New York harbor's oyster beds once protected against severe storm and extreme wave damage

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Jon Woodruff and doctoral student Christine Brandon collected core sediment samples from 5 to 6.5 meters (about 16 to 21 feet) deep, going back about 3,000 years in outer New York Harbor's hisory to analyze storm layers and other features. Credit: UMass Amherst

A recent study of past disturbance of the oyster beds in New York Harbor led by geoscientist Jonathan Woodruff and his doctoral student Christine Brandon of the University of Massachusetts Amherst is the first to link Europeans' overharvesting and disturbance of the ancient shellfish beds to loss of natural coastal defenses against floods and storm waves.

Woodruff and first author Brandon, with colleagues at Stevens Institute of Technology and the Woods Hole Oceanographic Institute, used a new approach based on sediment reconstructions from coastal ponds and hydrodynamic model simulations to show that the initial degradation of oyster reefs in the harbor following European settlement coincides with "a significant increase in wave-derived overwash deposition" at all of their field sites. Details appear in an early online issue of *Earth Surface Processes and Landforms*.

Woodruff says, "We initially set out to investigate what Hurricane Sandy's resultant sand deposit looked like in coastal ponds on Staten Island, a location in outer New York Harbor that is occasionally exposed to ocean swells. These sites were flooded severely during the event and we were curious how this "Sandy" deposit compared to sediments deposited by earlier flood events. An event layer from Hurricane Sandy was clearly present at all our sites, as well as older storm deposits that dated to historical floods." An event layer is a tell-tale sign in sediment, in the case of Sandy a red layer of denser, coarse-grained sediment associated with storm overwash.

He adds, "However, prior to between 1600 and 1800 these storm deposits went away. If it were just one site it would have been one thing, but at every site we saw the same: no storm deposits for thousands of years before European settlement and then after colonization, storm waves start to become more and more effective in transporting sand inland to our field sites. Something the early colonists did seemed to

increase storm-induced overwash at the study sites. The million dollar question was what."

At first the authors thought the answer might be sea-level rise, variability in storm activity or land clearing, but when reviewed in detail none of these explanations was consistent with observations, Woodruff notes. "We kept reaching dead ends until we considered one of the largest impacts European settlers had on New York Harbor, the decimation of its natural oyster beds."

These beds were one of the most notable features of New York Harbor when Europeans arrived, covering as much as 220,000 acres of the Hudson and Raritan Rivers' estuary. Oysters were a staple of early colonial diets, and an important lime source for farm fields and construction mortar, the geoscientist says. Between 1600 and 1800, the New York oyster beds were rapidly over-harvested by hand and from dredges towed by sloops and schooners. The authors hypothesize that the reefs had absorbed a significant fraction of storm-wave energy before they were destroyed.

To test this hypothesis, co-author Philip Orton at Stevens used a circulation and wave simulation model to reconstruct past wave heights and storm surge elevations, and to model the effects of oyster beds on wave heights in two historic storms, Sandy in 2012 and a severe 1992 winter storm. Woodruff and colleagues also collected core sediment samples from 5 to 6.5 meters (about 16 to 21 feet) deep, going back about 3,000 years, to analyze storm layers and other features.

Simulations for the two storms included a control case without oyster beds, as well as with oyster beds at locations roughly corresponding to those historically documented in New York's outer harbor. The authors conclude from this modeling that "sensitivity to reef height is strong." For example, in the control with no oyster bed present, the 1992 storm

model showed as much as a 200 percent increase in wave energy when compared to the oyster reef cases. Thus, they say, "reefs provided significant coastal protection from waves prior to their disturbance between 1600 and 1800."

They acknowledge, "As with any sedimentary record, there will always be a certain level of uncertainty related to its interpretation." However, numerical modeling shows that the overharvesting and destruction of oyster reefs "provides a reasonable explanation for the increase in storm -induced overwash observed at our study sites."

The study showed that this area of New York Harbor is now experiencing between about 30 percent and 200 percent higher wave energy from extreme storms than in the distant past. "This translates into increased vulnerability of the area to storms: a result most likely shared by other coastal areas that have lost their natural oyster beds," Woodruff and colleagues note.

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