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# Changing the Paradigm of Response to Coastal Storms

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Federal, state, and local agencies mounted a massive preparation and response to post–tropical storm Sandy, which made landfall along the northern New Jersey coast on 29 October 2012. The data collected and knowledge gained in response to Sandy are unprecedented and provide critical information to agencies, local emergency responders, and coastal managers and planners.

The traditional response to extreme coastal storms such as Sandy is to restore beaches, close breaches in barrier islands, and rebuild infrastructure swiftly. For a variety of reasons, including access, safety, and future risk reduction, this response can be necessary and justifiable. On the other hand, barrier islands are dynamic, and landward movement can result in increased resiliency of the barrier system. In addition, there are numerous benefits of breaches, such as enhanced bay circulation, improved water quality, and creation of habitat for wildlife.

In a unique coastal management approach, a breach in Fire Island, N. Y., remains open more than 6 months after the storm. The breach is being carefully evaluated and monitored by a multiagency group, balancing increased risk to infrastructure and human safety with benefit to the natural environment. This is an unparalleled management approach along a developed coastline and could serve as an option for response to future storms.

*Post–Tropical Cyclone Sandy*

Post–tropical cyclone Sandy was nearly 2000 kilometers in diameter, making it the largest storm on record in the Atlantic basin (National Hurricane Center, 2012, http://www.nhc.noaa.gov/). At landfall, peak wave heights and storm surge coincided with astronomical high tides, with the highest waves and surge focused along the heavily populated New York and New Jersey coasts. Record significant wave heights of 9.9 and 9.6 meters were measured at buoys offshore of Sandy Hook, N. J., and Fire Island, N. Y., respectively (Figure 1a). Beaches and dunes were extensively eroded and overwashed, barrier islands were breached, and there was widespread damage and destruction of coastal infrastructure ranging from private residences to major transportation routes.

*Prestorm Data Acquisition*

Collection of field data and predictions of storm impact in advance of landfall of a major storm along the Eastern Seaboard were comprehensive. Prestorm data collection included the deployment of a network of water level sensors (http://water.usgs.gov/floods/events/2012/sandy/index.php), generation of predictive models to forecast effects on the physical coastal system, and remote sensing and field surveys of coastal morphology.

Coastal change impact models for the mid-Atlantic coast from Maryland through Long Island, N. Y. (http://coastal.er.usgs.gov/hurricanes/sandy/coastal-change/), predicted that dune erosion was very likely to occur over 90% of the impact region and that there was widespread potential for overwash (Figure 1a). Maps showing the distribution of vulnerability were available before landfall to aid responders and the public. Field data collection of beach and dune morphology was focused on Fire Island (Figure 1a), within the boundaries of Fire Island National Seashore. The morphologic data collected immediately prior to Sandy allowed for a rapid assessment of extreme storm impact on the beach and dunes of Fire Island (Figures 1b and 1c).

Initial efforts focused on Fire Island primarily because a broad interagency group has been working together for a number of years to develop a storm damage reduction plan for the south shore of Long Island, the Fire Island to Montauk Point Reformulation Plan (FIMP) [*U.S. Army Corps of Engineers*, 2012]. Planning discussions have addressed long-term sediment management issues (e.g., beach nourishment) as well as responses to major storm events. The group includes the National Park Service, the Fish and Wildlife Service, the U.S. Army Corp of Engineers New York District, the U.S. Geological Survey, the State of New York Department of Environmental Conservation, and local agencies.

*Poststorm Response*

The effects of Sandy were widespread and catastrophic. The reconfiguration of the coast, beyond the extensive destruction of infrastructure, included significant beach erosion, dune overwash, landward island migration, and breaching of barrier islands along the Eastern Seaboard, including three breaches on Fire Island. Prestorm survey sites were revisited to provide measurements of beach erosion and dune retreat and loss (Figure 1b). Initial results indicate that 50% of the dunes along the Fire Island barrier were overwashed and lost an average of 60% of their volume. These data and analyses provided a scaling for the magnitude of the storm impacts throughout the broader affected areas of New York and New Jersey, where access was limited and prestorm data were not available.

A breach contingency plan [*U.S. Army Corps of Engineers*, 1996], part of the draft FIMP, was developed as an interim project to provide specific guidance for management in the event of a breach [*Williams and Foley*, 2007]. Options include rapid closure of breaches to reduce flood risk on the mainland coast of Long Island and allowing breaches to remain open for some period of time so that the back barrier bay can benefit from the increased circulation and sedimentation related to inlet processes. These options provide engineered versus natural approaches to coastal management and raise a spectrum of issues ranging from the potential cost to human life and loss of infrastructure to the essential processes that sustain the natural barrier island environment. Sandy resulted in the first breach since the creation of the breach contingency plan and FIMP, allowing a management and response experiment that as yet had not been tested.

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### *The FIMP Model: Management and Planning Post-Sandy*

The response to post–tropical storm Sandy required rapid and immediate coordination and implementation, with federal, state, and local agencies working together to formulate and implement a breach response effort that balanced the beneficial aspects of breach processes but acknowledged the potential for increased flood risk and coastal vulnerability. Within days after the storm, the team of scientists, engineers, and managers from the various agencies who were responsible for the breach continuity plan conducted field assessments of morphologic changes, including breaches, overwash, and beach loss.

Of the three breaches on Fire Island, one closed naturally, and another, within a county park, was closed manually weeks after the storm. The third, within a federal wilderness area of the seashore, remains open. This is the first time that a breach in a barrier island that provides storm protection along a developed and densely populated coastline has deliberately been allowed to remain open to benefit the natural environment, albeit with close evaluation of its evolution and effect on bay water levels.

Based on historical data and initial assessments of stability, the breach is likely to close naturally and, if left alone, will yield a more resilient system. When this might occur, however, depends on the wave and wind climate and sediment availability. The breach contingency response at Fire Island provides a model of how multiple agencies with varying agendas and mandates can come together to respond in the aftermath of a natural coastal disaster and begin rethinking standard, reactive approaches to coastal management.

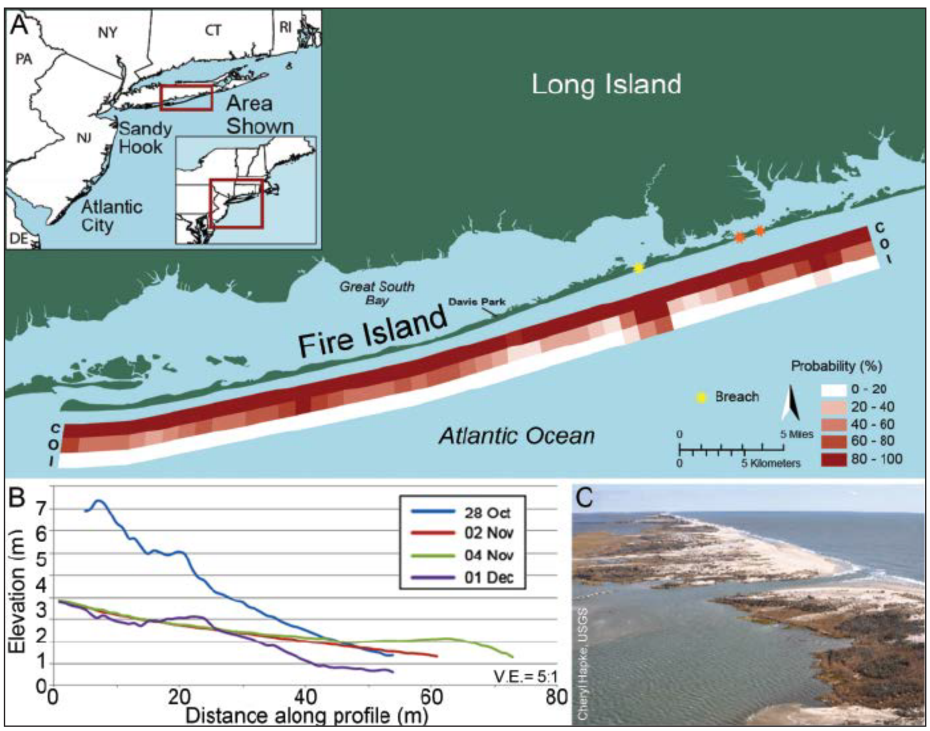


*Fig. 1. (a) Location map of Fire Island, N. Y. The stars show the locations of the breaches formed by Sandy. The yellow star is the breach within the federal wilderness portion of Fire Island National Seashore. The prestorm coastal erosion vulnerability prediction for Fire Island is shown by the colored bands. Inner to outer bands represent areas very likely to experience collision (C), overwash (O), and inundation (I). As defined by* Sallenger *[2000], collision occurs when waves reach the base of dunes and cause dune front erosion. Under higher-surge conditions, waves can overtop dunes, leading to overwash, which transports sand inland. In the most extreme storm conditions, inundation may occur when the elevation of storm surge exceeds the elevation of the primary dune. (b) Cross-shore beach profile from Davis Park on Fire Island. The blue profile (28 October) is the prestorm profile. The dune was completely overwashed at this site, which resulted in an elevation loss of 5 meters. This is typical of the morphologic change along many portions of Fire Island. (c) A breach in the federal wilderness area within Fire Island National Seashore.*

### *Challenges for the Future*

The extreme redistribution of sediment during Sandy has altered the morphologic evolution of the coast in affected areas. This has substantial repercussions on the suitability of prestorm coastal management plans, which will require new scientific data and a thorough understanding of the altered physical system to address coastal vulnerability and resiliency.

With predicted acceleration of sea level rise [*National Research Council,* 2010] and a potential increase in storm intensity, events similar to Sandy may occur more frequently in the future. The most resilient coasts may be the ones that are managed to allow some natural storm processes to occur, and sound science will be necessary to help guide this potential new management strategy.

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