PRESQUE ISLE STATE PARK, ERIE COUNTY

A DYNAMIC INTERFACE OF WATER AND LAND

An eroding beach deposit shows layers of sand built up over a long period of time by wave-deposited sand and migrating sandbars. A change in lake level or wave conditions triggered erosion. Repeated cycles of beach building and erosion are normal and are an essential feature of a moving sand system.

Presque Isle State Park is one of the few places in Pennsylvania where you can see evidence of the recent geologic past and watch geologic processes in action. It is the only place in the state where waves break on extensive sandy beaches. Waves and currents remove sand from some parts of the peninsula and deposit it in others. The beaches, the sheltered harbor behind the peninsula, and the many different environments supporting unusual plant and animal communities all exist because of lake-related processes and the movement of sand over many years. Presque Isle is a *recurved spit.* Waves, currents, and wind have moved sand, creating a series of dune ridges and interdune ponds and marshes

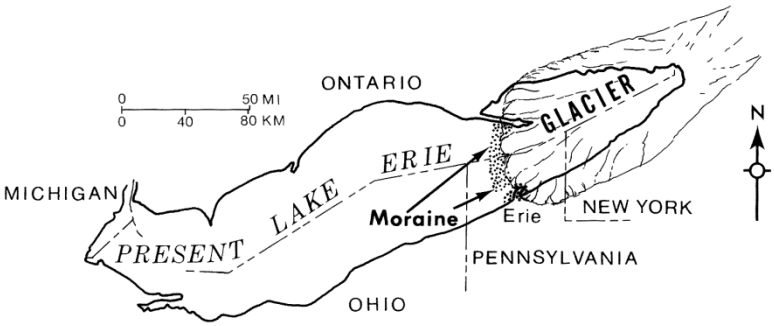
While in the Park:

* Look at the old dunes and lagoons along the trails in the interior of the park.
* Compare the shoreline along the protected bay shore with the beaches exposed to waves from the lake.
* Look for areas of beach erosion (common along some of the neck beaches) and areas of new beach growth (most likely between the lighthouse and Beach 10, and on Gull Point).
* Look across from Beach 11 at the newest bars and ponds growing at Gull Point.

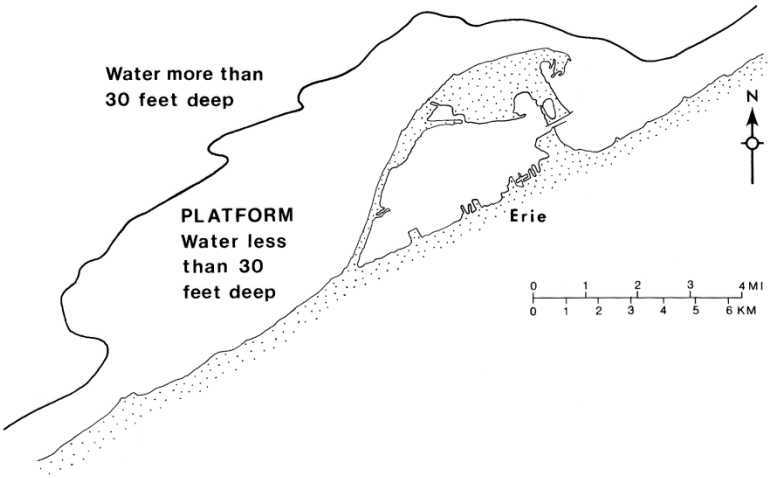
The Origin of Presque Isle

The location of Presque Isle is related to the presence of a ridge of sediment, called a *moraine,* that crosses Lake Erie. Moraines consist of clay, sand, and gravel that are carried by huge bodies of slowly moving ice, called *glaciers.*

The glacier that formed the moraine across Lake Erie was a late, minor advance of the



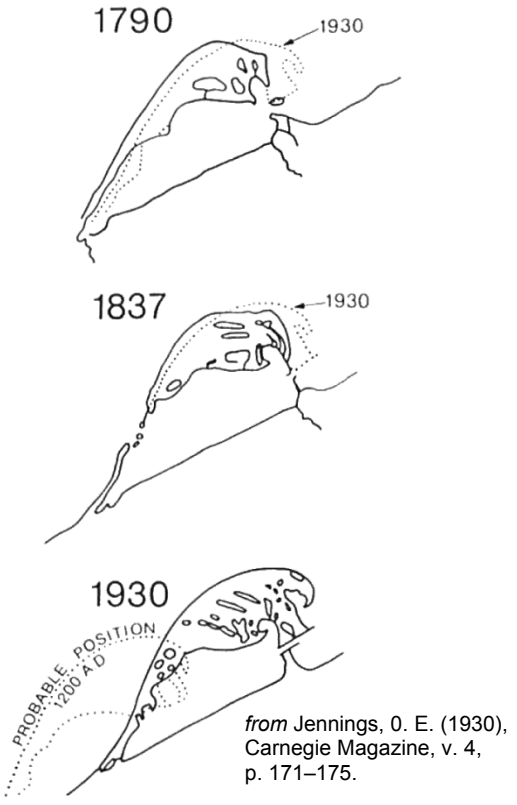
last major ice sheet that covered much of northern Pennsylvania. About 13,000 to 14,000 years ago, the small glacier moved southwestward into the valley now occupied by Lake Erie. The moraine marks a point where the advance of the ice halted, and was left behind as the ice melted away. The top of the ridge today is about 30 to 50 feet below the level of the lake.



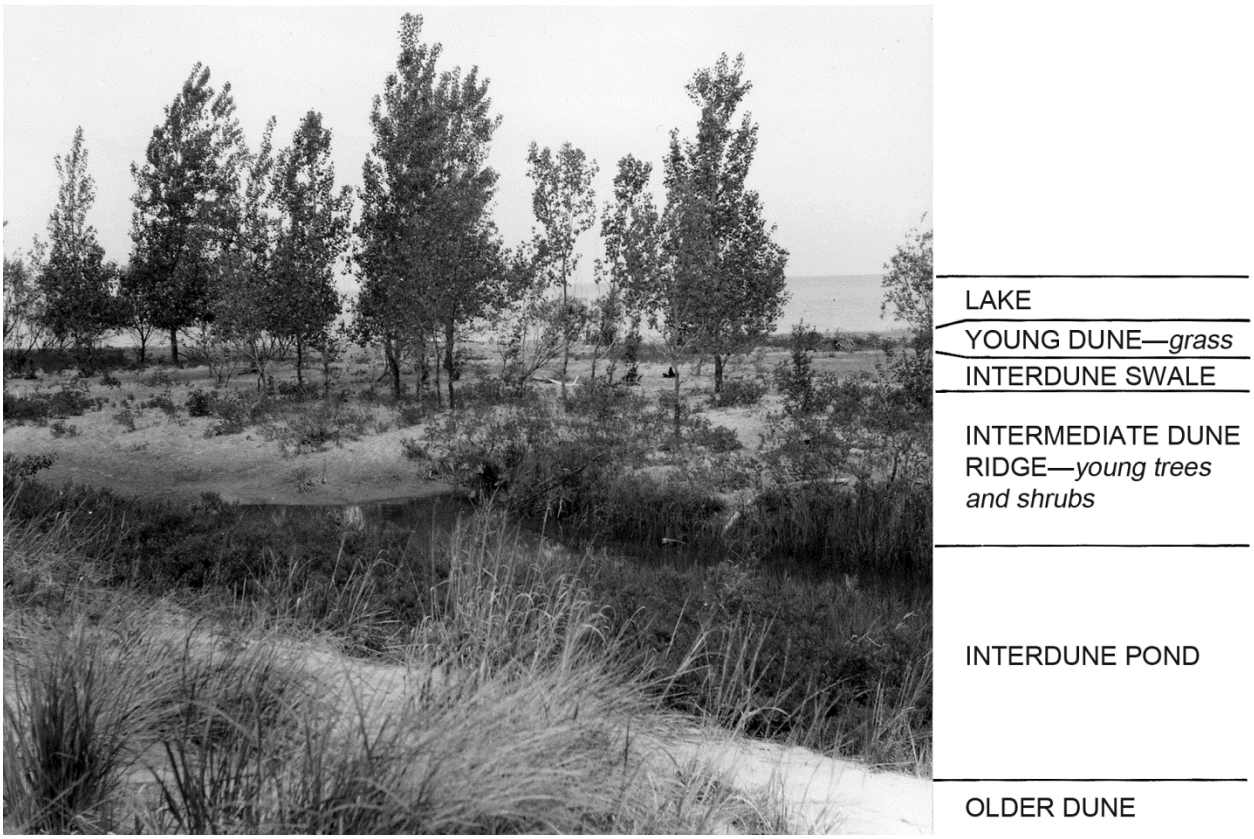
When the ice melted back from the Lake Erie area, the lake was much lower than at present, and the moraine stood up as a ridge of dry land. A channel, now about 5 miles offshore from Presque Isle, was cut through the ridge by stream erosion. This separated the main ridge from a platform along the southern edge of the lake. As the lake level slowly rose between 12,000 and 3,500 years ago, the shoreline migrated across this platform. Waves and currents shaped loose sand deposits into bars and beaches. As lake levels continued to rise and the lake cut bluffs along the shore, the newly eroded sand moved along the shore and was added to the spit, or sand peninsula, which has become Presque Isle. The exact geologic history of Presque Isle will never be known, but present conditions provide some evidence of the history of the growth and migration of the peninsula.

The Growth of Presque Isle

Historical maps such as these, published in 1930, show that Presque Isle has changed over the last 200 years. The ages of trees on dune ridges and information from sediment in the interior ponds allow us to reconstruct a longer history of migration, caused by erosion along the west side and growth to the north and east. The spit grows by the addition of new beach and dune ridges parallel to the northeastern shore of the peninsula.

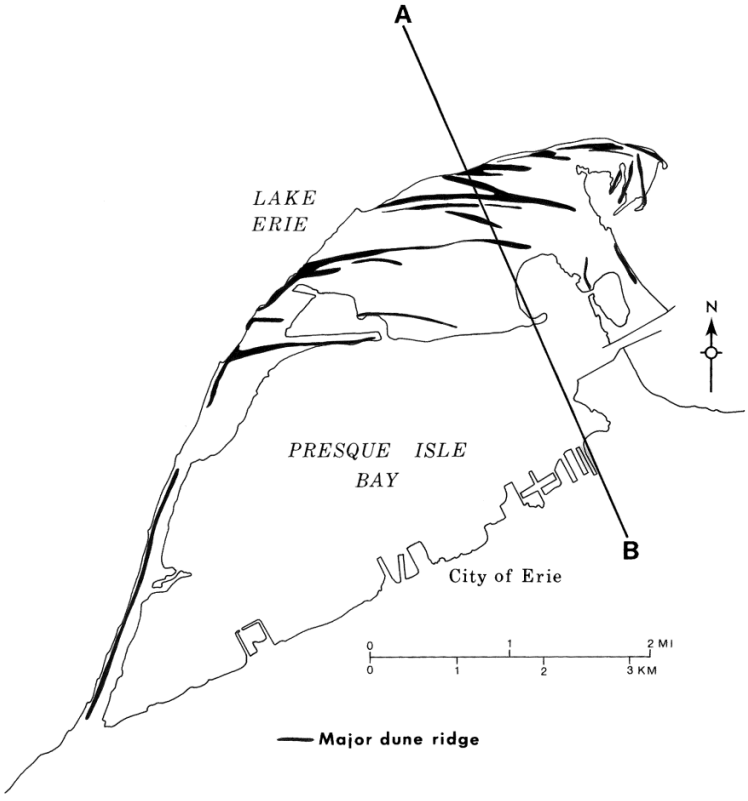


from Jennings, 0. E. (1930), Carnegie Magazine, v. 4, p. 171–175.



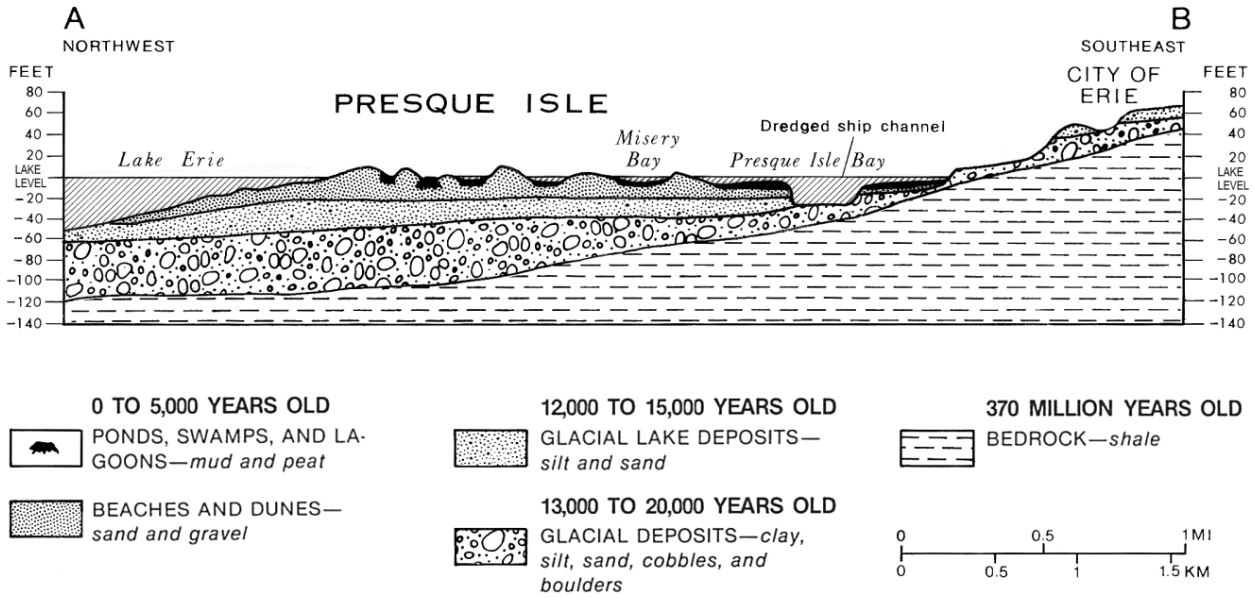
Series of developing dune ridges on Gull Point.

Although the name "Presque Isle" means "almost an island" in French, the area has been a real island several times. Storm waves have broken through the neck to isolate the main section of the spit at least four times since 1819. One of the gaps remained open for 32 years before being closed by natural siltation.



The Present Profile of Presque Isle

The history of growth and erosion of Presque Isle can be seen in the pattern of dune ridges and the swamps and ponds that commonly occupy the low areas between them. New ridges form parallel to the shoreline. Older ridges show the locations of earlier shorelines. The eroding shore on the west has cut off the ends of many older ridges, and the eroded sand has been reworked and included in new growth areas.

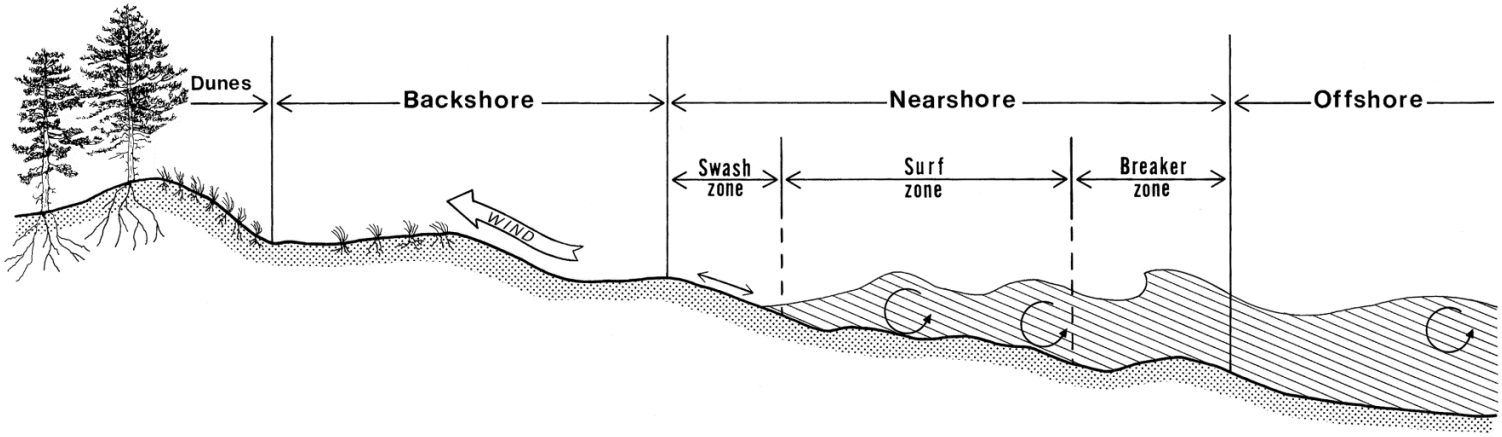


The schematic cross section above shows the arrangement of beach, dune, and swamp deposits over the glacial deposits and shale bedrock that underlie the peninsula along the line from point A to point B on the map on the previous page. The older materials are not exposed in the park but are known to exist through information from engineering test holes and gas wells.

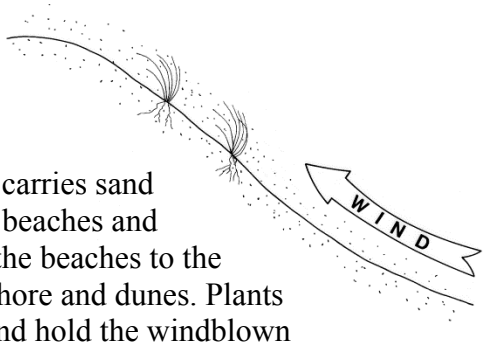
How Sand Moves

Wind causes waves and currents, the agents that shape Presque Isle. The stronger the wind and the farther it blows over open water, the larger and more forceful the waves. At Erie, the most common winds, from the west, also blow over the largest expanse of open water. Therefore, although storm waves sometimes come from the north or east, waves from the west move most of the sand along the shore of Presque Isle.

Large storm waves can move a great deal of material very quickly, and tend to move sediment from the beach face away from the shore, into the system of submerged bars and troughs. Some material is moved out into deep water where waves can no longer reach it, but much of the sediment moves parallel to the shore and eventually migrates landward again as individual bars move in response to the action of gentler waves.

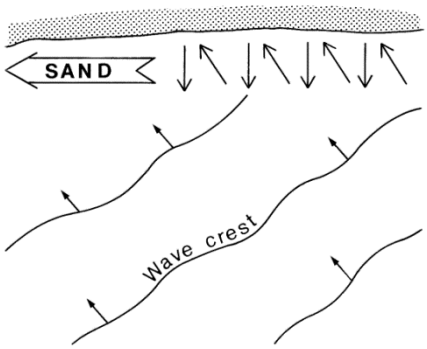


Sand moves along the shore by different processes in different parts of the nearshore zone.



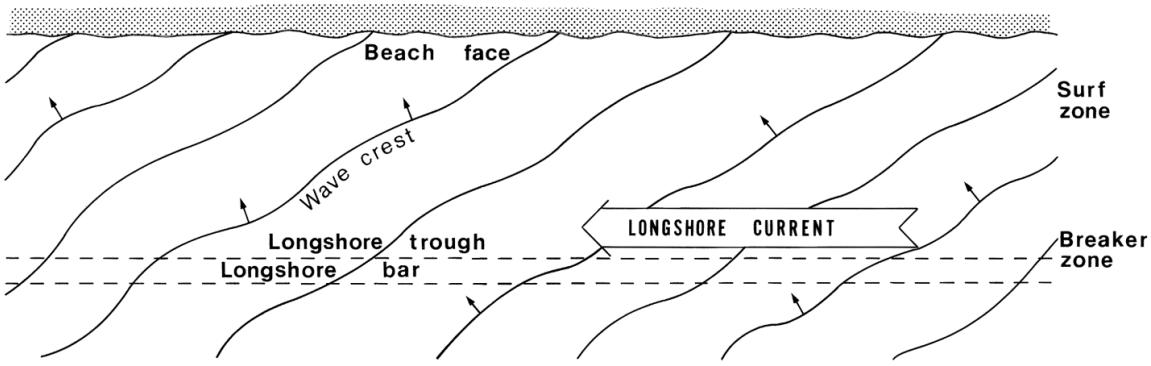
Wind

Wind carries sand along beaches and from the beaches to the backshore and dunes. Plants trap and hold the windblown sand, building new dunes.



Swash Transport

Waves move up the beach face at an angle, and the water returns to the lake by flowing straight down the slope. Sand grains moving with the water travel along the shore in a zig-zag path.



Wave Turbulence and Longshore Currents

Complex interactions of waves set up currents in the nearshore zone. Wave turbulence picks up sand grains, which can be moved offshore or along the shore by currents.

Bars and Troughs

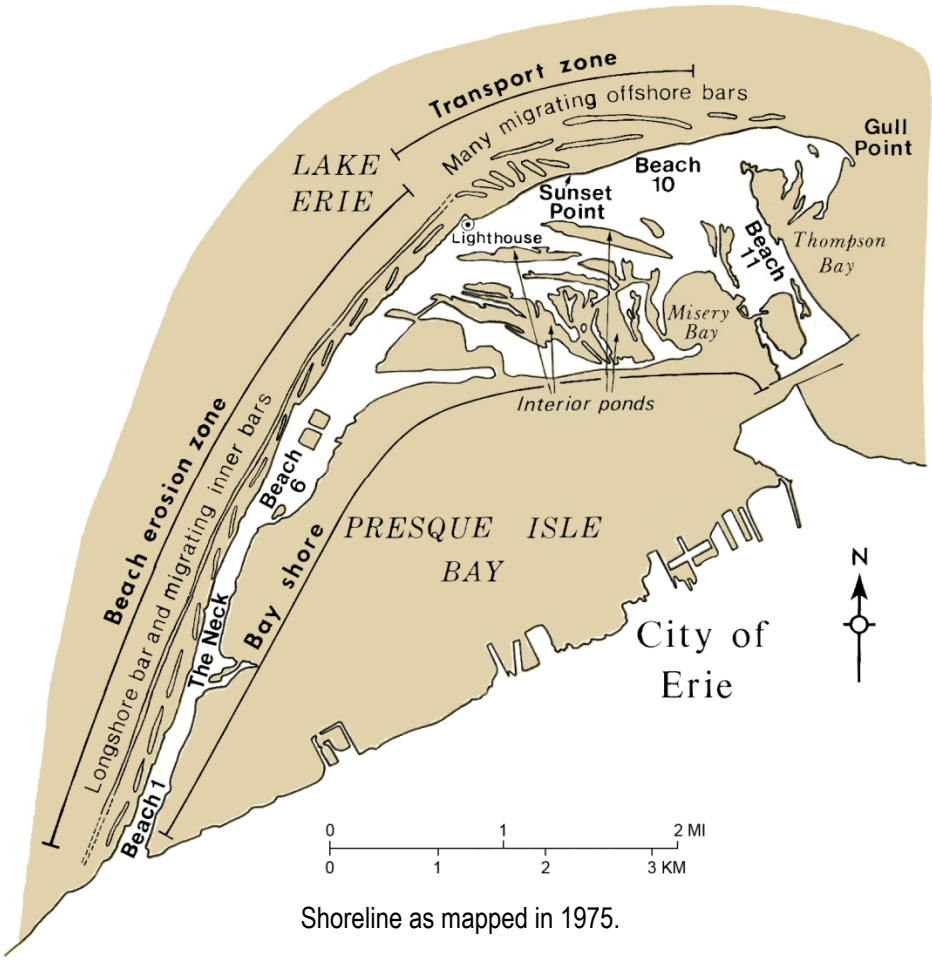
Waves and currents move individual sand grains over the surface of bars. When sand is eroded in one area and deposited in another, the whole bar or bar system migrates. Most sand moving along Presque Isle moves in a system of bars and troughs 150 to 600 feet from the shore.

The Shoreline of Presque Isle

Historical records show that Presque Isle has been continually moving and changing. The form of the spit is controlled by the relative intensity of erosion, transport, and deposition of sand in different areas.

Beach Erosion Zone— Beach 1 to Near the Lighthouse

These northwest-facing beaches are exposed to the major wave-approach direction. Waves move sand from the beaches into a system



Shoreline as mapped in 1975.

consisting of one continuous outer bar and many smaller, migrating inner bars. Most sand movement in this zone occurs by northeastward bar migration and the longshore current in the trough.

There is a long history of shore protection efforts in this area. Waves cut through the neck at least four times between 1828 and 1923. One opening grew to be a mile wide, remaining open for 30 years. Storm waves still occasionally break over the neck. They wash over the backshore, depositing sand on the old shore road almost every winter.

Transport Zone—Lighthouse Area to Beach 10

Most waves approach these beaches at a gentle angle. Most of the sand eroded from updrift beaches is carried through this area in a complex system of migrating bars. Some sand deposition occurs, usually when a bar moves shoreward and becomes attached to the beach.

New Land—Gull Point Complex

Gull Point is growing rapidly. Much of the sand that is eroded from the neck beaches comes back onto the shore here. In about 1900, the eastern end of the peninsula was near the location of Beach 10. Gull Point has grown since then by the migration of new sandbars toward the shore, where they become connected to the beach. Grass and other small plants grow on the new land, trapping windblown sand and creating dunes. As dunes get higher, larger plants and small trees grow; water-tolerant plants spring up in ponds and swamps between the ridges. At Gull Point, you can walk from newly formed beaches and ponds across older and older land to dune ridges covered with mature forests.

Quiet Bay Shore

The shoreline of Presque Isle Bay is less active than the lake shore and provides protected areas for boat launching and other access. However, storm waves sometimes cause sand to move even here, although plants along the shore and low stone protective walls limit most erosion.

From the bay shore, a visitor can see the city and port of Erie, which exists because Presque Isle shelters the harbor from the winds and waves of the open lake.

Interior Ponds and Ridges

A large part of Presque Isle is now removed from the active beach environment. The interior ponds, swamps, and old dune ridges were created by beach processes, but are now geologically less active areas. These are important areas for the park environment because of the many different plant and animal habitats they provide.

Lake Levels

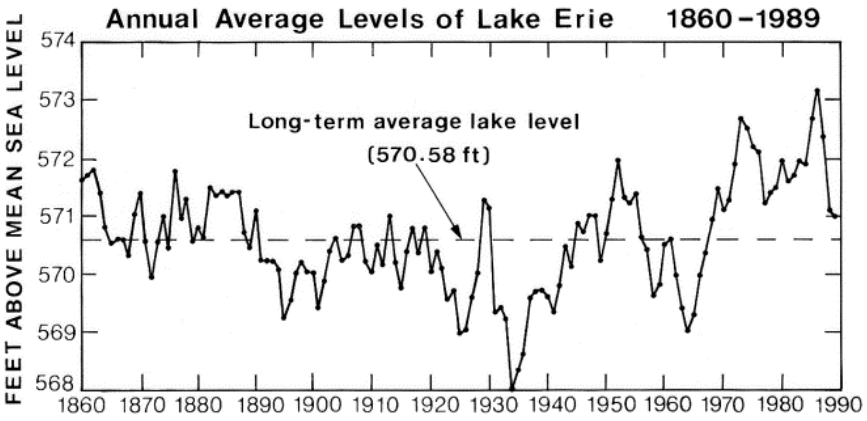
The level of Lake Erie changes from time to time. For example, when strong westerly winds blow, the lake rises at the east end and falls at the west. Records of lake levels show that this storm surge, or "set-up," can cause changes of more than 10 feet at the ends of the lake in a few hours. As the water returns to normal levels, it sloshes back and forth like water in a bathtub. Each wave takes many hours to travel the length of the lake, and the effect may continue for 2 or 3 days.

Lake levels also rise and fall annually with normal changes in rainfall and evaporation rates. Lake Erie is usually about a foot higher in June and July than it is in January and February. Longer term changes also occur, which are related to major variations in climate. Lake Erie reached its record high level in 1986. In the drought of the 1930's, the lowest historic level was 5 feet below the record high. No one can predict exactly how lake levels will behave in the future, but they will certainly continue to change.

When the lake level is high, more of the shore zone is flooded, and waves reach higher parts of the shore profile. Because waves are also moving in deeper water, they "touch bottom" less and may have more energy when they reach the shore. These factors lead to more severe erosion when the lake is high. In contrast, lower lake levels cause other problems, such as shallow shipping channels and harbors.

Groundwater moves through the loose sand on Presque Isle fairly rapidly. The interior ponds rise and fall with changes in lake levels. The ponds and swamps are larger during times of high lake level and sometimes flood forest areas, killing trees and other plants that cannot tolerate a saturated root zone.

When the lake around Presque Isle rises in response to a storm "set-up," water in the bay also rises, but, because it must flow in through the narrow channel, it usually rises more slowly. In the same way, if the lake level drops, the bay drains more slowly. These differences in level between the lake and the bay can cause rapid currents through the harbor entrance and help to mix bay and lake water.



Winter Conditions

The small waves and gentle winds of summer move only small amounts of sand. Large storm waves, mostly occurring in fall and winter, cause much of the erosion and sand movement at Presque Isle. When ice covers the beaches, it protects them from erosion, although waves and currents still move sediment in the offshore and nearshore zones.

Lake Erie rarely freezes all the way across, but ice forms along the shore during most winters.

Types of Ice Cover

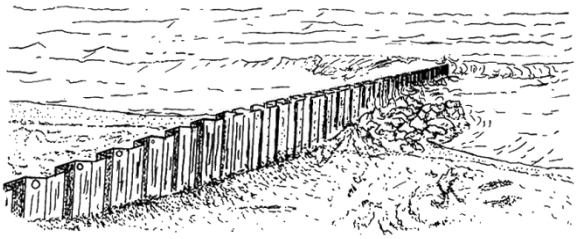
In the photograph above, frozen spray from breaking waves builds up on the beach and as a shelf for a short distance offshore.

When weather conditions allow the formation of a wider shelf of floating ice, wave action commonly breaks the ice into large slabs. Wave surge forces water under the ice up through the cracks between slabs, where it freezes. “Ice dunes” build up by this combination of lake ice, wave surge, and spray freezing over all. The unusually large dunes in the photograph below were formed in January 1981. Occasionally, when conditions are just right, geyserlike jets of water come up through holes in the ice and build layered cones of sandy ice.

Works of Man—Anchoring the Sand

We have seen that moving sand is essential to creating and maintaining the system of beaches, bars, and dunes. Roads, parking lots, and buildings have been constructed on Presque Isle so that people can use the beaches. These solidly located structures cannot exist if the sand under them moves. Human requirements for access to recreation on Presque Isle, and the need to protect Erie and its harbor from lake storms, sometimes conflict with the natural system of moving sand. For at least 170 years, people have tried many different ways to control erosion at Presque Isle and to stabilize the beaches.

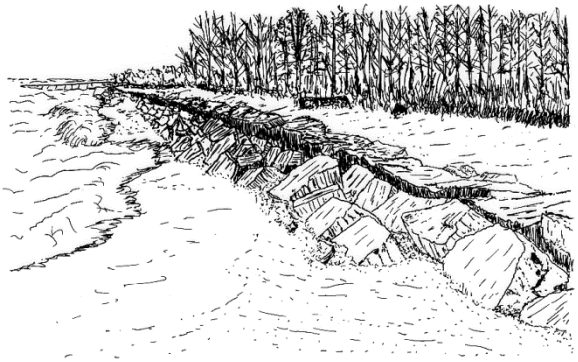
Groins, long, narrow structures that project from the beach into the lake, interrupt longshore transport of sand. There are 11 groins between Beach 1 and Beach 6, and a number of others eastward to the lighthouse. Over the years, they have been built of wood, metal sheet piling, rock, concrete, and combinations of these. The common accumulation of sand on the updrift side (usually the southwest on Presque Isle) shows that groins generally work as designed. An equally common side effect is that erosion occurs on the downdrift side.



Groin.

Seawalls, or coastal revetments, are a common way to protect critical areas from storm waves. A stone and concrete seawall was built along the neck of Presque Isle to protect the road and help keep the neck from being cut through

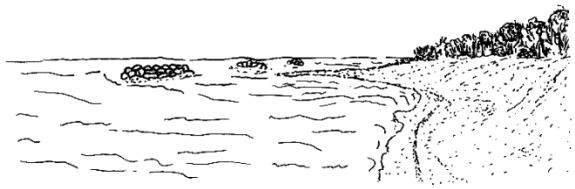
by storms. It is usually covered by sand, but is sometimes exposed by wave action from major storms. Another was built near Sunset Point after the road was damaged by storm erosion during high water levels in 1973. Smaller stone revetments shield much of the bay shore from erosion.



Seawall.

Beach nourishment has been used at Presque Isle since the 1950's. This method of shore protection combats erosion by replacing the eroded material and supplying new sand to the longshore transport system, allowing the growth of beaches downdrift. Successful nourishment requires determining the best combination of grain size and quantities of sand to match wave conditions. Ideally, a balance is reached between having some sand stay on the beaches and allowing enough to be carried along the shore to maintain active beaches downdrift. Nourishment must be repeated regularly and is expensive. For a large expanse of beach, adequate supplies of appropriate sand can be difficult to obtain.

Detached breakwaters were built at Beach 10 in 1978. They are designed to work by sheltering the shore from the full energy of the waves and allowing sand to accumulate behind them. They generally interrupt sand transport less than groins, but, like all shore protection structures, have side effects on the area downdrift. Construction of 58 new detached breakwaters along the lake shore between Beach 1 and Beach 10 was begun in 1989.



Detached breakwaters.

The Future of Presque Isle

All of these shore protection strategies work, but not perfectly, because all are trade-offs between producing desired effects and producing sometimes undesired side effects, such as downdrift erosion or diversion of sand offshore into deep water. When any "permanent" structures are built in a dynamic shoreline environment, such as that of Presque Isle, they cause changes in the system. Wise recreational use of this unique coastal land requires careful planning to balance the demands of maintaining public access and service facilities against the possibilities of damaging the complex system of interacting forces which is the shoreline environment.

It is anticipated that the new breakwaters will reduce erosion along the shore and thus reduce the huge volume of sand presently required each year for nourishment. The breakwaters have been designed to allow enough sand to move through the system that the growth of the peninsula at Gull Point should continue, although at a slower rate than in many previous years. The details of the park will change in the years to come, but it will continue to be a fine example of the dynamic interface between the water and the land.

—Helen L. Delano, Geologist
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