Bluff Erosion Rates in Complex Glacial Stratigraphy, Block Island, RI

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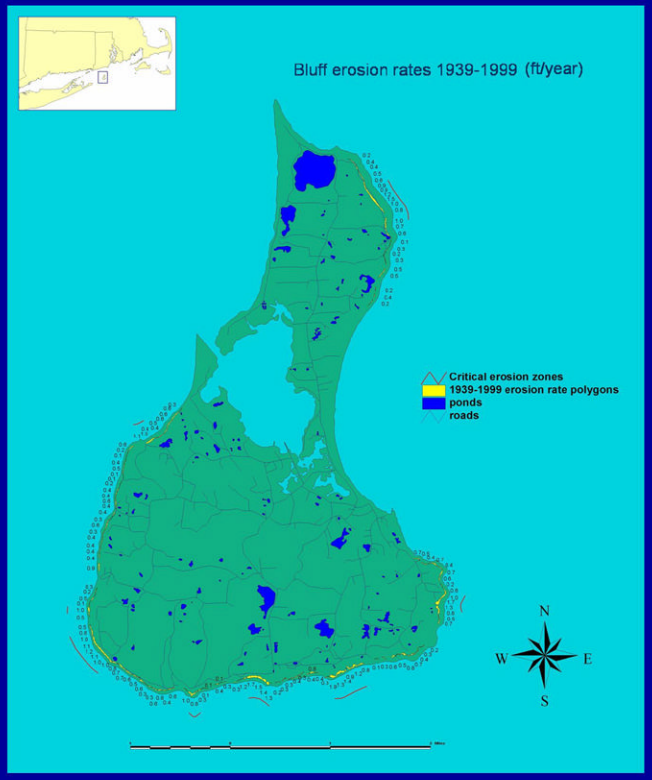
Southeast bluff (photo courtesy of Jon Boothroyd)

ABSTRACT:
Block Island, a small island located off the Rhode Island coast, formed as a result of the advance and retreat of the continental glaciers until about 20,000 years ago. The sediment comprising the island was deposited during two separate events and can be distinguished by color and composition. The lower sediment body consists primarily of compacted basil till, or very fine grained lake deposits. The upper sediment is coarser grained and less compacted, making it more permeable than the underlying strata. The island stratigraphy is complex, resulting in a mix of permeable and poorly permeable deposits.
Over-steepened bluffs rise more than 100 feet above the northeastern and southern shores of the island. Bluff erosion is both chronic (grain flows) and catastrophic (debris flows and slumping due to oversaturation of permeable sediment). The position of the bluff edge was interpreted on 1:12000 scale aerial photo series (1972-1999) using a four power stereoscope. The bluff edge was then delineated on the scanned, georeferenced aerial photographs. The resulting average annual bluff erosion rates were low during this time period. These data will be hindcast when 1939 soft copy aerial photographs become available in spring 2002.
The infrequent and unpredictable nature of the catastrophic erosion events presents management issues. Current erosion setbacks in Rhode Island are based on the average annual erosion rate with a minimum setback of fifty feet. This works well in homogenous stratigraphic environments such as coastal barriers. In areas with complex stratigraphy such as Block Island, setback modifications may be necessary. Maximum retreat values may be a more significant measure than averages



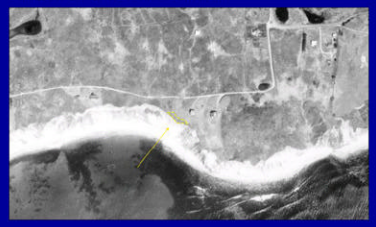
Introduction:

The Block Island stratigraphy is complex but is generally characterized by an under layer of poorly permeable sediment overlain by very permeable sediment. In wet periods, water is absorbed in the upper layers. Catastrophic slope failure can occur when the underlying clay rich lower layers loose strength. This is compounded by steep slope gradient and waves undercutting the base of the bluff. These catastrophic occurrences are both unpredictable and unforgiving.

Slump block in critical erosion area, note the extent of erosion after a month

Results:

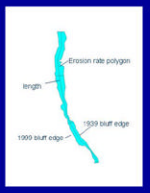
Bluff erosion rates for Block Island are relatively low (0.6 feet per year average). Preliminary data for rates between 1972 and 1999 were similar to 1939 to 1999 erosion rates suggesting that there are forcing mechanisms controlling erosion rates along critically eroding sections of shoreline. Wave climate can explain the rapid erosion in some sections, like the northeasterly facing shoreline on the north bluff that receives the brunt of wave energy during nor'easters. In other section, stratigraphy may play an important role.



1999 aerial photograph outlining the 2001 slump block

1972 aerial photograph outlining the 2001 slump block

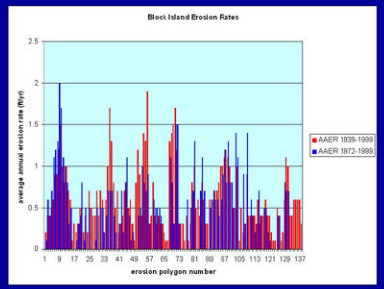
Features from 1997 DOQ overlay on 1939 aerial photo



Erosion rate polygons

Methods:

**Bluff erosion rates were calculated by delineating the edge of the bluff 1939, 1972 and 1999 1:12000 high resolution (300dpi) vertical aerial photographs. The photographs were geo-referenced with Geographic Transformer using the RIGIS 1997 1:5000 scale orthophotography as a reference map. An ArcView shape file was created by delineating features such as stonewalls and roads on the orthophotos. This shape file was used to check the accuracy of the transformations.
Erosion rate polygons were created from the bluff edges delineated from the 1939 and 1999 aerial photographs. The volume and length of each polygon was measured to calculate average annual erosion rates. Preliminary data was created for the 1972 to 1999 erosion rates for comparison of rates over time.**



Comparison of the 1939-1999 and 1972-1999 average annual erosion rates show areas that some sections of bluff are more resistant to erosion than others.

Discussion:

A catastrophic slope failure in April 2001 occurred along a section defined as a critical erosion area along the south shore of Block Island. In days, the sediment that jutted into the ocean was eroded from the block, revealing an underlying clay layer that had weakened under the weight of the saturated upper strata.

Calculated erosion rates in this section averaged 1.5 feet per year. This one catastrophic event represented 23 to 27 years of erosion, close to the predicted rate.