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Analysis of Coastal Erosion on Martha's Vineyard, Massachusetts: a Paraglacial Island

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Abstract
As the sea rises in response to global climate changes, small islands will lose a significant portion of their land through ensuing erosion processes. The particular vulnerability of small island systems led me to choose Martha's Vineyard (MV), a 248 km2 paraglacial island, 8 km off the south shore of Cape Cod, Massachusetts, as a model system with which to analyze the interrelated problems of sea level rise (SLR) and coastal erosion. Historical data documented ongoing SLR (~3mm/yr) in the vicinity of MV. Three study sites differing in geomorphological and climatological properties, on the island's south (SS), northwest (NW), and northeastern (NE) coasts, were selected for further study. Mathematical models and spatial data analysis, as well as data on shoreline erosion from almost 1500 transects, were employed to evaluate the roles of geology, surficial geology, wetlands, land use, soils, percent of sand, slope, erodible land,

wind, waves, and compass direction in the erosion processes at each site. These analyses indicated that: 1) the three sites manifested different rates of erosion and accretion, from a loss of approximately 0.1 m/yr at the NE and NW sites to over 1.7 m/yr at the SS site; 2) the NE and NW sites fit the ratio predicted by Bruun for the rate of erosion vs. SLR, but the SS site exceeded that ratio more than fivefold; 3) the shoreline erosion patterns for all three sites are dominated by short-range effects, not long-range stable effects; 4) geological components play key roles in erosion on MV, a possibility consistent with the island's paraglacial nature; and 5) the south side of MV is the segment of the coastline that is particularly vulnerable to significant erosion over the next 100 years. These conclusions were not evident from simple statistical analyses. Rather, the recognition that multiple factors besides sea level positions contribute to the progressive change in coastal landscapes only emerged from more complex analyses, including fractal dimension analysis, multivariate statistics, and spatial data analysis. This suggests that analyses of coastal erosion that are limited to only one or two variables may not fully unravel the underlying processes.

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