C. Natural Environment

1. Geology and Barrier-Island Dynamics

a. Geologic History of Fire Island

Fire Island is a 32-mile-long barrier island lying on the continental shelf off the southeastern coast of Long Island, New York. At the beginning of the Cretaceous period, about 135 million years ago, the terrain in this area had been reduced by erosion to a rather featureless plain that tilted to the southwest. Cretaceous seas encroached upon the continent and deposited gravel, sand, and clay upon the older, tilted metamorphic rocks (figure 18). These marine sediments accumulated to thicknesses of several thousands of feet and thickened rapidly seaward. The Cretaceous period ended with the retreat of the seas from the area about 70 million years ago. Evidently this last 70 million years has been largely one of nondeposition and erosion, for the next rocks found in the area are of Pleistocene age.

Beginning about 1 million years ago, the Pleistocene epoch was a time of continental glaciation. At least twice, advances of the continental ice sheets reached Long Island, and glacial outwash materials of sand and clay were deposited in the Fire Island area. The end of the last glacial advance reaching Long Island was about 18,000 years ago, and at that time the sea level was about 420 feet lower than it is today, and the seacoast was some 80 to 100 miles to the southeast of Fire Island.

Water from the melting of the great Pleistocene glaciers caused a worldwide rise in sea level. As the sea advanced northwestward onto the continental shelf, barrier islands were formed along the retreating coastline. During periods of rapidly rising sea level and an insufficient sediment supply, the barrier islands became overtopped and drowned. The ocean currents reworked and eroded the submerged islands until they no longer existed as topographic features on the floor of the sea. Much of these sediments would be moved shoreward to provide material for the growth of new barrier islands closer to the coastline.

During periods of more slowly rising sea level, and when the amount of sediment was sufficient, barrier islands could migrate landward, keeping pace with the retreating coast by sediment deposition on the landward side to make up for erosion on the seaward side.

The rising waters of the advancing sea continually reworked and relocated the sediments of the glacial outwash plain it covered. The sea eventually encountered the coarser end morainal material left by the

glaciers along a line from the Ronkonkoma moraine in eastern Long Island to the outermost moraines at Marthas Vineyard and Nantucket Island. These moraines provided gravel and cobbles to the sea, as well as additional amounts of sand and clay. The headland section of the beaches of south-shore Long Island extends southwestward from Montauk Point for about 37 miles. In this headland section the sea has eroded a steep, 60 foot high cliff into the Ronkonkoma moraine, and the beaches are typically narrow and paved with cobbles and gravel from the moraine and its outwash plain. Fire Island is in the western section of the beaches of the south shore of Long Island, which is 92 miles long, and consists of sandy barrier islands and spits.

Waves generally strike the coastline in the Fire Island area from the southeast and generate a longshore current flowing to the southwest. The sediment, or littoral drift, carried in this longshore current is derived from onshore streams, updrift glacial debris from the headland section, and from offshore bottom sources carried by onshore bottom currents. Irrespective of its source, it is this sediment which is available for barrier island building along the coast.

Geophysical and sedimentological evidence indicates that there was a chain of barrier islands similar in size and height to Fire Island, parallel to it, and 4.4 miles to the south about 8,000 years ago. This island chain was unable to keep pace with a rapid rise of about 27 feet in sea level and it was drowned in place. Back-barrier peat deposits, which have been radiometrically dated at 7,500 years, have been found 1.25 miles south of Fire Island at depths of 50 to 60 feet below present sea level. Because the rise in sea level during the past 7,500 years has been too slow to drown the barrier island behind which this peat was deposited, it is inferred that the barrier island migrated northward over the top of its back-barrier deposits for 1.25 miles to become the present Fire Island. Sea level is continuing to rise, and landward migration by erosion and deposition is an active process shaping the future of Fire Island.

It appears that Fire Island developed as a spit of littoral drift material deposited southwestward from the headlands section of Long Island. The spit was later broken into a series of barrier islands by inlet cutting storms (figure 19). In the face of wave erosion and rising sea level, both the headland coast and the spit-derived barrier islands have retreated northward. Between 1825 and 1940, Fire Island grew westward some 5 miles from deposition of littoral drift at the end of the island.

Barrier islands may develop under a number of different situations (figures 20 and 21); however,

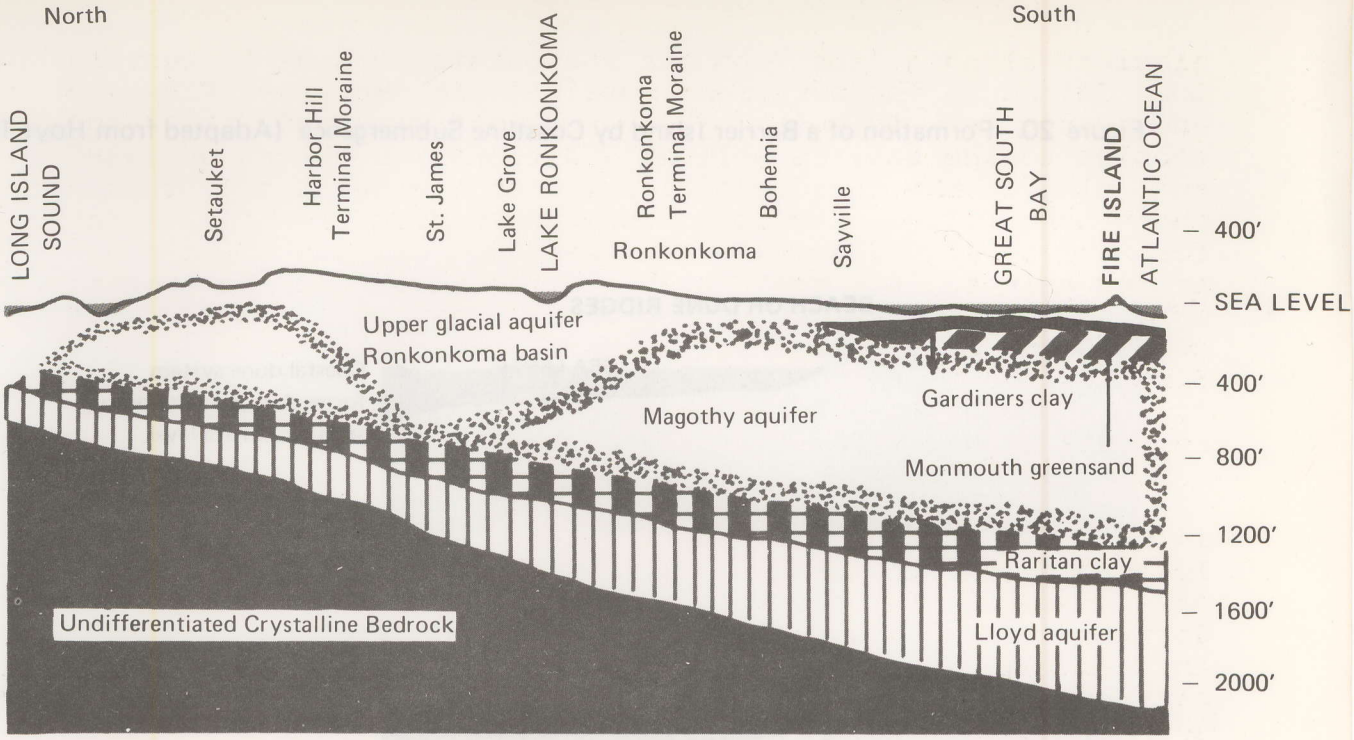


Figure 18. Geologic Cross Section of Long Island between Old Field Point and Point O'Woods (Adapted from Taney 1961)

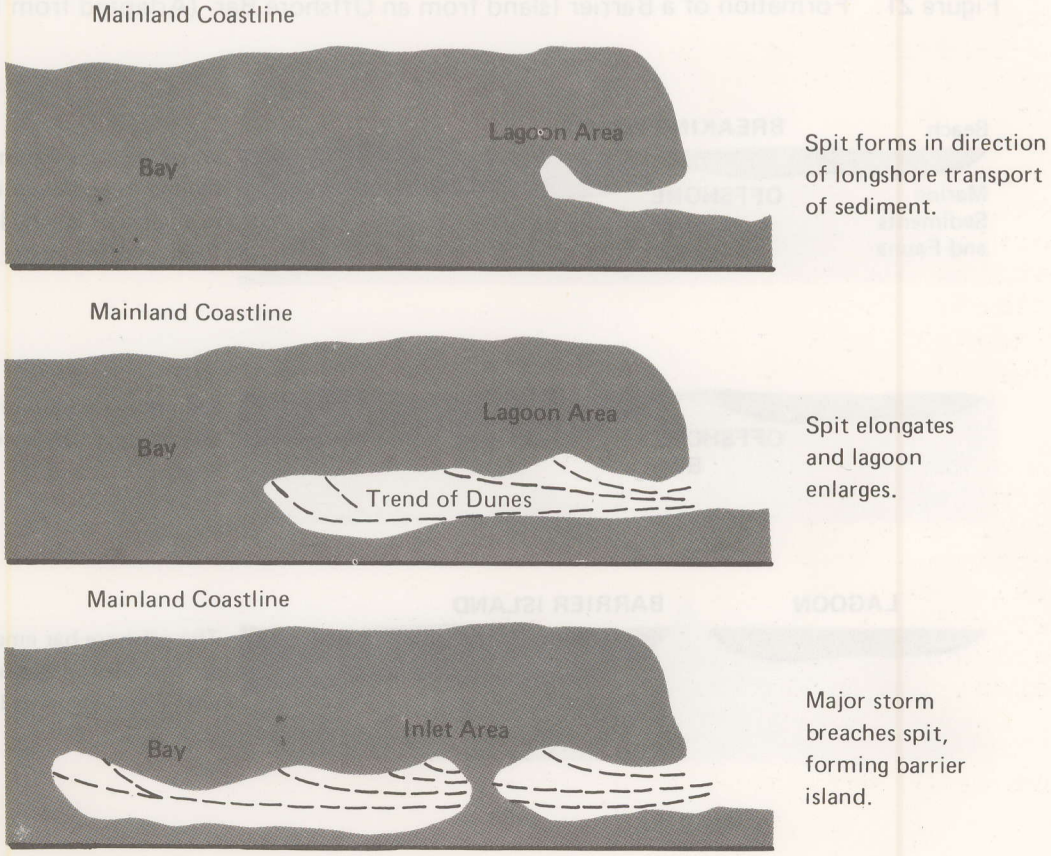
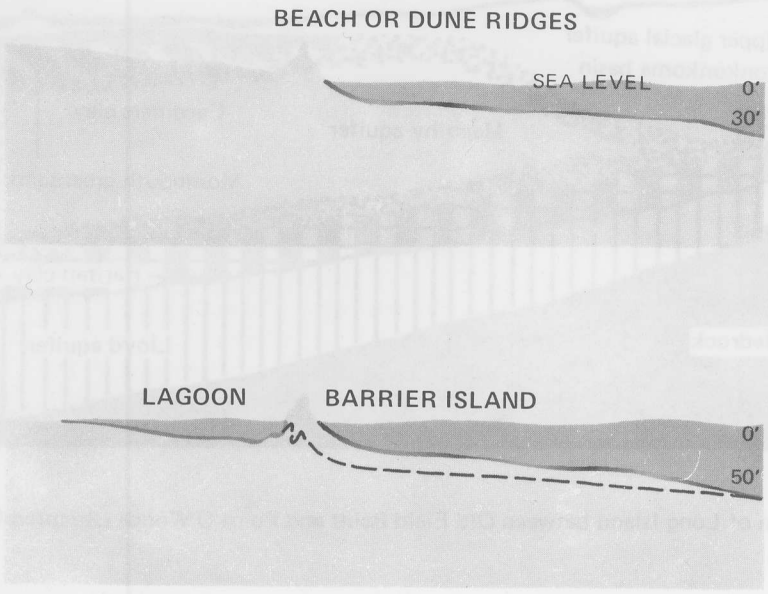


Figure 19. Barrier-Island Formation from a Breached Spit (Adapted from Hoyt 1967)

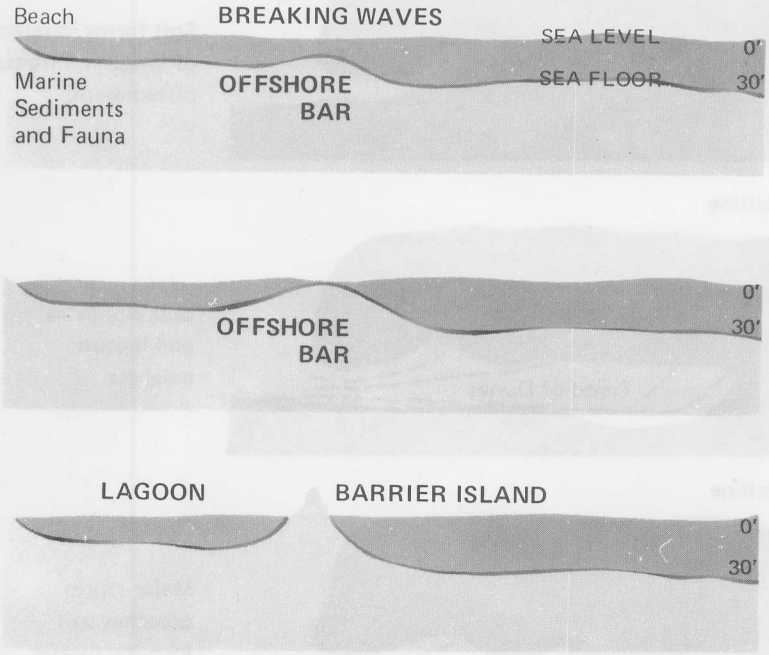
Figure 20. Formation of a Barrier Island by Coastline Submergence (Adapted from Hoyt 1967)



Coastal dune system forms during a temporary stillstand of sea level.

Sea level rises. Lands behind the dune system are flooded, forming a lagoon. The dune system remains as a barrier island.

Figure 21. Formation of a Barrier Island from an Offshore Bar (Adapted from Hoyt 1967)



Waves pick up seabottom sediments and deposit them in an area of energy loss to form an offshore bar.

Sediment accumulation builds the offshore bar to near sea level.

The offshore bar emerges above sea level, forming a barrier island with a lagoon on its landward side.

current geological evidence indicates that Fire Island developed from an inlet broken spit, which has been modified by the formation and downdrift migration of inlets, water- and wind-driven erosion and deposition, and unnatural conditions imposed by man.

b. Island Dynamics

Fire Island and other east-coast barrier islands are primarily perpetuated by the following sand-moving processes: littoral currents, onshore bottom currents, storm overwash, inlet formation and tidal delta growth, and deposition of wind-carried sands. Against these processes are arrayed the forces of a rising sea level and the sand-moving processes of coastal erosion. An overabundance of sediment supplied to the dynamic processes of the island would allow the island to stabilize in place and grow both westward and northward. However, there is no geologic evidence that indicates that this condition has ever occurred at Fire Island. If insufficient sediment is provided by the sand-moving processes, the island will dwindle under the forces of erosion and eventually be drowned by the rising sea level. This apparently did not happen to the present Fire Island prior to the intervention of man in the dynamics of coastal processes. Therefore, Fire Island has been in a state of dynamic equilibrium since its creation, with the effects of erosion on the seaward side being equalled by deposition on the back-barrier (bay) side.

Sand from offshore and updrift sources is carried along the south shore of the island in the littoral current. This littoral drift material is washed onto the beach by both normal and storm waves. The sand dries and is carried above the reach of normal waves by onshore winds. Low dunelets form around detritus and begin to support beach grasses and other low vegetation which in turn trap blowing sands. The perennial dune plants bind the sand and grow upward through it, and eventually a full dune is formed.

Only small amounts of sand are removed from the dunes by wind (the process of deflation), but during hurricanes and other severe storms, onshore winds and waves redistribute large volumes of sand. The ocean occasionally sweeps over and between the dunes, carrying the sands from offshore deposits, beaches, and dunes to the back of the island. There the sands form terraces and increase the elevation of the backshore, increase the size of tidal deltas, or are dispersed in the backbay waters. Tidal surges caused by hurricanes can wash over the island from the sea into the bay and they occasionally wash back across the island as storm winds reverse. Where the island is low and narrow, with a poorly developed or absent line of dunes,

the returning storm waters may carve an inlet through the island.

If an inlet remains open, sand from the littoral drift will be channeled into it and a tidal delta will begin to develop and shoals will occur on the bayside of the inlet. Deposition of sand will occur on the updrift side of the inlet and erosion will begin to carve at the sand-starved downdrift side. If erosion and deposition on either side of the inlet keep pace with each other and tidal currents are strong, the inlet will remain open and slowly migrate downdrift through the island. If deposition exceeds the rate of erosion on the downdrift side of the inlet, it will slowly fill and close. Vegetation will stabilize the deltaic sediments and a tidal marsh will form. After the inlet is closed there will be times of overwash that will fill the old tidal channels and build up the back of the barrier island. Ultimately, tidal marsh islands will become interconnected and join to the back side of the island, providing a platform for the deposition of sediments from hurricanes and other heavy storms that overwash the island. It is this condition that allows Fire Island to migrate slowly toward the north in the face of erosion and rising sea level.

Man's intervention now keeps these inlets from closing or migrating, and the back-barrier side of Fire Island is no longer being supplied with sufficient sediment for back-barrier growth. Man is maintaining the inlets in an open condition and not returning the sediments robbed from the littoral drift by the inlet to the coastal processes on the seaward side of the island. Thus, beaches downdrift from the inlets are sand-starved and are being rapidly eroded. In the past 7,500 years, Fire Island has migrated northward at a rate of about 1 foot per year. Recent measurements (Ruzyla 1972) of one typical berm scarp 3 feet (1 m) high located 10 feet (3 m) above the mean low tide line on Fire Island indicated that during half of one tidal cycle (6 hours) 1,060 cubic feet (30 cubic meters) of sand were removed for each 3-foot (1 m) long section of the beach. This quantity, when extrapolated, yields an erosion rate of about 30,000 cubic meters for each kilometer of beach, or about 52,600 cubic yards per mile of Fire Island beach during the 6-hour period. Unless man compensates the natural processes for his disruptive activities, the islands and the productive estuaries behind them will continue to deteriorate.

c. Dune Systems

Most of Fire Island consists of crescent-shaped secondary dunes and beach areas just seaward of the secondary dunes. Some of these dunes are high, like those east of Watch Hill, but most are low ridges a few feet

high. All have formed at the elongating end of the spit and are recurved (crescent shaped) because of the peculiar wave-induced refraction of sand around the tip of the spit. The recurving phenomenon is evident today at Democrat Point east of the jetty that has temporarily interrupted normal depositional processes.

A few parts of Fire Island have well-developed primary dunes fringing the beach in front of secondary dunes. Some reach heights of 40 feet in the natural area east of Watch Hill. The existence of generally linear primary dune ridges suggests a change in shoreline orientation, probably in response to changes in offshore topography and amount of sand in the longshore drift. The beach has aggraded seaward and stabilized for a long enough time to allow the dunes to form. In these areas, a less active interdunal zone has been established between the recent primary dunes and the older secondary dunes (see the accompanying photograph). Seaward accretion of Fire Island has occurred primarily east of Watch Hill. The intersection of a primary dune ridge and the secondary dunes near Long Cove is approximately a nodal point between the accretion and erosion zones. Much of the island west of Long Cove has no interdunal zone, and its single dune line is relatively low and more subject to breaching. Between Fire Island Pines and Cherry Grove, the island begins to widen and a second, but smaller, seaward accretion zone is apparent. The zone extends through Point O'Woods, where once again an interdunal swale separates large primary dunes from secondary dunes.

d. Wind Erosion

Wind erosion has produced blowouts in both foredunes and secondary dunes throughout the island (see the accompanying photograph). Unless stabilized by vegetation, blowouts can expand and level large areas of dunes. This process is ecologically beneficial in areas behind the primary dunes where erosion of blowouts eventually reaches the water table and creates freshwater marshes, the island's scarcest habitat, thus increasing diversity naturally.

e. Wave Erosion

Wave erosion is apparent in several zones on the island, and research has been done to determine its causes. Ruzyla (1972) studied a 6-mile-long section of Fire Island southeast of Smith Point and found significant landward erosion of the beach (3 to 5 feet per year), as well as considerable evidence of overwash and reworking of sediment. Although some areas are accreting seaward, landward erosion seems to be the predominant process on Fire

Accretion zone, showing primary dunes, interdunal swale, and secondary dunes. **A** Primary dune ridge covered with beach grass and low shrubs. **B** Interdunal swale. **C** Secondary dunes east of Old Inlet, looking toward Moriches Inlet.

Blowout area near Long Cove. Unless vegetation stabilizes the blowouts in these dunes, a wide area of dune topography will be leveled. Without stabilization, downcutting will proceed until it reaches the water table.

Island. (Note closing sentences under paragraph c. Dune Systems above. See the accompanying photograph.)

During periods of normal tides, the everyday small waves striking Fire Island produce a net sediment movement onshore when the waves are from the southeast. However, if the waves are driven by more easterly winds and the waves strike the beach at an acute angle, there is swash undercutting of the berm and the net sediment movement is off the beach and into the longshore current.

During periods of moderate waves produced by average storms, the amount of sediment in the littoral drift is increased and usually results in an extension of the beach berm rather than erosion. Again, if these waves are moving westward and strike the beach at an acute angle, there will be swash undercutting of the berm and the net sediment movement will be toward the sea. The net result of major storms such as hurricanes has been one of accretion by island migration landward (inlet and overwash fans) rather than erosion.

It would seem then that major beach erosion occurs when spring high tides and exceptionally low barometric pressure coincide with an acute angle approach of wind-generated waves. These waves rush onto the beach as sheets of shallow water running nearly parallel to the beach. They undercut the berm and dunes, allowing large amounts of sand to collapse and be carried back to the longshore current. Such times of erosion are only ephemeral and occasional, but their effects can be severe. The longer periods of normal wave activity would replace the sands removed by swash undercutting if there was sufficient sediment present in the littoral current from updrift and offshore sources. Inlet dredging and jetty construction have robbed the littoral drift of sufficient sediment to maintain the beaches of Fire Island against the forces of erosion.

Bayside erosion is evident nearly everywhere and is particularly severe between Watch Hill and Fire Island Pines, where high dunes limit overwash except during unusually severe storms, and the absence of nearby inlets reduces the availability of deltaic sediments for enrichment. Marshes here, however, might have been historically sediment-starved by high dunes. Recent investigations indicate an easterly transport of sand on the bayside of the island in this zone. In some places, this eastward movement has been at the expense of bayside secondary dunes, which have been severely eroded. Considerable bayside erosion is also occurring in the Sunken Forest area. In order to reduce erosion here, the desirability of artificial marsh building on a trial basis

Severe beach erosion threatens large homes in Point-O'Woods.

Sand piled in front of threatened structures affords only limited short-term protection.

Beach erosion at Atlantique Beach, December 1965. Note storm debris on the beach and damage to sand fences.

has been suggested, pending completion of studies to determine whether the natural sedimentary environment makes such an operation feasible.

Any proposed measures to ameliorate man's impact on the coastal processes affecting Fire Island must be evaluated in terms of the dynamic forces that are responsible for both erosion and deposition. The direction of wave approach to the beach could only be controlled by extensive offshore artificial reef or breakwater building. Sand can be shunted, or bypassed, around inlets and replaced in the littoral drift. When available, sand from dredging in inlets can be replaced downdrift in the littoral current, or in offshore deposits. Beaches can also be enlarged by direct sand nourishment programs. Snow fences and vegetation can retard dune erosion, and vehicles and pedestrians can be controlled from contributing to the destruction of dunes. Groins and other such structures reaching into the water from the shore have been shown ineffective in reducing erosion except immediately updrift and usually cause more erosion downdrift than deposition updrift.

f. History of Inlet Formation on Fire Island

Inlets are temporary features that form when a spit or barrier island is breached by severe storm tides. They are important both in the geomorphic evolution of the spit/barrier island complex and in the maintenance of the ecological productivity of estuaries.

Inlets act as funnels through which sands pirated from the littoral drift are carried into estuaries; there they are reworked to form tidal deltas (see table 20). The tidal deltas typically support productive marshlands, which provide wildlife habitats and organic detritus for estuarine food chains. The breaches facilitate the mixing of estuarine waters and seawater, a process that is required to maintain proper salinity, nutrient balance, and temperature, as well as the delicate interrelationships between marine and estuarine life forms. Inlets also provide for voiding of pollutants that would otherwise accumulate in these shallow water bodies.

Historical records dating back to the early 17th century document the formation and closure of many inlets through the spit/barrier-island system. Fire Island Inlet, the oldest on record, reportedly was opened by severe storm waves in the winter of 1690-91. The original breach was about 9 miles wide. As the western end of Fire Island accreted, the inlet narrowed. The first Fire Island Lighthouse, built adjacent to the inlet in 1826, is now almost 5 miles to the east of the inlet's earlier location

The Ocean Beach Groins (Photographs taken in September 1974)

View of the two Ocean Beach groins from the east. Note accumulation of sand in the wide beach updrift (east) of the groins and the starved beach downdrift.

Close-up of Ocean Beach groins. Groins consist of a double line of interlocking concrete columns. Updrift accumulation and downdrift erosion of the beach are significant.

TABLE 20

PHYSICAL CHARACTERISTICS OF, AND LITTORAL DRIFT VOLUMES ASSOCIATED WITH, INLETS ALONG THE SOUTH SHORE OF LONG ISLAND (Adapted from U.S. Army, Corps of Engineers 1972)

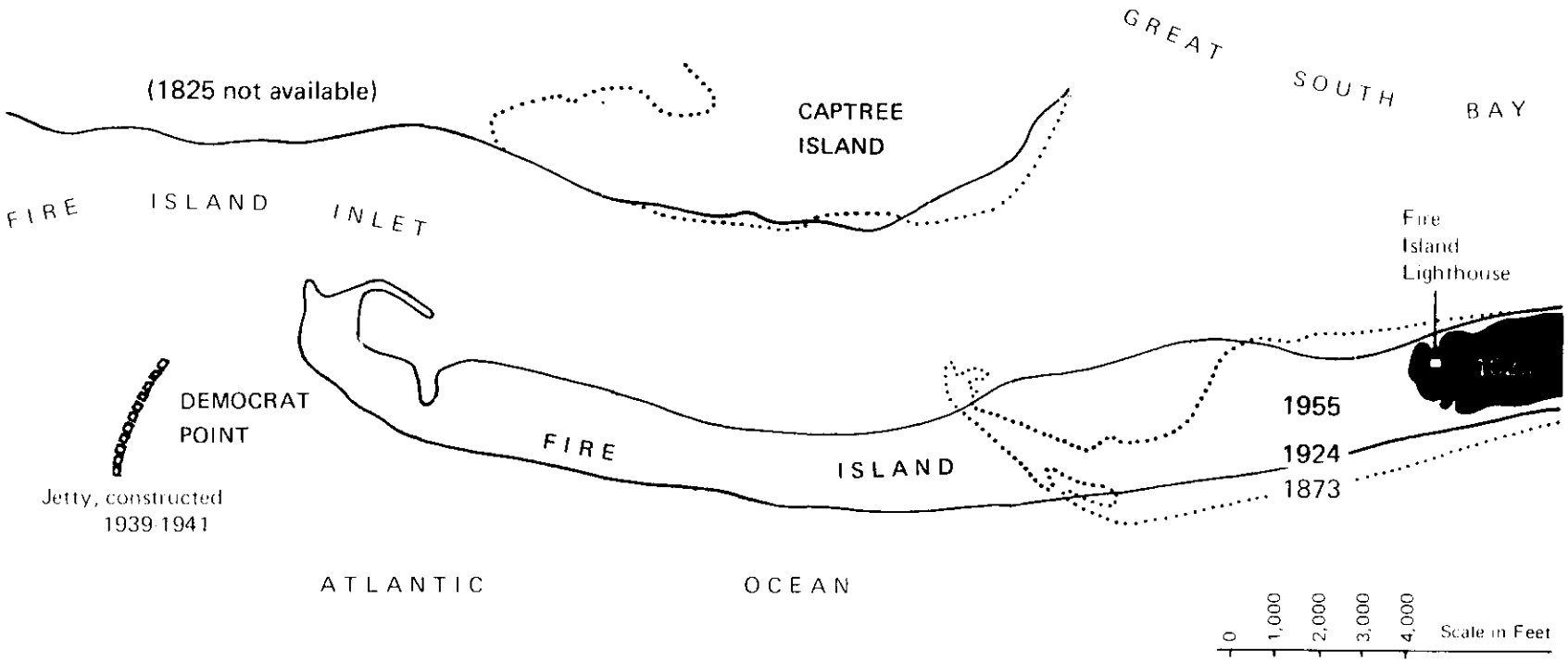
Inlets	Tidal Prism (mil. cubic yards)	Average Maximum Tidal Velocity (knots) Flood	Ebb	Yearly Littoral Drift (cubic yards)	Drift Removed by Inlets[1] (cubic yards)	Percent	Average Annual Amount (cubic yards) To Be Made Up By Removal from Intervening Beaches Between Inlets	Inter-Inlet Beachfront Length (miles)	Average Annual Amount Returned to Drift from Beachfronts Between Inlets[2] (cubic yards per mile)
East Rockaway	660	2.2	2.3	400,000	250,000	62.5	300,000	9.5	31,600
Jones	1,300	3.1	2.6	550,000	450,000	81.8	150,000	14.7	10,200
Fire Island	2,100	2.4	2.4	600,000	400,000	66.6	500,000	30.8	16,200
Moriches[3]	300	1.1	1.3	350,000	250,000	71.4	200,000	15.6	12,800
Shinnecock	325	2.5	2.3	300,000	150,000	50.0			
Totals/Average				**2,200,000**	**1,500,000**	**68.2**			

[1] Presently without sand-bypass mechanisms

[2] Ignores presently unknown contribution from sea-bottom offshore

[3] Ignores presently unknown amount removed by Westhampton groin field

Figure 22 Changes in the Location of Fire Island Inlet, 1825 to 1955 (Adapted from U.S. Army Corps of Engineers 1956)



(figure 22). A jetty was constructed in 1939-41 to block littoral drift, westward accretion of the island, and further narrowing of the inlet. The structure was temporarily effective, but is now largely buried in sand. The island continues its westward growth but the resulting spits are dredged annually by the Corps of Engineers. The inlet is about 3/4 of a mile wide. The highly productive marsh islands north of the inlet (Sexton Island, East Fire Island, and Captree Island) are part of one of the system's largest flood tidal deltas.

Moriches Inlet, at the eastern end of Fire Island, opened during a storm in March 1931 and closed by 1951. It was reopened in 1953 and stabilized by jetties. Since that time, it has been kept open, although badly shoaled, by periodic dredging.

Four former inlet sites have been recognized on existing federal lands, and others are suspected. Smith's Inlet (located opposite Smith Point) and Old Inlet (about 2 miles west) probably opened around the time of the Revolutionary War. Both sites developed mature flood tidal deltas. Although no records are available for Smith's Inlet, Old Inlet reportedly closed around 1827. The high dunes that formed on the downdrift side of the latter are today nearly surrounded by tidal marshes. Two other former inlets at Long Cove and Bayberry Dunes (Watch Hill) may have shared a similar history, but documentation is unavailable.

A map showing the principal features of the terrain of federal parts of Fire Island was prepared in 1971 to define areas where geological conditions would limit planning options. The map (figure 23) shows areas of severe erosion, probable locations of former inlets, and other features that had to be located before planning was begun. The map has recently been supplemented by a similar map for non-federal portions of the national seashore.

2. Hydrology

a. Groundwater Hydrology

In central and eastern Long Island, as well as on the barrier islands, groundwater is the only significant source of potable water. Unlike the New York City region, where most of the water supply is imported, land-use planning on the rest of Long Island is closely linked to the quantity and quality of available groundwater.

Both natural and cultural factors influence groundwater supply. Although the amount of precipitation is the major natural control, vegetation types and geological characteristics also influence the amount of

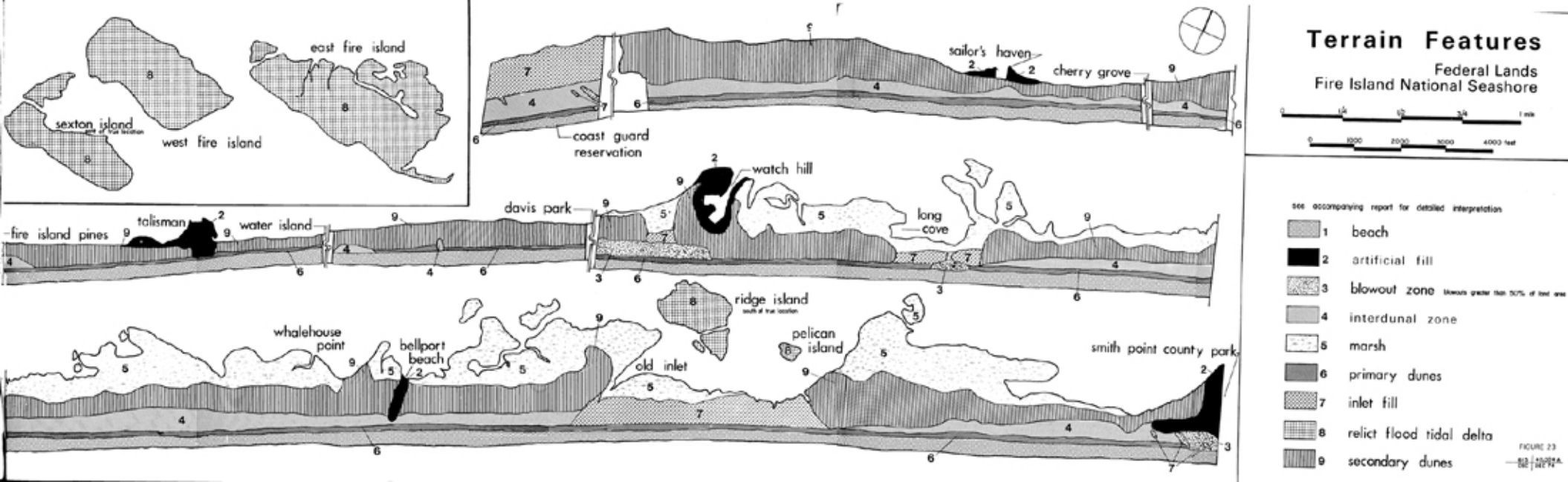
precipitation infiltrating water-bearing strata tapped for consumption and use. On Fire Island, the relation between fresh water and the heavier salt water is an important determinant of water quality.

Certain land uses can have significant effects on groundwater recharge. The water-bearing strata, or aquifers, beneath Fire Island slope steeply downward toward the southeast. Although deep below the surface of Fire Island, these aquifers become progressively nearer the surface on mainland Long Island to the north (see figure 18). In parts of Long Island, the aquifers are covered only by a relatively thin surface layer of recent geologic materials. These materials are freely infiltrated by precipitation, which recharges the aquifers. When these recharge areas become covered by buildings, pavement, and other impermeable surfaces, water no longer infiltrates the aquifers. Rainfall and meltwaters are shunted rapidly to streams and ultimately to the ocean by storm sewers, and they are therefore unavailable for the groundwater recharge. Eventually, reduced recharge will lower the water pressure in the aquifers and cause progressive intrusion of saline water from the southeast, which would be discernible first on Fire Island.

Use of water on Fire Island by residents and visitors can affect local water supplies if a particular water-bearing stratum is unable to meet the demand. Reduced pressure in the aquifer and increased risk of saltwater contamination can occur in both confined and unconfined strata.

Although the entire 1,900 feet of bedded sediments beneath Fire Island are hydraulically interconnected, three sediment beds are particularly permeable: recent beach deposits (0 to about -40 feet), the Magothy formation (existing seashore wells tap this formation at -300 to -600 feet), and the Lloyd sandbed of the Raritan formation (below -700 feet; no wells tap this deep aquifer in the seashore). The recent beach deposits constitute the water-table aquifer recharged directly by local precipitation.

Near the center of Fire Island, the local water table is as high as 2 feet above mean sea level. The aquifer discharges into the bay and ocean and is subject to saltwater intrusion under conditions of excessive pumpage and/or prolonged drought. Although most Fire Island residents are served by community water systems, older homes often have wells that tap only the subsurface aquifer. The water typically is slightly brackish and is used largely for irrigation, laundry, and other domestic purposes, but not for drinking. Only Water Island has no community water-supply system, and depends on the subsurface aquifer for


Terrain Features
Federal Lands
Fire Island National Seashore
see accompanying report for detailed interpretation
1 beach
2 artificial fill
3 blowout zone
4 interdunal zone
5 marsh
6 primary dunes
7 inlet fill
8 relict flood tidal delta
9 secondary dunes
FIGURE 23
east fire island
sexton island
west fire island
sailor's haven
cherry grove
coast guard reservation
watch hill
fire island pines
talisman
water island
davis park
long cove
ridge island
whalehouse point
bellport beach
old inlet
pelican island
smith point county park

most of its domestic water supply, except for drinking water, which is brought in from outside. This community has a low level of development and is flanked on both sides by federal lands, so the subsurface aquifer has adequate recharge to meet present demand.

Nineteen community wells, three federal wells, and at least three wells serving non-federal public recreation areas tap the Magothy formation. The aquifer produces high-quality water with no present evidence of saltwater contamination. Yields are good to excellent and vary from 30 to 500 gallons per minute. Pressure surface levels reach +20 feet above mean sea level.

The adverse effects of progressive urbanization of Long Island and its barrier beaches diminish from west to east. Water-table depth, saltwater contamination, and pollution from sanitary wastes increase as density of settlement increases westward. Hydraulic conditions that have developed under the western beaches are useful in predicting the tolerance of the more easterly beaches to increasing urbanization pressures. On western Long Island, natural recharge areas are densely urbanized. The barrier beaches have been graded, developed, and paved. Except for parts of the deep Lloyd aquifer, the groundwater reservoir in Brooklyn and Queens is contaminated. In Nassau County, the Lloyd still produces fresh water, but portions of the Magothy formation are contaminated, particularly in the western part of Long Beach, an intensively developed barrier-island community in the extreme southwestern part of the county. While some saltwater contamination of aquifers is known to have occurred in this area prior to extensive pumping and urbanization, progressive declines in artesian heads and increases in salinity have occurred during this century. The correlative evidence for a cause-and-effect relationship is substantial.

In eastern Nassau and all of Suffolk Counties, there has been no documented decline in artesian heads or increase in salinity. The rate of saltwater encroachment under existing conditions of increasing development is not known with certainty. According to one estimate for southern Nassau County between 1950 and 1960, the salt line was moving northwestward at about 100 feet per year (Perlmutter, Geraghty, and Upson 1959). However, even if valid, the long-term effect of this rate of landward incursion is difficult to predict because it is not known where the present artesian salt lines are located. In addition, the rate of urbanization on Long Island, which may be closely linked to the movement of the salt line, will depend on future economic trends, land-use controls, and other factors difficult to predict.

On an average summer day, the communities in the national seashore consume about 1.2 million gallons of water, and public recreation areas about 0.2 million gallons. There is no evidence that past and current use of groundwater on Fire Island has substantially depleted the groundwater reservoir of the deep Magothy aquifer. During the summer season, the seashore accounts for only about 1.5 percent of the daily pumpage from deep aquifers in Suffolk County. This percentage would decrease if urbanization on the mainland were to intensify more rapidly than on Fire Island. According to one estimate, groundwater use in the county is likely to double by 1990, a rate that is unlikely on Fire Island. The availability of high-quality groundwater on Fire Island is much more likely to be influenced by progressive urbanization of the recharge areas in central Long Island than by potentially increased pumpage on the island itself.

b. Surface Hydrology

Fire Island consists of unconsolidated sands highly permeable to water. Rainfall and meltwaters infiltrate these deposits and recharge near-surface groundwater lenses. There are no streams, and the only open freshwater areas consist of a few small ponds and bogs in places where the water table is either permanently or intermittently at the surface.

Because of its position at the interface of land and sea, Fire Island is extremely vulnerable to flooding during major storms. The most severe flooding typically takes place during great tropical hurricanes, with sustained winds averaging 125 mph or more. These storms pass through the New York coastal region about three times per century. However, other storms--both tropical and extratropical--cause moderate damage somewhere on Long Island about once a year.

Severity of flooding is influenced by the intensity of a storm, its rate of movement, and its track with respect to Fire Island. Strong longshore winds, such as occur during the winter northeasters, can create destructive currents that severely damage beaches and dunes. Under such conditions, the surf becomes a swift-running river eroding its banks, which in this case are the beaches and dunes. Severe flooding may occur if the dunes are breached. However, during average intensity storms rainwater causes the greatest flooding.

High storm tides, usually associated with strong onshore winds, occasionally overwash the dunes and cause flooding of lands behind them. The Great Atlantic Hurricane of September 1938 inundated all dunes less than 18 feet above mean sea level.

Bayside flooding often results when a severe storm passes over the island. As the storm approaches, high tides and severe onshore winds push water into the bays through the inlets and sometimes over parts of the island. The winds caused by low barometric pressures set up waves in the shallow bay, which tend to cause the water to pile up on the mainland side. This pile-up, augmented by water from rain-swollen streams on Long Island, may cause flooding of low-lying lands on Long Island. As the storm passes, the wind shifts direction and pushes the water southward, sometimes flooding the barrier island from the bayside. In some storms, the bayside flooding is more severe than the flooding from the ocean side, particularly if there has not been extensive breaching of the dunes, which would otherwise allow bayside water to return to the ocean.

The Federal Insurance Administration, which provides federally subsidized insurance to private interests in flood-prone areas, has identified Fire Island as a special flood-hazard area. The agency has established certain building standards to be met if a community is to be eligible for federally subsidized insurance. At Fire Island, lands extending 100 feet landward from the crest of the ocean-facing dunes are identified as areas "subject to special flood hazards with velocity." In this zone, the first floor of all structures must be at least 11 feet above sea level. Behind this zone is a second zone, where first floors must be at least 7 feet above mean sea level. In the wider parts of the island, from Kismet to Point O'Woods, the second zone varies from about 400 to 1,000 feet in width; where the island is narrow (from Cherry Grove to Davis Park), all lands behind the dune zone are included. A third zone is defined on the bayside of the island in places where the island is particularly wide (notably from Kismet to Point O'Woods). This zone, which varies between 100 to 1,800 feet in width, contains structures whose lowest floor must be at least 5 feet above sea level.

The tidal marshes and adjacent lands of the William Floyd Estate with elevations less than +5 feet are also in a special flood-hazard area. Higher ground in the central and northern parts of the estate are rated as subject to "moderate flood hazards."

Existing Federal Insurance Administration regulations do not require structural adaptations, such as pilings, to increase the resistance of structures on the barrier island to flood damage. Therefore, a home built on a 12-foot-high dune without adequate pilings would still be eligible for flood insurance, even though storm tides might rapidly erode away the dune beneath it.

All development on Fire Island should be built above the 100-year flood elevation, and all town building codes should require structural modification appropriate to a flood-prone area. Because many of Fire Island's existing structures were not built to withstand flooding, and because of the narrowness of the beach, the next major hurricane is likely to be extremely destructive.

3. Soils

a. Fire Island

Most of Fire Island's surface has been naturally formed by materials deposited or reworked by wind or water, and except in the bayside tidal marshes, soils are almost exclusively sands.

The surface deposits on the beach typically are layered, the particle size of the layers depending on the energy of the depositing waves. The predominant material of the beach is white quartz sand of varying grain size, although occasional layers of heavy mineral sands, such as garnet, appear as colored bands between the white sand strata.

Between the beach and the tidal marsh, surface deposits are transported by onshore winds from the beach to the dunes and from the dune zone to areas behind it. When the blowing sand encounters a stationary object, such as a sand fence or zone of vegetation, the sand drops to the ground, causing a buildup of material. The stability of sand in a particular area depends on the amount and type of vegetation, the area's orientation with respect to prevailing winds, the configuration of the local topography, susceptibility to flooding, and other factors. In most places, no distinct soil structure, which is usually indicated by the development of discrete zones called soil horizons, is present. However, forested areas behind high secondary dunes that have been stable for a century or two support rudimentary soils in which there are layers of surface litter, humus, and several weakly defined subsurface zones in the subjacent sand. The soils of inland Fire Island place severe constraints on development. Low-lying areas between the dunes have seasonally high water tables and are occasionally subject to flooding during storms, especially if not protected by well-developed dunes. Rapid infiltration rates in coarse sands increase the likelihood of contaminating near-surface groundwater lenses from septic tank effluents or leaching from dumps and sanitary landfills. The erodibility of Fire Island's inland soils constrains the development of trails, dune crossings, and building sites, because scars due to damage or clearing of vegetation would become major erosional areas. In general, zones of exposed bare sand may be subject to severe erosion.

Tidal marshes along Great South Bay and Moriches Bay contain a layer of organic materials and sediments ranging from a few inches to several feet thick. This surface muck is underlain by pale gray to white sands. Most of Fire Island's marshes are believed to have developed on tidal flats deposited following the storm-induced opening of inlets. A lesser percentage of the marshes may have developed on overwash fans created when storm waves breached the dune lines and pushed sand into the bay. Because of their value to marine ecosystems and their susceptibility to frequent flooding, tidal marshes are unsuitable for most forms of development. In fact existing state and local regulations and regulations currently being formulated under the federal coastal zone management program severely limit development of tidal marshes.

Small areas of Fire Island were formed as a result of man's manipulations. Some areas, such as the parking lot at Smith Point County Park, have been graded and paved. Others, such as the Point O'Woods dump, consist of man-made land containing sand, garbage, broken concrete, and other materials. Still others, such as Bellport Beach and most of Smith Point County Park, are fill areas, containing materials of variable composition. Some fill areas contain dredged bay-bottom materials high in silt and clay, while others are mostly sand. One large fill near Forge Point contains organic duck-farm wastes. The material, which has formed a hard surface crust, appears to inhibit recolonization by native plants.

Man-made land and fill areas may provide suitable sites for development, depending on the physical and chemical characteristics of the materials used, the elevation of the land, and other factors.

Soil maps for Fire Island and the William Floyd Estate are available and have been used in planning for the development of these specific areas. However, they are not presented here because of space limitations.

b. William Floyd Estate

The William Floyd Estate on Long Island extends from the tidal marshes along Moriches Bay about 1.5 miles inland to areas as high as 15 feet above mean sea level. The property therefore illustrates a variety of soil types typical of southern Suffolk County.

Along the bay shore, tidal marshes range from 0.2 to 0.4 mile wide and are regularly flooded. Soils with a seasonal water table at or near the surface extend inland from the marshes; four soil types have been identified in this zone, which is intermediate between the

upland areas and the tidal marshes. The generally forested uplands of the northern two thirds of the estate contain sandy soils typical of the glacial outwash plain of the south shore of Long Island. Three upland soils have been identified.

The muck of the tidal marshes is unsuitable for development because of frequent flooding. The intermediate soils are sandy to loamy in texture, are moderately to rapidly permeable, and during rainy periods may have seasonally high water tables about 1 to 2 feet below the surface. Flooding occurs periodically, and the soils are generally unsuitable for septic-tank/leach-field systems. The three coarse-textured upland soils are well drained and suitable for many types of development.

4. Climate

Fire Island has a temperate maritime climate. The proximity of the sea moderates extremes of temperature so that minimum winter temperatures and maximum summer temperatures are relatively mild. The mean annual temperature is about 50 degrees Fahrenheit, while recorded extremes to date have been -10 degrees and +100 degrees. January and February are the coldest months; July is the warmest. The average frost-free period is about 180 days a year. During the winter, Great South Bay rarely ices over completely, although coves, lesser bays, and especially the shores along marshes frequently freeze for several weeks at a time in January and February.

An annual precipitation of about 45 inches per year tends to be evenly distributed throughout the year. Precipitation at Fire Island results from cyclonic storms in winter, spring, and fall, thunderstorms in the summer, and hurricanes in the late summer and fall. Measurable precipitation occurs about once in every 4-1/2 days. Snow falls periodically from October to April, but rarely remains on the ground for more than a few days. In winter, Fire Island is normally snow-free. Relative humidity varies little with the seasons and averages about 75 percent. High humidity can make the climate uncomfortable, particularly in the winter when wind chill factors may be high. An average year contains about 29 percent clear days (0 to 30 percent cloudiness), 36 percent partly cloudy days (40 to 70 percent cloudiness), and 35 percent cloudy days (80 to 100 percent overcast).

Fire Island's climate is most suitable for outdoor recreation between April and October, and is not conducive to substantial outdoor winter use. The east-west trending Fire Island has primarily onshore winds during spring and summer, and offshore winds during the winter. Mean annual wind speed at New York's LaGuardia Field during

1951-60 was about 13 mph. Since the critical speed for the movement of sand particles is 8.9 mph, loose or unprotected sand on the island may be expected to shift with the wind, although distance traveled is a function of both wind speed and sand wetness. The strongest and driest winds generally occur in November and December, but are offshore; hence, sands moved by wind during these months would be blown towards the ocean, rather than the bayside marshes. Frequent and severe storms play a major role in the modification of the barrier-island environment. The storms tend to occur as late summer or autumn hurricanes or as wintertime northeasters. The average frequency of major destructive storms (including hurricanes but not limited to hurricanes) is reportedly one every 10.1 years.

5. Vegetation

The vegetation of Fire Island is diverse and reflects great variation in such environmental factors as wind, salinity, the availability of soil moisture, and the extent of human activity. The gradient in the intensities of each environmental factor across the island is neither gradual nor uniform, causing the floristic composition of the vegetation to change abruptly in many places. Many habitats are so severe that only a few plant species can survive; yet in scattered protected habitats many species may thrive.

Onshore winds desiccate vegetation on the oceanfront dunes and periodically mist the vegetation with salt spray. Roots and underground stems of plants stabilize dunes. Leaves and aerial stems of plants trap wind-blown sand, which may eventually engulf and cover low vegetation. Eventually a dynamic equilibrium becomes established whereby the plants help stabilize the dunes and the vegetated dunes ameliorate the harsh environmental conditions for plants growing behind the dunes. Because of this process, the diversity of plant species generally increases with distance from the ocean and the density of cover.

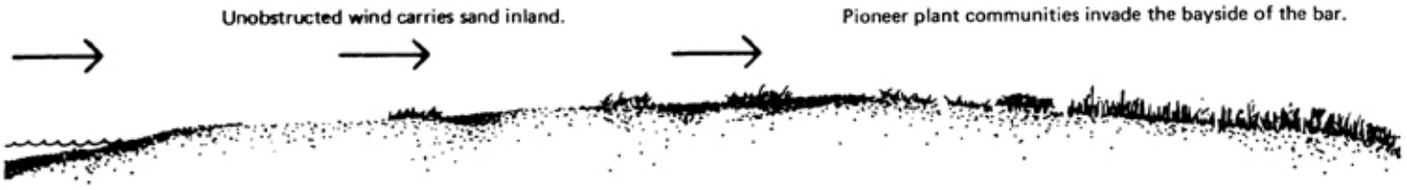
If primary dune or swale vegetation is disturbed by trampling or vehicles, the sand may be moved about by the wind. Vegetation develops slowly on bare sand, and the early colonizing plants in many places are beach heather and seaside goldenrod. These species also are associated with sites disturbed by other agents. Beach grass normally is absent from surfaces that are being actively eroded.

On backdunes, dunelets, secondary dunes, and in swales, shrubs grow with many other species of herbaceous plants, and they may form dense thickets over many acres. Winds and salt spray that pass over the foredunes or through gaps in their crests control the height

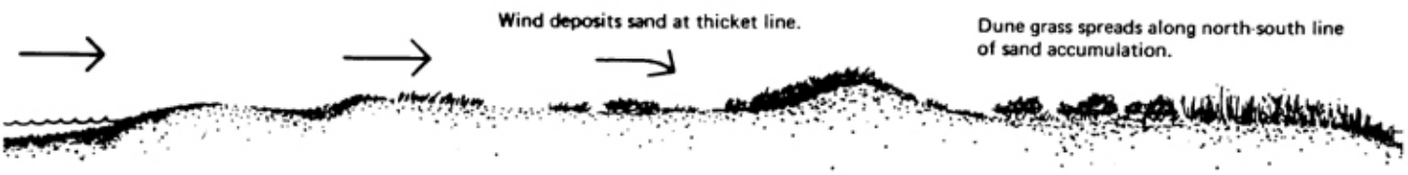
Cross Sections of Barrier-Island Development

Typical of Fire Island

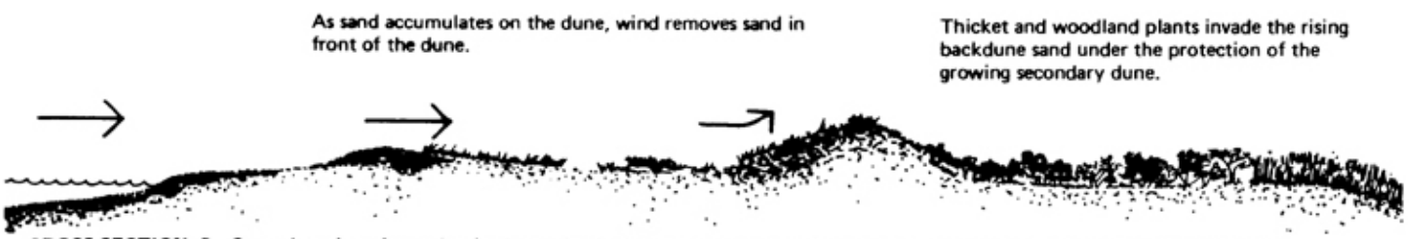
Figure 24.



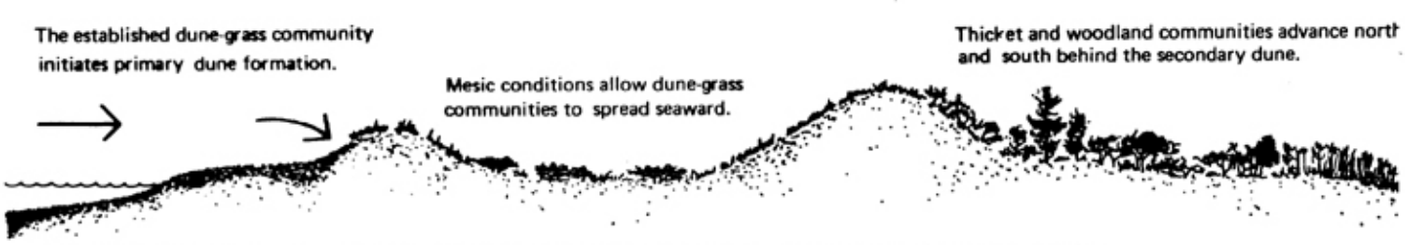
CROSS SECTION 1 A sandbar is created by deposition from large waves breaking offshore.



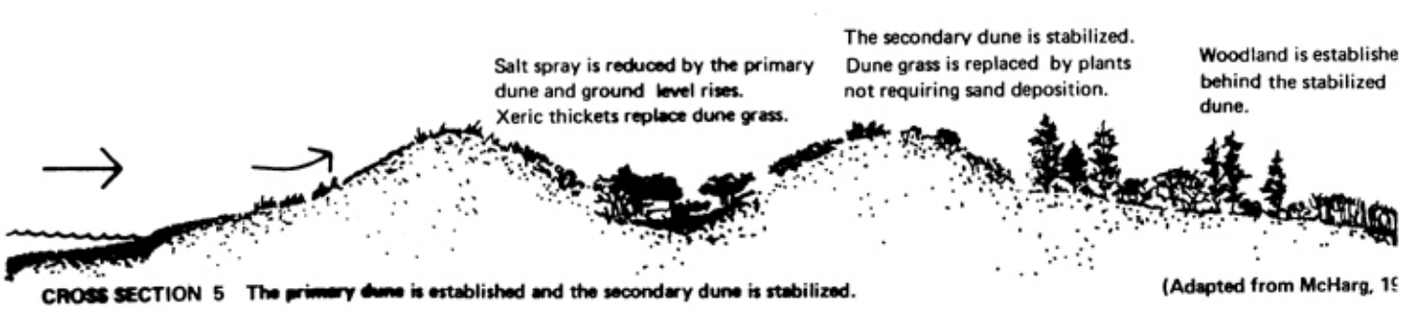
CROSS SECTION 2 Dune formation begins at the thicket line with deposition of windblown sand.



CROSS SECTION 3 Secondary dune formation begins as the dune-grass community is established. Sand is removed from front of the dune.



CROSS SECTION 4 The dune-grass community advances seaward to the high-tide line. Primary dune formation begins.



CROSS SECTION 5 The primary dune is established and the secondary dune is stabilized.

(Adapted from McHarg, 19

of the shrub canopy, and the height increases northward, away from the ocean. The shrubs of the backdune zone can tolerate limited burial by sand.

In swales behind the dunes, the availability of soil moisture, the salinity of the water, and the depth to the water table are major determinants of the distribution of vegetation types and of the floristic composition of vegetation on Fire Island. Where the surface of the porous sand is more than a few feet above the water table, soil moisture fluctuations may be critical for plant survival. Many such areas support shrub thickets or temporary herbaceous vegetation types. Small depressions in which the freshwater table is at or near the surface during much of the year support bogs or marshes.

On the bay shore, extensive salt marshes occur in areas subject to inundation by salt water. The floristic composition of salt-marsh vegetation is related closely to the salinity of the water and to the frequency of inundation. Nearly all of the extensive salt-marsh grasslands on Fire Island have been ditched for mosquito control. These ditches increase the inland flow of brackish tidal waters and probably have disturbed the natural zonation of salt-marsh vegetation. Both marsh and upland vegetation have been subject to an unknown degree of grazing by cattle and sheep, but virtually no records of grazing on Fire Island are known from the 20th century.

The preceding narrative describes the environmental factors affecting plant distributions on Fire Island and figure 24 graphically illustrates typical plant distributions that occur in response to these microenvironmental conditions. Table 21 presents a general description of major vegetation types and subtypes for Fire Island. A complete list of common and scientific names of plants mentioned in the text, tables, and figures is contained in "Environmental Inventory of the Fire Island National Seashore and the William Floyd Estate, Suffolk County, New York" (McCormick and Associates, Inc. 1975).

The William Floyd Estate is located on Long Island and has been occupied by one family since the 18th century. This 612-acre estate supports a diverse mosaic of forests, thickets, and herbaceous plant communities characteristic of southern Long Island (table 22).

For many years the estate has been manipulated to increase its attractiveness to wildlife species. Fields, meadows, and access roads are cultivated or mowed at intervals to prevent encroachment by forest and high thicket. Rye is planted annually in some fields; other fields contain hedgerows, lespedeza, and multiflora rose for wildlife habitat. Two large and two small artificial ponds

TABLE 21

GENERAL DESCRIPTION OF MAJOR VEGETATION TYPES AND SUBTYPES, FIRE ISLAND NATIONAL SEASHORE
(Based on surveys of seashore lands, 1971 and 1974.)

Vegetation Type or Subtype	Distribution[1]	Principal Species[2]	Occurrence	Best Example(s)	Habitat Value[3]
WETLANDS					
Bayside Tidal Marshes Low-Water Cordgrass Low Marsh	1	*Low-water cordgrass,* saltwort, glasswort (samphire), spreading orach, hairy sea blite, maritime sea-blite	Areas subject to flooding by normal tides; outermost tidal marsh zone	East Fire Island, Ridge Point	1
High-Water Cordgrass High Marsh	1	*High-water cordgrass,* black grass, Russian thistle, samphire, spike grass, three-square rush, maritime sea blite	Areas subject to occasional flooding (about twice a month)	High dune management unit[4]	3
Black Grass/Spike Grass/Three-Square Rush High Marsh	2	*Black grass, spike grass, three-square rush,* high-water cordgrass	Areas flooded by storm tides only	High dune management unit	3
Goldenrod/Rush/ Three-Square Rush High Marsh	3	*Narrow-leaved goldenrod, grass-leaf goldenrod, rush, three-square rush,* marsh pink, sweet pepperbush, New York aster, gerardia, swamp rose, salt-marsh fleabane, etc. Most diverse vegetation on Fire Island	Areas flooded by high storm tides only; fresh to slightly brackish water; most inland zone, often in interior of island and isolated from tidal influence	Southeast of Hospital Island, tract 2.	2
Marsh Elder/Groundsel Bush Tidal Swamp		*Marsh elder, groundsel bush,* various high-marsh species	Along mosquito ditches in high marsh (marsh elder only); inland marsh borders.	High dune management unit	4

Vegetation Type or Subtype	Distribution	Principal Species	Occurrence	Best Example(s)	Habitat Value
Common Reed Grassland	2	Common reed	Inland marsh borders, occasionally farther inland in areas of impeded drainage; often along bay where tidal marshes are absent	West Fire Island, John Boyle Island, scattered locations in high dune management zone	5
Cattail/Cranberry/ Rush Marsh	4	*Narrow-leaved cattail, spike rush, rush, sphagnum, large cranberry,* water smartweed, marsh rose, seaside spurge, marsh fern, saltmarsh fleabane, poison ivy, etc. Floristic components highly variable	Very restricted depressions in interior areas; fresh water, sometimes at base of dunes, sometimes occurring as incipient bogs	Lighthouse tract, eastern unit of Robert Moses State Park, and scattered elsewhere on Fire Island	2
UPLAND VEGETATION					
Beach Grass Grassland	1	*Beach grass* – behind primary dunes, pure or in mixture with beach heather, seaside goldenrod, golden aster, bearberry, Virginia creeper, poison ivy, beach plum, or bayberry. On primary foredunes with sea rocket, dusty miller, beach pea, seaside goldenrod, poison ivy, or Virginia creeper.	Primary dunes, interdunal swales, disturbed upland sites; occasionally on high ground bordering the bay; common on dredged material	Common throughout; best pure stand between Smith Point West and Hospital Island	3
Beach Heather Dwarf Scrub	2	*Beach heather,* usually pure or mixed with beach grass	Blowouts and recently disturbed areas of bare sand; early successional vegetation	Lighthouse tract, scattered elsewhere on Fire Island	4

Vegetation Type or Subtype	Distribution	Principal Species	Occurrence	Best Example(s)	Habitat Value
Bearberry Dwarf Scrub	3	*Bearberry*, pure or mixed with beach grass or beach heather	Primary backdunes and interdunal swale, usually on recently disturbed areas	Lighthouse tract, Watch Hill area	4
Beach Plum/Poison Ivy/Bayberry Low Thicket	1	*Beach plum, poison ivy, bayberry, Virginia creeper, black cherry, red chokeberry*, wild roses, blackberry, catbrier, sawbrier, wild grape	Primary backdunes, interdunal swale, secondary foredunes	Between Fire Island Pines and Davis Park	2
Black Cherry/Bayberry/Highbush Blueberry/Chokeberry High Thicket	1	*Black cherry, bayberry, high-bush blueberry, chokeberry*, Virginia creeper, poison ivy, wild roses, wild grape, catbrier, sassafras, shadbush, inkberry, shining sumac	Protected areas of primary back dunes and swales; on uplands landward of low thicket zone	Between Fire Island Pines and Davis Park	2
Pitch Pine Woodland	2	*Pitch pine*, poison ivy, Virginia creeper, bayberry, catbrier	Protected depressions, usually in secondary dune areas near the northern border of upland vegetation with Great South Bay or wetland vegetation types	Southeast of Robinson Cove to Whalehouse Point, west of Watch Hill, Lighthouse tract, between Goose Point and Old Inlet	2
American Holly/Sassafras/Shadbush Broadleaf Forest	3	*American holly, shadbush, sassafras, black gum, black cherry*, black oak, pitch pine, red maple, red cedar (major overstory species)	Protected areas behind high secondary dunes	Sunken Forest to Point O'Woods	1

[1] Distribution key: 1. very widespread 2. widespread 3. local 4. very local

[2] Scientific names of vegetative species are found in "Natural Resources Inventory of Fire Island National Seashore" (McCormick Associates 1971). Most common of dominant species are underlined.

[3] Habitat value key: 1. very high 2. high 3. moderate 4. moderately low 5. low

[4] Between Watch Hill and Smith Point West

TABLE 22

VEGETATION OF THE WILLIAM FLOYD ESTATE, FIRE ISLAND NATIONAL SEASHORE

Vegetation Type	Principal Species	Occurrence and Characteristics
UPLAND FOREST		
Oak Forest	Red oak, white oak, shagbark hickory, mockernut hickory	Uplands free from major disturbance in recent past. Covers about 50 percent of the estate. Understory less dense than in other forest types. Canopy is dense, typically more than 30 feet high.
Black Locust/Black Cherry Forest	Black locust, black cherry, sassafras, red maple, winged sumac, oak saplings, pitch pine	Uplands possibly encouraged by fire. Successional forest. Trees typically less than 12 inches dbh. Canopy relatively open, less than 30 feet high; understory dense.
LOWLAND FOREST		
Tupelo/Groundsel Bush/ Swamp Forest	Tupelo, groundsel bush, red maple, white oak	Lowlands with high water table between uplands and either open water or tidal marsh; often grades into swamp thickets of groundsel bush and marsh elder. Best developed in central part of estate. Canopy moderately dense, sometimes exceeding 30 feet, dense understory of shrubs.
THICKETS		
Arrowwood/Black Cherry/ High Thicket	Arrowwood, black cherry, sumac, sassafras, black locust, oak saplings, summer grape	Uplands. Probably transitional to oak forest on previously disturbed areas. Dense thicket, 10-20 feet high.
Sassafras/Winged Sumac/ Scrub	Sassafras, winged sumac, eastern red cedar, black locust, black cherry	Uplands. Open thicket with understory of grasses and old-field forbs. Early successional stage following abandonment of cultivation, probably transitional to arrowwood thicket or oak forest. 2-8 feet tall.
Hedgerows	Russian olive, Engelmann spruce, Scotch pine, shortleaf pine, Austrian pine	Uplands. Planted in or near cultivated fields. If not maintained, typically invaded and replaced by native communities.

Vegetation Type	Principal Species	Occurrence and Characteristics
HERBACEOUS VEGETATION TYPES		
Upland Meadow	Upland grasses and old-field forbs	Uplands. Maintained by mowing, common along roadways. Replaced rapidly by thickets if not maintained.
Cultivated fields	Winter rye, lespedeza, old-field herbs and shrubs	Uplands. Maintained by periodic cultivation.
Residential land	Lawn grasses, cultivated ornamentals	Uplands in vicinity of the manor house and appurtenant structures.
Common Reed Grassland	Common reed grass	Lowlands, usually on slightly higher ground between open water or tidal marsh and the tupelo forests. Locally abundant around artificial ponds. Understory sparse. To 12 feet tall.
Tidal Marsh	Low marsh cordgrass, high marsh cordgrass, spike grass.	Lowlands bordering Moriches Bay and lower portions of Home Creek and Lawrence Creek. Ditched for mosquito control.

in the tidal marshes and lowland forest serve to attract birds; the easternmost large pond is natural.

Virtually all land on the estate that lies below +10 feet mean sea level was flooded during the hurricane of 1938. Most large red oaks, the dominant upland species at that time, were uprooted or broken by the high winds.

6. Wildlife

a. Marine

Fire Island forms an interface between two distinctly different marine environments. The Atlantic Ocean (neritic zone) borders the southern exposure of the island, and Great South Bay (estuarine zone) borders the northern exposure.

The high productivity of phytoplankton, eelgrass, and the cordgrass marshes is maintained by the nutrient rich waters of Great South Bay. The high primary productivity is cycled into many diverse food webs that include fish, shellfish, and other valuable wildlife resources utilized by man.

The permanent animal communities of the intertidal zone of Great South Bay are generally similar to those occupying the intertidal zone on the oceanside of the barrier island. Although where the bayside intertidal zone includes cordgrass marshes, the faunal diversity increases. This is largely caused by detritus, which is utilized by many organisms for food and is washed into the bay from the adjacent marshes. The productivity of these marshes also significantly influences the production of economically important shellfish--oysters, blue mussels, bay scallops, hard-shell clams, soft-shell clams, and blue crabs.

Eelgrass, which also significantly contributes to the detritus food web, is important in providing a productive habitat for waterfowl. The eelgrass serves as habitat for many organisms, which are used for food by waterfowl.

Great South Bay has optimal water depth, salinity, water temperature, and productivity to sustain a high shellfish harvest. Some of the best Great South Bay shellfishing beds are located along the north shore of Fire Island. Shellfishing is one of Long Island's oldest and most important marine-related industries. The dockside value of the commercial shellfish harvest there is more than six times that of finfish. Shellfishing is also a

major recreational activity, which provides food for thousands of Long Island residents (see figure 25).

In past years, Great South Bay was home of the famous Blue Point oyster industry. During the first decade of this century, the bay was producing more than 2 million pounds of marketable oysters each year. At its peak, the oyster industry produced a crop valued at $50 million and employed 3,000 people.

The sudden decline of the industry during the 1940s is well documented. The salinity increase due to the opening of Moriches Inlet may have decreased the survival of young oysters. Another problem was an increase in two predators, the oyster drill and starfish, which are favored by increased salinity. In 1964-1965 heavy mortality to oysters was caused by MSX; however, MXS-related mortality is not a problem in the bay at the present time. Duck farm wastes and other water pollution sources caused increased blooms of the Nannochloris algae. These algal blooms produce shellfish mortality by means of three mechanisms: the algae suppress growth of other organisms necessary for shellfish growth; the algae clog shellfish's ciliary feeding mechanism; and Nannochloris may be directly toxic to shellfish.

It now appears that the oyster is starting to make a comeback. In 1968, the oyster population increased for the first time in 15 years, and it has been increasing ever since.

Total shellfish landings vary greatly from year to year, but presently, the leading bay industry is harvesting hard-shell clams. In 1972, the hard-shell clam catch was valued at more than $13 million at dockside. The annual U.S. production of hard-shell clams has been valued at $100 million, and New York leads the nation in production. About 95 percent of the value of the New York harvest comes from Long Island's south shore. The bay scallop industry, however, has been declining in recent years. A 23-year low was reached in 1972. The reason for this decline is not clear, but there seems to be a reduction of the species throughout its geographical range.

The future of shellfishing in Great South Bay will be eventually determined by the balance between beneficial and detrimental actions, which are affecting water quality there. The general reduction in duck farm effluents and the initiation of more environmentally compatible farming methods in the region have reestablished water quality conditions conducive to the cultivation and propagation of shellfish. However, the availability of shellfish for commercial harvest has been significantly reduced by closure of more than 10 percent of

Figure 25

Hunting, Fishing, and Shellfishing

Fire Island National Seashore

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the north-shore shellfishing grounds due to water pollution from various other sources.

Great South Bay is an important spawning and nursery ground because of its abundant food supply. A recent study has shown that at least 40 species of fish regularly inhabit the bay and that this diversity of fishes is related to aquatic vegetation.

Commercial fishing is relatively unimportant in the bay. Species harvested commercially include eel, flounder, fluke, striped bass, white perch, and silversides. In 1968, commercial fish landings in Great South Bay totaled 268,000 pounds, worth only about $50,000 out of the total $2,880,000 catch computed for all Long Island marine waters. However, 75 percent of the 1968 commercial catch value was represented by species that depend upon the estuaries at some stage in their life history, and an estimated 67 percent of all commercially important species found on the continental shelf are dependent upon estuaries.

In contrast, bay sport fishing was worth $5 million in 1968, and its effect on the economy of Long Island is greater than $100 million annually. Fluke and winter flounder make up 90 percent of the sport fishing catch. Other important species are striped bass, blowfish, bluefish, blackfish, seabass, and scup. Between 1956 and 1960, Great South Bay was fished by more than 250,000 anglers each year.

Undoubtedly, increased leisure time and increased population in the Long Island area will affect the sports fisheries in Great South Bay. The larger demands probably will be made on the fluke, winter flounder, weakfish, and snapper. Fluke use the bay as a nursery ground. Tagging operations indicate that young fluke leave the bay over winter and then return. Fishing pressure, which removes 20 percent of the population each summer, may be responsible for the decline of this species since the early 1950s. As with shellfishing, the best sport fishing in the region was in the vicinity of Fire Island.

In contrast to the high productivity of Great South Bay, the neritic zone of the Atlantic Ocean is relatively sterile. In this nearshore water zone productivity increased as the distance from shore decreased, probably as a result of land-derived nutrients.

The open water of the Atlantic Ocean along the southern shore of Fire Island does not provide the protection for organisms that is afforded by the less turbulent, estuarine waters of Great South Bay. Although few ocean habitats are available to organisms other than

free-swimming forms in the nearshore water, a number of invertebrates, including the economically important surf clam, dwell in the bottom of the continental shelf along Fire Island.

Sandy beaches within the intertidal zone (i.e., that portion of the shore alternately exposed and inundated by tides) support algae, bacteria, and a few species of small crustaceans and worms, which can be locally abundant. The intertidal zone is a particularly difficult environment for invertebrate inhabitants; here, they are periodically exposed to drying and extreme temperatures; fish and carnivorous invertebrates feed upon them during high tides; and they fall prey to shorebirds and insects during low tides.

The surf and nearshore waters off Fire Island are inhabited by a wide variety of fishes. However, about 15 species typically comprise more than 90 percent of the total fish catch. Most abundant are six species of herring. Several fish species in the area are rare or uncommon in New York waters. Five potentially dangerous fishes occur in nearshore waters: the sand shark, dusky shark, sandbar shark, roughtail sting ray, and barracuda. Threat to human safety from these animals is minor, and they rarely venture sufficiently close to shore to enter bathing areas.

In offshore waters, flounder, bluefish, fluke, mackerel, cod, whiting, and striped bass are important to the Long Island commercial fishery. The so-called industrial fishery primarily harvests fish not utilized for direct human consumption, such as menhaden, hake, scup, butterfish, and other "trash" fish used in the production of oils and fish meal.

Most of Long Island's commercial finfish catch is from ocean waters south of the barrier islands. The Great South Bay fraction is insignificant. Landing statistics from 1954 to 1972 indicate a downward trend in the total weight of the fish landed by commercial interests, which ranged from 86 to 165 million pounds in the years prior to 1963, but which ranged from only 20 to 67 million pounds from 1964 to 1972. The species composition of the commercial fish catch has fluctuated widely during recent years in most coastal areas. During years of high abundance, menhaden constituted over 80 percent of the weight of total landings, but the catch of this species has declined more rapidly than any other. Four species have shown an upward trend in recent years--yellowtail flounder, black-backed flounder, bluefish, and striped bass. It is unknown at this time whether these changes are the result of natural population fluctuation, pollution, overfishing, or other factors.

Much recreational fishing is done in the surf for striped bass, even during the summer months when other species (such as northern kingfish) are readily available and striped bass is not. The species composition of the surf catch is almost entirely dependent upon striped bass, kingfish, and adult bluefish. The other kinds of sport fishing (from banks, piers, rowboats, open boats, charter boats, and private boats) occur primarily within the bays, and all depend heavily upon fluke, winter flounder, weakfish, snappers, and blackfish.

b. Terrestrial

No significant studies of terrestrial invertebrates have been done on Fire Island or the William Floyd Estate. Only the so-called pest species have received attention, and then the studies were usually directed towards methods of control. However, insects form an important part of the Fire Island ecosystem, both as food for various other organisms and as plant pollinators.

Numerous species of insects and spiders occur, and ticks are locally superabundant from about May to September, particularly on West Fire Island. The latter infest many species of ground-inhabiting or foraging birds, and virtually all species of mammals, particularly rabbits and rodents. Greenhead flies and deer flies are abundant. Mosquitoes of several genera are natural and seasonally abundant components of the marshes and ponds of Fire Island and the William Floyd Estate. Their larval forms are food for fishes, predatory insects, frogs, and many shorebirds, while adults are consumed by more than 100 species of birds and bats. Attempts to control mosquitoes have caused extensive disruption of Fire Island's tidal marshes. (See II.C.7.a.(1) (g), Pesticides.)

Many migratory insects pass through the seashore, particularly following autumn cold fronts, when hundreds of migrating dragonflies and monarch butterflies can be seen. In September 1973, monarchs numbering in tens, scores, and sometimes hundreds of thousands settled in selected pitch pine groves while on migration to their Florida wintering grounds, especially by the lighthouse.

Little work has been done to establish a checklist for any terrestrial vertebrate fauna except birds. There are almost no numerical data on abundance and distribution of species.

Only one species of amphibian, a toad, is known to occur on Fire Island, but there are 12 species of amphibians (frogs, toads, and salamanders) that inhabit the William Floyd Estate. The general lack of suitable

freshwater habitat appears to be the reason there are so few amphibians on Fire Island. There is a greater diversity of reptiles on both Fire Island and the William Floyd Estate, each having seven species of turtles. In addition, there are seven species of snakes on the William Floyd Estate and two species of snakes on Fire Island, none of which is poisonous.

Birds are the best known and most frequently encountered form of wildlife on Fire Island National Seashore. Approximately 352 species have been recorded in the general vicinity of Fire Island. Of the 352 species, about 270 are to be expected annually, while the remainder only occasionally pass through the area.

The breeding land birds of Fire Island and the Floyd Estate have never been examined in detail, but colonially nesting water birds (gulls, terns, shorebirds, herons) have been. Suitable habitat for colonially nesting water birds has been drastically reduced in and near Fire Island, largely because of development and erosion of the beaches and from recreational use of Great South Bay and Moriches Bay. Consequently, these birds have been all but extirpated from the main portion of Fire Island's barrier beach. However, dredging of navigation channels has resulted in the creation of artificial spoil islands in the vicinity of Fire Island, Moriches Inlet, and Shinnecock Inlet. The birds have adopted these sites, and now nearly all the 2,200 pairs of gulls, terns, skimmers, and wading birds nesting in the seashore area are on these islands. In fact, about 75 percent of these birds on Long Island use such sites, emphasizing dramatically their importance as wildlife habitats.

Great South Bay has long ranked with Chesapeake Bay, Barnegat Bay, and Currituck Sound as one of the nation's most valued waterfowl areas. Despite intensive human use, the bay is still heavily used by wildfowl, the most valuable sections being the shallow waters immediately behind Fire Island from Smith Point to Water Island, east of the Smith Point Bridge, and near and on virtually all bay islands.

Although counts of migrant shorebirds on mud and sand flats are not available, the extensive flats on the west side of the large artificial island just north of Moriches Inlet are one of the four or five most important marine shorebird habitats on all of Long Island. The pools in Long Island's last unditched salt marsh of any size, just north of Fire Island Inlet at Oak Beach, support species found nowhere else on Long Island except at a few artificial freshwater ponds in refuges and sancturaries.

Virtually all habitat is used extensively by breeding birds, except perhaps for large stands of reed grass and beach grass. Human disturbance of birds and their habitat is probably the most important factor limiting distribution of breeding birds on Fire Island, but probably far less so on the Floyd Estate.

Twenty-nine species of terrestrial mammals are known to occur within national seashore boundaries. Although their occurrence is uncommon, 17 species of whales, porpoises, and dolphins and two species of seals have been recorded in the marine and estuarine waters surrounding the seashore. Harbor seals are regular at both inlets in winter.

Eight species of bats have been captured at the William Floyd Estate, but on Fire Island only two species have been recorded. Deer mice and meadow voles are abundant in virtually all habitat types. Other species of mice occur, but are less common. Muskrats and Norway rats are numerous on both the barrier beach and mainland. However, squirrels are restricted to the mainland.

Red foxes are very common throughout the seashore, but raccoon are far less numerous on Fire Island than on the William Floyd Estate. Weasels and mink are secretive but locally common predators throughout the seashore.

Cottontail rabbits are abundant throughout the seashore. Permits (which are governed by pertinent state and federal regulations) are issued to hunt rabbits and waterfowl. A herd of approximately 50 white-tailed deer is maintaining itself on the island. The deer have no natural predators on the island, and hunting deer is illegal.

Tables 23 and 24 indicate the potential number of terrestrial species which utilize various habitats on Fire Island and the William Floyd Estate.

No nationally threatened species of amphibians, reptiles, or mammals (excluding marine species) has been recorded from Fire Island, nearby small islands, or the William Floyd Estate. Six species of birds that have been observed at Fire Island are classified by the National Endangered Species Conservation Act of 1969. The brown pelican, bald eagle, peregrine falcon, and Ipswich sparrow are "threatened" nationally; the osprey and merlin are considered "status undetermined" species (U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, 1973).

TABLE 23

NUMBER OF TERRESTRIAL SPECIES EXPECTED TO UTILIZE HABITAT TYPES IN THE FIRE ISLAND VICINITY*

(Species expected to breed are indicated in parentheses)

Habitat	Amphibians	Reptiles	Birds	Mammals	All
Ocean	0 (0)	2 (0)	55 (0)	2 (0)	59 (0)
Bay waters	0 (0)	3 (0)	96 (0)	1 (0)	100 (0)
Freshwater pools	1 (1)	6 (0)	48 (0)	3 (0)	58 (1)
Tidal marsh	0 (0)	5 (0)	129 (8)	6 (3)	140 (11)
Nontidal marsh	1 (1)	6 (0)	95 (6)	11 (3)	115 (10)
Tidal swamp	0 (0)	1 (0)	51 (2)	8 (2)	60 (4)
Common reed grassland	0 (0)	0 (0)	42 (4)	8 (2)	50 (6)
Bare sand	1 (0)	0 (0)	55 (7)	1 (0)	57 (7)
Beach grass	1 (0)	8 (7)	58 (7)	9 (1)	76 (15)
Beach grass/low thicket/ beach heather	0 (0)	3 (0)	61 (7)	11 (3)	75 (10)
Dwarf scrub	0 (0)	1 (1)	52 (0)	6 (4)	60 (5)
Thicket	0 (0)	1 (1)	109 (14)	10 (9)	120 (24)
Broadleaf forest	0 (0)	3 (1)	101 (22)	13 (11)	117 (34)
Pitch pine woodland	0 (0)	2 (1)	113 (23)	13 (10)	128 (34)
Black pine stands	0 (0)	1 (0)	39 (2)	3 (2)	43 (4)
Residential land	1 (0)	1 (0)	35 (11)	8 (4)	45 (15)
All	1 (1)	9 (9)	300 (51)	17 (16)	327 (77)

* Fire Island, surrounding waters, and small islands in Great South Bay and Moriches Bay, Suffolk County, New York.

TABLE 24

NUMBER OF TERRESTRIAL SPECIES EXPECTED TO UTILIZE HABITAT TYPES ON THE WILLIAM FLOYD ESTATE

(Species expected to breed are indicated in parentheses)

Habitat	Amphibians	Reptiles	Birds	Mammals	All
Bay water	0 (0)	9 (0)	68 (0)	3 (0)	80 (0)
Fresh water	11 (11)	10 (0)	65 (0)	3 (0)	89 (11)
Tidal marsh	3 (2)	11 (0)	125 (8)	11 (3)	150 (13)
Common reed grassland	1 (0)	0 (0)	28 (2)	7 (1)	36 (3)
Swamp forest/thicket	11 (11)	10 (9)	125 (22)	11 (8)	156 (50)
Upland forest	10 (10)	6 (2)	105 (21)	24 (20)	146 (53)
Upland thicket	9 (0)	7 (7)	91 (16)	14 (13)	121 (36)
Scrub	0 (0)	6 (5)	80 (12)	9 (6)	95 (23)
Old field	6 (0)	13 (13)	70 (5)	12 (8)	101 (26)
Cultivated field	1 (0)	2 (2)	68 (5)	10 (0)	81 (7)
Residential land	1 (0)	4 (4)	37 (11)	14 (10)	56 (25)
All	12 (12)	13 (13)	290 (52)	29 (28)	344 (105)

7. Environmental Quality

The enabling legislation for Fire Island National Seashore obligated the National Park Service to conserve and preserve "certain relatively unspoiled and undeveloped beaches, dunes, and other natural features. . . which possess high values to the Nation as examples of unspoiled areas of great natural beauty." Implicit in this directive is the maintenance and enhancement of environmental quality, which has always been a major management objective of all units of the National Park System.

a. Water Quality

(1) Great South Bay/Moriches Bay

Great South Bay and Moriches Bay are part of an interconnected series of shallow estuaries that lie between the barrier beach and Long Island from Southampton on the east to Atlantique Beach on the west, a distance of about 75 miles. Water quality in these estuaries is strongly influenced by land-use patterns and development on Long Island and, to a lesser degree, on the barrier islands.

The estuaries are shallow throughout the study area; mean low-water depths range from about 7 feet near the Robert Moses Causeway to about 4 feet in Moriches Bay. Navigation channels have been dredged to facilitate east-west boat traffic along the intracoastal waterway and for access between Long Island and the barrier islands. Most such channels average 6 to 10 feet deep, but some reach 28 feet in places. The bays are used primarily for navigation, recreation, and commercial shellfishing, all of which are essential to the regional economy.

The water in the bays is derived primarily from groundwater seepage from Long Island and tidal inflow through the inlets; surface flow from Long Island streams is relatively insignificant. Tidal influx is largely restricted to the inlets, where the average tidal range is about 4 feet (data for Fire Island Inlet). Near the center of the bay, tidal range is only about 1 foot, decreasing to about 8 inches along the Long Island shore. Tidal currents during flood tides generally flow eastward from Fire Island Inlet and westward from Moriches Inlet, reversing direction on the ebb. Areas of Fire Island nearest the inlet therefore receive relatively efficient flushing of pollutants due to tidal action. In general, however, directional water movement in the bays is slow, and the flushing time is long (a 1972 Corps of Engineers estimate is 48 days for the Great South Bay System). Because of the slow flushing rate, accumulation of

pollutants is a potentially more serious problem in this system than in many other estuaries.

Throughout most of the bay, circulation is strongly influenced by wind. In Moriches Bay, the wind is capable of preventing the normal reversal of tidal currents between ebb and flood tides. Circulation patterns, and therefore the dispersion of pollution from known sources, are difficult to predict because of the great variability in wind-induced water movement.

During the last 20 years, there have been many studies of the chemical and biological characteristics of the south-shore estuary system (Lackey et al. 1950; Guillard et al. 1960; Redfield 1951, 1952; Ryther et al. 1956, 1957, 1958). The following general information forms a useful overview of water quality.

(a) Temperature

Mean temperatures of bay waters range from about 37 degrees Fahrenheit in February to 77 degrees in July, and there is no significant temperature difference between the bottom and the surface of the bay. Freezing of large areas of surface waters during midwinter occurs infrequently. Waters along the Long Island shore average about 2 degrees warmer than elsewhere in the region. (See figure 14 for a map of the region.)

(b) Dissolved Oxygen

Bay waters are normally at or about 100 percent oxygen saturation, indicating good water quality. The high dissolved oxygen levels are probably due to good mixing by winds in these shallow estuaries.

(c) Salinity

Salinity averages about 26 parts per thousand (ppt), ranging from around 22 ppt near the mouths of certain Long Island streams to about 29 ppt near the inlets. By comparison, open seawater averages 35 to 36 ppt. Before Moriches Inlet opened, salinity in this area averaged 10 to 12 ppt. After the inlet opened naturally in 1931, salinity in Moriches Bay increased to 23 ppt, and circulation patterns in the bay developed rapidly.

(d) Turbidity

Bay waters typically are relatively clear, and sunlight penetrates the entire depth of the water column. Temporary increases in turbidity periodically result from disruption of bottom sediments due

to dredging, gouging by propellers of motorized boats, commercial clamming operations, and other cultural sources of direct disturbance, as well as from locally excessive growth of plankton, discharge of turbid wastewater, and increased runoff and disturbance of the bay bottom during storms.

(e) pH

The bay water tends to be slightly alkaline, ranging from pH 7.8 to 8.6. The high pH is due in part to photosynthetic production of carbon dioxide by aquatic plants and algae in this well-illuminated system. As carbon dioxide tends to form alkaline carbonates in solution, a high level of photosynthesis therefore may substantially raise the pH of an estuary. High pH levels are not abnormal for warm, shallow estuaries like Great South Bay.

(f) Nitrogen and Phosphorus

The annual mean total phosphorus level, which includes organic, particulate, and dissolved inorganic components, has been estimated at about 66 to 68 parts per billion (ppb), with an October high of 115 ppb. The total phosphorus level is considered high for an estuary and suggests substantial phosphorus pollution, which may be controllable through reduction cf phosphorus input from known sources on Long Island.

Nitrogen in the form of nitrate followed a similar pattern to phosphorus, with concentrations in the rivers averaging three times that of the bay. The highest levels in the bay were recorded near the mouths of heavily developed streams, the lowest values near the inlets and along most of the north shore of Fire Island. The only elevated nitrate level near Fire Island was recorded near the outfall from the primary sewage-treatment plant at Ocean Beach. This plant is being upgraded to provide secondary treatment, but even after the improvement, substantial nitrogen enrichment will probably still occur in this area. Levels of nitrite and ammonia were also highest on the north shore and lowest near Fire Island. In summary, nutrient enrichment appears to be largely related to land use on Long Island, is most pronounced on the north shore, is least significant near Fire Island Inlet where tidal flushing is greatest, and is generally a less serious environmental problem near Fire Island than elsewhere in the bay.

(g) Pesticides

Pesticide pollution poses a serious threat to the estuarine environment. Low concentrations of DDT and its metabolites are present in shellfish. The Sandy Hook Marine Laboratory noted that DDT, parathion, and detergents in very small quantities immediately affect larval eels and juveniles of many fish species (Ernst 1963).

DDT contamination of the tidal marshes has been severe in recent years. Many species of marine animals, which spend all or part of their lives in the tidal marshes, reportedly have been drastically reduced in numbers. The economic loss has been large, but the damaging effect upon the food chain of the entire ecosystem might be even more substantial. However, it is difficult to determine with certainty whether pesticide contamination has contributed significantly to the reported population declines, as these species are known to undergo large, possibly natural, fluctuations in population size.

The Suffolk County Vector Control Board (formerly the Mosquito Control Commission) has stopped the use of DDT and its derivates already present in the bay, therefore a gradual reduction in the level of these pesticide residues is likely to occur through natural processes.

(h) Bacteria

High concentrations of coliform bacteria indicate serious pollution from domestic sewage or animal wastes. Coliform bacteria and certain pathogenic bacteria with similar habitat requirements can accumulate in the mantle cavity of bivalve mollusks (clams, oysters), making them unsafe for human consumption. Large portions of Great South Bay and Moriches Bay have been closed from time to time by New York State because of elevated coliform levels. The off-limits acreage has been increasing in recent years, which may be due either to increased pollution or simply to increased surveillance by the state. At present, much of northeastern Moriches Bay is closed to shellfishing. Within the national seashore, a small area near the Ocean Beach sewage-treatment plant outfall, the waters adjacent to marinas at Watch Hill, Davis Park, Barret Beach, Fire Island Pines, Cherry Grove, and Sunken Forest have been closed because unacceptable coliform levels have been found.

As of 1970, only 7 percent of Suffolk County was served by sewers. The remaining acreage depended primarily on the traditional septic-tank/leach-field method of primary sewage treatment for

individual residences. Malfunction of these individual systems may be contributing to significant pollution of Long Island's rivers and the estuaries into which they flow. Most of the pollution probably results in increased nutrient levels rather than bacterial contaminants. Effluents from duck farms were a major source of elevated coliform levels in the 1960s, but recent governmental controls and subsequent implementation of pollution-control measures have reduced pollution from this source substantially. In addition, the number of duck farms has also declined.

Even though sewage treatment in Fire Island's communities is almost exclusively by septic tank/leach field (except in Ocean Beach), there is no evidence to suggest that seepage of contaminated groundwater has resulted in elevated coliform levels in the bay. However, recent bacteriological surveys of shellfish-growing areas during periods of maximal recreational activity indicate several locations that may be sources of pollution during such periods. High coliform levels have been recorded near Sunken Forest and Fire Island Pines during the peak visitor season, as well as near Point O'Woods, Cherry Grove, Barrett Beach, and Water Island. High concentrations of small pleasure craft have been suggested as a possible source of this pollution, but the evidence is inconclusive.

The New York Department of Environmental Conservation has recommended that shellfishing restrictions be implemented near the boat basins at Watch Hill and Davis Park/Leja Beach, and testing is underway to determine whether closure of shellfish beds in these areas is necessary. As a general rule, shellfish beds in areas of intensive recreational boating should be monitored frequently to ensure that the public health is not jeopardized.

Coliform levels on Fire Island's bayside beaches are well below the maximum for swimming beaches, and there are no data to suggest that swimming in the bay should be restricted. However, coliform levels in much of the bay have been rising in recent years, and frequent testing will be needed to detect unusual increases in the Fire Island area that might cause swimming restrictions to be imposed.

(i) Plankton

The shallow nutrient-rich waters of the bay support a high level of plankton productivity, which may be greater than in any other estuary in the northeastern United States. In general, plankton blooms occur in midsummer and again in the fall or early winter. Although the long-term effects of algal blooms are not known, the adverse effects of past algal blooms suggest

that any further rate increases in the addition of nutrients--particularly phosphorus--may be harmful to the ecosystem.

(j) Rooted Aquatic Vegetation

Eelgrass (*Zostera marina*) is the predominant rooted aquatic plant of the bay. It typically grows in 7 to 8 feet of water and has leaf blades up to 6 feet long. Adapted to a wide variety of salinities and substrates, it is a major component of the ecosystem, providing valuable food, shelter, and nursery grounds for estuarine biota.

Eelgrass is subject to periodic population declines, during which it may virtually disappear from the ecosystem. Although declines may be linked to a recurring fungus blight, the precise cause is unknown. Eelgrass has become a major problem in the Fire Island region, choking propellers, clogging fishing and shellfishing gear, and littering bayside beaches. The smell of rotting eelgrass is noticeable in many places on Fire Island. Gases from rotting submerged eelgrass in docking areas cause severe discoloration of painted hulls and other surfaces, and the decomposition process itself may result in local oxygen depletion leading to fish kills.

(2) Atlantic Ocean

Water quality in the ocean adjacent to Fire Island is generally good. Salinity ranges from about 24 parts per thousand (ppt) to 33 ppt, or slightly less than the 35 to 36 ppt found in the open sea. The reduction is probably due to dilution by fresh water from the mainland and limited seepage of groundwater from the barrier island. Surface water temperatures range from about 37 degrees during late winter to 70 degrees in late summer, averaging 52 degrees. Comfortable temperatures for swimming occur from late June through October, although the water temperature may drop to the high 50s or 60s anytime during the summer. Dissolved oxygen level, turbidity, pH, nutrient levels, and coliform levels are all within normal limits.

Nearshore ocean waters in this area typically undergo major spring and autumn blooms of phytoplankton and minor midsummer blooms. Each bloom has its own assemblage of species. Productivity tends to increase nearshore, possibly due to the input of nutrients from the estuaries.

b. Air Quality

Air quality is variable depending on turbulence, wind direction, and thermal stratification of the atmosphere. Prevailing westerly winds often carry pollutants over Long Island from the heavily industrialized areas of New Jersey and metropolitan New York. The far western horizon is usually shrouded in smog. The nearest air quality monitoring stations to central Fire Island are at Islip, about 8 miles away. In general, the levels of most monitored pollutants are in the intermediate range--much lower than downtown New York City but still substantially higher than rural upstate New York. Activities on Fire Island itself generate almost no on-site air pollution.

c. Noise

Natural sources of noise, such as wind, wave, and wildlife, provide the background for Fire Island visitors' experiences. Most of the sounds of the barrier island are manifestations of the dynamic forces that continually mold and remold its profile. To most people, such noises--regardless of how loud--are acceptable and even desirable components of the total environment. However, the introduction of the noises of man's technological society into this natural acoustical system is obtrusive to many, if not most, visitors to the national seashore. These are the very sounds that many hope to leave behind during their seashore visit.

Almost all major unnatural noise is generated by motorized vehicles. Ferries are among the noisiest, and it is a rare visitor who can conduct a conversation on the deck of the ferry amid the din of wind, wave, and engine. Speedboats in the bay and large craft in the marinas produce considerable noise, most of which cannot be controlled if the seashore is to continue to provide for pleasure boating, water-skiing, sport fishing, and related boat-oriented activities.

Four-wheel-drive beach buggies, operated under special-use permits from the National Park Service and the towns of Islip and Brookhaven, are restricted largely to the beach, where the noise and the sight of these vehicles irritates many seashore visitors. These vehicles are disruptive to wildlife and, along with pedestrians, are responsible for almost total elimination of beachfront nesting water birds on Fire Island. The town of Islip severely restricted use of overland vehicles beginning summer 1973, and the National Park Service has been reducing the number of permits issued each year. Eventually, the noise generated by these vehicles should be reduced to negligible levels.

Aircraft of all types are increasingly more significant sources of noise. Helicopters and seaplanes are used frequently for access to private lands (although they are not permitted for access to federal lands, except for official purposes). Both types of aircraft generate substantial noise on landing and especially on takeoff, and use of seaplanes is also a safety hazard to boaters in certain parts of the bay. Aircraft that occasionally pass over the beach in the summer at dangerously low altitudes constitute a particular safety hazard. Cooperative agreements between the National Park Service and other interests may soon be necessary to define landing, takeoff, and overflight zones, thereby reducing noise levels, particularly near important natural areas and visitor-use zones. Commercial aircraft fly over Fire Island frequently, but noise levels generally are not great enough to disturb most visitors.

d. Solid Waste

Solid wastes from most of Fire Island's federal and community developments are transported by truck, or barge and truck, to mainland sanitary landfills. The towns of Brookhaven and Islip provide solid-waste collection and disposal service by agreements with most exempted communities. Both New York State and Suffolk County truck solid wastes from their park facilities to landfills on Long Island. The National Park Service has a waste-disposal contract with private contractors to transport wastes by barge and truck to municipal sanitary landfills in Islip and Brookhaven.

Open dumps still occur at scattered locations on Fire Island, the largest in Point O'Woods. Trash occurs on small unimproved tracts within or adjacent to exempted communities where residents illegally use them as dumps. The dumping areas are almost always located on high ground behind the primary dunes. In addition to their unsightly appearance, materials leached from trash accumulations may pollute near-surface groundwater and therefore present an obvious health hazard. Decomposition of most solid wastes on the dry sand surface is slow, and much of the material remains visible at the surface until it becomes buried under natural accumulations of sand or is washed into the bay by overwash or bayside flooding.

A portion of old surface trash deposits has been removed from federally owned lands east of Point O'Woods, but tracts 2, 3, and 4 in the western community zone are still used occasionally as dumping grounds by community residents and have never been cleaned up. Dumps on private lands will continue to be used occasionally until they are cleaned up and further dumping is strictly prohibited.

Makeshift dune-stabilization programs in some of the communities have involved the dumping of old Christmas trees, appliances, and other materials on the ocean-facing dunes. Such practices establish specialized dumps in the most often seen part of the seashore's landscape, and they contribute substantially to the already excessive load of trash in the ocean when storm tides wash away the would-be stabilizers.

e. Visual Quality

The objective evaluation of visual quality is impeded by extreme differences in individual viewpoints on what constitutes a visually attractive or unattractive environment. The new visitor complex at Watch Hill, with its multicolored panels and modernistic design, is viewed by some as an architectural nightmare and by others as a fine example of environmentally compatible design. Controversial visual scenes such as this therefore will not be a part of the following discussion, which will deal largely with visual intrusions that are obviously incompatible with the maintenance of the natural beauty of Fire Island.

Landscape scars constitute a major source of visual degradation. Some, such as eroded dunes and blowouts, may be of natural origin. Others, such as zones of graded fill and cleared vegetation, may be due to man's activities. Still others may be caused by both natural and cultural agents, an example being the eroded dunes that have been damaged by both vehicles and natural forces. In all cases, the aesthetic integrity of the natural environment has been interrupted. Landscape scars are particularly evident at Watch Hill (leach-field area), Bellport Beach (graded fill), near Forge Point (graded fill), and on the beaches and behind the dunes wherever vehicular travel is frequent.

Visually incompatible development constitutes another impairment to the visual environment. Structures that interrupt the expanse of undeveloped beach, such as groins and jetties, fall into this category. Sand fences, particularly if damaged or erected haphazardly, as well as other artificial dune-stabilizing devices, degrade the naturalness of the dune zone, as do homes and other development on the dunes themselves. The extent of degradation depends on the visual characteristics of the surrounding environment. A new home on the dunes in an area where the rest of the dune line is undeveloped constitutes a more significant aesthetic intrusion than an additional home on a dune line that is already 80 percent developed. Visually incompatible development includes the groins and water tower at Ocean Beach, the "dune project" zone in many

communities, and the remaining residences in the high dune management unit.

Structures that are visible above a high ocean-facing dune line are visually incongruent, as are poorly maintained structures wherever they occur. Within the communities, great differences in architectural style or the condition of residences may result in visual incompatibility or degradation locally.

Dumps and trash deposits behind the dunes and on the beach are significant sources of visual degradation. Most of the material in the interdunal area has been intentionally discarded by community residents, but a substantial amount of trash, often originating as far away as New England, is washed up on the beach.

The trash that litters the bay-bottom and bayside beaches is more likely to originate within the Long Island region. In view of the large volume of cultural debris already in the estuaries and ocean, trash removal is certain to be a major management problem for an indefinite time.

D. Cultural Resources

1. Brief History of Fire Island Area

European contact with the lands now comprising Fire Island National Seashore may have begun as early as 1524, when Giovanni de Verrazano may have passed along the coast after leaving New York Harbor. Dutch and British settlement of Long Island occurred during the 18th century, and the eastern part of the Fire Island barrier beach was purchased from the local Algonquin Indians by Colonel William Smith in May 1691. This section subsequently became part of the Manor of St. George. An inlet in the general vicinity of the present Fire Island Inlet was created by a storm in 1688 and subsequently widened in 1690 and 1691, but the name Fire Island Inlet was not recorded until 1781.

There are conflicting views as to the origin of the name Fire Island. According to one hypothesis, the name is a corruption of the Five Islands patented by William Nicholls in 1688 in what is now the western end of Fire Island. Under another hypothesis, the name originates from the fires reportedly set by pirates to lure vessels to shore. Regardless of whether either hypothesis is true, the name Fire Island has long been applied to the western part of Fire Island, as now roughly defined by the communities governed by the town of Islip. The more easterly part of the barrier island was known as