

## Assessing the impact of ferry boat wakes on shoreline erosion in Boston Harbor, Massachusetts.

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The Boston Harbor Island National Recreation Area is an exceptional natural resource. The islands are recognized as being a unique system (in the U.S.) resulting from the gradual inundation of glacially formed drumlins. The islands are diminishing in size due to rising sea level and coastal erosion. A dramatic example of this land loss is Sheep Island, located in relatively low energy Hingham Bay that has decreased in size from approximately 100000 m<sup>2</sup> in the 1600s to less than 5000 m<sup>2</sup> today (Rosen et al., 2005).

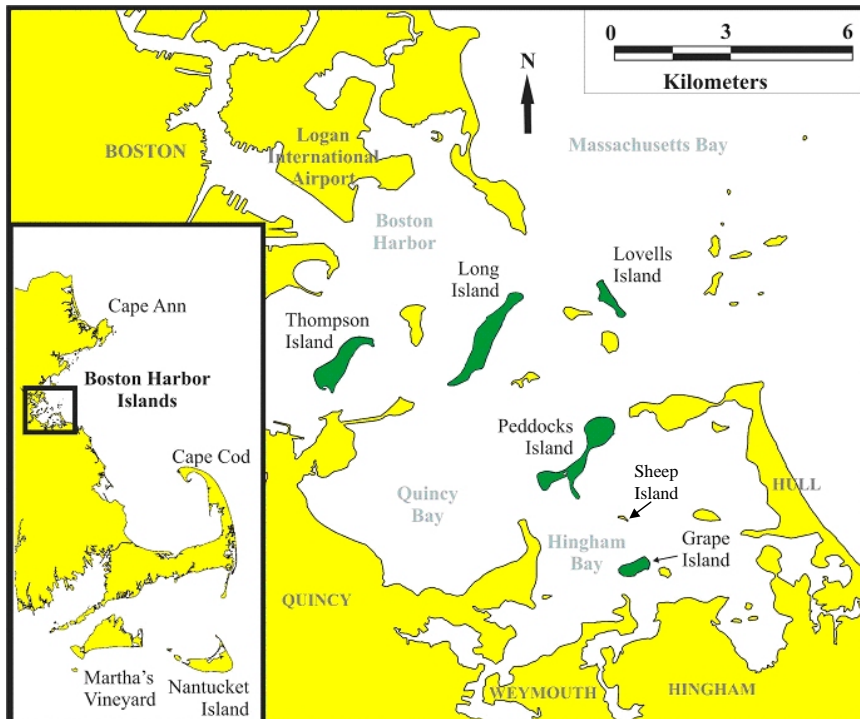


Figure 1: Boston Harbor, a drowned drumlin field. There are officially 34 islands within the system.

The island shorelines are primarily bluffs composed of unconsolidated glacial sediment (till or reworked till). The short-term rate of erosion and shoreline recession is predominately related to incident wave energy (dependant on fetch), exposure to storms, extent of coastal vegetation, nearshore bathymetry, sediment composition and meteorological effects (Himmelstoss et al. 2005). Erosion rates varies from island to island e.g. between 1938 and 1977,

bluff retreat along the northwest shore of Thompson Island was 18 m. The more exposed, seaward islands tend to erode in the northeastern quadrant and are depositional along their southwest shores (Himmelstoss et al. 2005). However on certain islands, e.g. Thompson, the highest rates of bluff erosion have been observed along a shoreline subjected to only moderate waves, and not that portion of the island exposed to the dominant northeast storm wave climate. This is thought to relate to the high-speed ferries, which are playing a growing role in the transportation infrastructure for both island access and regional mass transit, and pass close to the island at this location. During spring high tides and other times of elevated water levels, waves created by boat wakes break at the top of the beach eroding the bluff base. This enhancement of natural wave conditions may increase rates of bluff retreat. Previous studies have linked boat wakes, within enclosed waters such as harbors and estuaries, to increased sediment resuspension and shoreline erosion. (Schoelhamer, 1996; Parnell and Kofoed-Hansen, 2001; Stevens and Ekermo, 2003). Unfortunately, to date, the inferences in Boston Harbor have been neither verified nor quantified for relative contribution of the anthropogenic role.

Observations of the rate of bluff retreat have allowed us to identify areas where bathymetry and ferry activity contribute to a higher potential for wake-related erosion. In addition to regular

topographic surveying of these critical sites, a suite of instrumentation including pressure transducers and a capacitance wave staff have been deployed nearshore. The sensors collect near continuous high frequency surface elevation data capable of describing waves of periods as short as circa 1 second. During deployments, vessels passing close to the unit were monitored and their size, estimates of their speed and the behavior of their wake were recorded.

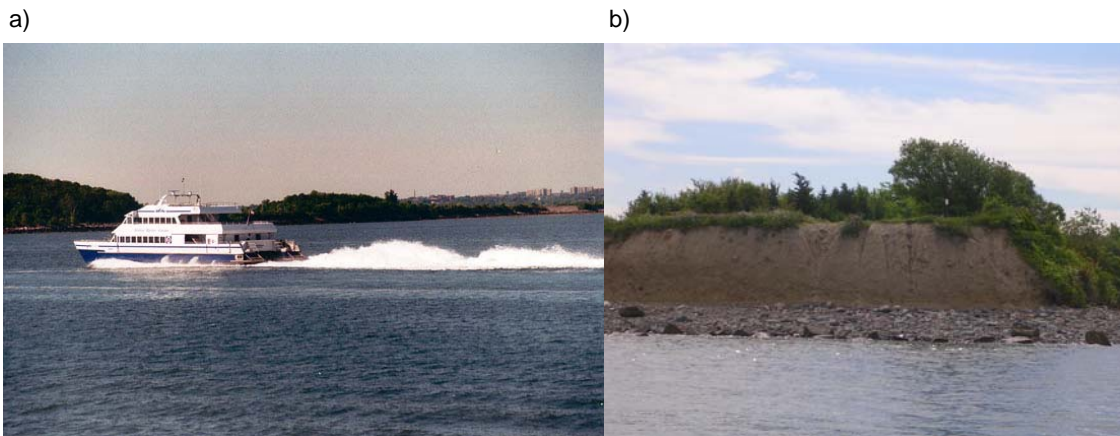


Figure 2: a) 40ft Ferry producing a large wake within a channel in the island; b) An eroding bluff in Webb State Park opposite Grape Island, between the two is a very narrow channel through which runs a frequent ferry service.

The time-series of surface elevation, in conjunction with observations of passing ferries, provide comparative details of the period, amplitude and groupiness of both the ferry wakes and locally generated wind waves. Calculations of the wave energy density at different frequencies, through spectral analyses, allow us to determine the frequencies at which wakes contribute to the wave energy impacting the shoreline. Concurrent evaluation of wave climate and boat activity allows the determination of the relative magnitude of the anthropogenic and natural wave components comprising the energy spectra. These data have been augmented with results from a numerical model (Simulating WAVes Nearshore) of Boston Harbor, enabling an assessment of potential wave related erosion and sediment transport pathways in the absence of boat traffic. Estimates of the frequency with which boat wakes reach the base of eroding bluffs indicate that such conditions often coincide with low pressure systems and storms. These periods are marked by high local wind wave activity and, at more exposed sites, the influence of low frequency swell. Under these conditions the influence of ferry wakes may be insignificant, however survey data link these storm events with the greatest short-term rates of bluff retreat.

Although boat wakes are observed to increase the level of wave energy reaching the shoreline, the impact on rates of bluff erosion is less conclusive, as often the wakes may only reach the bluff base during storm conditions when local wind waves dominate the energy spectra.

Himmelstoss, E.A., D.M. FitzGerald, P.S. Rosen, and J.R. Allen. 2005. *Bluff Evolution of coastal drumlins; Boston Harbor Islands, Massachusetts*, Journal of Coastal Research, *in press*.

Parnell K.E. and H. Kofoed-Hansen, 2001. *Wakes from large high-speed ferries in confined coastal waters: management approached from New Zealand and Denmark*. Coastal Management, 29: pp217-237.

Rosen, P.S., D.M. FitzGerald, E.A. Himmelstoss, J.R.Allen, 2005. *Morphology and Evolution of the Boston Harbor Island shorelines, Massachusetts, USA*: Journal of Coastal Research, *in press*.

Schoelhamer D.H., 1996. Anthropogenic Sediment resuspension Mechanisms in a Shallow Microtidal Estuary. Estuarine, Coastal and Shelf Science, 43: pp533-548.

Stevens, R.L. and S. Ekermo, 2003. *Sedimentation and erosion in connection with ship traffic, Götensborg Harbour Sweden*. Environmental Geology, 43: pp 466-475.

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