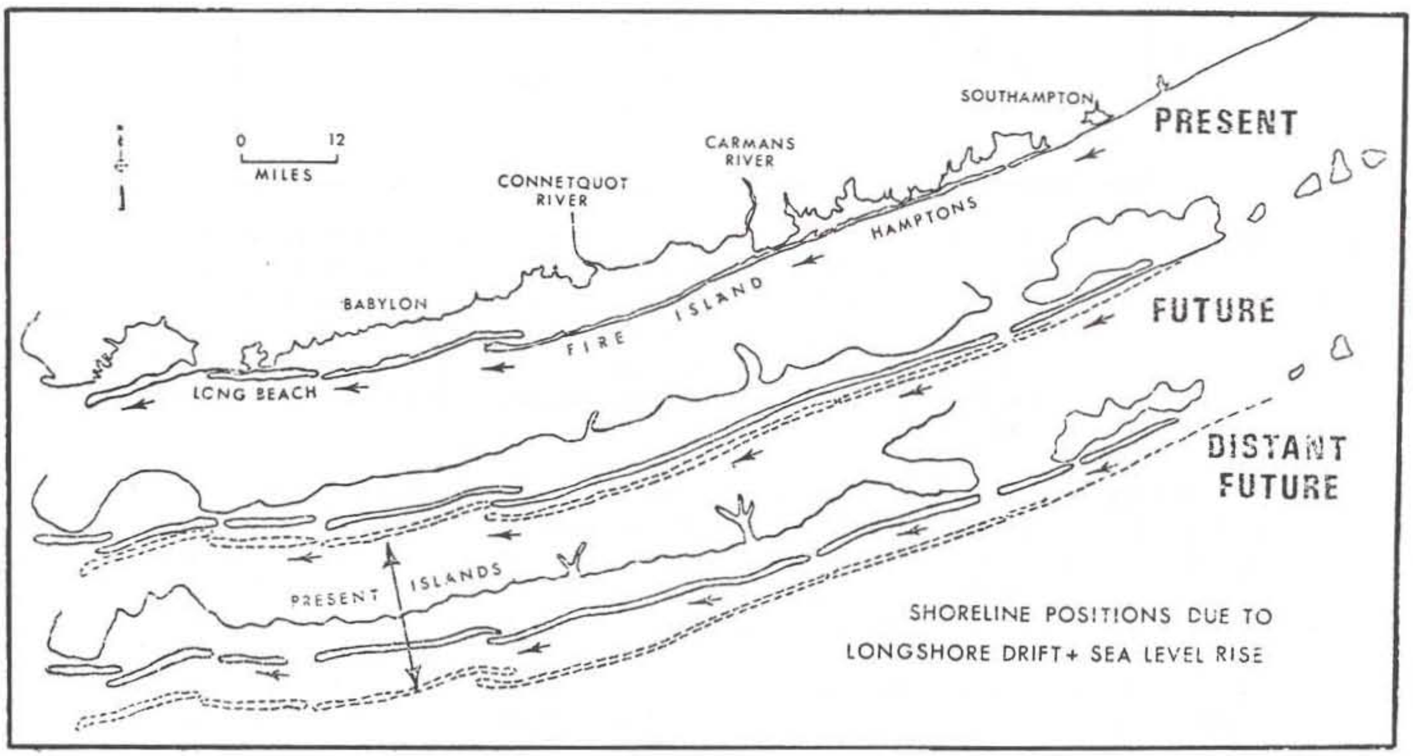

Figure 10. Schematic projection of changing positions of Great South Bay and south shore barrier islands (dashed lines at arrow indicate present barrier islands). Inlets assumed constant.

This new evidence suggests that the previous concepts regarding inlet and barrier island stabilization must be altered - Fire Island and the other barrier islands cannot continue to migrate landward without the return of some natural migration processes. Though the rate of sea level rise is about 4 inches/100 years (Fairbridge and Newman, 1968), the wide inlets and extensive marshes of the western barrier islands are not characteristic on Fire Island. During the past 200 years, the closing off of small embayments and the erosion of glacial cliffs from eastern L. I. indicate that a large amount of sand, coupled with the strong littoral drift, has enabled wide beaches and high and extensive dune fields to develop (i.e. the rate of shoreface retreat has slowed down, though the rate of sea level rise continues). People began occupying this island during this interval, and now, further shoreface retreat is prevented by beach and dune stabilization. The result, as at Cape Hatteras, is that the stabilized dunes act as a wall against overwash deposition during storms and thus lead to implement the beach erosion (Godfrey & Godfrey, 1973). Instead of bringing sand onto the backbarrier by the natural effects of storms and hurricanes, periodic beach nourishment and marsh dredging must be initiated and maintained (Figure 11).

Continuing westward from Fire Island (the main sand reservoir) the remaining barrier islands indicate, in progressive order, further stages of shoreface retreat through landward migration. Thus, there is a direct contrast between the (originally) wide beaches, high dunes, few inlets, and lack of tidal marshes on Fire Island with the (originally) narrower beaches, lower dunes, more inlets and extensive marshes of the western barrier islands (Wolff, 1973).

This again demonstrates the need for a long range coastal zone management plan. While the rate of beach erosion continues at about 2 feet (63 cm.)/year (Shepard & Wanless, 1971) or reaches 4-5 feet/year in some instances (House Document #191, 1967) there is no corresponding rate of backbarrier migration because of stabilization. Further, with a reduced sand supply, an effect from initial stabilization, the pattern of coastal retreat changes to one of in-place drowning as sea level rise continues.

Though the rate of beach erosion remains at 2-4 feet/year, the rate of westward inlet and barrier island migration is 150-200 feet/year (Taney, 1963) - about 75 times faster, under natural conditions. A return to these conditions, aided by sand bypassing near the inlets, would transfer much of the sand now locked behind groins and jetties toward the western barrier islands. Yet, the "buffer mechanism" of littoral transport is waning. Most of the sand supply that should occur on Fire Island has already been "lost" to the sea because of dune stabilization, and is now located in the offshore zone. While it may be another 50-100 years before in-place drowning is recognized, some of the effects, through beach erosion have already taken place. The only remaining major source of sand for natural beach replenishment and barrier island migration occurs along the glacial cliffs of eastern L. I. Who will decide if and when this area will be "sacrificed" to provide sand for the western barrier islands, or will the slow process of "in-place" drowning be allowed to continue?

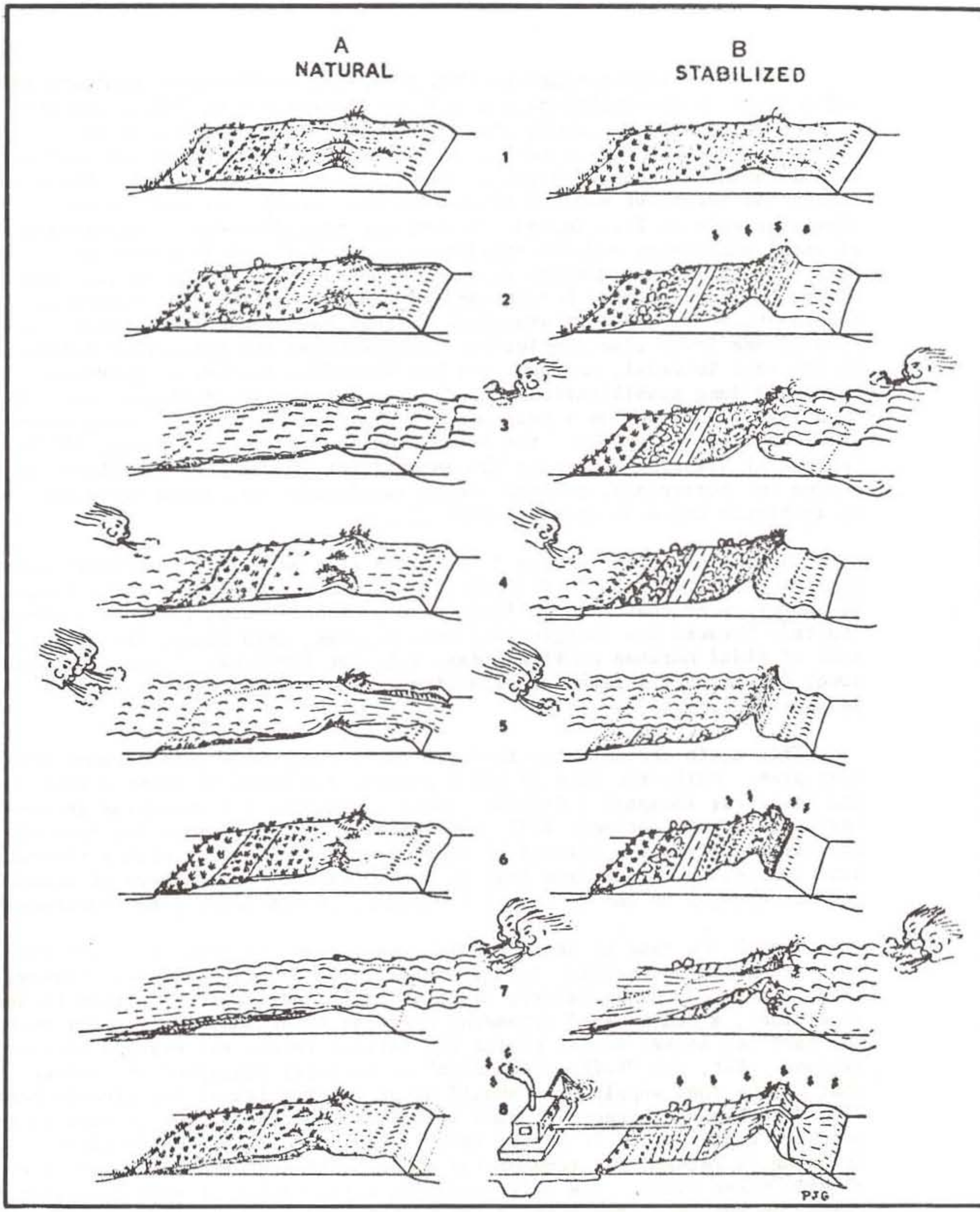

Figure 11. Changes (1-8) between natural and stabilized barrier islands. Under natural conditions storms permit overwash and inlets and with a rising sea, shoreface retreat. Under stabilized conditions this is not possible and periodic maintenance is necessary (After Godfrey & Godfrey, 1973).

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NOTES

ENVIRONMENTAL GEOLOGY OF THE JONES BEACH BARRIER ISLAND

Peter J. R. Buttner, Director of Environmental Management
New York State Parks and Recreation

Francis A. Hyland, P. E., Chief Engineer, Long Island State
Park and Recreation Commission

Manfred P. Wolff, Professor of Geology, Hofstra University

and

LONG ISLAND SOUTH SHORE SALT MARSH DYNAMICS

Robert Johnson, Professor of Biology, Hofstra University

Over the last several years, New York State Parks and Recreation has begun a state-wide review of the environmental context of all aspects of the management of public recreational facilities. Included in this review is the complete range of activities including planning, acquisition, development operation and maintenance of each element of the New York State Park System.

The Jones Beach Barrier Island, with its bay-side wetland complexes, tidal channel estuary systems and classic coastal dynamics presents a collage of special problems to the recreational resource manager. He must rely on assistance from many disciplines to define and analyze these problems. A key part of this information concerns the past, present and future environmental geology of the barrier system, both its land and its water components. As with such natural resources as the gorge of the Genessee River at Genessee State Park and the meromictic lakes at Green Lakes State Park, the Jones Beach Barrier Island system owes its existence and continuance to the interaction of complex geological processes. Each of these natural resources is defined by unique morphological, terrestrial and aquatic systems that reflect a special geological setting. Water and sediment and their hydrodynamic effects, both short and long-term, are the main geological fluxes of these settings. Any changes in the quantity or quality of these, in time or in space, will bring about modifications to various components of the morphological, terrestrial and aquatic systems. The Jones Beach-Fire Island Barrier Island system is especially sensitive to any changes in the quality of water and in the quantity of sand; it occupies the surface and near-surface interfaces between the marine waters of the New York Bight, the tidal waters of Great South Bay and the barrier islands.

Perhaps one of the most important aspects of the environmental geology of the Jones Beach Barrier Island is its effect as an energy sink and dispersant. Without this protective buffer, coastal storms would significantly modify the shore of the mainland.

Since 1970, with the passage of PL 91-190, the National Environmental Policy Act of 1969, the development of environmentally-sensitive management policies for such natural resources, as the Jones Beach Barrier Island, has become of great interest and concern. Moreover, with the passage of the New York State Environmental Quality Act (SEQA), additional attention is to be given to the environment of such sensitive areas as the Jones Beach-Fire Island barrier islands.

With the introduction to long-range barrier island migration patterns completed (Wolff, Stop 1 - previous article, A-5-AM), let us now move from the primary sediment doner (Fire Island Robert Moses State Park) to an important sand receiver (Jones Beach Barrier Island and State Park) and consider the importance of environmental geology with regard to the planning, development and operation of public recreational resources. We will discuss environmental aspects of sand nourishment and beach protection, pollution control and waste management, and marsh ecology with wetlands preservation. We hope to maintain a balance between the desire for natural environmental resources and the needs of public recreational resources through long range land use planning and the analysis of environmental impacts.

ROAD LOG

Cumulative Mileage	Miles from last point	Description
0.0	0.0	Leave Parking Field #2 of Robert Moses State Park (Stop #1 of A-5-AM trip). (Figure 1.)
0.8	0.8	Drive about circle at Fire Island water tower and cross bridge to Jones Beach-Captree Island.
1.9	1.1	Leave bridge and follow signs to Captree Beach State Park.
2.5	0.6	STOP #2. Captree Beach State Park

Walk east across dunes to area of highest elevation. From this point one can see the end of the Jones-Captree Beach barrier island, remnants of an earlier extension of Fire Island (Sexton Island and the Fire Islands), and the position of the old and new inlets. All of this area was once exposed to the open ocean. The lighthouse on Fire Island indicates the western edge of that island and the wide inlet that was present over 140 years ago. The barrier beach west of the lighthouse and the now parallel inlet indicate the changes that have occurred since that time. (Wolff, Article A-5-AM.)

Captree Beach and its extensive backbarrier salt marsh (partially dredged for the state boat channel) is the first area in western Great South Bay with this development, and this initiates the pattern that characterizes the remainder of the barrier island chain to Jamaica Bay. The extension and overlap of Fire Island has curtailed most erosion, though some modification by the ebb and flow of tidal currents continues. Note the bulkheads and the position of the dense scrub vegetation and trees on the dunes near the inlet. Though protected by Fire Island, it also receives no sediment from that source and some erosion continues to persist.

Captree is an important bird nesting area and, because of its proximity

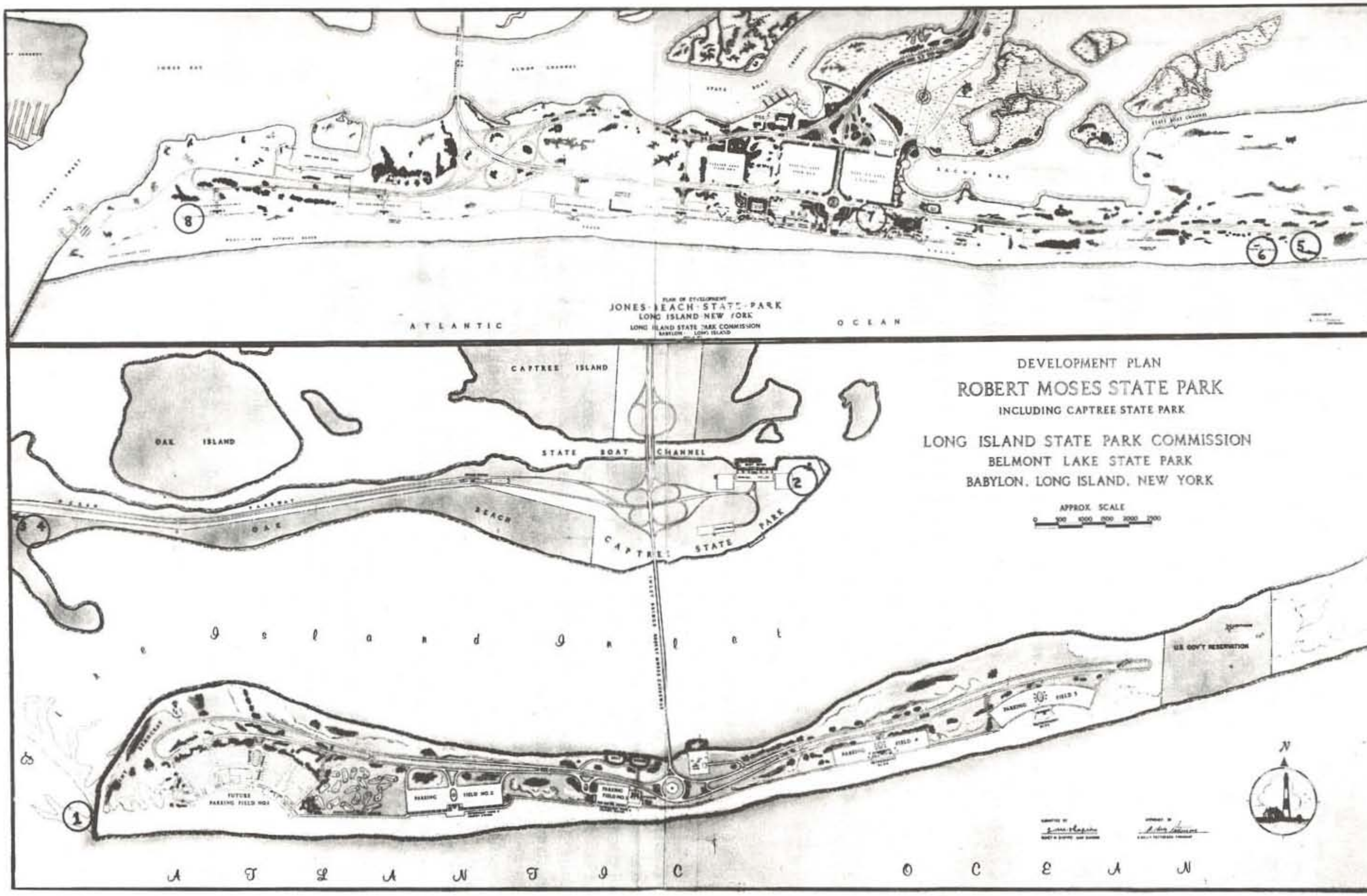

Figure 1. Field Trip stops and proposed development plans for Robert Moses and Jones Beach State Parks.

to the mainland and the inlet, an important area for bathing, boating, fishing and picnicking. Each morning a fleet of fishing vessels leave the boat basin for points within the bay, in the inlet, or in the ocean.

3.2	0.7	Leave Captree Beach and continue west on the Ocean Parkway. Junction with ramp to Fire Island - continue straight on Parkway.
5.1	1.9	Oak Island on right (private ownership) with town of Oak Beach on left (you are now near the mouth of Fire Island Inlet).
6.5	1.4	Cedar Beach Overlook and Cedar Beach on left.
9.9	3.4	Gilgo Beach - continue west on Ocean Parkway.
10.9	1.0	Hamlet of West Gilgo on right; park near western edge of this developed area after crossing Suffolk-Nassau County border.
11.3	0.4	STOP #3. Erosion of dunes near West Gilgo Beach.

It is normally dangerous and unlawful to stop here on the road during the summer and parking in the West Gilgo Beach Parking Lot is advisable - but for the sake of completeness there will be a "quick stop" at this point.

This area is characterized by previous beach and dune erosion to the extent that this process has almost reached the position of the Ocean Parkway. Many areas on the adjacent barrier islands - from Fire Island to Rockaway - exhibit similar effects. The sand bypassing from Fire Island Inlet, coupled with the littoral drift, still assures the preservation of a broad, well-nourished beach at this point and indicates the positive effects of man-made intervention without the necessity of groins. However, the lack of natural sand supply for the more western barrier islands (especially the Rockaways) continues to impose a serious problem. Should attempts at stabilization continue or, considering the long-range effects, should "nature take its course?" These are questions that have important social, economic, and political as well as environmental consequences, and must be handled both on a local and on a regional basis.

11.8	0.5	Leave West Gilgo and continue to Tobay Beach. As you enter the Parking Lot, turn left and follow the signs to the Bird Sanctuary.

STOP #4. Tobay Beach and Bird Sanctuary.

This area will illustrate the creation, development, and maturation of backbarrier tidal salt marshes.

LONG ISLAND SALT MARSH DYNAMICS

Dr. Robert Johnson

Coastal marshes occur as a result of estuarine sedimentation and are now included as a class of distinct landforms. On the south shore of L. I. these marshes, originally well south of this area, are superimposed over the drowned lower coastal plain that extends seaward as the nearshore continental shelf. This region, including past and future sites of salt marsh development, is underlain by a layer of glacial outwash that has been modified into barrier beach-estuarine environments by the rising sea.

The estuary forms a partially enclosed body of water where mainland fresh-water and sea water meet to form a region of shallow brackish water with variable salinity, water temperature, and sediment load. The Great South Bay Estuary System is a 70 mile long "bar-built estuary" extending from Lawrence in Nassau County to Southampton in western Suffolk.

Suspended sediments are washed into the estuary by mainland stream flows, enter through the inlets from the open ocean, or are picked up and resuspended within the system by waves and tidal currents. At any given time the total suspended particle load consists of some proportion from all three sources. In areas of low energy the settling and accretion of the flocculated clays along with intermixed sand produce intertidal flats - vast areas of shallow shoals and salt marshes that are drained by channelized networks of creeks, leads, and channels.

Typically there are three distinct types of salt marshes: the first (backbeach) type is associated with the ocean and occurs on the backside (in this case north) of the barrier island. The second (mainland) type occurs on the bay edge of the mainland, and is associated with the fresh-water wetlands and streams. The third (bay) type occurs as isolated islands or hassocks within the estuary. Sediment transport and deposition account for all three types, but each has its own peculiarities.

The "back beach" on the estuary side of the barrier beach is often fairly protected from wave action. Its intertidal zone is covered by water containing considerable suspended organic and inorganic particles. The back beach may be a relatively fertile area conducive to the establishment of the salt marsh cord grass _Spartina_ _alterniflora_.

Patches of this tall cord grass soon occupy much of the upper part of the intertidal zone and act as effective sediment traps since their stems decrease current velocities during the last stages of the high tide. Often the increased sedimentation in the proliferating grass may result in a shelf at its bay edge. This shelf is short lived as the cord grass fringe extends out into the intertidal zone until water depth becomes prohibitive or currents make further outward movement through sedimentation difficult. (Marshes are also building out in the bay, although somewhat differently, and as bay hassocks and back beach marshes approach each other the bay circulation is forced through narrower channels.) Back beach marshes may extend far out into the bay and perhaps even join with bay hassocks if the intermarsh currents are not strong enough to keep them separated.

Simultaneously, the marsh grass area at the upper end of the intertidal zone has continued to receive sediments and is in the process of building up to a table-like surface about level with the elevation of the usual high tide. Two things now happen: First, deposition slows down since particles can only be carried up on the marsh by the highest tides, such as full moon (spring) and storm tides. Secondly, salt marsh cord grass is replaced by salt meadow cord grass and salt grass (Spartina alterniflora, Spartina patens and Distichlis spicata). These secondary plants will dominate the marsh as long as it exists, however, a number of other species will invade and co-exist with the dominants.

If the marsh is extensive, or as it becomes extensive, a sheet flow or movement of outgoing tidal water drains off the marsh. Any slight variation in the marsh floor at this stage will channelize the outgoing tidal water. Erosion will occur and a system of tidal creeks will develop. These creeks will reach a depth about equal to the usual low tide elevation.

If the barrier beach is moving (as is often the case - Wolff, Article A-5-AM) because the source of its maintenance material is waning or being transported landward, the entire barrier island may migrate landward over the estuary. Proof of such a northerly movement on Long Island exists in the form of salt marsh peat exposures along the ocean front (Wolff, Article B-3-AM). Since salt marshes cannot form in the surf area, the wave energy associated with the rising sea cuts northward, eroding the older estuarine deposits. Histori al records indicate that extensive back barrier type marshes existed behind Fire Island - "hay cutting" expeditions were commercially feasible during the 18th and 19th centuries. Virtually none of these marshes still exist.

The back beach marsh can be heavily effected by inlet formation, and. in turn, can effect or deter permanent inlet formation. If the marsh is extensive, the peat is thick and marsh creek development is not concentrated in the area where storm waters have broken through the dunes, the subsequent littoral drift will "heal" the break. The break usually occurs outward in any case. A great deal of water will build up in the estuary during these extraordinary storms.

The build up of water is due to low atmospheric pressure during storms as well as wind driven water. The tide drops quickly on the ocean side of the barrier beach. It drops faster than it can run out through the existing inlets and the variation between bay and ocean elevation results in enormous outward pressure. If the dunes were breached previously in some area, a flood of this extra high water will escape into the ocean at that point, tearing its way through the barrier beach sand and creating a channel which may persist for years.

If an extensive salt marsh protects the back beach it will resist this occurrence once the outflowing storm water reaches the upper level of that marsh. Salt marsh peat, particularly that formed by the secondary dominant plants S. patens and D. spicata, is tough, resiliant material. The living marsh will take an enormous beating before it disintegrates. This is particularly true if the estuary level is dropping via area subsidence and new marsh peat is superimposed on old. The tough. resistant-to-decay root systems of the secondary dominants may be several to many feet thick depending on subsidence rates.

If the marsh is broken at any point the breach through the barrier beach will quickly widen as sand washes out to sea. The marsh adjacent to the break will be lost as the peat is undercut by a loss of underlying sand. This process occurs along every narrow boat channel in the estuary as boat wakes undercut the adjacent marshes at low tide.

From the preceding discussion one can build a case for encouraging salt marsh development on the natural areas of Jones Beach and Fire Island back beaches. It also seems that cutting mosquito control drainage ditches into the back beach marsh is somewhat risky. One might want to encourage as complete a marsh coverage in this area as possible; even to the point of filling in larger natural waterways and minimizing weak points in this system.

The processes of erosion, sedimentation, and the importance of plants in marsh formation and maintenance is easily seen in the developmental history of a salt marsh island or hassock. In this second major type of salt marsh we can start with the relatively flat bottom of some open water portion of the estuary. Presently, and on and off historically, areas of bay bottom support heavy growths of eel grass Zostera marina. This species is really a pond weed adapted to a saline environment and in no way a true grass. It flourishes in patches or extended coverages between depths of about eight to one feet below mean low water. In deeper water it does not receive sufficient light and in very shallow water it is subject to too much light and probably too much wave action.

A patch of eel grass is a sediment trap due to the frictional "baffling effect" of its profuse long thin fronds. In some areas it is possible to observe a ridge around the periphery of the patch caused by the concentration of particles coming out of suspension as water enters the grass and slows down. Eel grass is self-limiting in the sense that the depositional process it accelerates leads to depths too shallow to support the plants. It is at this point when sediments have brought the bottom elevation close to the lower intertidal zone that salt marsh development may begin. Typically Spartina alterniflora invades the higher areas and, as in the case of the back beach marsh, acts as a sediment trap. Sediments continue to build up around the salt marsh cord grass until what was once a patch of submerged eel grass is now a young marsh. Usually the marsh will extend bayward, but not in a concentric pattern. One side or another will receive more sediments due to the local current patterns and the marsh will build in that direction.

As before, sediments will continue to arrive and marsh elevation changes at first occur rapidly. They occur very slowly as we approach the high tide elevation. Once the usual (modal) high tide elevation is reached the primary salt marsh cord grass will be replaced by the secondary salt meadow cord grass and salt grass (S. patens and D. Spicata again). As this table-like surface is extended to the point of significant coverage some sort of channelization of runoff during a falling tide will lead to a typical dendritic marsh drainage system. Some marsh islands or hassocks are miles long and miles wide. They may also "grow into" or adjoin back beach marshes or mainland marshes. They can never form a complete dam across a bay by joining both, since, high current velocities (in a sense caused by the constrictions of marsh growth) in creeks and arms of bays will prevent this.

The hassock is a very stable place. It will maintain its elevation (which is about equal to the higher high tides) as long as the subsidence rate of the area is not too great (or sea level is not rising too quickly). Again, the longer the duration of inundation during a tidal cycle the more sediments a marsh will receive. As the marsh level approaches that of the usual high tide, gains in elevation are minimized. As the marsh level approaches that of the highest tides, inundation becomes rare and sedimentation is almost non-existent. Thus an equilibrium is reached a few inches above the usual high tide "mark."

Leaving the ecology of the hassocks and forsaking the snails, worms and crabs that are very important to marsh stability, we are finally ready to discuss the mainland salt marshes. These formerly existed along the entire south shore of Long Island's mainland where the outwash plain dips into the bay or, conversely on the north side of the Great South Bay Estuary System. This gently sloping sandy outwash plain extends north across Long Island to the moraines near the North Shore. This outwash that forms so much of Long Island is one enormous reservoir of formerly cool, clean water. At any significant depression in the outwash surface the high water table (resulting from 40 to 50 inches of annual precipitation) intersected the surface as a stream. Dozens of relatively constant flowing streams flowed south across the outwash to enter the estuary.

Like the native brook trout the mainland salt marshes of the Great South Bay Estuary System are largely gone or going. Unlike the hassocks and back beach marshes they were privately owned. Nassau County's mainland salt marshes have been planted to cape cods and split levels and Suffolk marshes are severely threatened with this development. Recent tidal wetland legislation on New York State's part has slowed the process but as Long Island's human population continues to grow toward New York City - densities of habitation in wetlands will increase and the outlook in the long term appears grim.

These mainland marshes existed as thousands of acres of points of marsh between dozens of fresh-water streams entering the bay. Their formation started with the colonization of the intertidal zone by _S. alterniflora_. The presence of rich sediments of inland origin must have accelerated the process of marsh growth and development. One suspects that these marshes appeared earlier than the other two types. They were extensive and fringed with _S. alterniflora_ when they existed. The immediate areas away from the bays and marsh drainage systems were dominated by the shorter secondary dominants. The processes leading to marsh formation and stabilization are exactly as described earlier.

There is one important difference in the equilibrium vegetation of the mainland salt marsh and that is the occurrence of fresh-water marsh vegetation along the upland border. Often a full blown fresh-water marsh occurs in that area. The fresh-water table of the adjacent mainland is often exceedingly close to the surface along the salt marsh mainland border. This water tends to move down hill and when confronted by the soils of the salt marsh it tends to flow out over it. It is contained in areas away from salt marsh plants and their replacement by fresh-water species (or at least plants that do well in brackish water of very low and variable salinity). These conditions may also occur on a back beach marsh or even a hassock where a great deal of dredging spoil was dumped. All that is required is a sufficient water shed and the reservoir capacity of sandy soil adjacent to a marsh. The interesting thing is that the salt marsh must develop first. Recently various agencies on Long Island have had considerable success in the artificial development of salt marshes where none previously existed.

13.6 1.8 Leave Tobay Bird Sanctuary and continue west on Ocean Parkway to area with construction buildings on left.

STOP #5. Area for sewage outfall line from Cedar Creek Sewage Treatment Plant.

In order to curtail estuarine pollution, a series of sewage outfall lines extending across the bay and beneath the barrier islands into the ocean have been proposed - this is one of the first to be completed (1973). While there is little that can be observed on the surface, the vegetation across the dredged zone (the pipe was 8 feet in diameter) clearly demonstrates the progressive succession of different barrier island species and the return of the native flora.

14.1 0.5 Leave the sewage outfall area and, within 0.5 miles, stop at the entrance to Parking Field #9 (now closed to the public).

STOP #6. Parking Field #9 of Jones Beach State Park.

This area is similar to Stop #4. Note the position of the Parking Lot versus the line of the primary dunes and the successive zones of berm accretion. Originally intended to handle the overflow from neighboring Parking Lot #6, after at least two attempts to repair the area, the project has been abandoned. The collapse of the southern edge of the parking lot was due to undermining by lateral erosion. As with Stop #4, each of these areas of extensive erosion are near old inlets. (Wolff - Article A-5-AM.)

16.1 2.0 Continue west on Ocean Parkway toward the Jones Beach water tower. Swing about the traffic circle and follow the signs to Parking Field #5 - Administration area.

16.4 0.3 STOP #7. Parking Field #5 and Administration Area.

The previous stops have emphasized some of the dynamic natural and man-made changes that are occurring on the barrier islands. Administrative personnel will review some of these processes and explain how the L. I. State Park Commission, is trying to achieve a balance between the requirements of the natural environments and the importance of the maintenance and development of public recreational resources (Figure 1). Any man-made structure has a limited life expectancy, usually measured within 1-3 human generations. Coastal zone management with regard to public recreation cannot consider long-range (100-year) changes since the demand for recreational resources varies within 10-20 year intervals. By working within these intervals useful environmental and recreation resource management policies can be established and these can be modified to fit the long-term coastal changes.

16.7	0.3	Leave Parking Lot #5 and continue west on Ocean Parkway toward the West End of Jones Beach.
17.7	1.0	Pass Parking Field #3 and #2 and follow signs to "West End", Parking Lots #1 and #2.
19.0	1.3	Enter Parking Field #2 at West End, go to southwest corner.

STOP #8. West End of Jones Beach, Parking Lot #2.

As with Democrat Point (Stop #1) this area exhibits all the characteristic features of lateral and vertical sand accretion. The construction of the jetty in the 1950's now provides a very wide beach and a wide zone of dune development. Note in particular the type of vegetation associated with these recent dunes.

Leave Parking Lot #2 and follow the signs to the mainland and Meadowbrook Parkway - return to Hofstra University.

NOTES