CHAPTER 3

SEDIMENTATION IN THE LOWER HERRING RIVER

Introduction

The question most frequently asked, and apparently of greatest concern, was whether opening the Herring River Dike would affect sedimentation on shellfish beds below the structure. A sample of these questions is provided below:

- What is the expected sedimentation and reconfiguration of Egg Island once the dike is opened?
- What are the short-term effects of opening the dike before the system reaches a new equilibrium?
- What is going to happen (with respect to sediment) below the dike?

Strategy

The above questions regarding sedimentation below the Herring River Dike were addressed by:

1) Synthesis of existing scientific research on Herring River and on diked salt marshes in general.
2) A new study designed specifically to address the sedimentation concerns below the Herring River Dike. The approach of this study is described in the methods section below.

Literature Review

In order to acquire as much information as possible, an extensive literature review was conducted. In addition to regular access to the North Atlantic Coastal Laboratory Library, multiple trips were taken to Marine Biological Laboratory Library (Woods Hole) and Boston University's Science and Engineering Library. Several geology database search engines were used such as GeoRef and Geobase. Despite this intense effort, no other studies were found with respect to sedimentation associated with restoration of a diked salt marsh. In contrast, many studies on the Herring River were found; however, only one addressed the issue of sedimentation. This study performed by Malcolm L. Spaulding and Annette Grilli in 2001 entitled *"Hydrodynamic and Salinity, Modeling for Estuarine Habitat Restoration at Herring River, Wellfleet, Massachusetts",* was extremely useful as a base for the new investigation and will be referenced frequently throughout the remainder of this report.

Synthesis of the 2001 Hydrodynamic Study

Effects of Dike Construction

The dike across the mouth of the Herring River has reduced the tidal range above the structure by greater than 4.5 times (Figure 3.1). The difference in tidal range from 2.53 meters below the dike to 0.56 meters above the dike, causes an asymmetry between the flood and ebb flow velocities in the lower portion of the river. The faster flood currents, particularly during very high and storm tides, result in a dominant transport of sediments in an upstream direction. Once sediment-laden water enters the sluice gate the constriction of flow causes the water to speed up, much like putting your finger over a garden hose causes the water to spray out. With this increased flow, sediment is rapidly transported through the dike and into the relatively unconfined, large portion of the lower river. The entrance into this comparatively quiet water causes the flow to disperse, much like the jet stream of a Jacuzzi dissipates with distance, and forms what is known as a plume (Figure 3.1). As the plume velocities and turbulence decrease away from the sluice opening, to suspended sediment settles. The larger grains settle first and are deposited just landward of the dike in a fan or triangular shape bedform, similar to a delta at the base of a river. The finer grains are carried farther and deposited just upstream of the delta. This system is more analogous to a tidal inlet than a river mouth because of the confined bi-directional flow created by the tides. In sticking with the model of a tidal inlet, this sedimentary deposit above the dike will be called the flood-tidal delta (Figure 3.1 & 3.2).

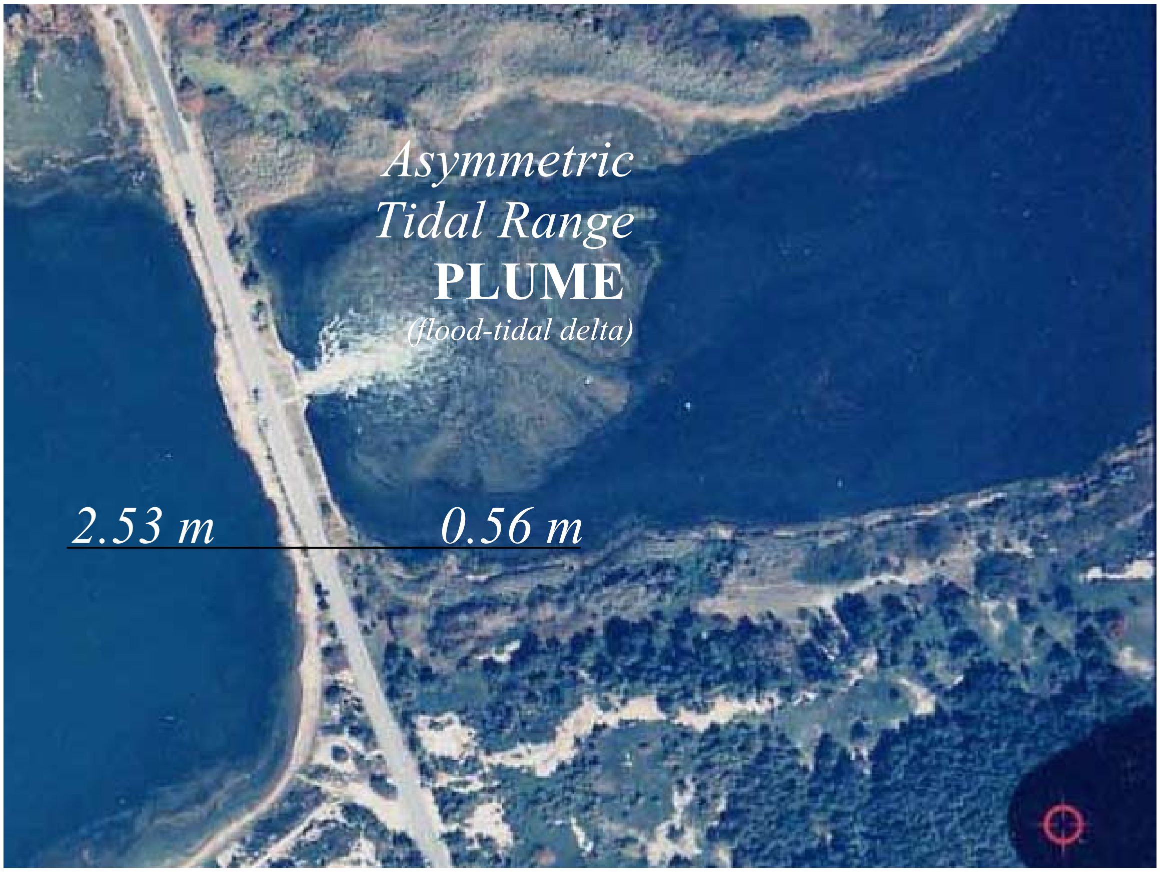

Figure 3.1: Aerial photograph of the Herring River Dike during flood tide showing the flood-tidal delta. Sediment accumulates above, rather than below, the dike because flood-tide velocities are higher and thereby transport more sediment than ebb tides (Figure 3.2).

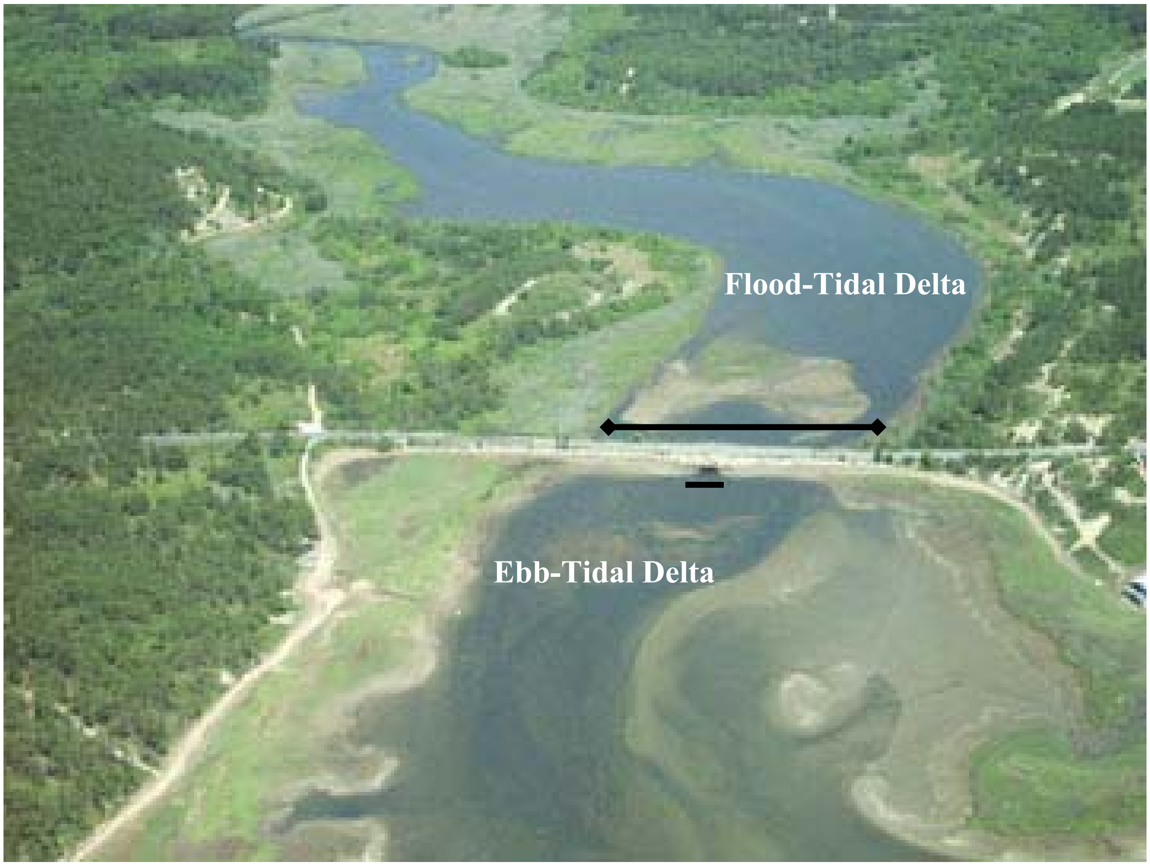

Figure 3.2: Air photograph showing the location of the flood-and ebb-tidal deltas, as well as the reduction in width of the river (black line with diamond end points located above the road) to the small opening of the dike (black line below the road).

The same process occurs during an ebb tide, but to a lesser extent because the flow is weaker. While the force of the rising tide in Cape Cod Bay pushes floodwaters, the ebb is driven only by gravity. The dike restricts the amount of water entering the river during the flood; this results in less hydraulic head forcing the water back out on the return tide. These low ebb velocities transport little sediment in a seaward direction, as evidenced by the smaller size of the ebb-tide delta (Figure 3.2).

This lack of sediment moving in a downstream direction prompts the question of why an ebb-tidal delta exists at all. It is thought that both deltas initially formed when the dike was built and flow was constricted to one small area (Figure 3.2). Erosion caused by the focused flows scoured a channel proximal to the culverts and perpendicular to the dike. The scoured material was then deposited at the upstream and downstream ends of the channel, forming the flood-and ebb-tidal deltas respectively. Once the channel became established and the area reached equilibrium, little additional sediment was added to the ebb-tidal delta allowing oysters to colonize it (Figure 3.3). In contrast, the flood-tidal delta continues to grow by the constant addition of sediment brought in from the ocean, preventing colonization by oysters.

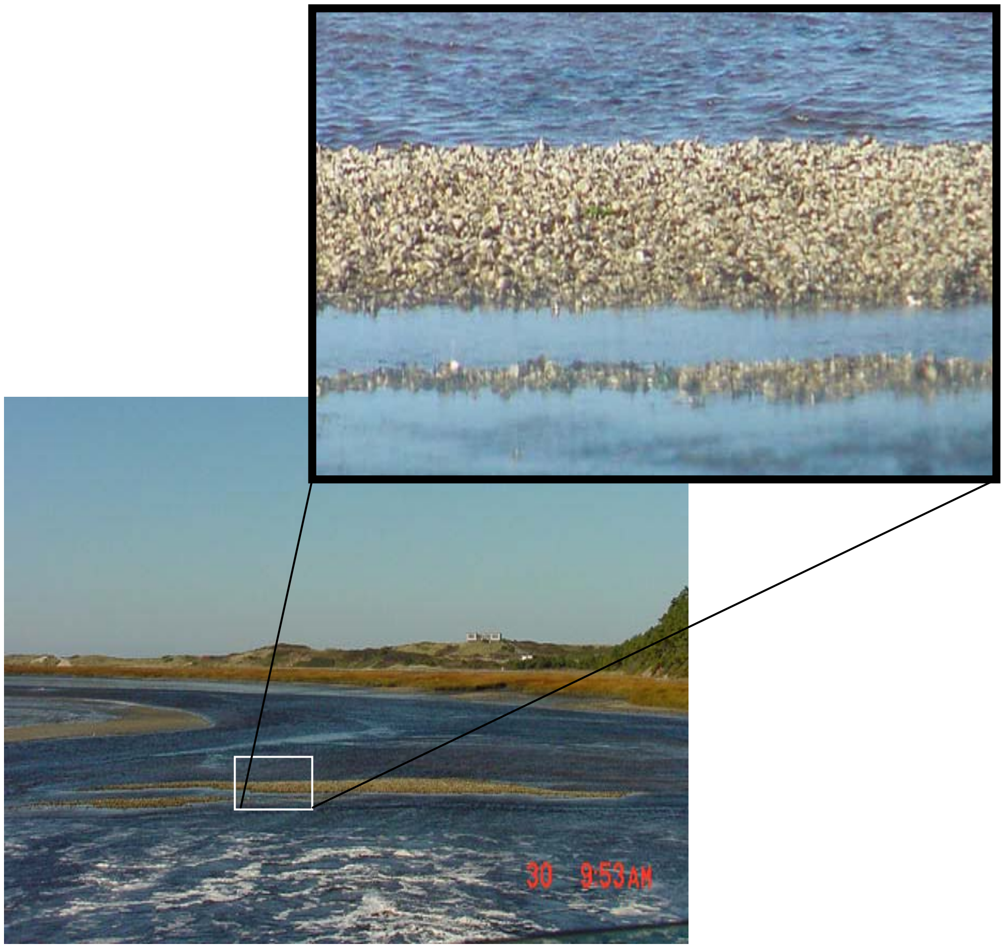

Figure 3.3: Digital photo of ebb-tidal delta armored with shellfish.

Above the Dike

Spaulding and Grilli's (2001) extensive hydrodynamic study measured the velocities of the ebbing tides proximal to the flood-tidal delta and found them to be insufficient to resuspend the sediment within the delta or the fine-grained material just upstream of it. These currents will be reduced even more if the dike is opened to allow more water to flow through the structure. In keeping with the above hose analogy, the situation is likened to taking your thumb off of the nozzle, thus increasing the opening and causing the water to stop spraying and to return to a slower flow. Although increased sluice gate openings will cause water velocities through the dike itself to decrease, both tidal range and current velocities will increase in the river upstream of the dike; however, flows will still be far too slow to resuspend sediment. Spaulding and Grilli's study determined peak velocities in the river with all three dike gates open to be less than 10 cm/sec, which is half the 20 cm/sec necessary to resuspend sand within the river (Figure 3.4).

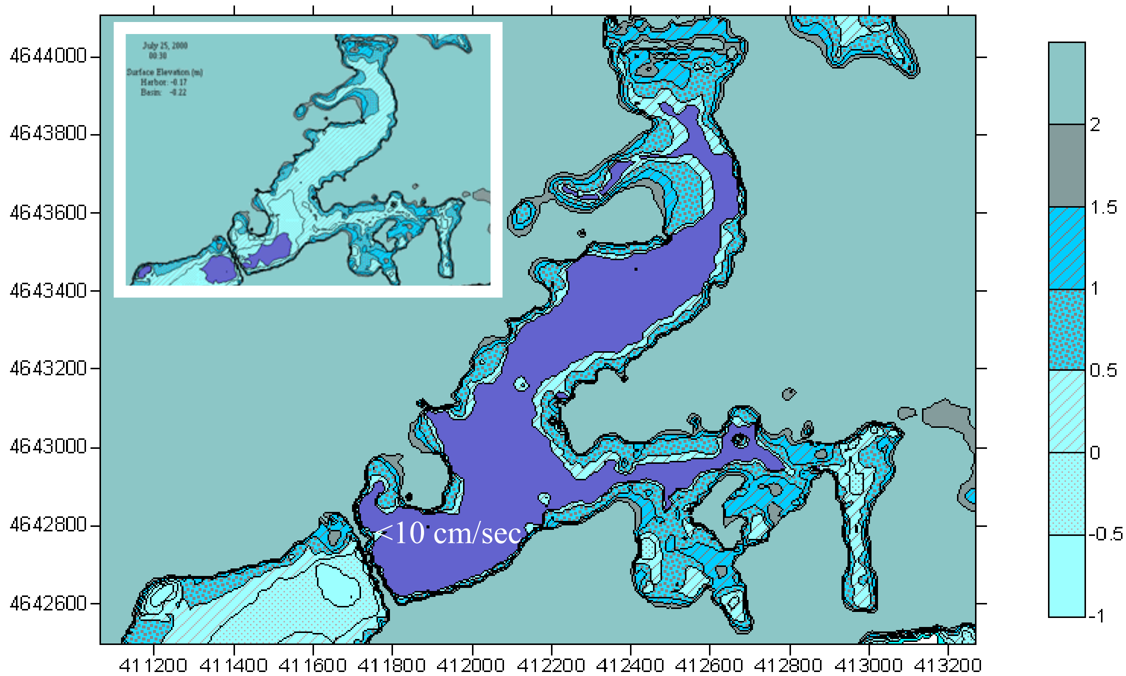

Figure 3.4: Snapshot of Spaulding and Grilli's hydrodynamic model that predicted maximum velocities above the dike, with all gates open, to be less than 10 cm/sec.

Spaulding and Grilli also estimated that the flood-tidal delta will undergo minor changes during storm events, but for the most part it is likely to remain much as it is at present. Under these storm conditions the delta and riverine sands would probably undergo very slow erosion and dispersal within the river. The finer-grained sediment such as silt and clays, which would be resuspended under normal tidal forcing, would be transported both up-and downstream during storms. However, keeping in mind that the stronger flows are associated with the flood tide, the dominant transport direction would remain upstream. Therefore the fine-grained material that is usually deposited in the channel above the flood-tidal delta, due to lack of flow energy, would then be moved farther upstream and deposited in the marsh. In the case of a large rain event, Spaulding and Grilli report that the ebb tides may transport sediment in a seaward direction. The rain is an independent driving mechanism responsible for the re-suspension of the sediment and its movement out of the drainage basin. Once this sediment is suspended it would be carried seaward through the dike in the same manner as is the case today, regardless of the dike's configuration, because all three flapper gates allow water to move in a seaward direction. Therefore, it is likely that the resulting sediment transport patterns with the dike open would be identical to those during past rainstorms with the gates in their current configuration. During these events the larger sand size particles will likely settle just below the dike, near the present ebb-tidal delta, while the tiny silt-and clay-sized grains will widely disperse and deposit in the fringing marshes of The Gut or offshore.

In speaking with people, the fine-grained material that has been deposited above the flood-tidal delta was of particular concern. While discussing this material with Dr. Spaulding he explained that these fines are deposited mainly in the channel, instead of on the marsh surface as typically expected, because the flow above the dike is hindered by the structure. Under natural conditions, the flow within the channel would be too fast to allow fine sediment to be deposited. Instead it would be transported farther upstream and dispersed into the marsh where the grass disturbs and slows the flow. Thus, before the dike, these fine sediments were carried through the channel and settled on the upstream marshes. However, with the existing dike, even with three gates open, the flow is not strong enough to resuspend most sediment during a normal tidal cycle. During a rainstorm and subsequent runoff events, silt and clay may be suspended according to Spaulding and Grilli (2001), but they will behave much like the fine sediment from the delta. To reiterate, these fine-grained particles will likely be deposited in the fringing marshes or offshore where flows are low and the water is calm enough to let the small particles settle. It is unlikely, even during a rainstorm, that these fines will settle on sand flats because the flow environment is too fast. In researching this study and talking to local shellfisherman, no one reported of siltation on shellfish beds after rainstorms.

Below the Dike

The Spaulding and Grilli study predicted that velocities would not exceed the threshold necessary to resuspend sediment above the dike. However, the study did not directly model flows below the dike. To address this subject of sediment transport below the dike, Dr. Spaulding used existing field data to assess the potential for velocities to reach the necessary 20 cm/sec. The flow velocity is determined by taking the peak volume of water per unit time that is passing through a unit area. This basically means, to figure out how fast the water can possibly flow below the dike, divide the greatest amount of water per second by the cross-sectional area of the river. Below the dike the peak flow under present conditions was measured to be 5-8 m^3 /sec; which was rounded to 10 m^3 /sec. Since the cross-sectional area is smallest just below the dike (measured in the field to be 500 m^2), this area was used because the velocities are fastest there (Figure 3.5).

So if: **Velocity = volume of water per unit time / unit area**

Then: **Velocity = (10 m^3 /sec) / 500 m^2**

Or: **Velocity = 0.02 m/sec (*2 cm/sec*)**

This calculation shows that peak velocities below the dike are a 10^{th} of the 20 cm/s necessary to resuspend sediment. Spaulding and Grilli also point out that even during spring tides where 30% stronger velocities are expected, the threshold for resuspension will still not be approached. Even with all sluice gates open, which results in a volume increase by a factor of three (2 cm/sec X 3), the velocities would still be just over a quarter of the 20 cm/sec needed (6 cm/sec). Keeping in mind that this is the maximum velocity, because it was calculated using the smallest channel cross-sectional area, velocities will decrease with distance and enlarging channel cross-sectional area, below the dike, reducing even further the possibility of moving any sediment. Thus, the hydrographic model predicts no re-suspension of sediment above the dike, while the above calculations show no sediment movement below it. Changes in sedimentation patterns, as a result of opening the dike, will be minimal and very near the structure. In order to further test this conclusion, a new study was performed focusing specifically on the portion of the Herring River below the dike.

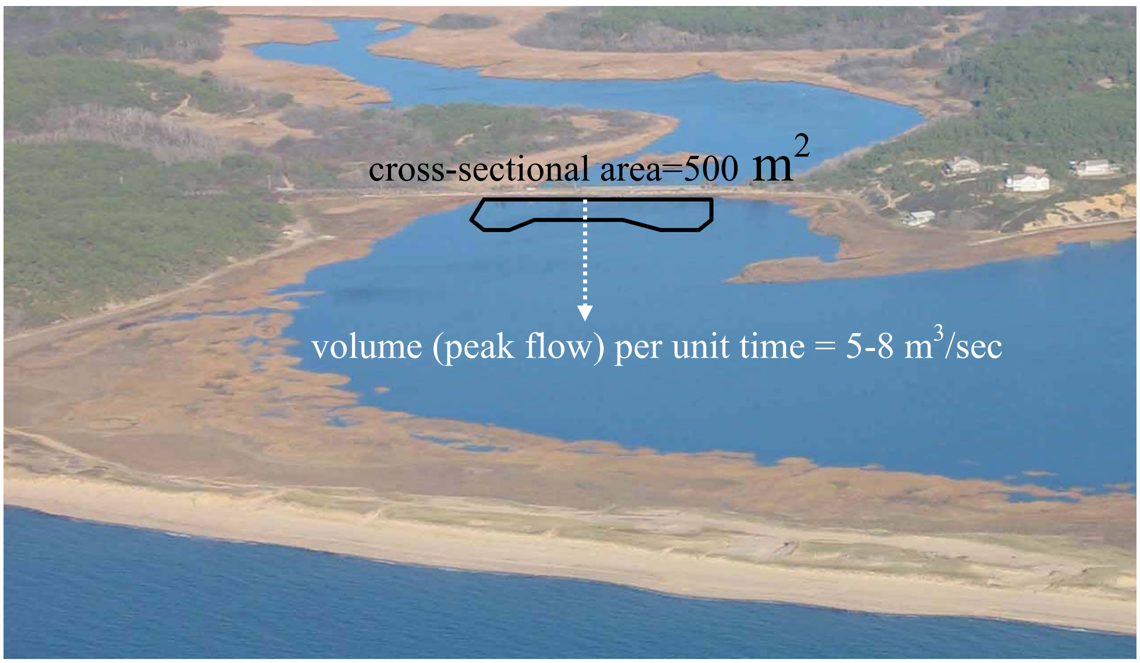

Figure 3.5: Pictorial display of the variables determining peak velocity in the river channel below the dike.

Methods

The approach was to map sedimentation patterns over time using historical data. The theory behind this approach is that by measuring the changes in sedimentation after construction of the dike, and during subsequent alterations to its configuration, it is possible to predict the response under similar or converse conditions. This is based on one of the major principles of geology: the present is the key to the past and the past is the key to the future.

Initially, historic aerial photos and coastal charts of the Herring River were acquired and scanned into digital form. When necessary these images were entered into a Geographical Information System (GIS) database and rectified. Once all of the images were geo-referenced or scaled, prevalent bedforms or channels were identified and mapped throughout time. From the changes in these large-scale features, long-term transport trends were extrapolated. Upon completion of the remote sensing component, field data were collected to ground-truth the results. Detailed field data were collected on present day bedforms and grain-sizes exposed at low tide, as well as flow directions during tidal cycles. Whenever possible these observations were documented using digital photographs (Appendix C).

Data Analysis

The investigation of long-term sediment transport patterns utilized historic t-sheets, coastal topographic maps and air photos spanning the last century and a half. The data consist of a series of images displaying the intertidal bathymetry of the same lower portion of the Herring River proximal to the dike. In accordance with the change in the intertidal geomorphology, the years selected straddle major events in the dike operation and are indicated as such in the figure captions. This section is separated into two parts: aerial photography and coastal topographic maps.

Aerial Photography

In each of these sections an untouched digital image is shown as raw data and below is a blow up of the area analyzed for comparison. The shape of the main ebb channel has been interpreted and mapped as white or yellow dots on the analyzed sections.

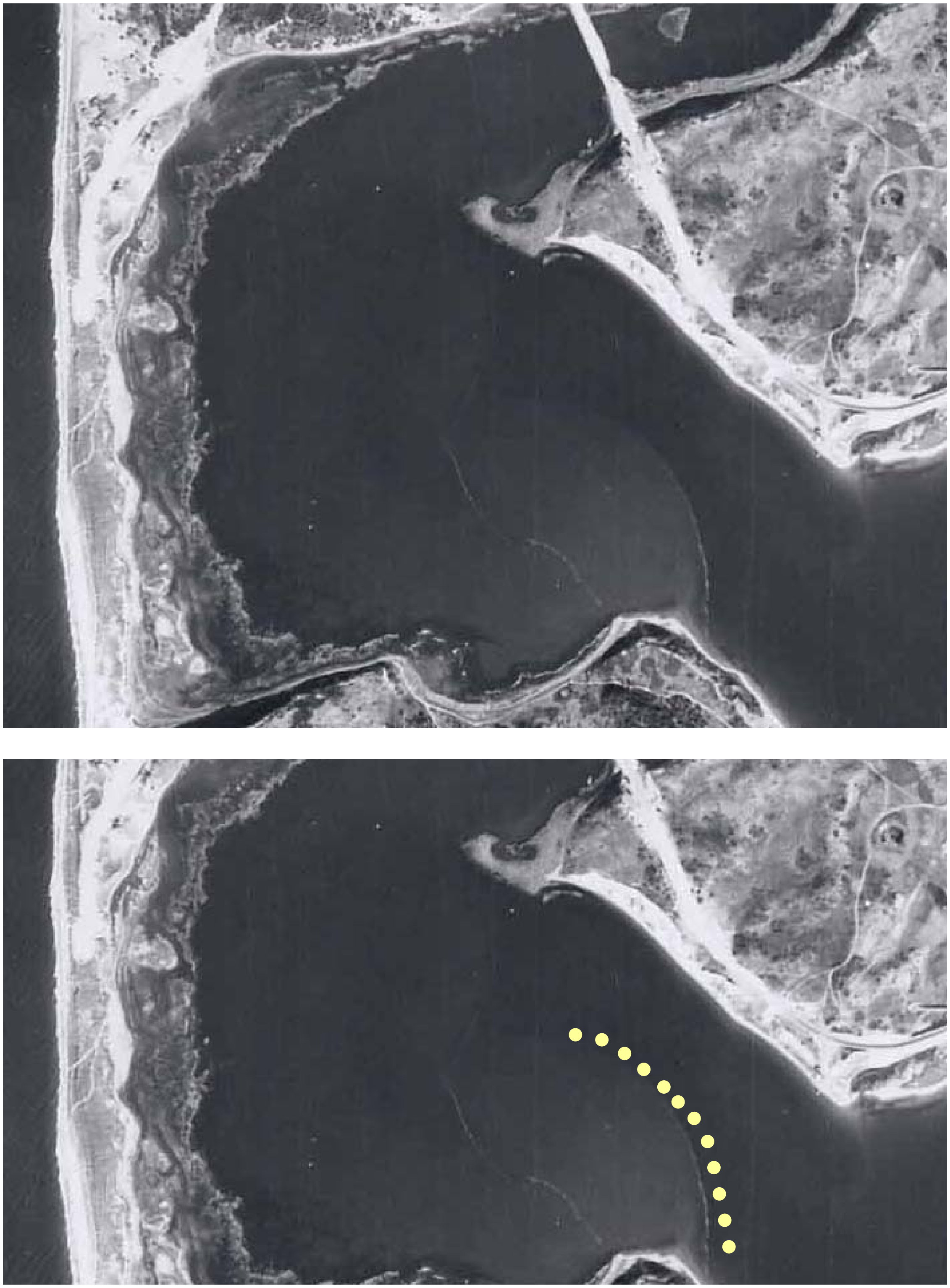

Figure 3.6: This is the first air photograph of Herring River taken in 1938, 30 years after the dike was constructed. It is hard to see what the configuration of the intertidal area is due to it being high tide, but you can make out what seems to be part of the main ebb channel marked by white (or yellow) dots.

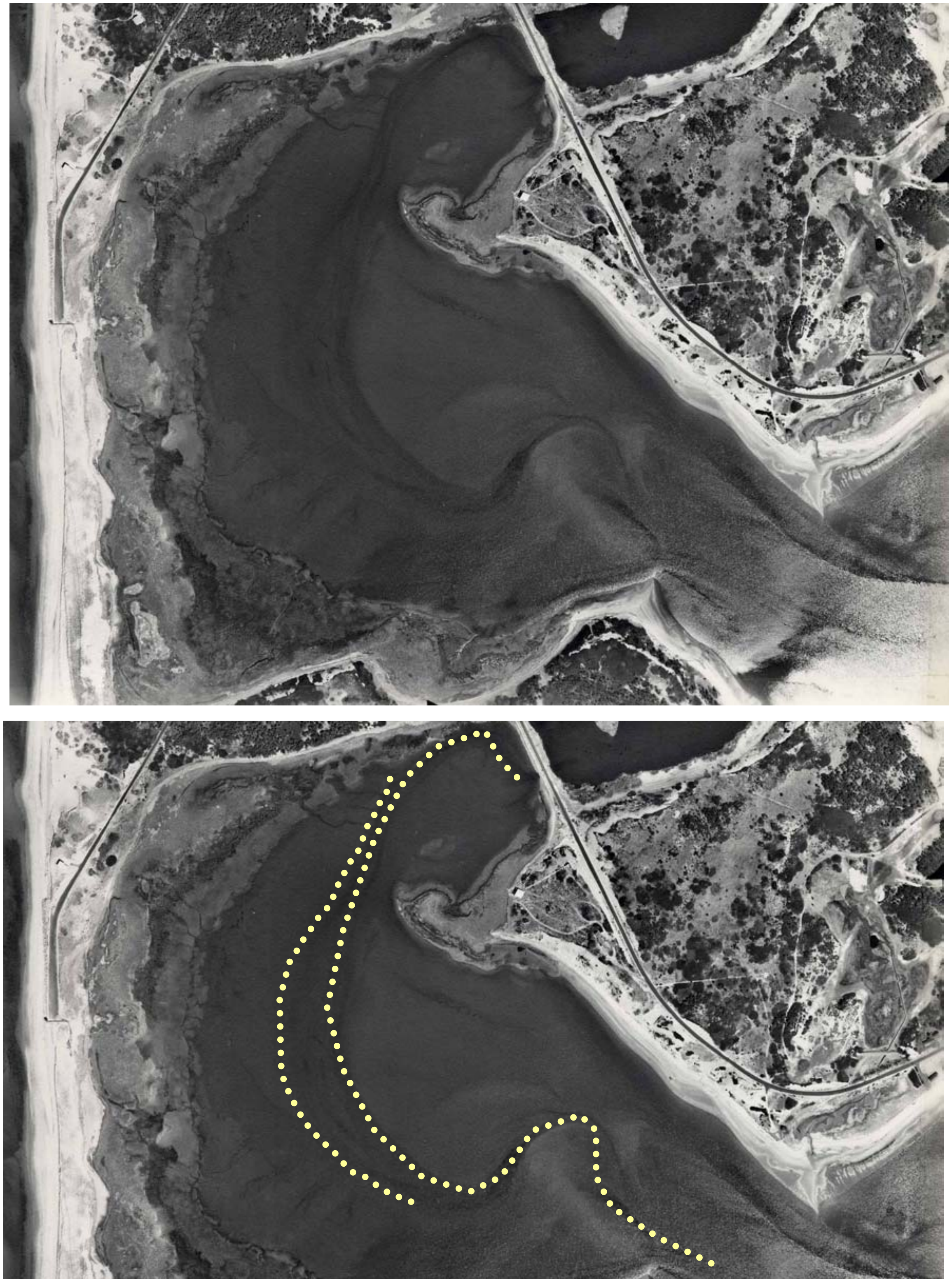

Figure 3.7: This 1960 air photo was taken at a slightly lower tide and you can start to see the whole length of the main ebb channel and the possibility of a second channel. For reference this is the last photo taken before the dike breach in 1968.

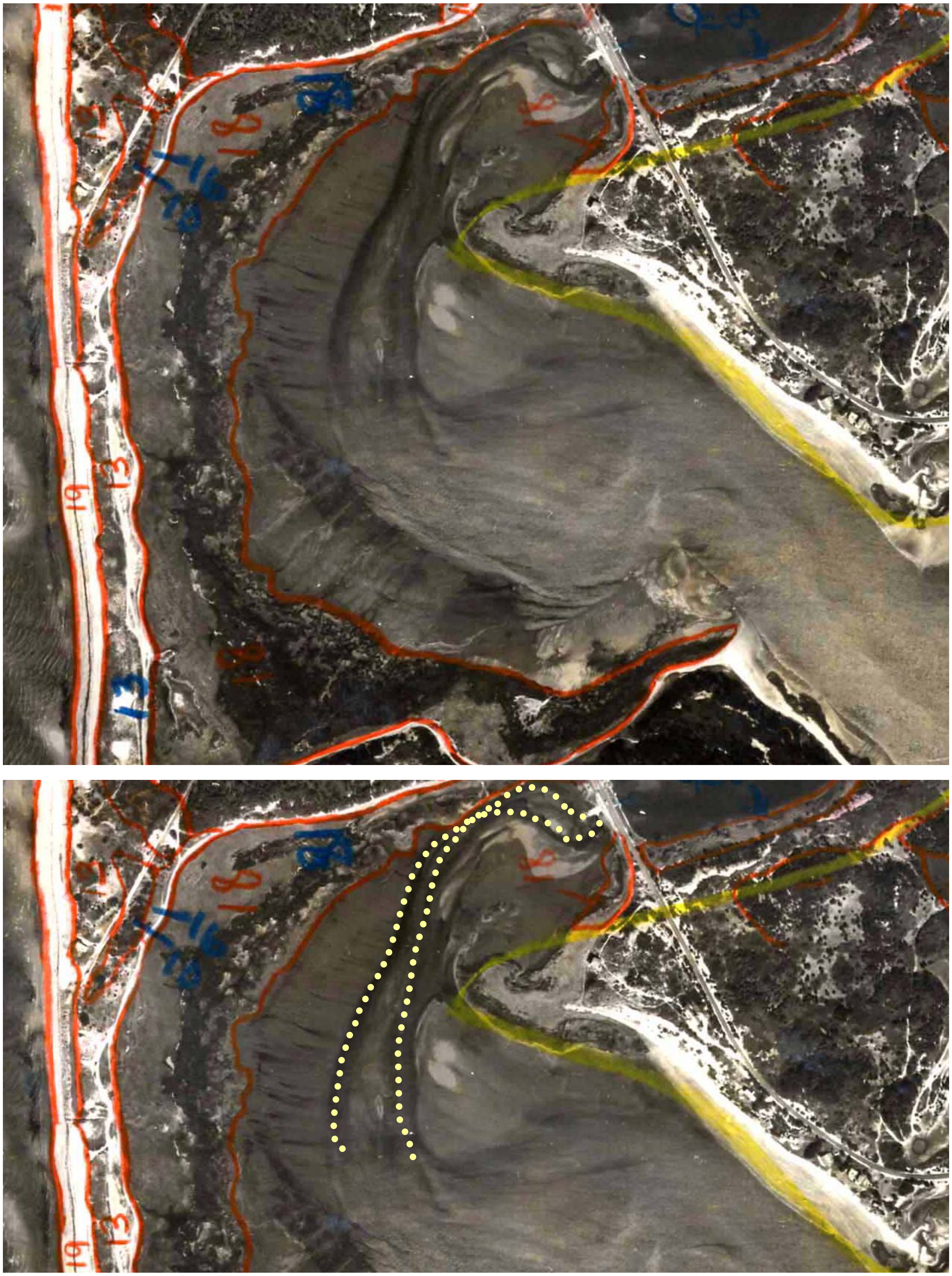

Figure 3.8: 1977 air photo taken just after the dike was rebuilt following the breach. This low-tide shot shows that the main ebb channel, while maintaining the same shape, actually splits in two just below the dike.

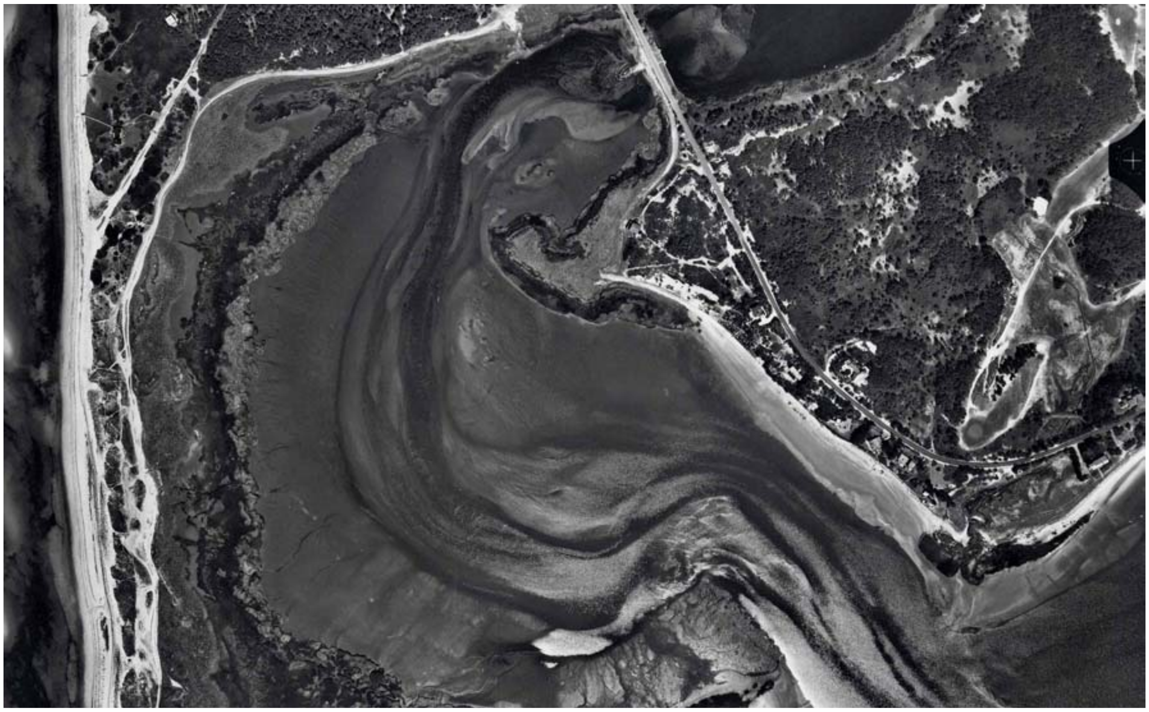

Figure 3.9: This 1987 air photograph, taken at the lowest tide in the series, shows the same main ebb channel morphology as the rest and also the split seen in 1977. This photo was taken over ten years after the dike was repaired following the breach.

Figure 3.10: This 1991 air photo was taken at high tide, thus restricting the view of the intertidal morphology with the exception of possibly the lower channel like 1848 (Figure 3.13).

Figure 3.11: This 2001 air photo was taken at about mid-tide revealing the same configuration and faint impression of the duel channels as seen previously.

Coastal Topographic Maps (T-Sheets)

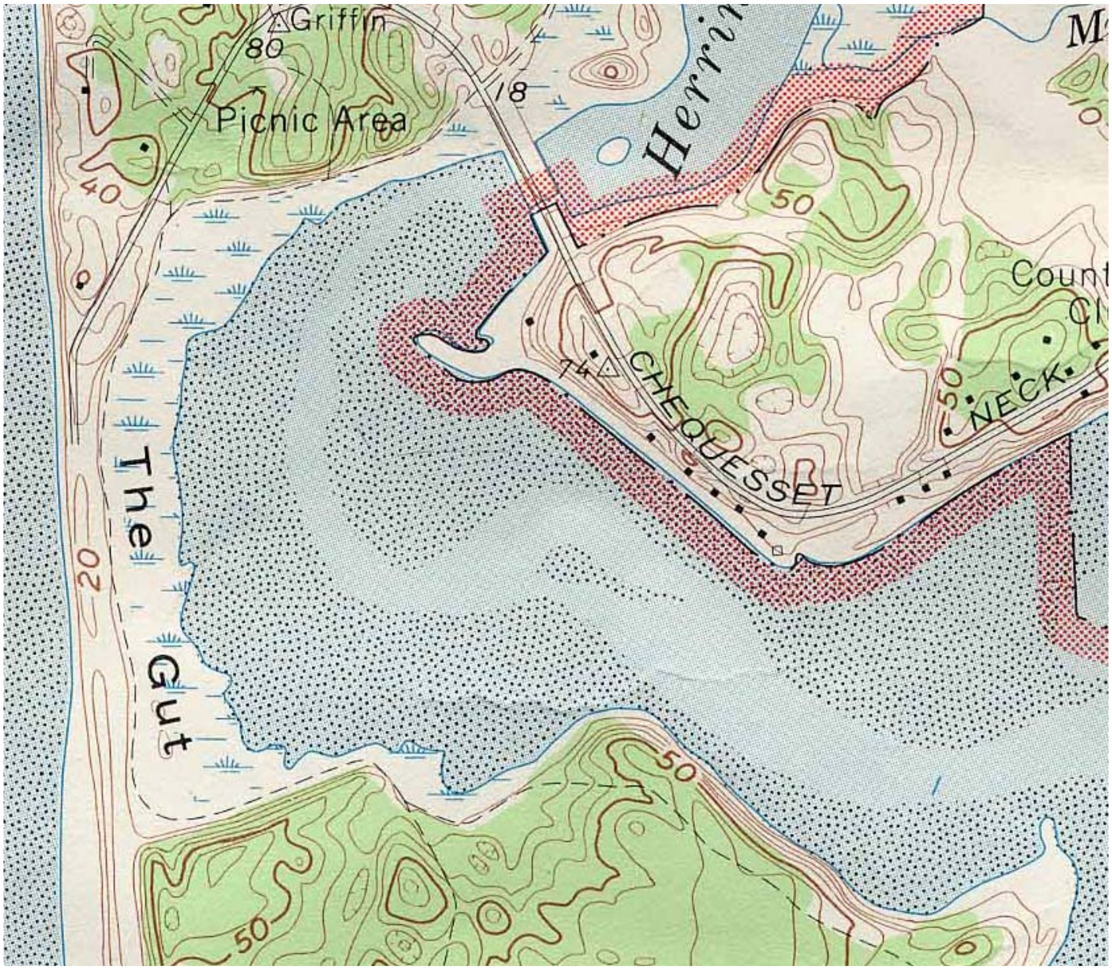

Figure 3.12: 1974 USGS topographic map showing the configuration of the intertidal bedforms in the stipple pattern. This depiction reveals the same main ebb channel geometry that was evident in the air photographs.

Figure 3.13: This t-sheet (coastal topographic map) from 1848 shows the intertidal morphology that existed prior to the dike's construction in 1908-1909. The configuration of the main ebb channel has the same s-shape geometry as the post-diked scenario depicted in the 1974 coastal chart.

Discussion

Despite difficulties in mapping sediment bedforms on some of the photos that were taken at high tide, historic photos are more than adequate to show the main ebb channel through time. The channel exists between intertidal flats; thus, mapping this channel through time is the same as mapping the extent of the intertidal flats. The aerial photographic time series shows that the visible parts, if not all, of the channel maintain a similar s-shaped geometry. At mid to low tide a split is evident around the ebb-tidal delta and then crosses and splits again just downstream of it. This geomorphic consistency indicates that no significant change in channel morphology has occurred since 1938. This period includes any changes in flow caused by the breach and subsequent repair of the dike in 1968 and 1975, respectively.

Coastal bathymetric surveys, referred to in earlier time as t-sheets, were used in order to study the shape of the actual intertidal flats themselves. These bedforms have been consistently mapped at low tide by the United States Geologic Survey. The most recent of these maps was made in 1974 (Figure 3.12). By comparing the 1974 map to the aerial photograph closest to that time (1977) (Figure 3.9), it can be seen that the main ebb channels are identical in shape. Since the main ebb channel in 1977 appears to be the same in all the rest of the air photographs, the 1974 coastal chart is representative of the post-dike morphology in the intertidal region of the lower Herring River.

Even though no real change appears to have occurred after the installation of the dike, the question still remains as to whether original dike construction in 1909 affected sedimentation downstream. To address this question, an 1848 t-sheet / coastal topographic map was acquired (Figure 3.13) and compared to the 1974 map (Figure 3.12). This comparison revealed that despite the establishment of ebb-and flood-tidal deltas proximal to the dike, sedimentation did not change because of dike installation. Conversely, it is logical to predict that any future adjustment to the dike's configuration, including complete removal, would affect sedimentation very little and only very near to the dike itself. This lack of change in channel morphology and sedimentation below the dike is reasonable considering that the harbor's hydrodynamic regime (e.g. tidal range) was hardly affected by the emplacement of the Herring River Dike. In other words, any changes that have taken place below the dike have been minimal and are most likely a result of harbor dynamics that occur regardless of the dike's existence.

Real World Support for Discussion

Testimony about 1968 Breach in the Herring River Dike

In 1968 the sluice gate rusted out allowing an instantaneous, non-incremental, influx of salt water into the area just above the dike. This tidal flow continued for the following six years until the dike was repaired in 1975. During this period, there is no record of increased sedimentation onto areas of high shellfish production such as Egg Island. As part of this study, phone interviews were conducted with shellfisherman that were around during this time; they had no recollection of adverse sedimentation resulting from this breach. On the contrary, there were multiple reports of shellfish colonizing and thriving in the area around the dike with the increased tidal flow. A biologist for Coastal Zone Management, Gary Clayton, conducted a survey for the Commonwealth of Massachusetts that documented people's observations after the breach. The consensus was that the shellfish grew in the area around the dike and subsequently died after the dike was repaired (Figure 3.14 & 3.15).

This breach represents an opportunity to test the effects of opening the dike. With this perspective, it is logical to predict that if a sudden and large change in the tidal flow did not cause sedimentation on shellfish grants in 1975, then small and incremental changes would not initiate movement. These data support the conclusions of both this study and that of Spaulding and Grilli (2001). Additionally, the opening of this dike would initiate the return of the shellfish around the dike, and possibly even extend favorable habitat farther upstream.

With respect to concerns about sedimentation on Egg Island, the reality is that it is simply located too far away form the Herring River Dike to experience any change associated with the restoration (Figure 3.16). Shellfisherman that worked Egg Island during the dike breach in 1968 report no change in sedimentation. That is not to say that sediment is not accumulating on Egg Island, but any change in the tidal flats is a result of tidal dynamics in the Harbor and Cape Cod Bay rather than any influence of the Herring River. Indeed, if we compare the configuration of Egg Island from 1848 to 1974 (Figure 3.17), it appears that little has changed. By virtue of the fact that sea level is rising on an average of 2.5 mm/year in this area, sediment must be accumulating on these intertidal flats to keep then from becoming subtidal. Thinking back to sediment movement along the Cape, which was discussed in the previous chapter, sand is moving southward along Wellfleet's Cape Cod Bay beaches. The sand that is not incorporated into the barrier beaches connecting the Wellfleet Harbor islands is carried either into the harbor or the bay. Looking at a sediment transport map (Figure 3.18), large bedforms, known as sand waves, indicate the direction that sand is moving. This movement is indicated on the map with arrows sized to represent the sizes of the bedforms. All of these arrows show that the net landward movement of sand is coming along Cape Cod Bay beaches and into the harbor. Close study of these bedforms suggests that over time these sand waves have been stationary, indicating that the harbor has reached an equilibrium in which the sediment transported into the harbor is simply keeping up, or building vertically (aggrading), with sea-level rise. It is the tidal forcing of bay and harbor, and not the Herring River, that shapes Egg Island and the rest of the intertidal flats in Wellfleet Harbor (Figure 3.19).

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MEMORANDUM

TO: Gary Clayton, Biologist CZM

FROM: Bev Tangvik, Investigator Public Protection Bureau

DATE: March 20, 1979

RE: Herring River, Wellfleet

The following is a summary of telephone interviews with people who live and/or work near the Herring River in Wellfleet. The interviews were conducted to document personal observations and experiences of environmental alterations in the saltmarsh, shellfish and alewifes which they feel are attributable to the new tidal gate in the Herring River Dike.

1. Alton Atwood - Oysterman and member of the Shellfish Advisory Committee. He has lived and worked near the Herring River all his life. Since the new tidal gate was contructed he has observed that the oyster beds have been covered with mud on the Bay side. Before the dike was built the mud was washed away.

2. Steven Kozelka - Chairman of the Shellfish Advisory Committee. He has lived near the Herring River for four years. His observations describe the changes in the shellfish. There are no longer shellfish west of the dike and the area down toward the bay. He attributes this to silting on both sides of the dike. He has seen a reduction in growth rate of the oysters due to less feed coming down river. He believes the dike is detrimental to shellfish in the harbor as well, due to the reduction in feed.

Figure 3.14: Page #1 of interviews conducted by the Commonwealth of Massachusetts that clearly state that shellfish, which colonized after the dike breached, were subsequently silted over when the dike was repaired.

3. Russell Swart - Shell fisherman and member of the Shellfish Advisory Committee. He has lived and worked near the Herring River since 1972. He has observed changes in the shellfish during this time. When the gate was in need of repair in the early 1970's shellfishing was great with lots of shellfish on both sides of the dike. After the dike was fixed all the oysters and steamers died. The river is silting in on the salt water side.

He doesn't believe there were many herring this year.

4. Michael Parlenti - Shellfisherman and member of the Shellfish Advisory Committee. He has lived and worked near the Herring River all his life. His observations are focused on the changes in the shellfish in the area. Before the dike was repaired there were a lot of shellfish on both sides of the dike, but there has been a decline in the shellfish since the reparation of the dike. Since the dike was repaired there has been a reduction in tidal flow causing a decline in food on the salt side. When the dike went under repair sand was placed around the dike and this sand killed the shellfish.

He believes the herring in the river are about the same, maybe a little less.

5. Wilber Rockwell - Member of the Conservation Commission. He was Selectman for five years, retired Spring 1978. He believes there has been no detrimental effects to the alewifes with the new dike relative to the old dike and the time when the dike was in need of repair. He observed during the time the dike was in need of repair that trees were killed in the surrounding area due to the two foot difference in water elevation.

Figure 3.15: Page #2 of interviews conducted by the Commonwealth of Massachusetts that clearly state that shellfish, which colonized after the dike breached, were subsequently silted over when the dike was repaired.

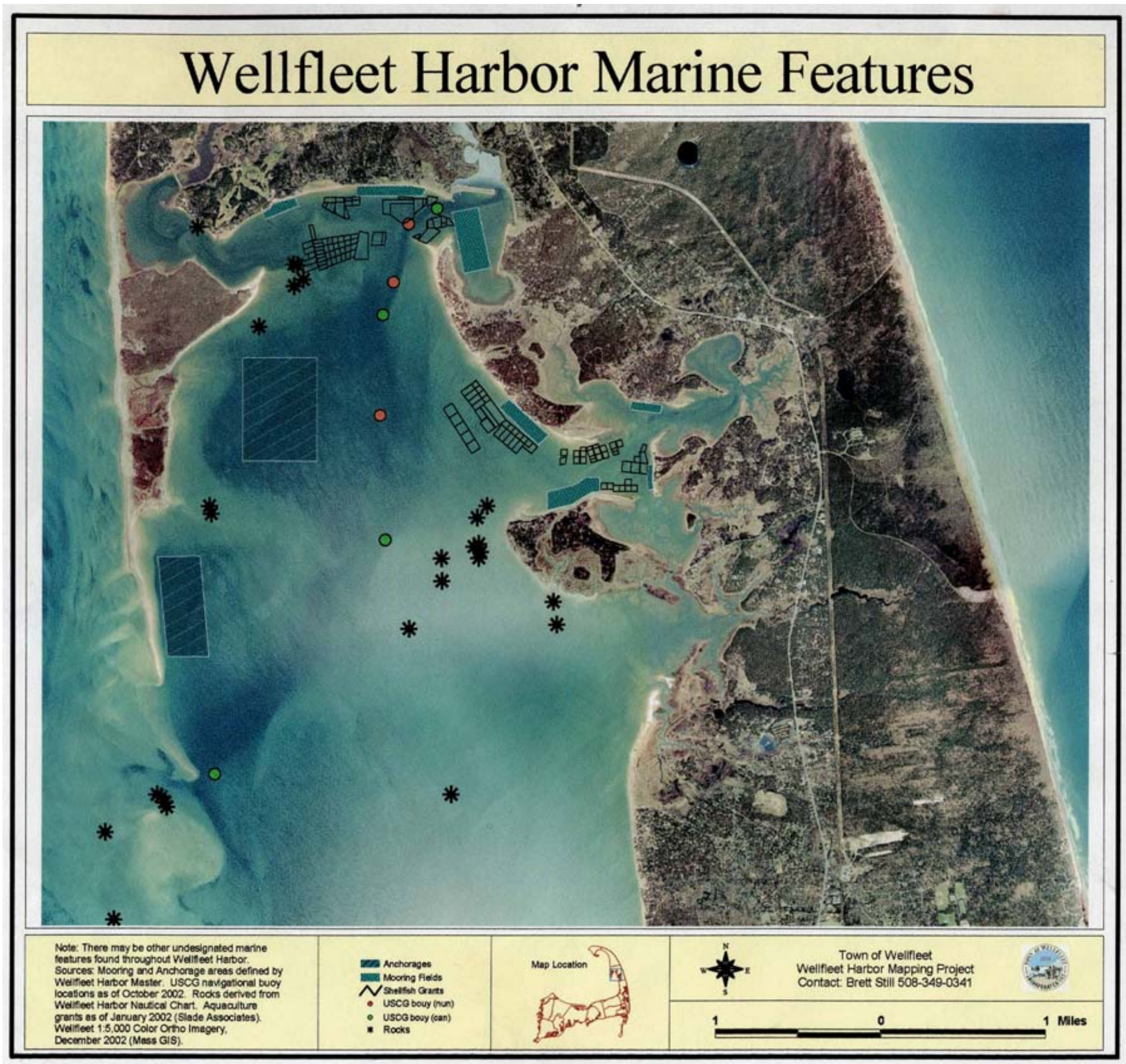

Figure 3.16: Location map of Wellfleet Harbor marine structures showing that the closest shellfish grant is over a mile away from the Herring River Dike.

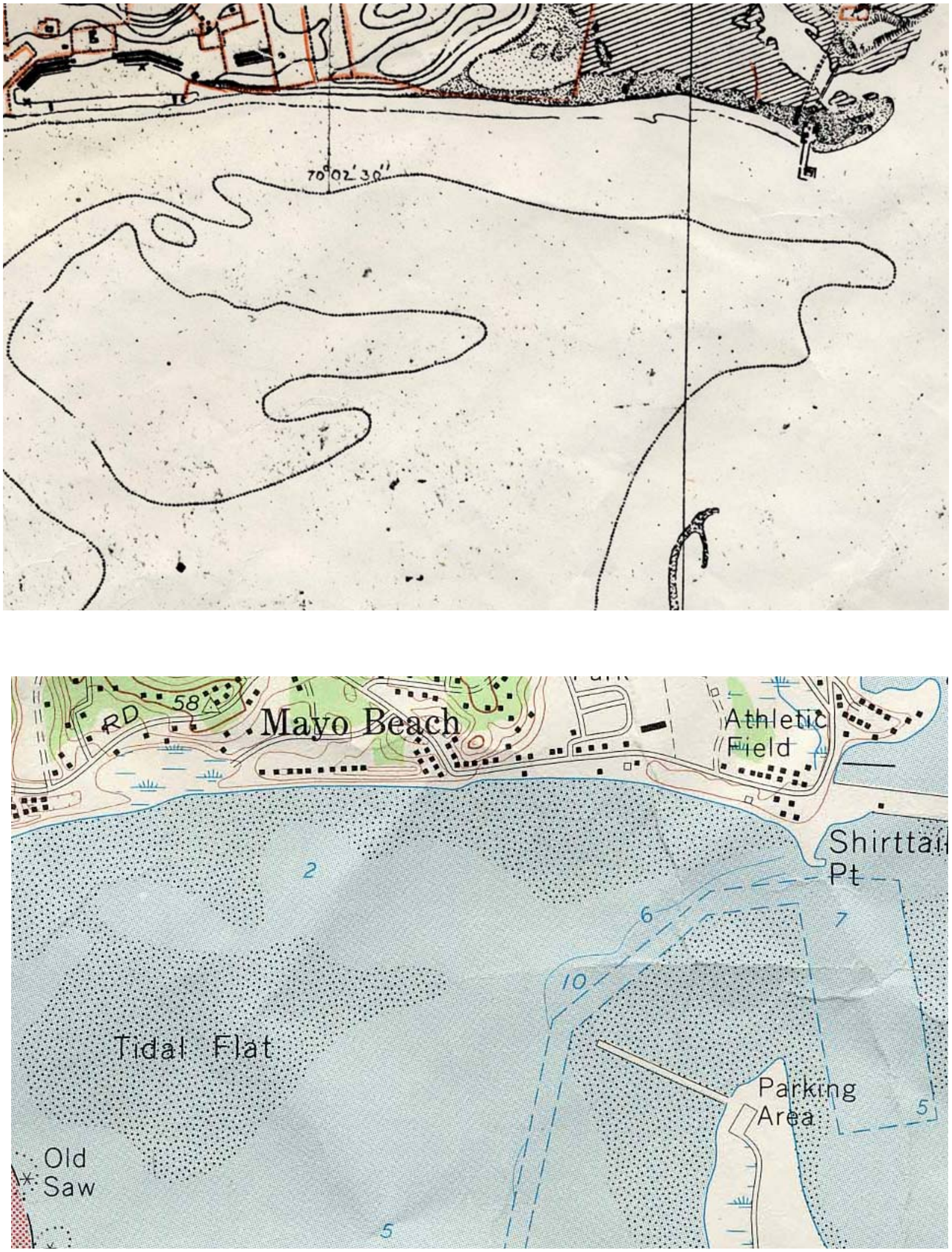

Figure 3.17: Comparison of maps from 1848 and 1974 in the area of Egg Island and the northeast part of Wellfleet Harbor reveals similar intertidal morphologies.

Figure 3.18: Sediment transport map of Wellfleet Harbor that shows the dominant direction of transport is from Cape Cod Bay up into the Harbor and Herring River.

Figure 3.19: Comparison of coastal topographic maps of Wellfleet Harbor from 1848 and 1974 shows similar intertidal morphology over the past 155 years.

Sedimentation Study of Hatches Harbor Restoration

Since March of 1999 portions of the Hatches Harbor flood plain, diked in 1930, have been undergoing incremental restoration of tidal exchange. As part of a large scale monitoring program associated with the restoration, sedimentation within the system was studied from 1997 to present, with the most recent data collection occurring in 2003 (Portnoy et al., 2004).

In order to measure sediment accumulation, nine Sediment Elevation Tables (SETs) were used. SETs allow accurate and repeated measurements of both sediment accretion and/or loss on the marsh surface. Three of these SETs are located below the dike in the unrestricted marsh, whereas six are above the dike in the restricted marsh (Figure 3.20). Of the six located above the dike, three are near the dike structure and three are located farther away. Looking at a graph of the data for the unrestricted marsh (Figure 3.21), there is a 3 mm/year accumulation of sediment within the marsh, compensating for the local rate of sea-level rise. However, the graph of all the data from the restricted marsh shows considerably more sediment accumulation above the dike (Figure 3.22). This increased upstream accumulation is a result of the dominance of landward sediment transport, just what is predicted for Herring River in the event that it undergoes restoration.

Focusing on sedimentation within the restricted area, the accumulation of sediment near the dike is similar to that of the unrestricted marsh (Figure 3.23), whereas highest sedimentation is occurring in the far reaches of the restricted system (Figure 3.24). The dynamics are similar to the Herring River during its breach. The water flowing through the dike is confined and moving too quickly to allow any sediment to be deposited. However, when the water reaches the upper portion of the stream and slows, fine-grained sediment can settle out of the water column. Indeed this is what happened when the Herring River dike breached in the late 1960s and explains the colonization by shellfish and their subsequent death following the dike's repair. Increased flood currents, caused by the deterioration of the tide gates, moved the fine-grained sediment coming from Cape Cod Bay past the dike and up into the marsh. In rebuilding the dike structure, tidal flow was again restricted and the fine grains that would have been carried into the far reaches of Herring River were deposited directly above and below the dike, thus covering the shellfish that had colonized since the breach. The Hatches Harbor SET data support the idea that increased tidal exchange at Herring River will shift sediment deposition from the vicinity of the dike to farther upstream, to the benefit of recolonizing shellfish.

Figure 3.20: Location of Sediment Elevation Tables (SETs) located within Hatches Harbor (Portnoy, Gwilliam & Smith, 2004).

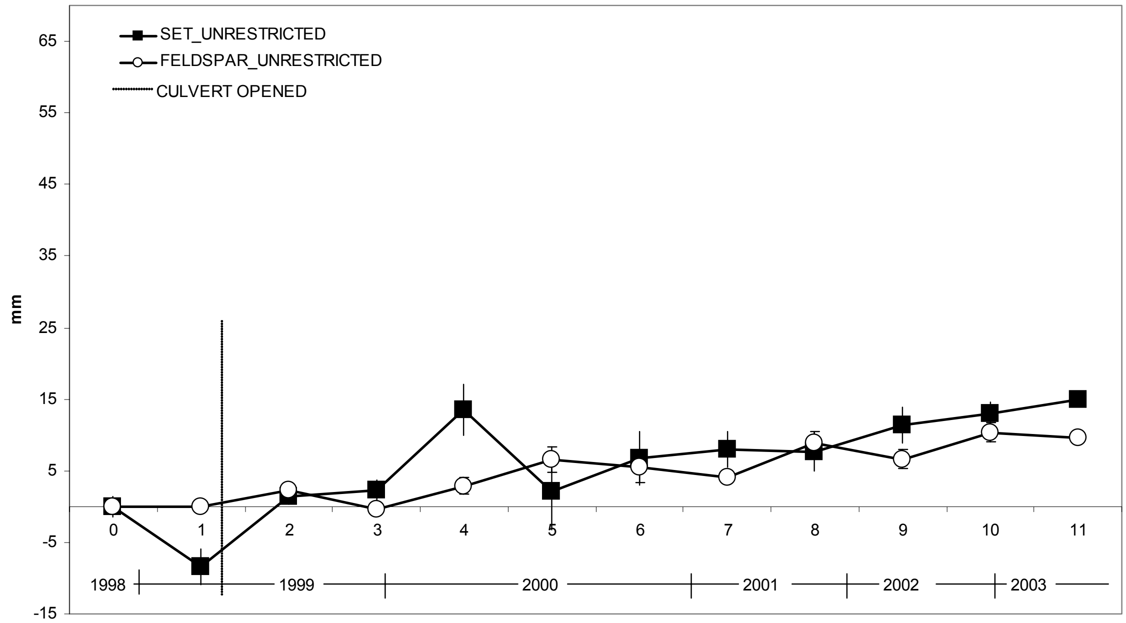

Figure 3.21: Trends in sedimentation as measured by sediment elevation tables (SETs) and feldspar horizons at Hatches Harbor in the unrestricted marsh below the dike. This shows a small increase in sediment deposited within the marsh, commensurate with sea-level rise. (Portnoy et al., 2004)

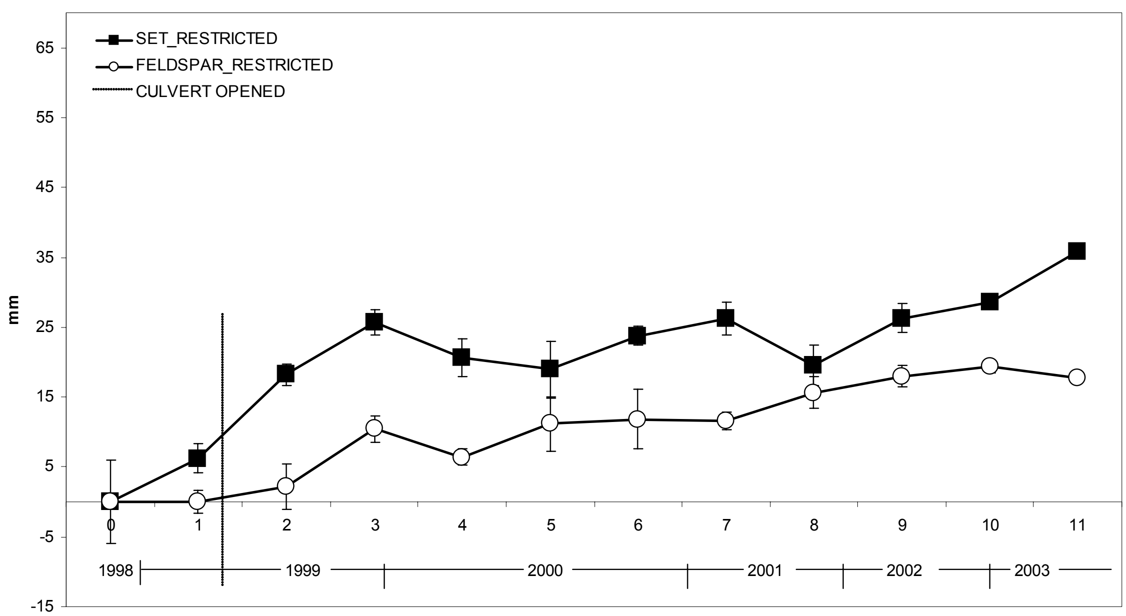

Figure 3.22: Trends in sedimentation as measured by sediment elevation tables (SETs) and feldspar horizons at Hatches Harbor in the restricted marsh above the dike. With tidal restoration, sedimentation above the dike has exceeded that measured in the unrestricted marsh downstream (Portnoy et al., 2004).

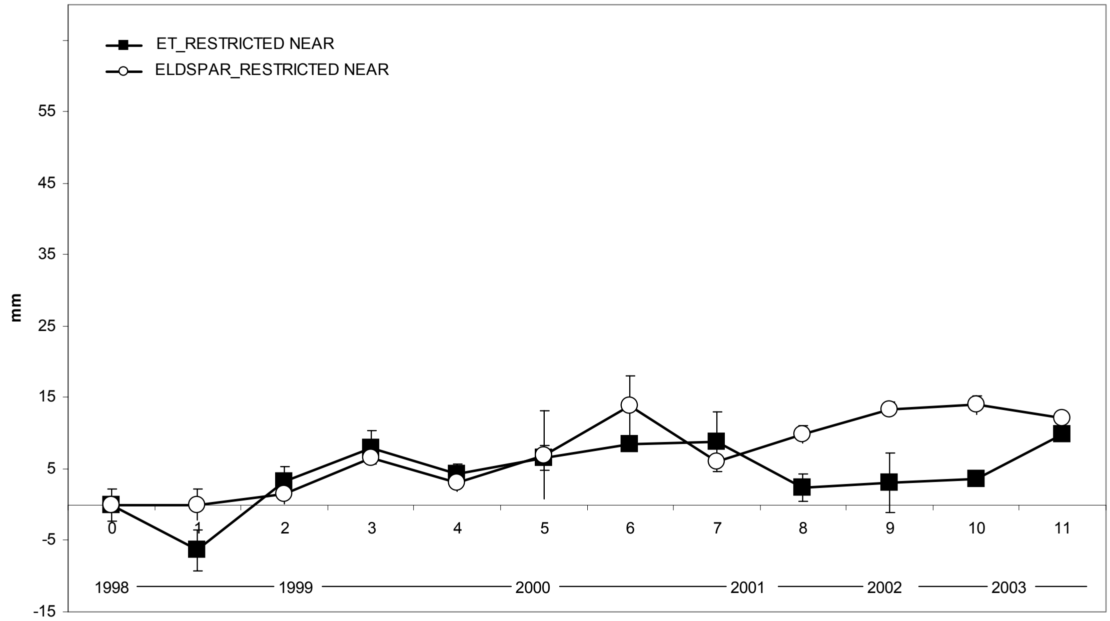

Figure 3.23: Trends in sedimentation as measured by sediment elevation tables (SETs) and feldspar horizons in the Hatches Harbor restricted marsh directly above the dike. These data show that accumulation rates just above the dike are similar to those just below. (Portnoy et al., 2004)

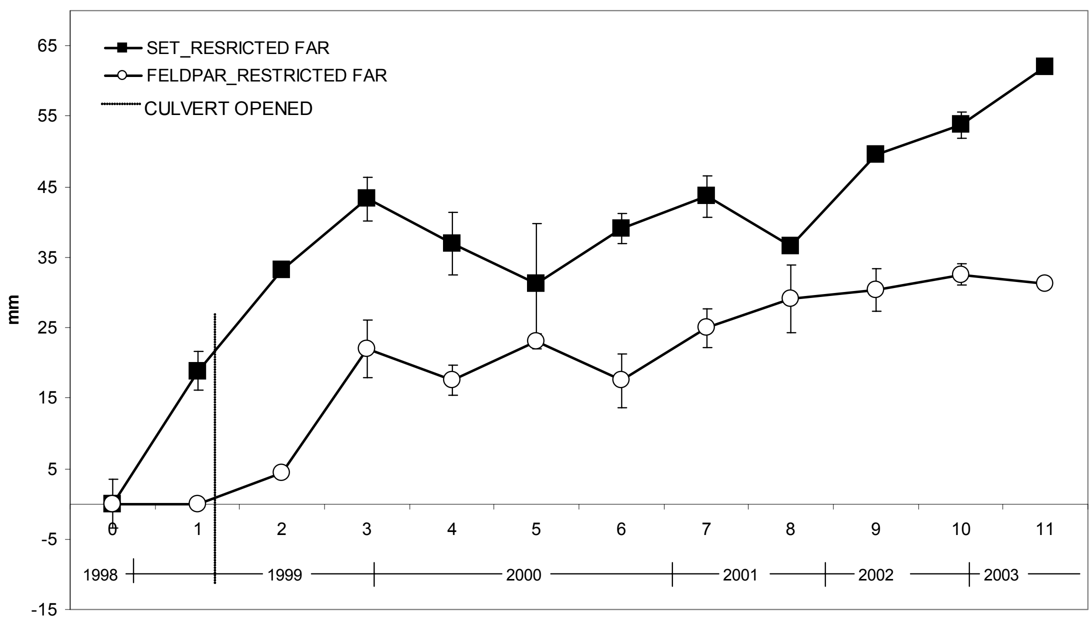

Figure 3.24: Trends in sedimentation as measured by sediment elevation tables (SETs) and feldspar horizons in the Hatches Harbor in the restricted marsh farther upstream of the dike. These data show that the majority of the sediment is being deposited farther upstream from the dike. (Portnoy et al., 2004)

Recommended Sediment Monitoring for Herring River

Current annual monitoring of sedimentation on the marsh surface (SETs, see above) below the dike at The Gut, in *Phragmites* below High Toss Road, and in the drained marsh above High Toss Road will continue as part a Park-wide program. Since these SETs focus solely on sedimentation within the marsh, monitoring of intertidal flats below the Herring River dike is proposed specifically to address concerns for sedimentation of shellfish beds. The objective of sedimentation monitoring on shellfish beds is to assess whether dike opening affects sediment quality on downstream intertidal flats used for shellfish culture. A suggested protocol follows:

1) Identify areas of concern to shellfishermen and Town resource managers. These will include shellfish beds closest to the river mouth, including the Town propagation area and Egg Island, but also should include reference (or control) sites. Reference sites, at sufficient distance from the Herring River Dike so as to be unaffected by river flow, are important to separate Harbor-wide sedimentation from river effects.

2) Randomly, i.e. without bias, establish sampling plots on the above-selected areas of concern, and use GPS to find them and to record their locations.

3) Prior to any dike openings and at least annually thereafter, collect the top 5 cm of sediment from each station (e.g. 3-inch diameter cores). Monitoring should ideally occur during the spring, winter and fall of each year, to account for seasonal differences.

4) Section the cores into 1-cm strata and analyze for grain size and organic content.

5) Compare sediment quality over time and among study sites, including reference areas.

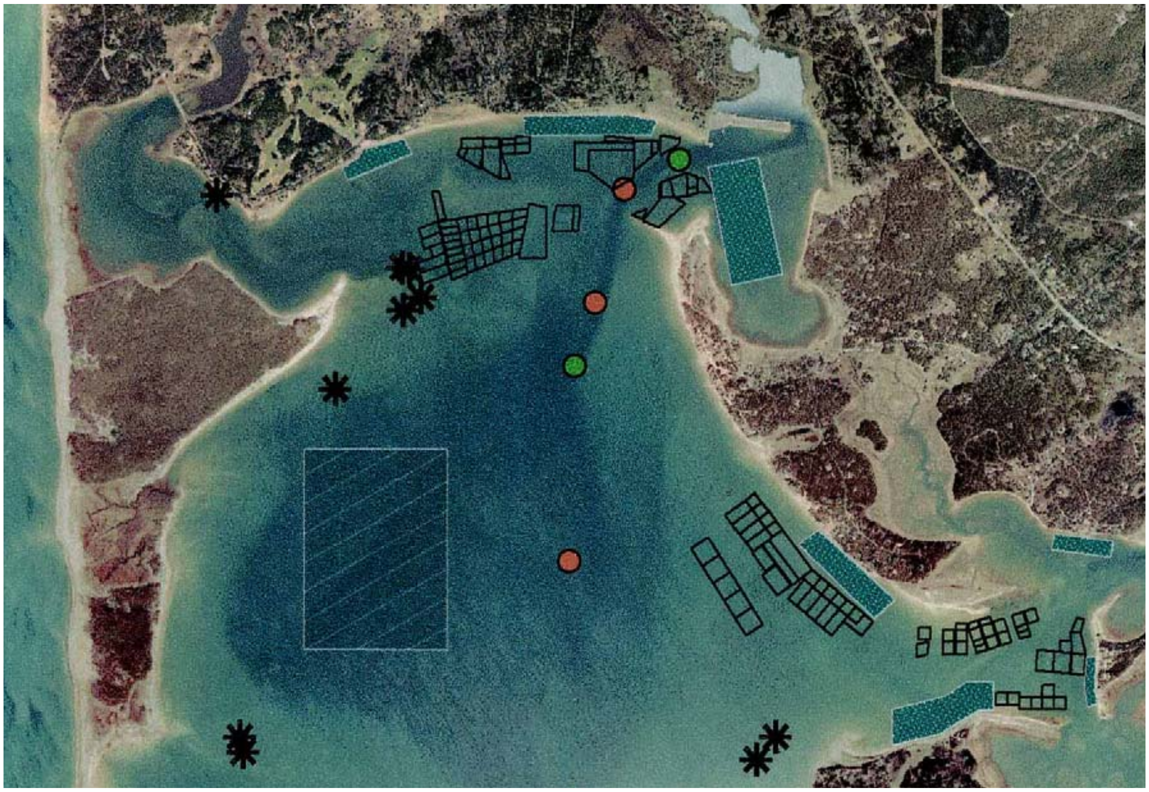

Figure 3.25: Enlarged version of hard structure map (Figure 3.16), focusing on the location of shellfish grants.

Conclusions

- Hydrodynamic models by Spaulding and Grilli in 2001 indicate that velocities above the dike, with all gates open, would be half that required to resuspend sediment.

- Calculations show that maximum flow velocities below the dike, with all gates open, will be just over a quarter (6 cm/sec) of the 20 cm/sec necessary to resuspend sediment.

- Geomorphic analysis of the intertidal area below the Herring River Dike shows almost no change over the past 155 years, with the exception of the formation of a small ebb- and larger flood-tidal delta. Otherwise, channel morphology below the present dike was the same before dike construction in 1909 as it is today; the dike has had little effect on downstream sedimentation.

- The predicted change in sedimentation, as a result of restoring tidal flow to the Herring River, would be minimal and proximal to the dike.

- Data from both the 1960s breach and from Hatches Harbor sedimentation not only support this prediction, but also indicate that the resulting changes around the dike will improve sedimentary conditions shellfish repopulation.