CHAPTER 2

STABILITY OF THE GUT AND ITS RELATIONSHIP TO THE HERRING RIVER

Introduction

People frequently ask whether opening the Herring River Dike would threaten the stability of The Gut or cause it to breach. This is of great concern because this strip of land channels the Herring River outflow into Wellfleet Harbor rather than directly into Cape Cod Bay (Figure 2.1). It is commonly thought that a breach might threaten shellfish resources in and around Wellfleet Harbor from an influx of bay water changing salinity, temperature and nutrients within the shellfish-rich inner basin.

This chapter explains how flow through the Herring River, even when unrestricted by a dike, is not a strong enough forcing mechanism to influence The Gut. In order to determine the relationship between Herring River and The Gut, one must first understand its formation in the context of the geologic history of the Cape.

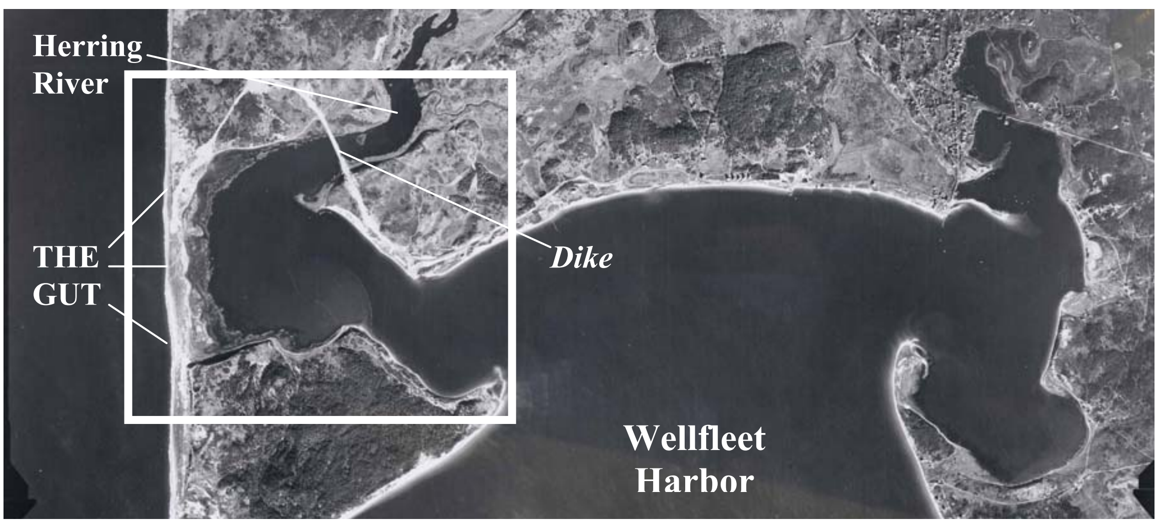


Figure 2.1: Location of The Gut in relation to the Herring River & Wellfleet Harbor

Brief Geologic Background

About 1.5 million years ago, global climate change caused glaciers to advance into the temperate regions of North America. These advances were followed by periods of warming and retreating ice. This cycle of glacial and interglacial periods occurred many times. The most recent glacial advance started about 50-70 thousand years ago. In the north, the ice that existed over Hudson Bay spread in all directions, and extended to cover all of New England. As the glaciers grew in size they incorporated a great deal of water evaporated from the sea causing sea level to drop considerably, estimated as much as 120 meters. The area where Cape Cod now exists was above sea level during the last glaciation. (Odale, 2001)

As glaciers move they scour the land underneath them and accumulate sediment within the ice. When a glacier stops and begins to retreat it leaves behind a large deposit of sediment, known as a moraine. The northern portions of Martha's Vineyard, Nantucket and Long Island are all moraines, known as terminal moraines, because they mark the southernmost extent of ice in the northeast region. As the ice retreated during the last glacial period, it either readvanced and/or stagnated just north of its farthest extent (Figure 2.2) forming a recessional moraine and outwash plains that now comprise Cape Cod (Figure 2.3). Further retreat and melting of this continental ice sheet returned water to the ocean basins causing global sea level to rise. Eventually the rising sea encroached upon the glacial deposits left behind by the ice. Around 9,500 years ago, rising sea level reached exposed Cape and wave erosion of the glacial deposits began. At first, uplands composed of glacial drift began to erode as waves attacked the fragile land forming sea cliffs. The eroded sand was then transported and redeposited by waves and currents to form bays, like Pleasant Bay and Wellfleet Harbor, protected from the open ocean by barrier spits and islands (Figure 2.3) (Uchupi et al., 1996).

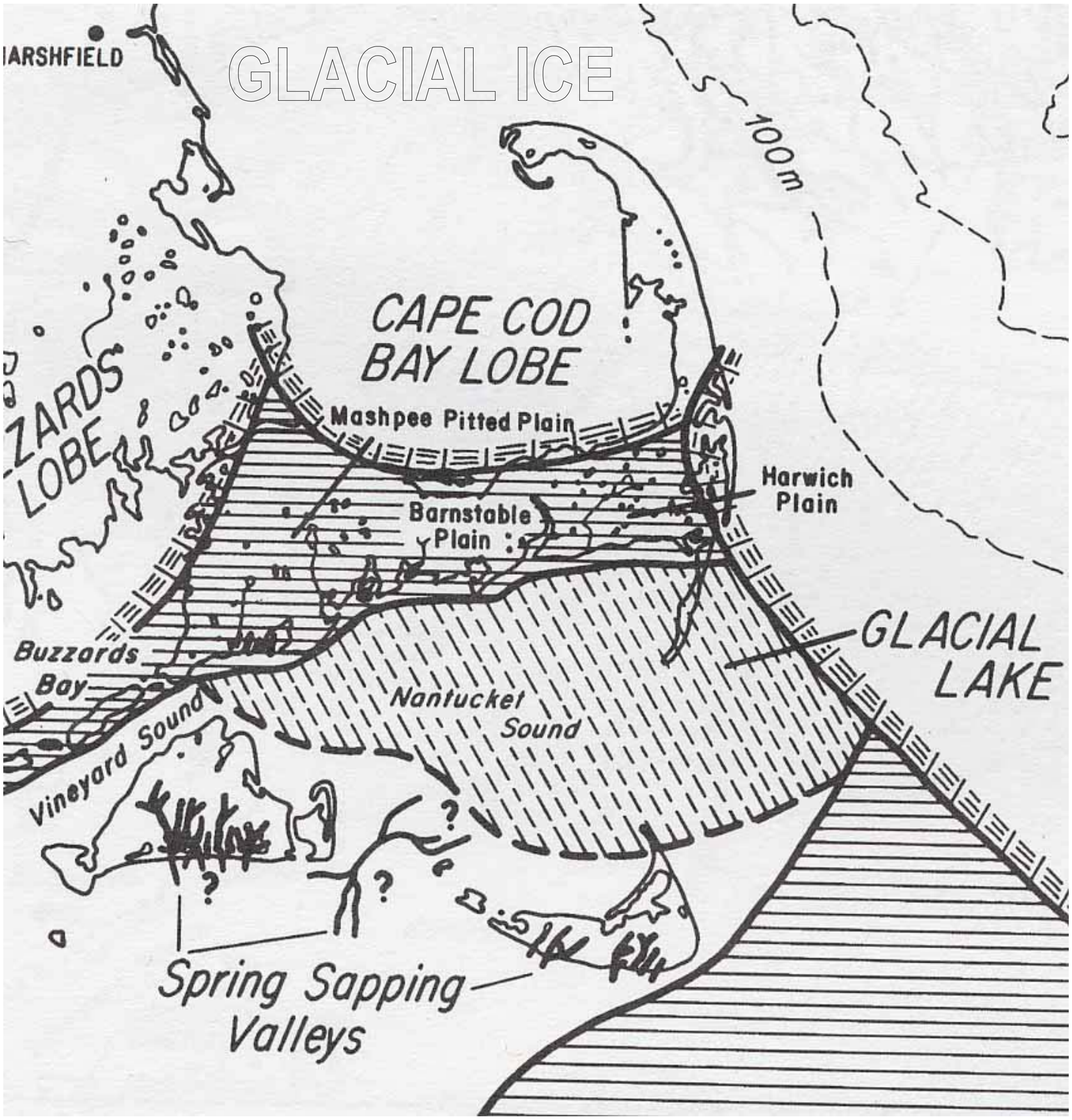


Figure 2.2: Map of southeastern Massachusetts as it looked prior to 18,000 years ago. Note the position of the ice lobe that occupied present-day Cape Cod Bay. (Uchupi et al., 1996)

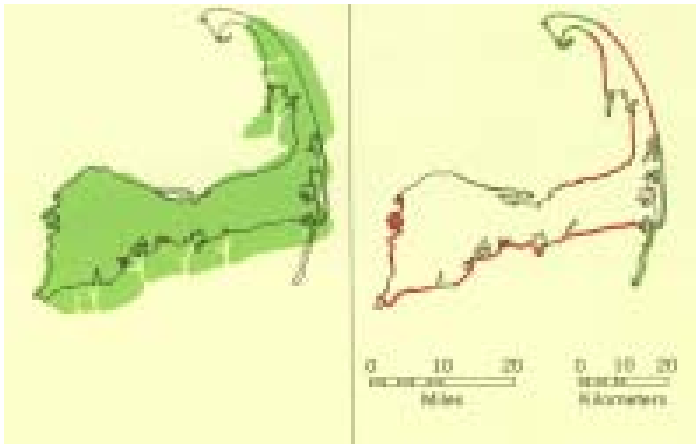


Figure 2.3: On the left in green/gray is the hypothetical configuration of the Cape about 6,000 years ago, before extensive wave erosion of these glacial deposits formed the current shape outlined in black. The right is a map showing the present pattern of erosion, with red (black) indicating shorelines experiencing erosion and green (gray) displaying areas undergoing deposition. (Odale, 2001)

Figure 2.4: This 2001 air photo of Wellfleet Harbor shows the present day connected nature of the Wellfleet Harbor Islands.

Formation of The Gut

Wellfleet Harbor occupies a part of a large depression that formed due to the existence of the glacial ice that prevented the deposition of outwash sands (Figure 2.2). As the ice melted and sea level rose the depression filled with water forming Cape Cod Bay. Islands such as Griffin Island, Great Island and Great Beach Hill formed from sands that filled holes or depressions in the ice; as ice melted and sea level rose, they became surrounded by water. Despite their names, one would not consider these features to be islands today due to their connections to each other and the mainland (Figure 2.4). However, in the 1720s many people lived on these islands, which protected deep and useful anchorages at the time (Wood, 1973). A sketched map of the Cape by Henry David Thoreau depicts these islands as such, isolated by water (Figure 2.5).

On the ocean side of the outer Cape, continued sea-level rise and persistent erosion took sand from the glacial sea cliffs and transported it north (Figure 2.6) to form the Provincetown Spit (Figure 2.7). A spit is a peninsula-like accumulation of sand that extends off the mainland, sometimes curving at the end to form a recurved spit. The formation of the Provincelands prevented sediment transport to the Cape Cod bay beaches form the Atlantic (Figure 2.6). However, sediment from the eroding bay-side uplands continued to supply sand to the bay side beaches by long shore drift. The sand moving south formed a spit of land off of the Wellfleet mainland. Eventually this spit connected to the northernmost island and then each successive island to the south (Figure 2.8). This accumulation of sand that ties two landmasses together is known as a tombolo. Once these tombolos were in place, they provided protection from waves and formed the sheltered environment of Wellfleet Harbor. As a result of this quiet environment, marshes formed behind these tombolos (Figure 2.8). The newly formed marshes became so extensive north of The Gut that they actually filled in Duck Harbor landlocking Merrick Island (Figure 2.10).

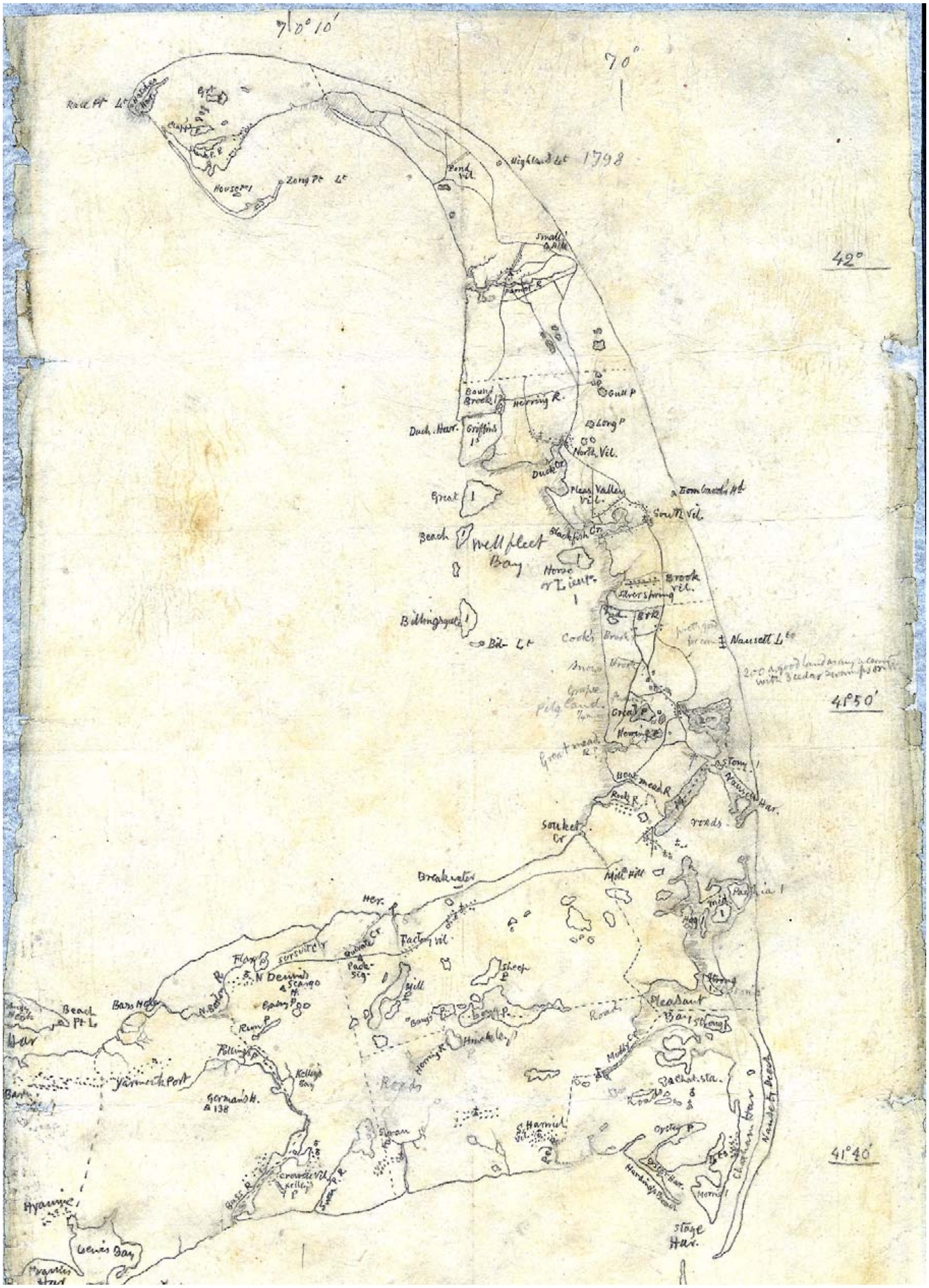


Figure 2.5: This map is a portion of a sketch of the Cape drawn by Henry David Thoreau. Note the depiction of the Wellfleet Harbor Islands as unattached.

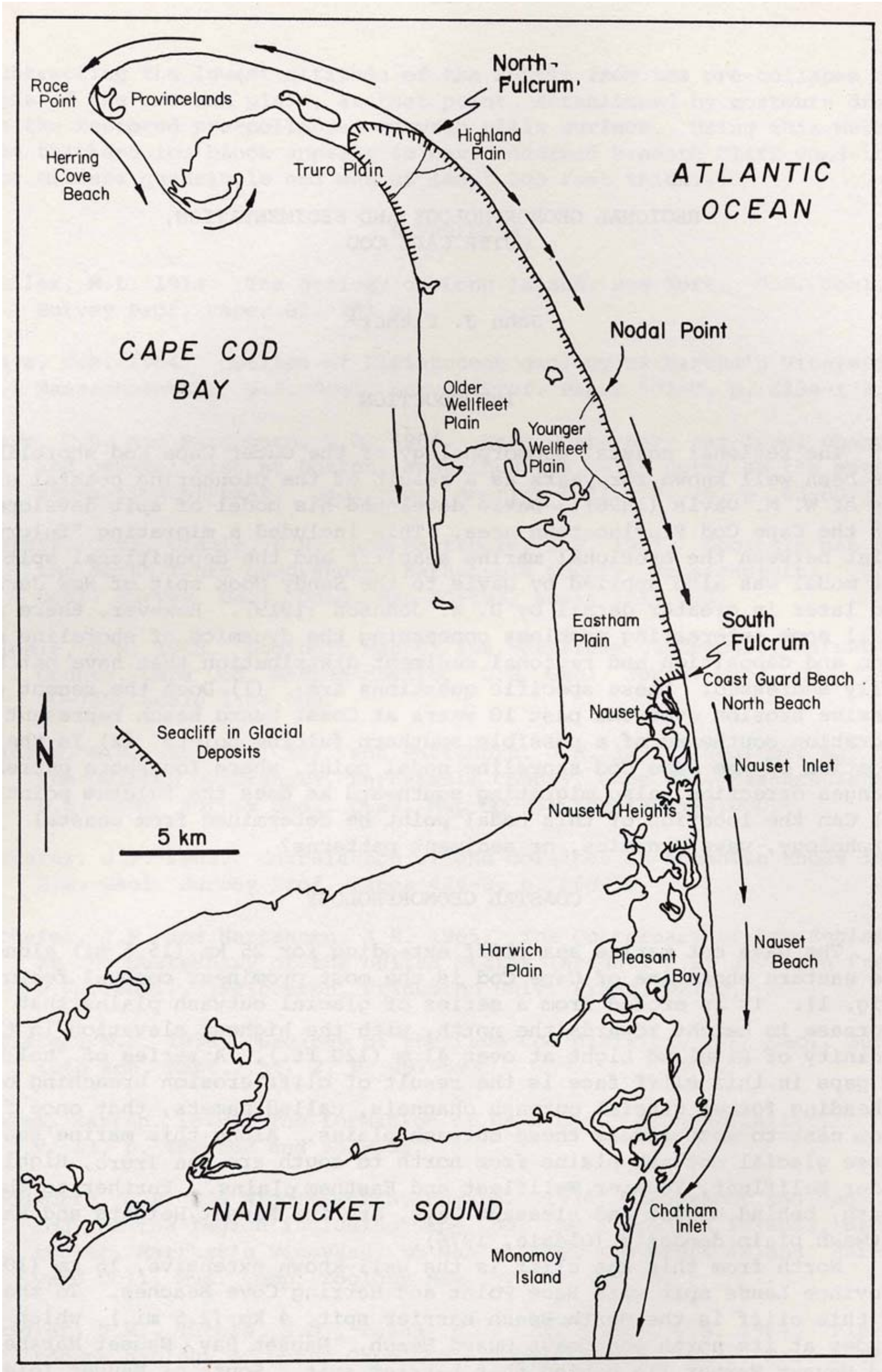


Figure 2.6: Sediment transport map of outer Cape Cod showing the southward transport of sands eroded from the adjacent Wellfleet bay side beaches. (Fisher, 1979)

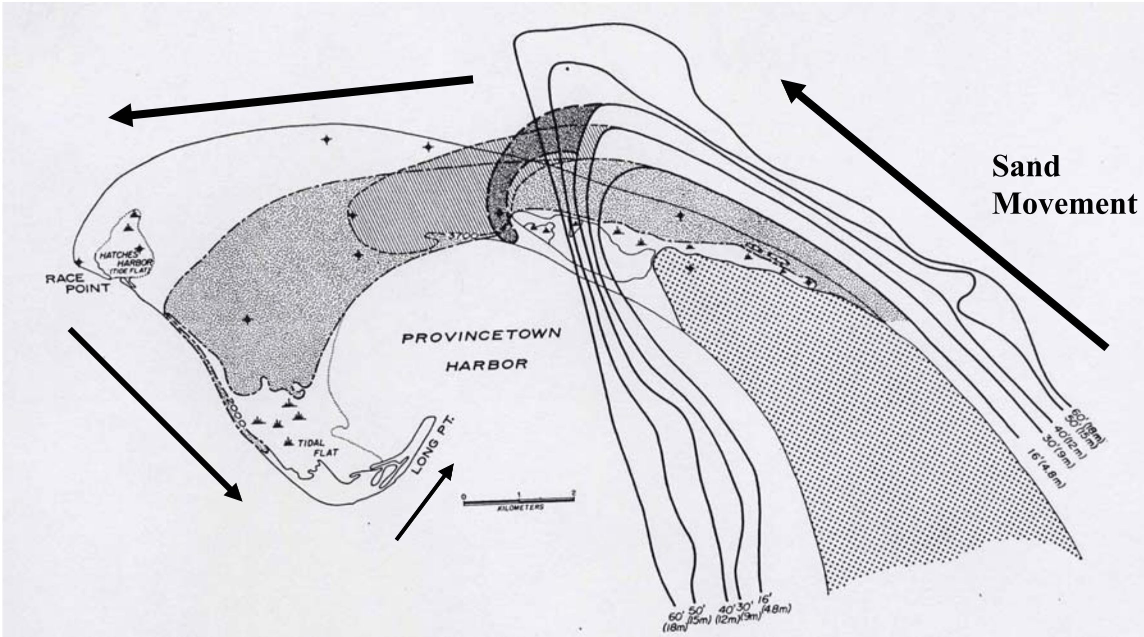


Figure 2.7: Sediment transport map showing the evolution of the Provincetown Spit. Note that each successive black line from right to left is the former configuration of the Provincetown Spit. The spit was initially building to the northwest and then begins to recurve due west, southeast and then due east. This shape is a result of open-ocean waves interacting with Cape Cod Bay tidal forces. (Zeigler et al. 1965)

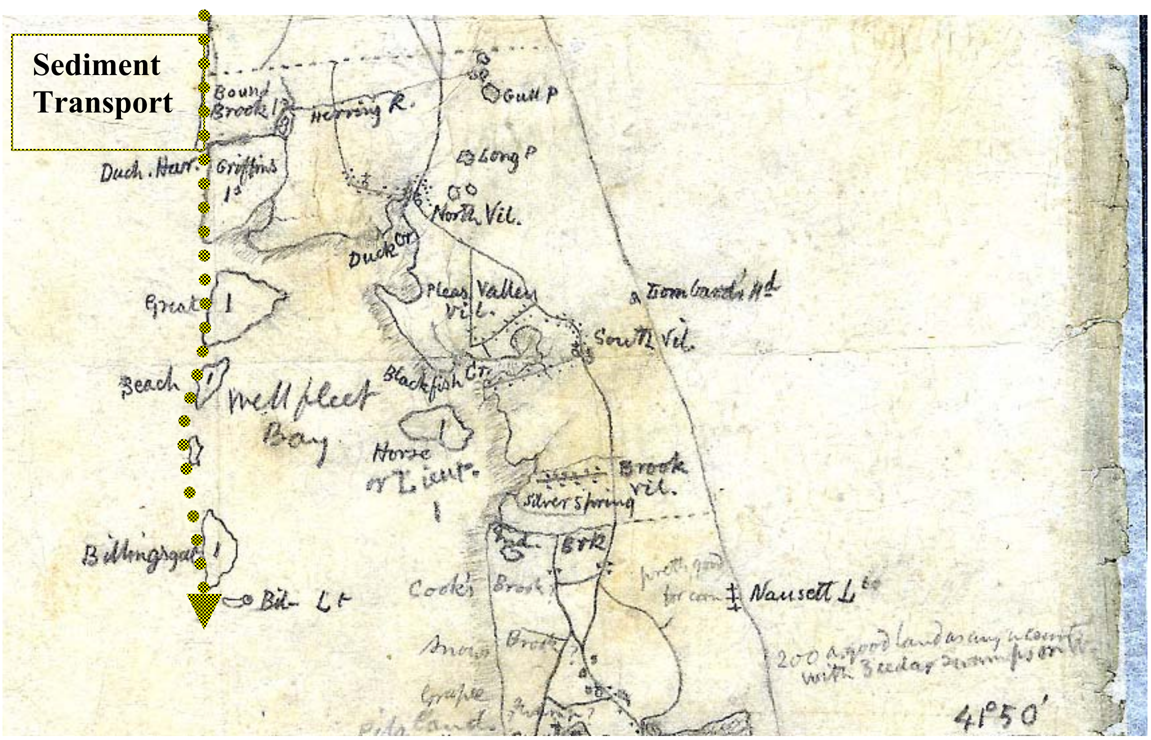


Figure 2.8: Map of sediment transport superimposed on Thoreau’s sketch showing the formation of tombolos that connect the islands.

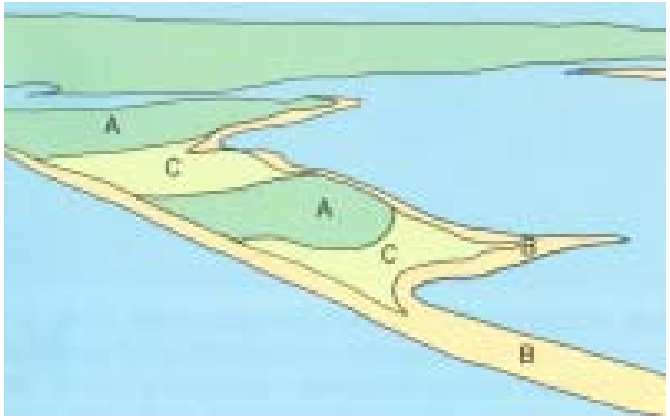


Figure 2.9: Top left is a cartoon schematic showing the evolution of the area directly south of The Gut, which is how it would have formed without the existence of the Herring River. First the islands are created by glacial deposits (A) then sand transported southward forms tombolos connecting them B) and as a result of the quiet water environment behind the spits and tombolos a thick marsh forms (C). The bottom right image is a photograph of the area illustrated above. (Oldale, 2001)

Figure 2.10: 1974 coastal chart showing the presence of marsh where Duck Harbor once existed.

Relationship of the Herring River to The Gut

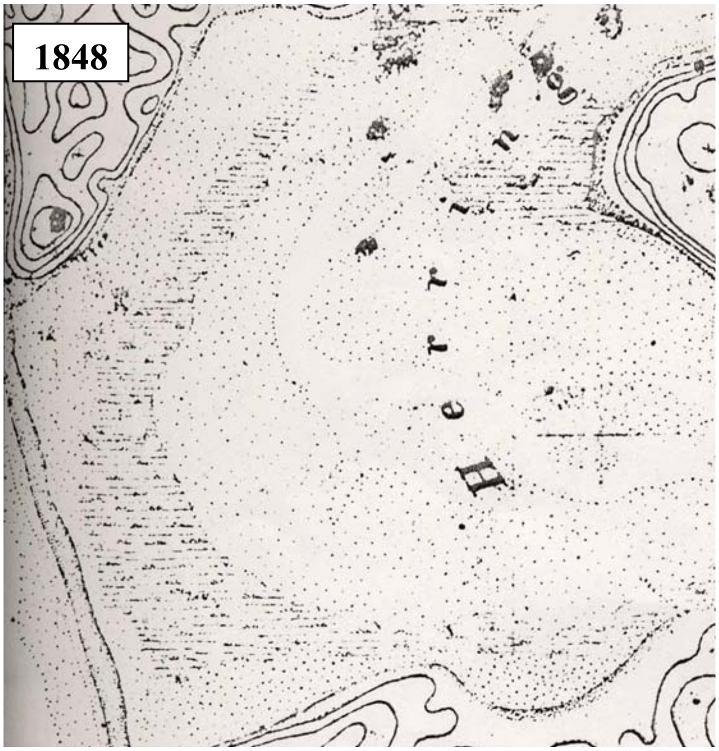
Historically, the Herring River most likely emptied directly into the bay through the area that The Gut now occupies. However, during the elongation of the spit, which formed the tombolo that is The Gut, the Herring River was deflected to the south. This deflection shows that the river (i.e. prior to any dikes and thus unrestricted) was not strong enough to maintain an inlet through The Gut. This change in the course of the river occurred naturally well before the Chequesset Neck Dike was built. Thus, the altered course was under the maximum flow condition afforded by an open tidal river system. Therefore, it is reasonable to conclude that small changes in the tidal flow through the dike would have no effect on The Gut. Furthermore, based on the above historical evidence, it seems safe to assume that even complete removal of the dike would not cause The Gut to breach. Maintenance of an open inlet requires there to be a large hydraulic gradient, i.e. difference in water levels, between two water bodies during the normal tidal cycle. Because of the large opening for tidal waters between Jeremy Point and Wellfleet mainland, no such gradient can develop. Water follows the path of least resistance: in this case it is much more efficient hydraulically for the Herring River to empty into open Wellfleet Harbor and out past Jeremy Point than through The Gut.

A testament to these low flow velocities is the existence of a broad mudflat of fine-grained riverine sediments behind The Gut's barrier system (Figure 2.11). This accumulation of fine sand proves that there is not enough energy in the ebbing tide to transport this sediment. There is not even enough energy to scour the edge of this mudflat along the main ebb channel. This lack of scour is evident in all available aerial photographs and charts dating back to before dike construction; the intertidal morphology below the dike has not changed despite radical human alterations to river flow (Figure 2.12). Thus, even with dike removal and maximum ebb flows, there should be no scouring of the mudflat.

Given that The Gut influences the Herring River rather than the converse, what factor controls the stability of The Gut? The continued stability of The Gut, like its formation, is primarily dependent on longshore sediment transport on the Cape Cod Bay beaches and aeolian (wind) transport of finer sand to make and maintain the barrier's dune system. Erosion of The Gut is most likely to occur as a result of a storm; however, the wide salt marsh that backs this beach and dune system provides formidable resistance to erosion. It is highly unlikely that a channel would be cut through these thick and cohesive marsh peats; therefore, there is little chance of a permanent inlet forming from a breach in The Gut. It is more probable that in the case of a high-energy storm, an overwash from the bay would occur through a low in the dunes. An overwash transports sand from the Bay beach through a breach in the dune system to form a fan-shaped sand deposit on the back-barrier salt marsh surface (Figure 2.13). Natural post-storm processes that bring sand back onshore and rebuild dunes (Figure 2.14) to subsequently heal the breach.

Importantly, even if a temporary overwash were to occur, it is unlikely that there would be significant changes in water characteristics in The Gut's basin. Hydrodynamically, tidal exchange associated with an overwash through The Gut would be only a fraction of the tidal exchange that presently occurs around the south end of Jeremy Point; thus salinity and temperature changes would be minor. (Argow, 2000)

Figure 2.11: Air photo taken at low tide reveals broad mudflats flanking either side of the main ebb channel of the Herring River. This shows that flow velocities are not strong enough to even scour the channel banks, much less breach The Gut.



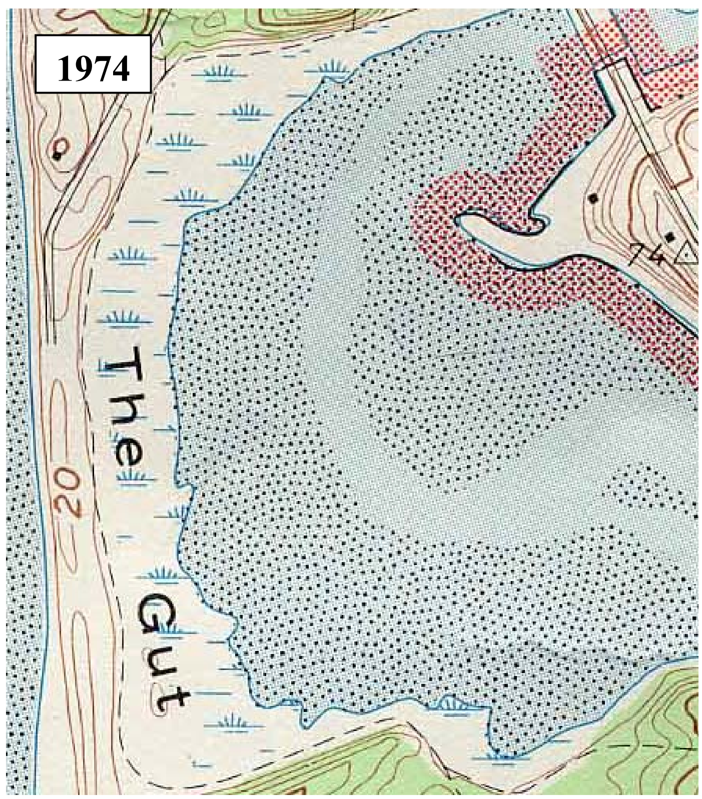


Figure 2.12: Comparison of coastal charts from 1884 and 1974 show that the main ebb channel has not moved throughout the last 100 years and thus was the same prior to the construction of the dike in 1909. Therefore, the position of the ebb channel is not expected to change if the dike were opened.

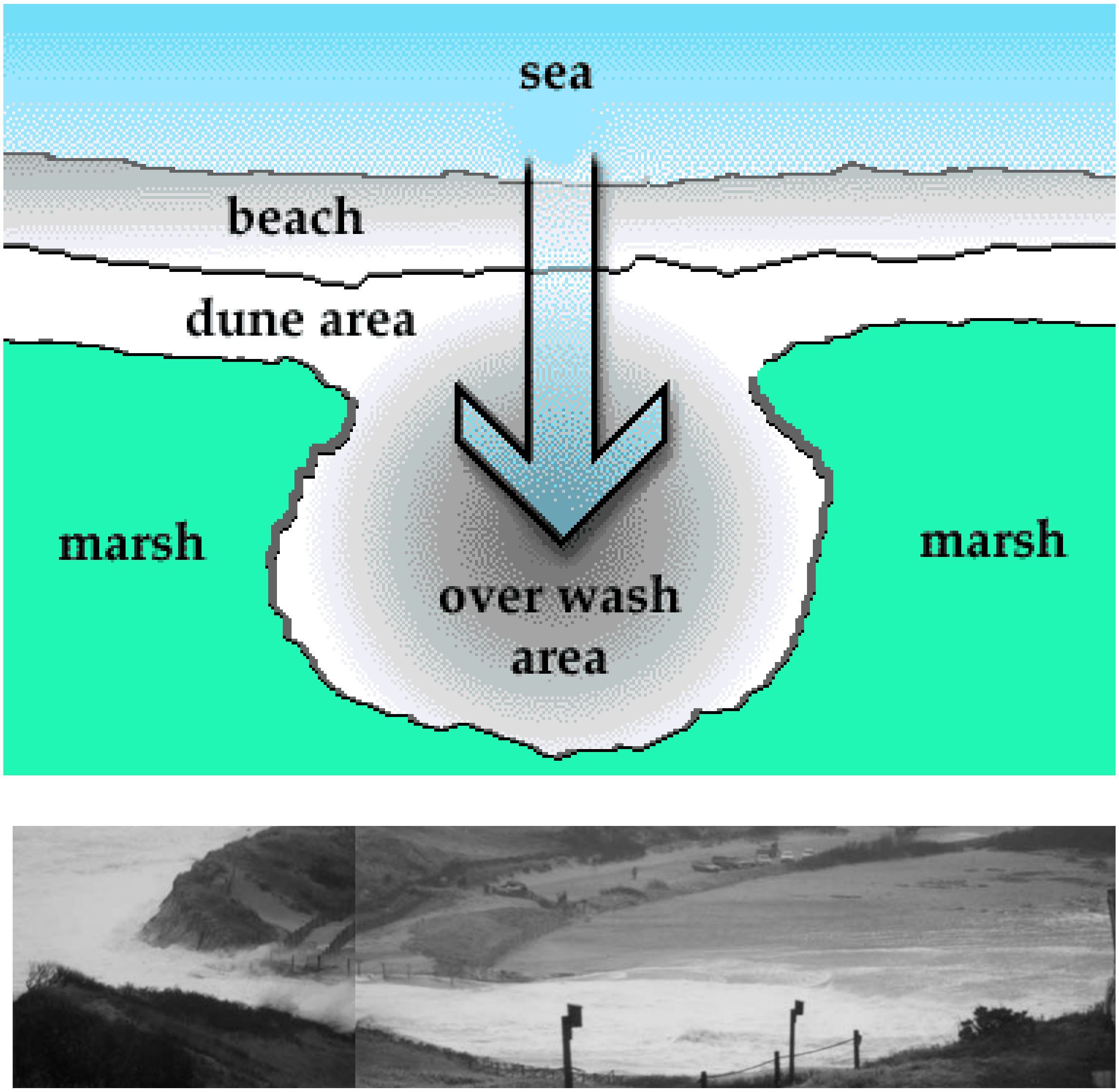


Figure 2.13: Above is a cartoon showing the aerial view of a washover forming on a barrier. Below is a photo taken at Ballston Beach during an overwash in 1991. Even this large overwash on the highly dynamic Atlantic shore did not result in a permanent inlet.

Figure 2.14: Present day pictures along The Gut showing barrier recovery mechanisms that occur after a storm to rebuild the beach. A) Shows a bar or ridge of sand that is reworking back onshore after being eroded by waves from a high-energy storm event. The topographic low landward of the ridge is known as a runnel, where water tends to pool after a high tide. B) Is a picture of a new dune that is forming from fine-grained particles of sand that are moved by wind.

Threats to The Gut

Both sea-level rise and a deficit in the sand supplied to this system are the main natural forces of erosion along The Gut. However, anthropogenic factors such as pedestrian traffic are exacerbating this erosion. The mere act of walking over the dunes to gain beach access results in the trampling of vegetation that is vital in stabilizing the dune sand (Figure 2.15). Loss of vegetation remobilizes sand and, where a path may form from cross-dune traffic (Figure 2.16), the wind is focused and causes downward erosion (Figure 2.17). These low-lying devegetated areas are ideal sites for blowout formation (Figure 2.18) and subsequent washovers during storms.

Figure 2.15: Vegetation loss on the dune due to pedestrian traffic.

Figure 2.16: Established path has caused complete elimination of vegetation.

Figure 2.17: Severe erosion, outlined in red (black), which can develop over an established path.

Figure 2.18: Dune blowout on the southern end of The Gut. These blowouts form as wind is funneled through topographic lows between dunes as a result of erosion.

With currently increasing sea level, it is common for barrier beaches to migrate landward; the process is known as barrier rollover. This transference of sand from the front to the back of the barrier is essential in maintaining the width of the barrier beach. On the river side of The Gut this natural process interrupted by a road (Figure 2.19). The maintenance of this road constrains barrier rollover by preventing sand accumulation. If the landward movement of sand is obstructed, the barrier becomes stationary and sand will simply be eroded and lost to the system. This erosion will result in an overall thinning of the barrier beach. The thinner the barrier, the more likely it is to be overwashed.

Figure 2.19: Wooden fence that leads to path/road behind the barrier.

Measures being taken to minimize erosion of The Gut

In reaction to the degradation of the dune system by pedestrian traffic, steps have been taken by the Town of Wellfleet and Cape Cod National Seashore to monitor this erosion and lessen the anthropogenic impact. Mitigation projects include road and path crossover closures utilizing signage and fences. As a result of the serious problem of blowouts related to foot travel, dune cross-overs for beach access will be limited to only two locations. These formalized crossovers are marked with signs (Figure 2.20) and string to provide “symbolic” fencing (Figure 2.21) making the accepted routes more obvious to encourage their use. The Town of Wellfleet established the northern route (Figure 2.20), located just south of the old Gut parking lot, many years ago. A second crossover was recently selected at the south end of the tombolo (Figure 2.21). The placement of these walkways at the ends of the Gut is not only convenient, i.e. closest to the parking area and to Great Island, but also environmentally optimal, i.e. adjacent to the widest expanses of storm-resistant salt marshes (Figure 2.22). In addition, the paths have a meander or zigzag pattern that should minimize erosion by wind and water (Figure 2.23).

Figure 2.20: Northern beach access on The Gut as indicated in posted sign.

Figure 2.21: Southern beach access marked by signs and symbolic fencing.

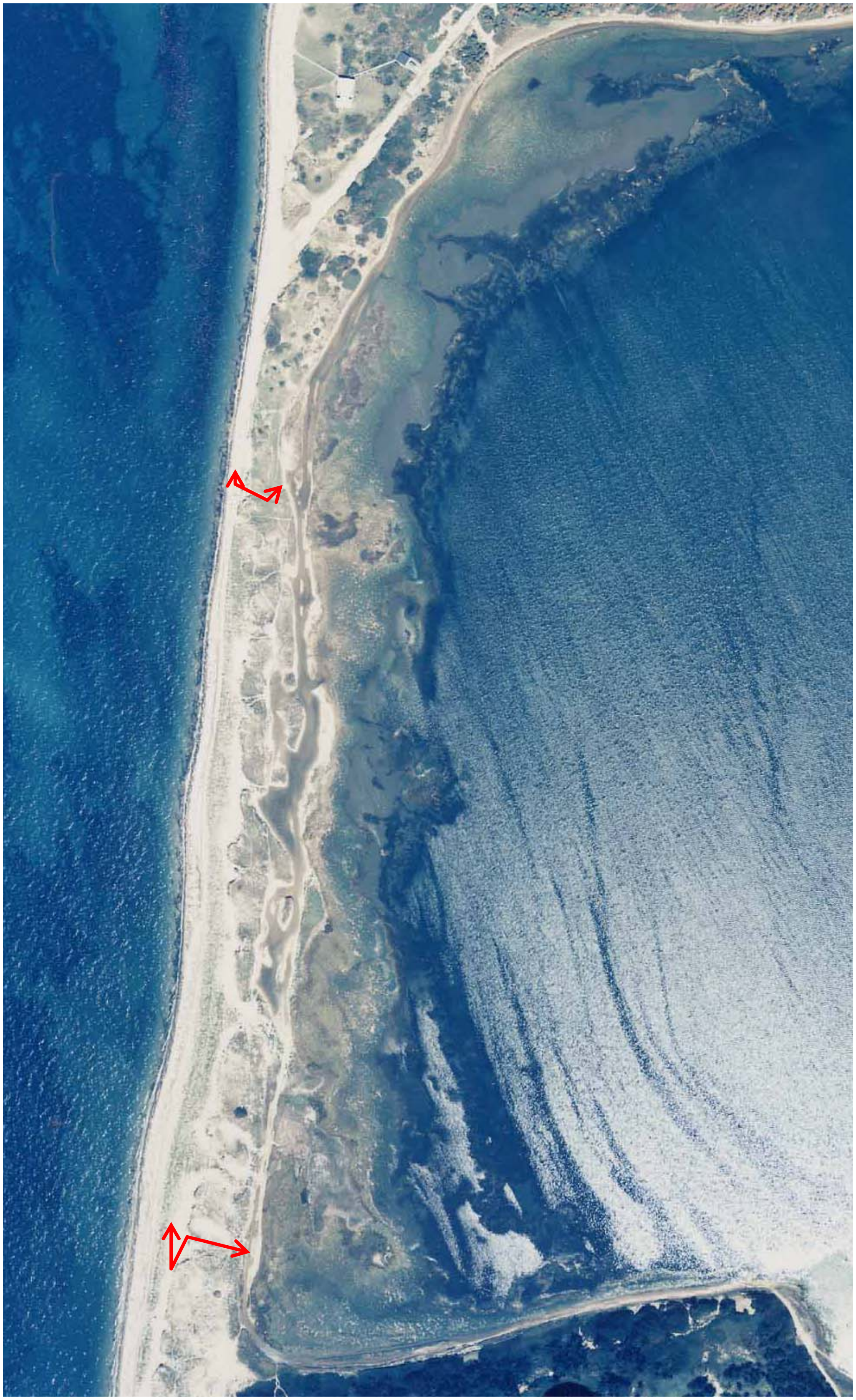


Figure 2.22: Location of north and south crossovers established along The Gut.

Figure 2.23: Photograph looking east of the southern beach access on the Gut. Note the meander or zigzag pattern of the path, highlighted in red.

In areas that have formed paths or blowouts in the more vulnerable central portion of The Gut, restoration projects were undertaken. The largest blowout, located on the southern portion of The Gut, has been sectioned off with dune/snow fencing to both block traffic and capture sand (Figure 2.18). In addition to posting signs (Figure 2.24), dune grass was planted to promote sand accumulation and stabilize the dunes (Figure 2.25). These management practices should minimize erosion due to pedestrian traffic on The Gut.

Figure 2.24: Signs successfully deter pedestrians and promote natural revegetation.

Figure 2.25: A dune stabilized through signage and revegetation programs.

Conclusions

- The continued stability of The Gut is dependent on the same two factors that governed its formation: 1) sand supply and 2) sea-level rise.
- The Gut influences the Herring River rather than vice versa as evidenced by:

- The large meander or bend in the river that occurred as a result of The Gut's formation, that forced water to flow south through the harbor.
- The existence of wide mudflat on either side of the main ebb channel present even before the dike was constructed, indicative of low ebb-flow velocities from the river.

- It is unlikely that The Gut would breach and form a permanent inlet due to the extensive marsh backing this barrier beach. If a large storm were to cause erosion along The Gut, a temporary washover may occur; however, natural post-storm rebuilding processes would quickly close it.
- Foot traffic across the dune system has worsened erosion and increased the possibility of a blowout. The Town of Wellfleet, Cape Cod National Seashore and volunteers are taking action to repair and limit this damage.