A Survey of the Natural and Urbanized Shorelines on Long Island, New York - A Dilemma in Coastal Management

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INTRODUCTION

This trip will examine six stops on the barrier island beaches along the south shore of Long Island (Figure 1). Such beaches were probably first formed during the Pleistocene glaciation from eroded and reworked continental Cretaceous-Tertiary strata 100Km. seaward of their present location. They were then gradually submerged and modified into shoals, lagoons, barrier islands and inlets by the current marine transgression. During the past 25,000 years of glacial melting and deposition the rising sea reached the outer edge of the glacial outwash and moraine deposits, perhaps 3-5 Km. seaward of their present location (Wolff, 1982). It is this newer source of Pleistocene glacial sediments that continue to undergo the transitory processes that modify them into the current coastal features. Ultimately, they will be eroded and deposited offshore, on the shoreface, and below wavebase on the inner continental shelf--as the Holocene transgression continues.

We accept the concept of of "barrier island migration" with the rising sea, and will provide evidence for it. This emphasizes the idea that the barrier islands have not been "drowned" but instead, continue to be preserved by progressive landward sand migration. This migration occurs during the shoaling associated inlet formation, and during the flooding and overwash deposition associated with the wave surge from major storms (Wolff, 1989).

Anthropogenic changes brought on by coastal habitation during this century have seriously curtailed the influence of these natural processes in maintaining the sporadic pattern of inlet formation and landward barrier island migration. Management philosophy has instead substituted a policy that now emphasizes mechanisms that attempt preservation of all the natural environments through coastal stabilization. While most of our field stops are on urban beaches, they are maintained by different levels of government (state, county, city and town) and the management policies may also differ. We will review the history of development (natural and urban) at each of these stops, examine the methods used for the artificial (and temporary) stabilization of the dunes and beaches, and discuss the impact of storms in promoting either the destruction or the preservation of these natural features in the future.

Most field trips at this meeting will examine outcrops visited by geologists for over 100 years; the road cuts remain the same-- but the interpretation changes. For our trip, the interpretation has remained the same, but the "outcrops" continuously change (in shape, form or position). As this is written the authors realize that the effects of a nor'easter or hurricane before October could significantly change the form or location of our "outcrops". Most of our stops were within the "zone of breaking waves" within the past few years but all of them have been recently "restored" by beach nourishment. Coastal inhabitants-- particularly park managers and home owners on or near beaches demand a permanent position for their beaches, and have in place a powerful political lobby (at all levels of government) that will fight "beach erosion" and promote coastal maintenance and stabilization (which we realize only promotes more beach erosion).

But nature still remains a powerful influence for coastal change. The most obvious one is the coastal storm that erodes barrier island beaches, breaches dunes, overwashes barrier terraces and marshes, creates inlets, and floods mainland beaches. It floods or destroys all the "permanent" anthropogenic infra- structure, but only temporarily disturbs the habitats of the natural flora and fauna. As with a forest fire, after the intial devastation, the habitats are frequently extended and improved as the cycle of biological and physical evolution is renewed.

The less obvious change is the influence of the rate of sea level rise. It is now 0.6 m./100 years and is estimated to be increasing to 1.5 m./100 years because of the global warming. Yet coastal management policies still reflect the "status quo"--the demands of the coastal managers and the communities. Because of the intense coastal development, they remain oblivious to the benefits of the storms, (which provide the natural sand migration) and because we haven't had a major hurricane crossing over this region in more than fifty years. There is never a discussion for the initiation of a policy that would emphasize the relocation or abandonment of destroyed structures after a major storm--only renourishment and renewed stabilization of the beach, and the return of larger (and more expensive) structures. In the meantime, the storms and sea level rise will continue. Thus, the dilemma!

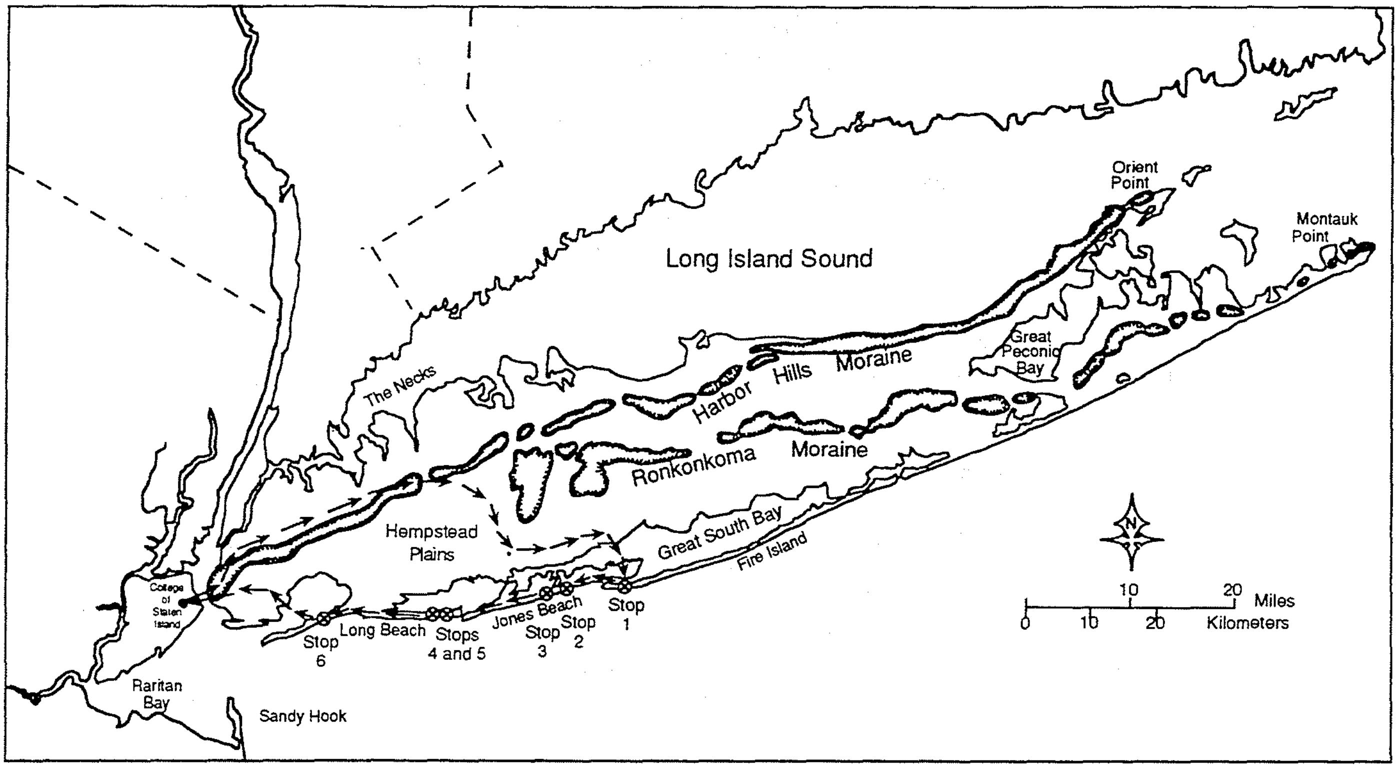

Figure 1. Geographic and geomorphic features, road traverse, and field trip stops related to the south shore of L.I. (See road log for more detailed description of traverse).

GLACIAL AND COASTAL GEOMORPHOLOGY

The glacial history and origin of Long Island (L.I.) was first described by Fuller (1914) and updated by Flemming (1935); Donner (1964); Jensen and Soren (1974), and Sirkin, (1982,1986). The nearly 1000 Km. of L.I. shoreline occurs in the transitional area between the glaciated coasts of New England and the unglaciated coastal plain beaches that extend from northern New Jersey - southward. The northern third of L.I. had the maximum extent of Wisconsinan glaciation with the formation of a series of continental ice lobes fronted by terminal or recessional moraines and kame deltas (Sirkin, 1982) - see Figure 1. Perhaps there were even earlier periods of glaciation that reached L.I. (Sanders and Merguerian, 1994). But it was the most recent interglacial stage that produced the meltwaters that formed the major and minor distributary outwash channels that spread across L.I., and well beyond the present edge of the mainland (Wolff, 1982).

These can be observed in the lobate shoreline configuration of the L.I. mainland behind the western section of barrier islands and marshes (Figure 1). This shape suggests the presence of submerged outwash lobes that originally extended much farther out into the Atlantic Ocean. Additional evidence for these eroded and submerged outwash deltas comes from the preglacial drainage channels cut into the Cretaceous bedrock and then filled with coarse meltwater sediments (Jensen and Soren, 1974). The location of the thalweg for these channels was determined by Williams (1976) and extended from the mainland to the shoreface by Wolff (1982).

SEDIMENT SOURCES FOR THE COASTAL BEACHES

Originally, most of the sand on the beaches was believed to come only from the receding glacial headlands of eastern L.I. As they eroded, the sediments were being continuously moved westward, from one barrier island to the next, by the influence of relatively persistent longshore currents (Colony, 1932; Taney, 1961; Krinsley, et al. 1964; McCormick, 1973; Williams, 1976). This would account for the long, persistent "chain" of barrier islands. However, recognition is now given to the presence of an offshore source that also supplies an important contribution.

The global volume of water within the Wisconsinan ice sheets was large enough to lower sea level by over 100 meters, positioning the present shoreline of New Jersey, New York, and Connecticut about 100 Km. seaward of its present location (Milliman and Emery, 1968). This lowered sea level allowed the south-flowing New England and New Jersey rivers to erode the Cretaceous and Tertiary highlands, drain across the Atlantic coastal plain (now the inner continental shelf) and disperse their sediments into the distant ocean. With the rising sea, these strata became the first offshore source of sediment for the initial beaches (Williams & Meisberger, 1987). Therefore, during the early phase of the Holocene coastal transgression, the initial barrier islands did not contain glacial sediments, but were composed of only reworked Cretaceous and Tertiary deposits. The sporadic occurrence of zones of glauconite in the recent sediments on the inner continental shelf may still be a reflection of this.

The melting that ensued at the end of the Wisconsinan epoch extended the outwash lobes at least another 5 Km. seaward of the present coastline, and these became the second sediment source. The glacial deposits could not be modified into barrier island-marsh sediments until they were reached by this transgression. Gradually, they became submerged, first beneath the bay and later, as landward barrier island migration continued, the upper 5-10 m. of glacial material was mixed with the older Cretaceous deposits and became part of the reworked Holocene sediments of the ancient barrier islands. The process of eroding old, submerged, mainland strata on the seaward side of a barrier island has been termed "ravinement" (Stamp, 1921). As sea-level rise continued, they were exposed on the shoreface, (the narrow, steeply-sloping seaward extension of the beach and nearshore bar, that extends out to a depth of about 10m.) Here they became an important new source of sediment. Once exposed, storm activity could move this glacial sand landward into the bays by inlet breaching and overwash during the flood surge, promoting deposition. Some of it is also moved seaward, back onto the shoreface during the ebb surge, to produce coastal erosion (but shoreface deposition). Some submerged areas may still contain inlet-filling sediments not entirely eroded beneath the shoreface (Sanders and Kumar, 1975; Williams, 1976; Rampino and Sanders, 1981; Wolff, 1982) though this has been questioned at Fire Island (Panageotou and Leatherman 1986). Such relict sediments would also provide evidence for the progressive landward migration (and not submergence) of the barrier islands.

As the sea level rise continues, the sand on the beach, nearshore zone, and shoreface is gradually moved offshore to form the ridge and swale topography of the inner continental shelf--the nearly horizontal zone beyond the shoreface (Swift, 1976).

The significant point is that not all of the sand for the coastal deposits of western L.I. came from the eastern mainland. The importance of this source and the dominant westward-flowing longshore current cannot be denied. But the more landward lateral offset between each of the barrier islands (Figure 1) also demonstrates the relative importance of onshore sand transfer by flood tides and storms.

The shoreface is also known as a source of sediment transfer (Duane et al., 1972). While long recognized as a depository for coastal sediments, it can also be a contributor (Swift, et al., 1973; Swift, 1976; Williams, 1976). An estimated 6 billion cubic yards of sand is available for recovery--but it tends to occur off the stable beaches, not the unstable ones currently undergoing erosion (Williams, 1976).

MARINE PROCESSES AFFECTING THE BARRIER ISLANDS

While most of the central Atlantic coastline has a north-south orientation, this pattern changes to an east-west one at New York City (Hudson River) and remains this way along Long Island, Connecticut, and Rhode Island. This right-angle bend, known as the N.Y. Bight, changes the direction and the influence of the oceanic processes that affect the shoreline. Onshore winds vary with the seasons, but the dominant set-up favors those from the northeast to the southwest. This produces the westwardflowing longshore currents that move the sand (as the littoral drift) from Fire Island toward Rockaway. Interference with this process at any point will create sand starvation (ie. beach erosion) west of that point. This is typically noted at any of the stabilized inlets.

Low frequency waves are associated with fair weather conditions (May-Oct.) and these return the sediment from the offshore" breaker bars" back into the inlets and onto the beaches. Onshore sand transfer can also occur from the flooding and overwash processes that form with the storm surge during hurricanes and nor'easters. This surge, if superimposed on a rising tide, can breach dunes and even barrier islands, producing large overwash lobes and flood tidal deltas in the new inlets (Leatherman,1981.

More often, it is the high frequency waves, associated with storm conditions, (Nov.-Apr.) that move the sediment from the beaches back into the nearshore zone as submerged "breaker bars". While all storms create erosion, it is the major storms (the "spikes" in the record of time transgression) that also promote the large scale landward sand deposition needed to preserve the barrier islands for future generations. Storms do not strictly produce beach erosion - only sand migration either towards, or away from the rising sea.

HISTORY OF URBAN DEVELOPMENT ON THE BARRIER ISLANDS

The progressive growth of communities from New York City (Manhattan) onto western L.I.(Brooklyn) and eventually eastern L.I. (The Hamptons) is also reflected in the urbanization of the barrier islands. Development started with the filling-in of the marshes behind Coney Island (with its parks and playlands of the 1880's-1920's) creating small plots of shoreline "property". Dunes were removed in many places so homeowners could get a better view of the ocean. Even then, homes were sometimes demolished by storms, but were rebuilt in a more landward location. As homes became blocks and streets became roadways, bridges were built for railroads (and later for cars). Groins and jetties soon followed.

Gradually, there were connections to Rockaway and Long Beach, and from 1910-1940's coastal urbanization on western L.I. spread and flourished. The late 1920's saw the construction of the major parkways, and this included bridges to the newly developed public beaches, pavilions, roadways, and parking lots at Jones Beach State Park. These western islands were originally narrow, irregular, "sand ribbons" with low-moderate dunes, extensive salt marshes (from frequent overwash) and numerous (temporary) inlets. These characteristics are typical of the microtidal transgressive barrier islands described by Leatherman (1982). The establishment of the urban communities on these islands (except Jones Beach) led to the removal of dunes, the closure of the small inlets, and the infilling of salt marshes by bayside dredging. This resulted in straight, wide, barrier islands - now with constant erosion problems and an increase in the construction of streets and houses.

Continuing eastward, we encounter the Jones Beach barrier island. Though its western portion was developed into an urban recreational park (ie. Jones Beach), the eastern part saw the creation of town beaches for the local residents, and the island was spared from further urbanization. Fire Island also experienced urban development, but it remained on a small scale (20 scattered communities) since their was no direct roadway access to the mainland until the construction of the Robert Moses Causeway Bridge in 1963. Development was further restricted by the enclosure western Fire Island into Robert Moses State Park, and central Fire Island into the Fire Island National Seashore (which now incorporates many of the communities).

Most of the island remained unbroken by inlets because of its relatively large volume of sand, creating natural high dunes and wide beaches--until 1933. As inlets were opened and stabilized near its eastern terminus, habitation increased, and soon, groin fields were added. Sand starvation ensued west of the field, and this region (Westhampton Beach) continues to have severe problems.

Since Fire Island was the only island on Long Island, and the last island on the Atlantic coast to be directly supplied by glacial sediment from longshore currents, it originally was quite high and had few inlets, and few tidal marshes (Wolff,1980, 1986). Some small stretches still have a forest cover, indicating stability over hundreds of years. Human-induced stabilization has been limited to jetty construction at inlets opened by historic hurricanes, and currently, by frequent beach nourishment from offshore dredging and inlet bypassing. A recent update on the status of the beaches on L.I. has been presented by Wolff (1989).

ROAD LOG

Introduction:

Our 7:30 A.M. departure will provide us time (2 hours) to reach the farthest point at Robert Moses State Park near Fire Island Inlet (Stop 1.) The remainder of the day will be devoted to various stops on the barrier islands of Long Island (Figure 1).

Cumulative Miles	Miles	Location
00.0	0.0	At CUNY College of Staten Island Parking Lot.
0.7	0.7	Turn right (east) onto Victory Blvd. and within 500 feet, right again onto S. Gannon Ave. (the spur road leading to Rt. 278, East.
5.2	4.5	Follow Rt. 278 to the Verrazano Bridge toll booths
7.5	2.3	Cross bridge and follow signs to Brooklyn-Queens Expressway - Rt. 278, East.
12.5	5.0	Rt. 278 narrows to two lanes.
14.5	2.0	Junction with Brooklyn Bridge overpass - New York skyline in view for camera shot.
19.5	5.0	Junction with Clearview Expressway (Rt. 495 E.) - get on ramp for Rt. 495 - eastern Long Island.
31.7	12.2	At Nassau County line - Rt. 495 continues as Long Island Expressway (LIE).
37.1	5.4	Pass junction with Northern State - Meadowbrook Parkway (approximately 1 hour since departure).
44.8	7.7	Get off at Exit 44 - junction with Rt. 135 south, Seaford - Oyster Bay Expressway.
50.2	5.4	Once on Rt. 135, get off at Exit 7 E (Hempstead Turnpike - Rt. 24).
51.5	1.3	Once on Hempstead Tpke., turn right onto Rt. 109 (Fulton St.).
52.8	1.3	Enter Suffolk County on Rt. 109.
56.4	3.6	Bear right and follow signs to Sunrise Highway E.
60.5	4.1	Once on Sunrise Highway, get off at Exit 41 - spur road to Robert Moses State Park (bear right onto ramp.)
61.1	0.6	Again, bear right onto ramp for Robert Moses Parkway to - (you guessed it!) Robert Moses State Park
64.0	2.9	Start across bridge over Great South Bay.
66.0	2.0	Leave bridge and enter east end of Jones Beach barrier island. Follow signs to Captree State Park, (NOT Captree Island!)
67.4	1.4	Bear right onto ramp for Captree State Park.
68.2	0.8	Enter Captree parking lot; park near Captree Cove Restaurant for last-minute preparations and a pit stop (Stop 0).
68.2	0.0	Leave Captree lot and head west on Ocean Parkway.
69.7	1.5	Turn right under the overpass onto route for Robert Moses State Park.

70.2	0.5	Start across (you guessed it!) Robert Moses Causeway Bridge that crosses Fire Island Inlet (see map) - one of the few parallel inlets on the East coast. Note Fire Island Lighthouse in distance on left; enter Fire Island.
70.8	0.6	At traffic circle (and Robert Moses Water Tower) go 20 degrees around circle and bear right - follow signs to "Fields 2 & 3 - Golf Course".
72.1	1.3	Go to end of parkway loop; at U-turn for entrance to Field 2 - pull off on shoulder.

STOP 1A. North side of Robert Moses State Park - The use of hard stabilization for erosion protection on the bayside of Fire Island.

Here we will examine the concrete "rubble" and and a gabion ramp that is being used as revetment to curtail bayside erosion at the end of the Loop Parkway. The reason for the initial loss of 75 meters of this beach and marsh relates to the curved spit seen at the western end of Fire Island (Democrat Point) in the distance. This was a coast-perpendicular inlet in the 1860's, but the extensive westward growth of the island from the lighthouse (over 6 Km.) has now produced a coast-parallel inlet (Figure 2). By the 1940's, it was in deep-enough water off Oak Beach to enable the flood-tidal currents and wave refraction to form a series of recurved spits at Democrat Pt. that began to constrict the inlet (Wolff, 1975a,b).

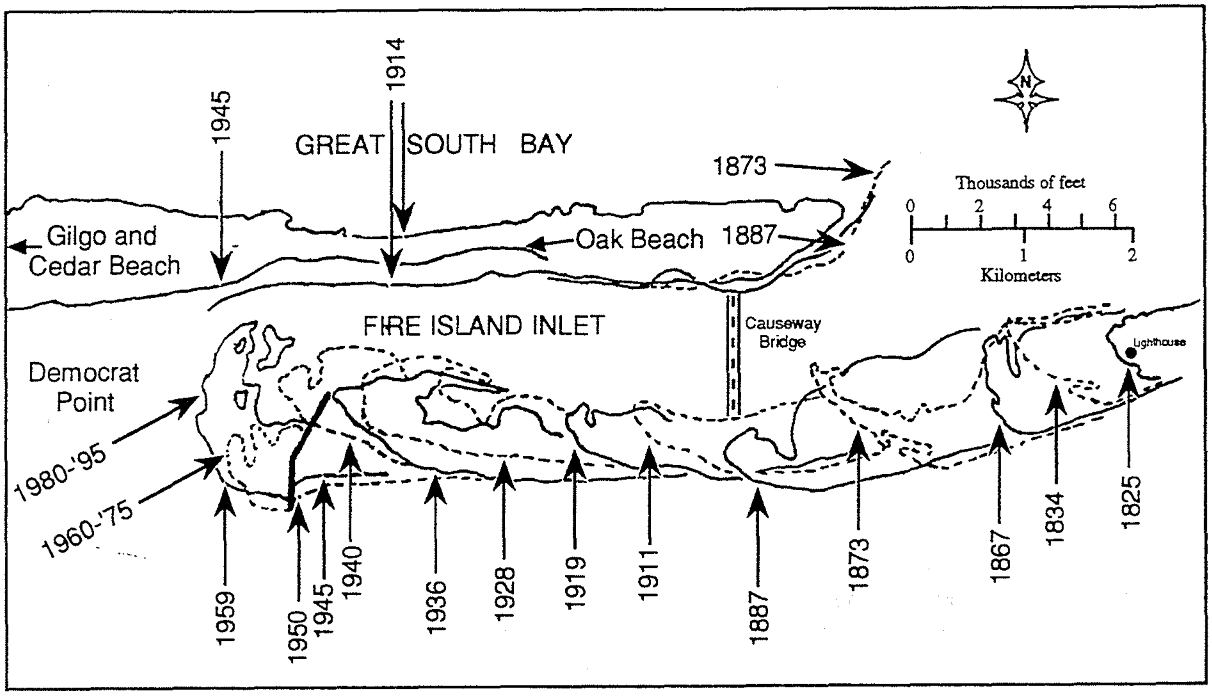

Figure 2. Progressive growth of western Fire Island(1825-1995) and the resulting inlet modifications.

As the tidal channel narrowed and deepened, its velocity increased, and it began forming a curved "meander" shape as it impinged on the Jones Beach barrier at Oak Beach. The resulting erosion required the construction of a jetty at Democrat point (to trap the littoral drift) and the dredging and by-passing of the accumulated sand across the inlet. But during the early 1950's, sand was already passing around the jetty, and by 1959 it was again constricting the inlet (Figure 2.) causing erosion near Oak Beach.

This led to the construction of a reveted sand dike by the U.S. Army Corps of Engineers west of Oak Beach. But this produced deposition and shoaling behind the dike (near Oak Beach) - which again increased the extent of the "meander" curve of the tidal channel. Acting as a "point-bar" in a meandering river, the shoals diverted the tidal currents against the bayside of Fire Island, resulting in the loss of the beach. The rubble and gabion ramp were added in 1986 to curtail the erosion.

The effect of hurricane track near this area would have particularly disasterous regional consequences since there could be a breach anywhere along Oak Beach, as there was in 1901 and 1923 (Wolff, 1975b). Depending on the extent of spit development in front of the Federal jetty, (Figure 2) this could lead to the closure of the present inlet and a deepening and widening of the new one. Such an opening recently occurred at Westhampton Beach, but was soon closed by offshore dredging (Wolff,1994).

72.1 0.0 Return to bus and continue east on the Loop Parkway back to the water tower.

73.3 1.2 Park on south shoulder of road at traffic circle.

STOP 1B. Water tower in Ocean Parkway loop at Robert Moses St. Park.- use of soft stabilization for erosion protection on the oceanside of Fire Island.

This elongate mound is composed of gravelly sand trucked-in from the mainland under emergency conditions by the N.Y.S. Department of Transportation during the winter of 1990-'91 and again in 1992-'93 when an additional 20,000 cubic yards of sand were added. It is meant to augment the eroded dunes that once protected this traffic circle along the Loop Parkway. The history of beach erosion here dates from the 1940's, but dune erosion did not occur until the 1960's. Wave surge reached the oceanside parking lots east of here by 1973, and this zone of erosion has continued to migrate westward. Using slat fencing with periodic beach scraping, the dunes in front of the parking areas were restored in the 1980's, but erosion here, at this circle continues, necessitating the mainland trucking of gravel against the roadway.

A hurr icane path near this area would not breach the barrier island, but it could create extensive damage to the parkway road, and to the water tower. The bridge is unlikely to be affected.

73.3	0.0	Continue north around traffic circle and return to Causeway Bridge; follow signs to "Parkway" North," and recross Fire Island Inlet.
74.6	1.3	Once across the bridge (after signs to "Captree State Park") follow signs to "Ocean Parkway Jones Beach" and bear right on ramp after the overpass.
77.1	2.5	Continue west on Ocean Parkway, with views to Oak Island (right) and Oak Beach (mouth of Fire Island Inlet) on left.
81.0	3.9	Continue west on Ocean Parkway - note region of high dunes on left.
82.2	1.2	Pass entrance to Gilgo Beach and get into left lane for U-turn.
82.7	0.5	Make U-turn for brief "leg" east to Stop 2.
83.6	0.9	Stop on pavement along right shoulder of road near sign for "4 wheel drive vehicular traffic".

STOP 2. Gilgo Beach (Town of Babylon) -use of soft stabilization for erosion protection of Ocean Parkway.

This stop was used by Wolff (1975b) to indicate the process of "ravinement" as described by Swift (1968) in which the active surf zone on a beach, during major storms, will expose old bayside marsh and lagoonal sediments. Such deposits were exposed on this beach during the nor'easters of 1972-73. Here is an area where over 400 meters of beach were eroded in 75 years--it was also used to demonstrate the effects of the process of barrier island "rollover" or landward migration. Once back-bay marsh sediments are buried beneath sands deposited as sand spits (by longshore currents) or overwash (from storm surges) they will later be overlain by sand from the terraces and dunes. As sea level rises, they will ultimately appear beneath the beach--were they can be re-exposed and excavated by the ocean waves (Figure 3). This beach has been renourished periodically since then (Buttner, 1989).

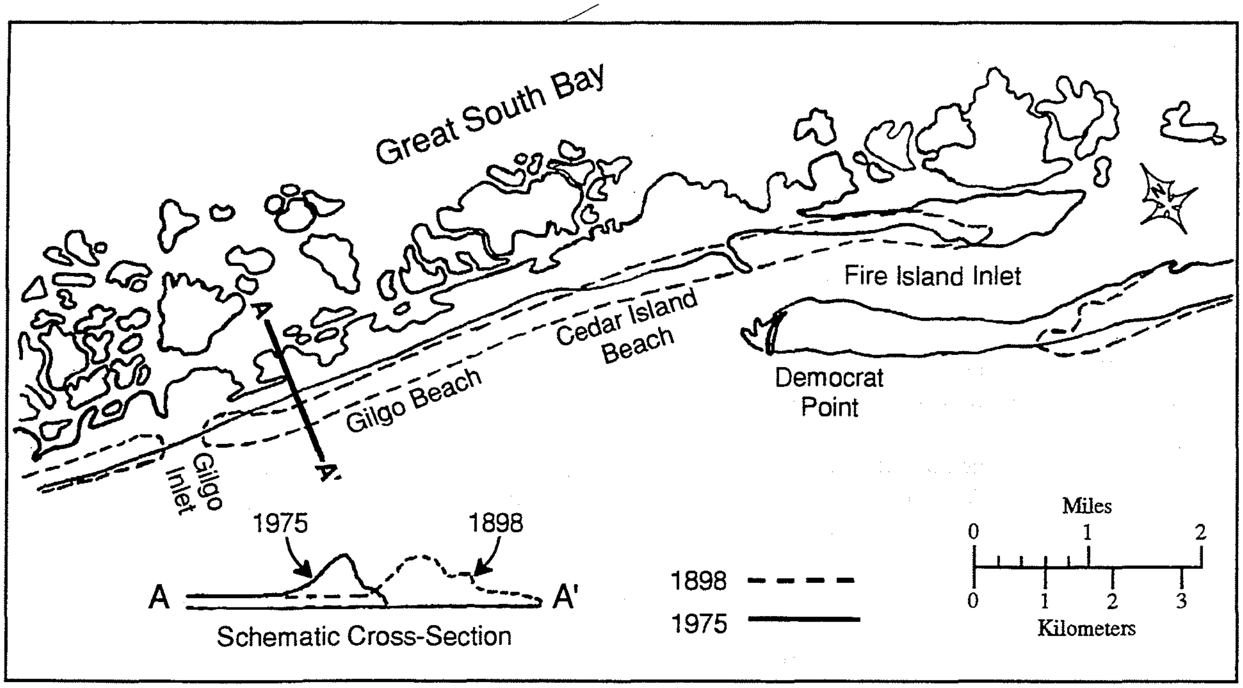

Figure 3. Overlay of 1898 and 1975 Geodetic maps to indicate the ravinement process and landward barrier island migration.

The wide beach at present is a result of several renourishment projects, initiated in 1988, that continue at present. Gilgo is the "feeder beach" for the cubic meters (or yards) of sand dredged and then pumped here from Fire Island Inlet. This sand will naturally feed the western town beaches and Jones Beach through the influence of the littoral drift.

The replenishment volume is as follows (Hanse, 1996):
1988 - 1 million cubic yards spread across 10,000 feet of beach
1990 - 1 million cubic yards spread across the same area
1992 - 1.7 mill. cubic yards spread across 18,000 feet of beach
1994 - 1.9 mill. cubic yards spread across 18,000 feet of beach
1994-'96 - an emergency stockpile of 20,000 cubic yards.

Note also the elongate ridge of gravelly sand used to replace the dunes along the edge of the Ocean Parkway. During the 1950's N.Y. State had constructed a pavilion near this location. It was being undermined and eroded by the 1970's and was abandoned and dismantled by 1975. The foundation was broken into "rip-rap" to armor the beach, and acted as a 'stubby' groin that trapped sand east of this location. But this resulted in a loss of beach at this location that, by 1986 was extensive enough to erode the dunes and nearly reach the Ocean Parkway. As at Stop 1B. N.Y.S.D.O.T., using emergency funds, was able to truck-in the gravelly sand from the mainland to save this vital roadway. The roadway is built on sand-clay fill dredged from the bay during its construction in the late 1920's and will erode even more quickly if it is ever undermined by the ocean waves. The replenishment of sand at Gilgo Beach (Stop 1B.) has kept the waves from returning.

The effect of a hurricane path passing near this area could also be quite profound since it was already near the site of a former inlet. While tidal marshes are extensive, the adjacent dredged channel for the boat moorings and the intra-coastal waterway leave this portion of the island quite narrow and susceptible to inlet breaching (Figure 3). There is not enough sand left for overwash. In fact, one of the ironies is that the sand that has been pushed by wind or water onto the Ocean Parkway over the past 30 years is rapidly collected and returned to the beach. Undermining of the south side of the roadway is imminent--but only if the trucking-in of sand and gravel is eliminated.

83.6	0.0	Continue east on Ocean Parkway, but get into left lane ASAP for another U-turn and the return to the western route.
83.8	0.2	Continue west on Parkway - past entrance to Gilgo Beach.
85.9	2.1	Pass sign for entrance into "Nassau County".
86.3	0.4	Pass entrance to Tobay Beach and get into left lane for U-turn
86.5	0.2	Make U-turn for brief "leg" east to Stop 3A.
86.9	0.4	Head east on Parkway and pull into Tobay Beach pavilion driveway.

STOP 3A. Tobay Beach (Town of Oyster Bay) - use of soft stabilization for erosion protection of Tobay Beach and the beach pavilion.

Note the location of the Tobay Beach Pavilion and the line of the eroded natural dunes. Note also the size and "storm-proof" construction of pavilion #4. This site for a pavilion goes back to the 1940's-when the dunes were in front of this location and the beach extended seaward another 115 meters. The construction of the Federal jetty at Democrat Pt. on Fire Island (Stop 1A.) blocked the sand from crossing the inlet, causing erosion along all the beaches of the Jones Beach barrier island during the 1950's. Without inlet bypassing, this pattern will persist. Once the beach and dunes were eroded, various storms undermined and partially destroyed the older pavilion. It was rebuilt, refurbished (and re-destroyed) several times before being completely torn down in 1986. Yet, instead of being rebuilt on the north side of Ocean Parkway, it was rebuilt (because of a need for convenient public access) at the same site in 1987. It has been "embraced" by waves from various storms, but the deep, sturdy concrete pilings assure its preservation - as long as periodic beach nourishment remains available. This one, and all the pavilions and bath houses to the west (ie. at Jones Beach State Park) now occupy sites in front of the natural duneline. Even the huge ocean-side parking lots are now in front of the dunes. This again demonstrates the subtle but continuous pattern of natural sand migration that, without continual stabilization, will ultimately cause all the barrier environments to migrate landward (Figure 4).

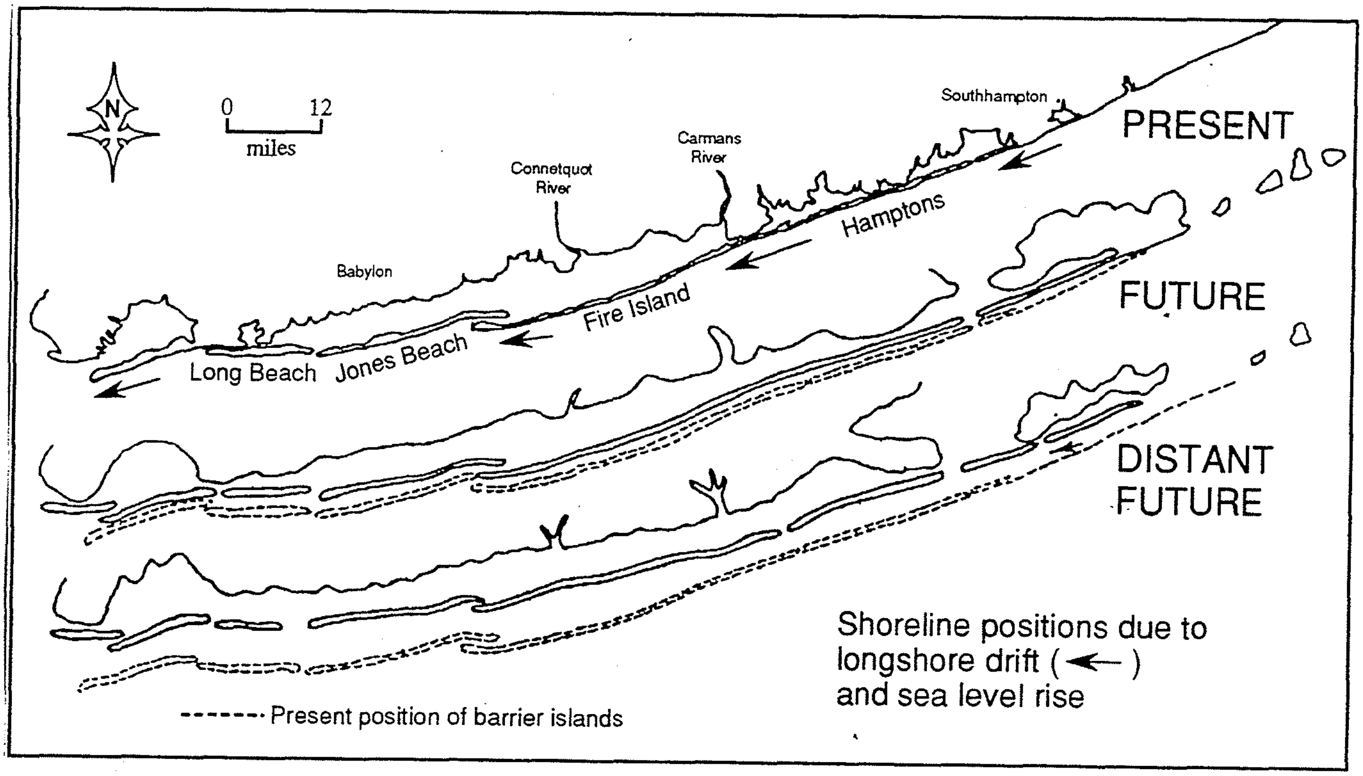

Figure 4. Schematic diagram of pattern of progressivelandward migration of bay and barrier island environments during sea level rise from present position (top) to distant future (bottom).

86.9	0.0	Return to bus and continue east on Ocean Parkway but again get into left lane ASAP for another U- turn and the return toward the western route.
87.8	0.9	Turn right into entrance of Tobay Beach parking lot, descend ramp, and turn left.
88.4	0.6	Follow single lane road back to J.F. Kennedy Wildlife Sanctuary.

STOP 3B. Tobay Beach - Wildlife Sanctuary (Town of Oyster Bay) - return of pre-historic inlets into ecologically productive barrier island forests, ponds, and marshes.

This is the site of a pre-historic inlet that retained a large volume of sand and relatively wide dunes and marshes for a long period of time. The result is (on a small scale) the development of freshwater ecosystem in a mature forest - something more characteristic of the mainland. While relatively rare, they demonstrate that certain areas on barrier islands do not rapidly undergo landward migration if enough overwash sand was deposited during prior storms; such areas may remain stable for long periods, and unaffected by the rising sea (Buttner, 1987).

The effect of a hurricane across this region, as before, has more regional than local consequences. Because of the prior overwash and inlet-filling sand, the extensive terraces and secondary dunes, and the wide expanse of salt marsh, a breach through here remains unlikely.

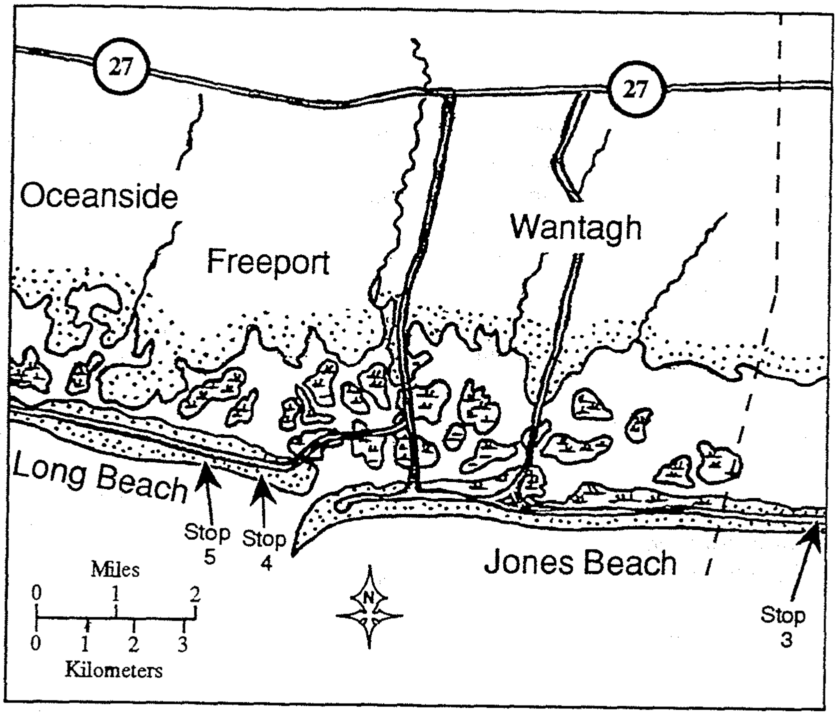

Figure 5. Location map for Stops 3A & B (Tobay Beach) 4 (Hempstead Beach Town Park) and 5 (Lido Beach). (Stops 4 & 5 are on the Long Beach Barrier Island)

88.4	0.0	Return on one-lane road to Tobay Beach entrance.
89.3	0.7	Return to Ocean Parkway and continue west.
91.4	2.1	Pass sign to "Jones Beach State Park".
92.7	1.3	Pass opposite entrance to "Field 6" of Jones Beach. Note the location of the dunes versus the location of the parking lot and pavilion.
93.4	0.7	Get in left lane and make U-turn just before the traffic circle (and water tower) to again continue east on Ocean Parkway.
94.1	0.7	Turn right into entrance at Field 6 and turn right in parking lot for a stop near the pavilion.

(This will be a quick 15 minute pit stop - Lunch can be eaten between here and Stop 4).

95.3	1.2	Return to bus for another U-turn and return to the western route - continue lunch aboard bus. Go 180 degrees (ie. straight) around traffic circle and continue west;follow signs to Meadowbrook Parkway.
96.5	1.2	Cross over Meadowbrook Parkway Bridge and bear right after underpass for "Loop Parkway" to Long Beach.
97.6	1.1	Cross over drawbridge to Long Beach; continue straight on Parkway and cross Lido Beach Blvd. directly into entrance for Hempstead Beach Town Park, Nassau County Park.

98.1	0.5	Bear left after the toll booths, turn left at stop sign, and head toward southeast corner of large parking lot.

STOP 4. Hempstead Beach Town Park, Nassau County- use of hard stabilization for ero sion protection at Jones Inlet.

Note the distance (over 350 meters) between the major roadway and the dunes. Though an urban park, there is a large "buffer zone" between the community and the beach - all urban development on barrier islands should have a management plan that will lead to this zonation. Once on the beach, view the shoreline from the last groin. Observe the wide beach and extensive dune field on the east (Jones Inlet) side of the groin. Note the large beach "re-entrant" and lack of dunes on the west side. This area was under water at various times during the 1970's and '80's, threatening the Town Pavilion (seen in the distance). Only the periodic sand bypassing from the inlet has prevented its annihilation. The last nourishment program ended in the spring of '96. You can already see the development of a beach scarp and the lowered profile as the swash undercutting continues to undermine the beach. Dune rebuilding through the use of slat fencing and Ammophila (beach grass) has been quite successful here, but only for a limited period.

This beach, near Jones Inlet, has a history similar to that of Oak Beach at Fire Island Inlet (Stop 1A.) The westward littoral drift from Jones Beach, as it moved into the deeper water in the inlet, created a series of recurved spits. By the 1950's the narrowing of the inlet forced the channel against the beach near the community of Pt. Lookout at the eastern end of Long Beach. Erosion also prevailed along much of Jones Beach. A jetty was now constructed at the western tip of Jones Beach. This led to the restoration of the state park beaches behind the jetty, but it increased the erosion at Pt. Lookout. This later required the construction of three groins east of this park, which trapped the sand supplied by the tidal currents in the inlet. But this also increased the rate of erosion beyond the most western groin - resulting in the need for periodic inlet sand bypassing for beach renourishment.

A description of the regional effects of wave surge from a hurricane passing near this inlet towards Freeport (Figure 5) was detailed by Coch and Wolff (1990). This was based on their observations of inland flooding and destruction of mainland communities behind tidal marshes after Hurricane Hugo in 1989. Less serious mainland inundation was noted along Long Island, opposite the recent opening of Little Pike's Inlet (Wolff, 1994). The extent of the enlarged tidal prism that must enter and exit an inlet during a hurricane are profound! The areal extent of the flood surge for hurricanes of different intensity has been depicted on N.Y. State SLOSH maps, and these depict inundations over hundreds of square kilometers that would affect thousands of houses.

Many beachfront homeowners have some low-level protection from bulkheads and retaining walls. But the ebb surge that follows will have some unexpected consequences. Besides opening barrier breaches into new inlets, it will also scour and erode the areas behind the bulkheads. These structures trap the ebb flood, preventing its return to the ocean. This "wall of water" will cause the houses or bulkheads to be overtopped or undermined as the surge seeks its way back to the ocean (Coch and Wolff, 1990).

98.1	0.0	Leave parking lot by going north, then bear left and follow "Exit" sign back to junction with Lido Beach Blvd., then turn left (west) again.
99.5	1.4	Entrance to Lido Beach Town Park (3rd light after water tower).
99.7	0.2	Turn right, and bear right; follow road to large parking lot. Turn right and park in southwest corner of lot.

STOP 5. Lido Beach Town Park (Town of Hempstead)- use of soft stabilization for erosion protection.

The western edge of this park occurs at the boundary between an area with proper urban coastal management and an area that sees the return of community development directly behind the dunes. This region has also experienced periods of extensive dune breaching and beach erosion, but the periodic beach nourishment and the extensive care given toward dune development have made it a "healthy" beach. This is the last area within the next 50 Km. where one can see dunes in front of coastal structures. In fact, if we continued across the Hudson River into Staten Island, and then across the Arthur Kill into New Jersey, other than a few short stretches along Sandy Hook, we would travel past the 50 Km. of seawalls in N.J. and all the way to Pt. Pleasant before again encountering dunes of this magnitude in front of houses. What was a coastal dilemma becomes a coastal crisis!

In descending the dune boardwalk "overpass," note the location of the dunes with regard to the gold-painted twin spires of the Lido Beach Towers in the distance - their position aligns itself with the mid section of this building. Dune restoration has been frequently attempted across this section of the "New York Bight" from Long Beach to Sea Girt, but it will always fail because the position of the natural dune line is now well-within the first block of houses on the urban streets. Without beach nourishment, all the "beachfront" houses would have been removed by erosion during the 1950's, and development has since increased 3-fold. The rebuilding of the dunes west of this area is an "effort in futility". As described at stops 2 and 3, the original dunes were trapped between the rising sea and the most shoreward anthropogenic structures--boardwalk, roadways, or houses (Figure 6). Other than this local area, any new dune restoration will rapidly be eroded. Not until the relocation or abandonment of the first 1-4 rows of houses can the shoreline adapt an equilibrium position that would retain natural dunes for storm protection.

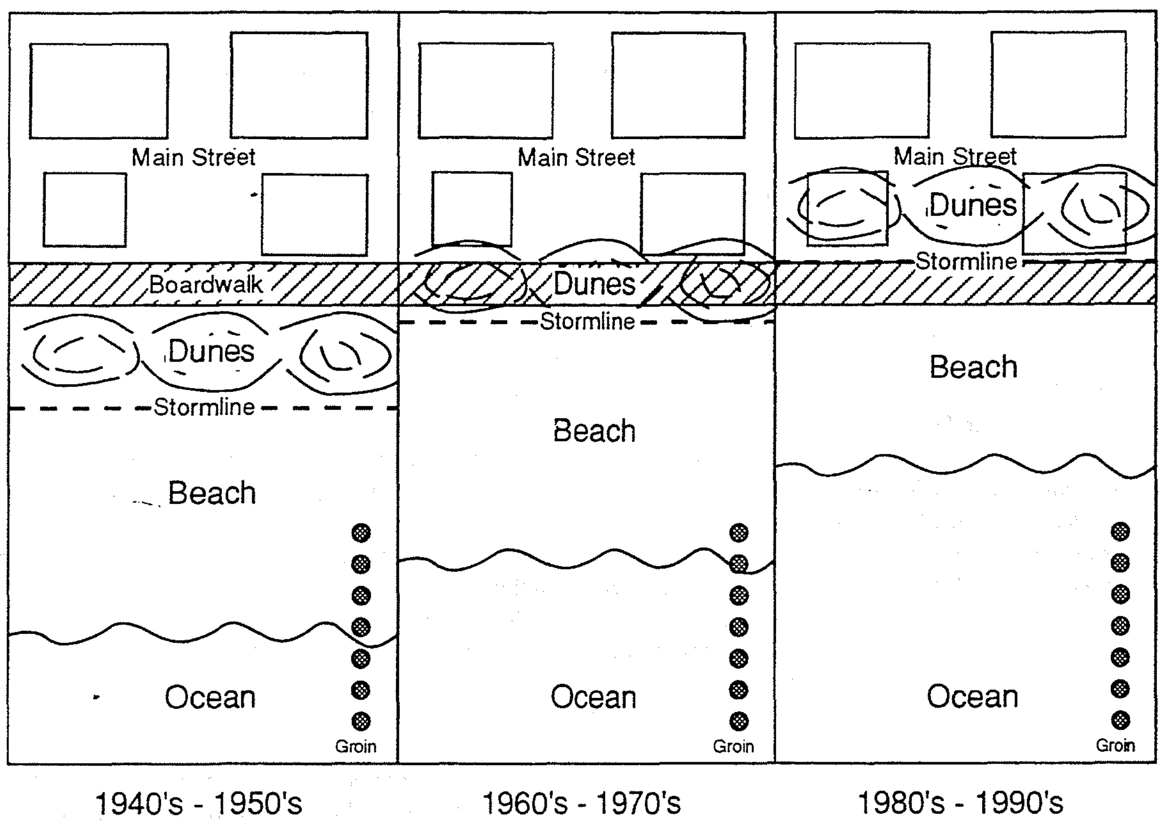

Figure 6. Landward migration of the dunes and stormline along urbanized coasts as the sea-level rises.

The effect of a hurricane path anywhere in the New York Bight, with its large coastal population density, would be overwhelming Wolff,(1992) and Coch,(1995). Though the erosion problems persist, the area canot be abandoned, and at, any expense, beach nourishment (without dunes) must continue--therefore, the coastal dilemma!

99.9	0.2	Return to Lido Beach Blvd. and turn left (west) into the City of Long Beach.
101.2	1.3	Lido Beach Blvd. becomes Park St.
104.9	3.7	Turn left 2 blocks after New York Ave. onto Pennsylvania Ave.
105.1	0.2	Turn right (west) onto Beech St.
107.2	2.1	Continue west on Beech St. and follow signs to Atlantic Beach Bridge.
107.7	0.5	Start over bridge - stay in right lane.
108.2	0.5	After toll booth - continue right onto ramp to overpass for Rockaway Beach (Sea Girt Blvd.)
109.9	1.7	Continue west on Sea Girt Blvd. until under the elevated railroad (El) and make a sharp left onto Rockaway Freeway.
110.0	0.1	After two blocks, turn left onto B35th St. and again pass under the El.
110.4	0.4	Go one block and turn right (head toward B36th St.); then turn left on B36th to dead end. (Walk out onto boardwalk and beach - then turn left (ea st) and walk to 32nd St. for bus pickup.)

STOP 6 - Edgemere Section of Rockaway Beach - beach dynamics and inlet sedimentation along a highly urbanized shoreline, Rockaway Peninsula, Queens County, New York.

Historical records show that the Rockaway Peninsula was largely pristine until the 1850's. In 1835, large areas were covered by cedar trees and sand ridges rising in places to altitudes of 25-30 feet above sea level. Urbanization, starting in the 1850's, was largely in the form of summer home developments. With the coming of the railroad in 1893, permanent communities became established. The increasing urbanization was to result in drastic changes in the morphology and hydrography of this area.

The Rockaway Peninsula, and the Coney Island barrier island to the east (Figure 7) are the most heavily urbanized and eroded hurricane - prone shorelines in the United States (Coch, 1995). The original dunes covering the Peninsula are long gone and the beaches have receded to such a degree that there is no longer any natural storm surge protection for the high-density structures along this shoreline. The major cause for this continual erosion has been the removal of sand from the longshore drift system by engineering structures and stabilized inlets in the areas to the east. This has deprived the beaches of Western Long Island of a sand supply sufficient to replace that lost to storms. In order to maintain this recreational area and protect the structures,. the Army Corps of Engineers must replenish this stretch every 3-5 years.

Our stop will cover the shoreline area from Beach 37th to Beach 25th Streets. We hope to answer the following questions :: 1) how does beach morphology and sediment dynamics differ from that along more pristine shorelines? ; 2) how has this shoreline evolved and what does this imply for the future?; 3) What accounts for the exceptional rate of erosion along this coastal segment? and; 4) how have engineering structures affected sediment dynamics in the vicinity of East Rockaway Inlet.

The area we will be examining today has a history of severe erosion . It was replenished in 1995, when it was built out 140 feet from the boardwalk. By March of 1996 it had eroded back nearly to the boardwalk. Replenishment in June 1996 built the beach out 240 feet from the boardwalk. High waves associated with the passage of Hurricane Bertha in mid-July, 1996, has already caused a beach recession of 40 feet.

The Eastern Rockaway Peninsula has been the subject of a continuing investigation by Queens College students since March of 1996. Examination of the beach section in March of 1966 showed a most unusual stratigraphic section. Sedimentary structures included upper flow regime plane beds, well defined channels oriented in a number of directions and avalanche bedding. The sediments consisted of sand, gravel and whole shells as well as shell fragments. However, as much as 5-30% of the section consisted of solid waste dating from the 19th Century. The debris included numerous rounded bricks, pieces of drainage pipe, pottery, plates bottles, personal items, animal bones and a few pieces of silverware and coins (Liogys et al, 1996).

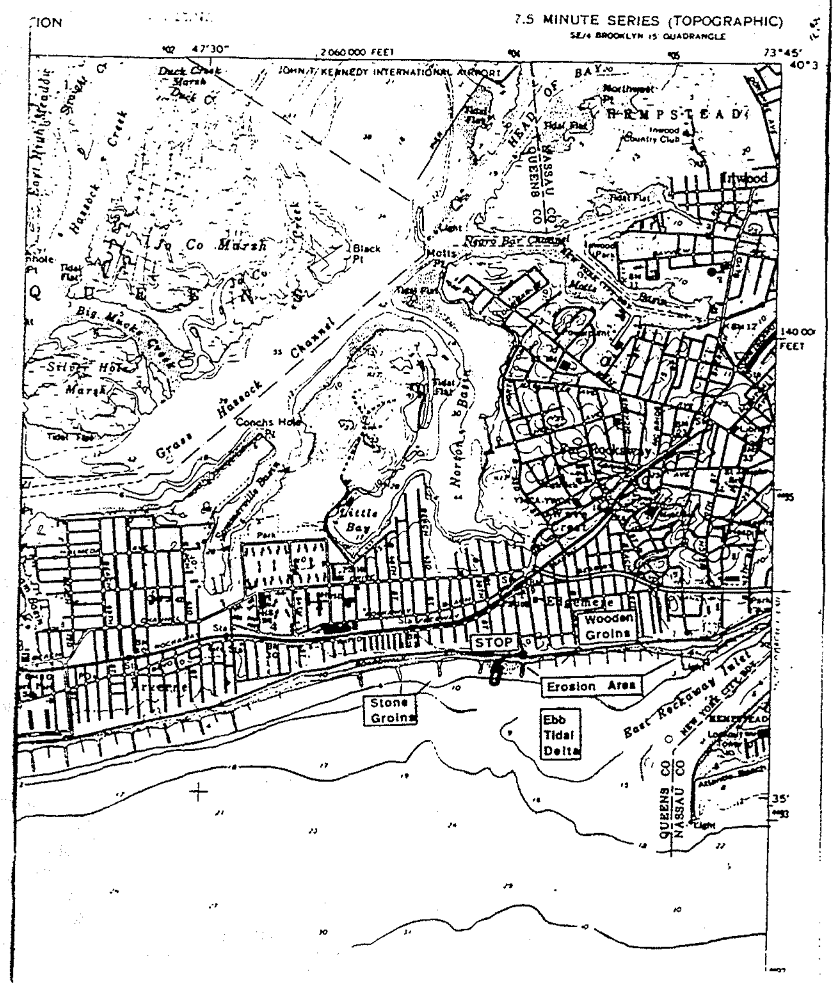

Figure 7. Topographic map of the features associated with Rockaway Inlet at Stop 6.

We considered two working hypotheses to explain this deposit. The dredging could have uncovered an old borrow pit into which solid waste was dumped in the 19th Century. Another possibility is that the debris was washed offshore in the ebb surge of a past hurricane.

Historical records synthesized by Fuqua (1996) indicate that a barrier island (Hog Island) existed 1,000 feet offshore of the Rockaway Peninsula in 1879. A number of recreational facilities existed on Hog Island at that time and they were reached by ferry and causeway from the Rockaway Peninsula. The New York Times of August 21, 1893 reported that a major storm completely inundated Hog Island and it was "the beginning of the end for the island". Later newspaper reports indicate that Hog Island disappeared completely in noreaster storms in 1893-4. The major storm was probably the "Jamaica Bay Hurricane" of 1893. The eye of that Category 3 storm probably did not pass over Jamaica Bay but crossed the coast in what is now the western part of Nassau County (B. Jarvinen, 1996, personal communication). This would have put the

Rockaway area on the weaker, or left side, of that hurricane, so how can we explain the extraordinary coastal damage that was reported? The wave and surge levels reported were much higher than expected. because of the unique shoreline orientation and offshore bathymmetry that occur in this region (Coch. 1994). The obliteration of structures on Hog Island would have provided debris that was washed onto the adjacent sea floor and covered by sand in the following decades. Dredging operations by the Army Corps of Engineers in 1995 (just south of the inferred position of Hog Island) returned this material to the land as part of the hydraulic fill used for beach replenishment. As you look around at the high rise buildings right on the boardwalk, think about the consequences of a major hurricane making landfall again in this highly urbanized area in the future.

Beach sedimentation in this area today consists of swash buildup of the beach face between storms as well as deflation of surface sands by southerly winds. The sand accumulates as drifts against the boardwalk. Some of the sand is blown under the boardwalk to form drifts against eroded vegetated dune remnants with incipient soil profiles. We will examine some of these dune remnants and discuss the inevitable consequence of "barrier rollover" in this area.

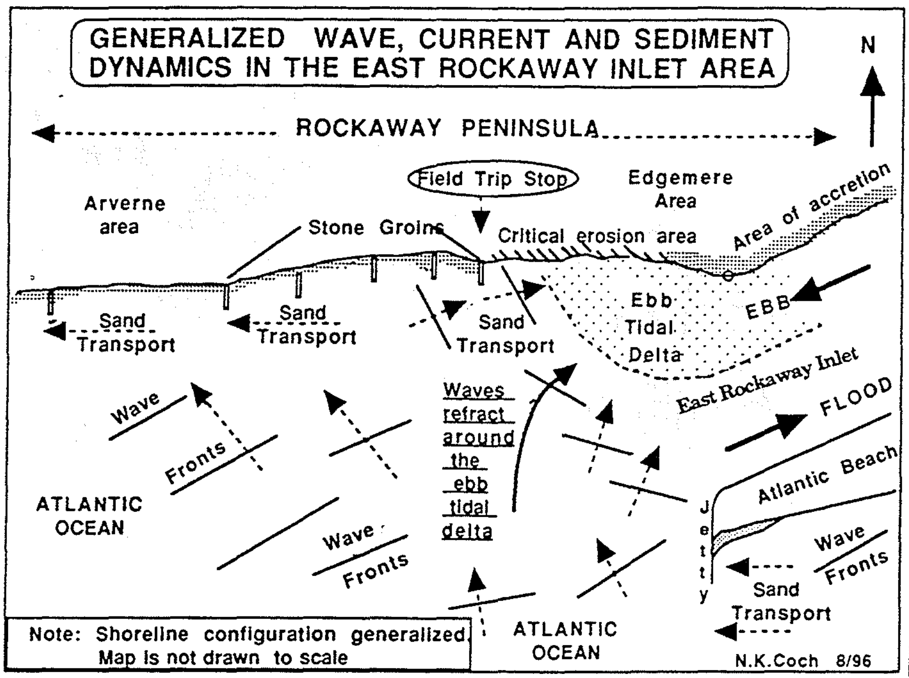

Figure 8. Generalized sediment and water dynamics map of Rockaway Inlet at Stop 6.

There are two sets of groins in the area (Figure 8). The older wooden groins were poorly maintained and are now largely destroyed. The newer stone groins function as effective sediment traps. The most easterly stone groin is at Beach 35th Street at our field trip stop.

A number of factors are responsible for the severe erosion in this area. Observations over several years suggest the following scenario for the water and sediment dynamics in the East Rockaway Inlet area. These dynamics are shown in generalized fashion in Figure 3. Sand moves in the predominant east to west drift toward the jetty at Atlantic Beach. Most of this sand is trapped against the jetty, but a portion is swept across the inlet area toward the Rockaways. Bathymmetric contours (Figure 8) indicate shoals that suggest the presence of an ebb tidal delta on the north side of East Rockaway Inlet. Some of the sand moved across East Rockaway Inlet is transported by waves refracted around that ebb tidal delta, and moved towards the inlet. The last stone groin at Beach 35th Street traps some of that sand, but most moves past the area towards the inlet. This sand is deposited in the vicinity of the "light" (Figure 8) where the ebb currents block further penetration

into the inlet. This scenario accounts for the presence of a sand-starved section from Beach 35th to Beach 25th Streets and the severe erosion that occurs c
ontinually along that coastal segment.

ROAD LOG FOR THE RETURN TO THE COLLEGE OF STATEN ISLAND.

110.4	0.0	Return north on B32nd St. to Sea Girt Blvd. and again turn left.
110.6	0.2	Once beneath the El, again make a sharp left onto the Rockaway Freeway.
115.1	4.5	Continue west on the freeway, past the entrance to Jacob Riis Park, to the junction with Beach Channel Drive.
117.9	2.8	Continue west on Beach Channel Drive to the Marine Parkway Bridge - follow the signs to Brooklyn.
118.8	0.9	Once over the bridge (toll) continue northwest on Flatbush Ave.
120.4	1.6	Cross over the Belt Parkway overpass and continue west on Flatbush Ave.
125.2	4.8	Two blocks after Church St., turn left onto Caton Ave.
126.4	1.2	Continue west on Caton Ave. until it merges.9 2.5 Follow Fort Hamilton Parkway over the Brooklyn- Queens Expressway (Rt. 278).
129.1	0.2	Turn left at 92nd St. for the spur road to the Expressway (Rt. 278).
131.5	2.4	Return on the Expressway, cross the Verrazano Bridge to the toll boths.
136.0	4.5	Follow Rt. 278 to Victory Blvd. and the return to the College of Staten Island (signs).
136.5	0.5	Return to the college parking lot.

ACKNOWLEDGEMENTS

The authors would like to thank Robert W. Johnson (Biology Dept.) for his field obervations and familiarity with most of our stops, and .J Bret Bennington (Geology Dept.) for his graphic computer software and expertise in improving our diagrams. Their assistance has immeasurably improved the quality of the article and field trip. Finally, N.Coch would like to thank B.Fuqua for her synthesizing of the historical data, and J.Healy, L.Kiefer and T. Liogys for their field measurements and sample collecting at Stop 6.

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