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Artificial Alteration of an Estuarine Basin: Restoration Case Study

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AGENCY PROBLEM:

Human utilization of estuarine systems has varied from industrial to recreational activities. One of the major outcomes of such activities has been alterations to the basin by removal (dredging) and addition (soil, rubble, docks) of solid material. Such alterations affect the hydrodynamics within the estuary. At present, the ability to predict whether hydrodynamic changes can adversely effect endemic ecological resources is poorly understood. In 2000 Congress passed the Estuary Restoration Act and the interagency Estuary Habitat Restoration Council was formed shortly thereafter. This council is responsible for the disbursement of funds to restore coastal estuarine systems impacted by human activities. To fund basin alterations it is essential to demonstrate the linkage between associated changes in hydrodynamics and any detrimental ecological effects. As a result of our current state of knowledge, our approach to developing such linkages is to focus, in the form of a case study, on systems with and without major basins alterations.

RESEARCH GOALS:

In 1738 the Hix Bridge was constructed at a natural constriction in the upper third of the East Branch of the Westport River, MA. The 1938 Hurricane destroyed this bridge and the associated construction rubble was dumped into the river reducing the water depth from 30 to 3 feet. A comparative case study approach will be utilized to develop methods and models to:

- ❖ Define cause and effect relationships between the specific basin alteration and measured ecological states of endemic fauna and flora
- ❖ Predict rate of recovery following removal of rubble material.

METHODS and APPROACH:

Comparative Estuarine Approach

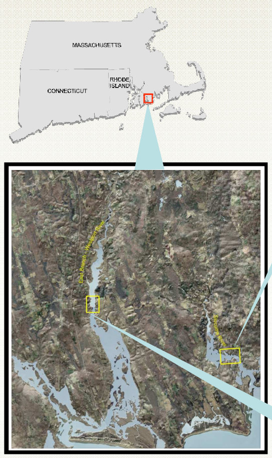
To define the effects of the rubble material on the hydrodynamics it is necessary to have a pristine or reference site for purposes of comparison. Slocums River, an adjacent estuary was chosen because its basin has been unaltered by human activities and it has a basin constriction similar to that found at the Hix Bridge in the East Branch of the Westport River. In both systems, above and below the constrictions, we measured bathymetry (sonar mapping surveys), bottom current speeds (continuous recording flow meter), salinity (continuous recording salinometer) and sediment type (sediment acoustic classification system). In addition, sediment cores were taken to enumerate benthic macroinvertebrates and the existence of relic bivalve shells.

Historic Reconstruction Wetlands

^{210}Pb dating was performed on a 50cm marsh core within a stand of *Phragmites australis*, the common reed, located in the upper reaches of the East Branch of the Westport River. Additionally, the sediment depth at which major floral changes occurred was noted. By so doing it is possible to correlate these floral changes to the construction of bridges at the Hix Bridge site over the last 200 years.

RESULTS:

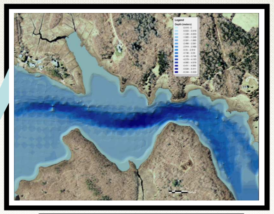
I. Estuary Comparison



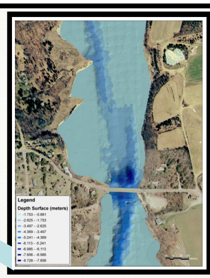
Bathymetry

The channel in Slocums River is continuous and of constant depth above and below the constriction. By contrast, the channel north of Hix Bridge shows an immediate deep hole with an abrupt shoal which has obliterated the original channel for some 500m further to the north. On the other side of the bridge heading south, the channel is continuous to the end of the surveyed area, approximately 1.7km.

Natural Basin

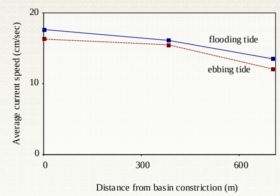


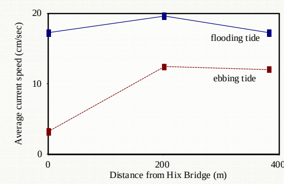
Altered Basin



Current Speed

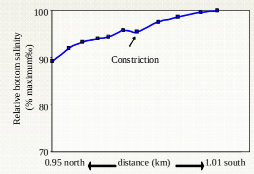
In Slocums River the average current speed at both the flooding and ebbing tides decrease with increasing distance from the basin constriction with the former being slightly greater than the latter. However, at Hix Bridge the average current speed during the ebbing tide is much lower than that at flooding tide and immediately at the bridge is three times lower.

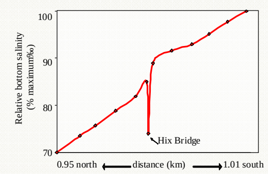




Salinity

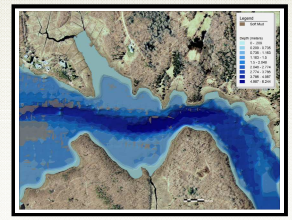
During a flood slack tide, the salinity distribution above and below the basin constrictions in the Slocums River and East Brach of the Westport differ. Slocums has a relatively constant rate of change in salinity from north to south of the constriction. At Hix bridge there is an abrupt increase in salinity after the bridge.

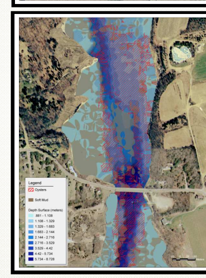




Acoustic Sediment Classification

The sediments north and south of the basin constriction within the channel of Slocums River are hard bottoms. However, north of the Hix Bridge the bottom sediments are soft and a large population of oysters is positioned on the sediment surface. Additionally, deep (45cm) sediment cores taken in these sediments revealed the presence of relic oyster (*Crassostrea v.*) and quahog (*Mercenaria m.*) shells; living populations of *Mercenaria m.* are missing above and below the Hix Bridge.





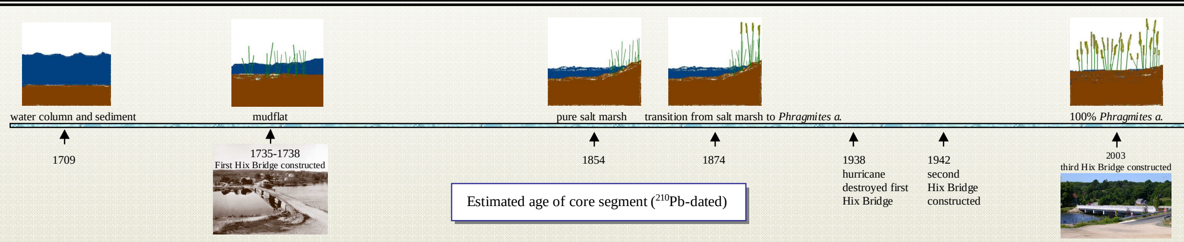
CONCLUSIONS:

- ❖ The bridge rubble has significantly reduced the ebbing current velocities such that the sediment habitat north of the Hix Bridge has changed from erosional to depositional.
- ❖ A large oyster population on top of the soft sediments north of the Hix Bridge is at risk from burial.
- ❖ The bridge rubble has reduced the input of seawater into the upper reaches of the East Branch of the Westport River. The reduction in salinity and increased sedimentation has possibly resulted in (1) loss of the commercial quahog and (2) increase in the invasion rate of the undesirable rooted aquatic plant, *Phragmites a.*

II. East Branch Westport River: Historical Marsh Succession

Wetland Succession: Upper Reaches of the East Branch of the Westport River

The relative rate of sediment deposition and ultimate filling of the entire upper basin north of the Hix Bridge may have been increased as a result of bridge construction over the last 300 years.



IMPACT and OUTCOMES:

This study has defined the degree to which a specific basin alteration has affected the hydrodynamics and in turn selected biological resources within a tidal estuary. Reductions in ebbing tidal velocities of three fold or more relative to flooding velocities result in significant accumulations of soft sediments. Natural populations of harvestable oysters are at risk from burial if similar artificial alterations in hydrodynamics are allowed to occur within affected areas of other estuarine systems. Similarly, quahog populations are expected to return to sections of an estuary where reduced salinities have precluded their survival. Removal of physical impediments is expected to allow for the recovery of higher natural seawater exchanges rates as well as water current velocities. This information will allow environmental managers to direct funding to those estuarine systems where the restoration of shellfish habitats is expected to be successful.

FUTURE DIRECTIONS:

- ❖ Acoustic mapping of ancient oyster reefs in sediment beneath existing reefs will test the implied hypothesis that the total area of the bottom containing oysters has decreased over time
- ❖ ^{210}Pb dating of sediment cores within *Phragmites a.* stands above and below the Hix Bridge will establish the influence of the bridge rubble on the rate of succession of major rooted aquatic plants

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