New Jersey State of the Shore Report 2010

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"It was the best of times, it was the worst of times." truer words have never been written. Although Charles Dickens' immortal words refer to French society embroiled in the throes of a revolution, they could just as easily could have been written about life along New Jersey's coast. New Jersey residents have always had a tumultuous relationship with the sea. At times this relationship has been cordial, but at others heart wrenching. Perhaps the most famous opening lines in English literature continues "it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair…", words that rang all too true to for New Jersey's coastal residents this past winter.

Coastal Storm Activity

After seven relatively mild winters in a row and two that rank amongst the mildest in the past last half century, New Jersey's coast was battered this winter by a series of storms that were unprecedented in the modern historical record. Winter storm activity was analyzed using a variety of approaches employing data collected by wave and water level gauges maintained by the National Oceanographic and Atmospheric Administration (NOAA) and Stevens Institute of Technology. Of the three long term water level gauges operated by NOAA (Cape May, Atlantic City, and Sandy Hook), only the Atlantic City gauge is situated directly on the ocean coast. Water levels measured by the gauge at Atlantic City are shown in the upper panel of Figure 1. Hourly observations are plotted in grey, with a thicker red line used to identify the maximum daily water level. Also included is a dashed line which indicates the water level corresponding to a 2-year return period (water level that has a 50% chance of being exceeded in any given year). The surge or difference between the predicted (astronomic) and observed water levels, is plotted separately in the lower panel of Figure 1. Wave information for the New Jersey coast is provided by three deep water gauges (44025, 44009, and 44065) operated by NOAA and several nearshore gauges (LBI, Avalon, and Ocean Grove) maintained by Stevens.

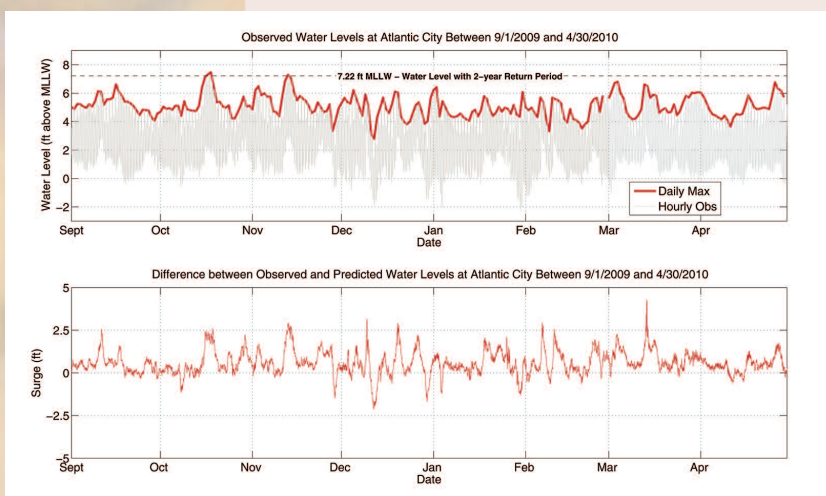
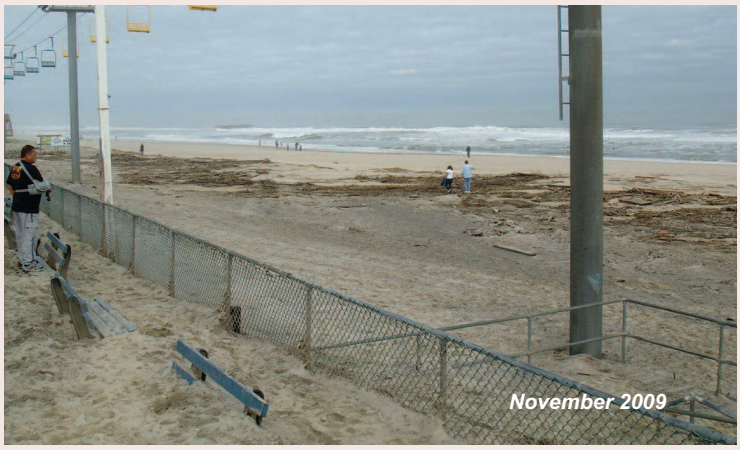


Figure 1: Measured water levels and water level differences at Atlantic City between September 1, 2009 and April 30, 2010.

The winter storm season got off to an early and inauspicious start as the remnants of Hurricane Bill threatened the New Jersey coastline in mid-August. Fortunately, the storm passed far enough offshore such that the most significant impact from the storm turned out to be some of the best surfing conditions of the past decade. The long period swell associated with the storm actually built out the beach in several communities. Rather than devastating the coast, Bill simply served as a warning of things to come.

September and the first half of October passed without much significant storm activity. In mid-October the first major storm event of the winter occurred, when a pair of Nor'easters acted in concert to elevate water levels along the coast ~~for~~ a period of 5 days. The combined storm resulted in moderate coastal flooding, beach erosion, and wide spread power outages. Traditional stage frequency analyses based on the maximum water level reached during the event suggest the storm had a return period of approximately 5-years (20% chance of occurring in any given year), a number roughly commensurate with the amount of damage reported.

New Jersey's coastal communities barely had time to recover from the October storm, when they were hit with what would become known as the "Friday the 13th Storm." Other monikers used in the press included "The Veterans Day Storm" and the "Son/Daughter of Ida"; however, given the major damage sustained during the storm, ~~the~~ Friday the 13th storm seems most appropriate. The storm began as the remnants of Hurricane Ida collided with and eventually became entrained into a low pressure system developing off the North Carolina coast. The resulting storm system created a powerful Nor'easter that generated water levels and storm surges that were remarkably similar (in terms of both magnitude and duration) to the mid-October storm. Again traditional water level based analyses indicate the storm had a return period of approximately 5 years; however the damage



estimates in excess of $50 million suggest the storm was much more significant. The storm prompted an immediate response from then Governor Corzine who declared a State of Emergency in six counties, a response that was followed up a month later by President Obama who signed~~signing~~ a Presidential Disaster Declaration. The contrast between the damages inflicted and the suggested significance based on traditional analyses prompted researchers at Stevens and elsewhere to perform a reanalysis of the storm using a more complete set of parameters. By including important factors like storm duration and wave height, the reanalysis confirms that the Friday 13th Storm was in fact much more significant than indicated by water level alone and suggests the storm had a return period closer to 20 years, making it the most significant event since the December 1992 Nor'easter.

In December, January, and February, a series of storms continued to eat away at the coast. Although several major snow storms occurred during this time frame, the coastal impacts were more muted, with the resulting erosion due more to the cumulative impacts of the storms than any one individual storm. Hopes that New Jersey might escape the winter without another major coastal storm were quickly dashed in mid-March. A major snow storm that stalled off the Mid-Atlantic coast buffeted the New Jersey coastline with tropical storm force winds and energetic waves over a period of several days. The storm resulted in the most significant storm surge of the season at just over 4 feet; however, the surge peaked during low tide during a period when the tides were transitioning from a neap phase (lower than normal). As a result, the maximum water level reached during the storm fell well short of that associated with even a modest 2-year storm. Once again however, the damage caused by the storm suggests its significance was much higher than that associated with a typical 2-year storm. The damage was so significant in fact that President Obama once again declared parts of New Jersey a major disaster area. Using the same reanalysis procedure that was applied to the November storm, a more realistic return period of 6 years was determined for the March storm ~~when factors such as storm duration and wave height are included~~.

Cumulative Impact

The severity of the storms this past winter has sparked numerous inquiries as to just how bad it was. In terms of coastal water levels as recorded by NOAA's tide gauges, the winter was in fact quite ordinary. The major factor in the amount of beach erosion and coastal damage experienced ~~this past winter~~ was the unprecedented level of wave activity. Figure 2 shows a comparison of the monthly average wave heights recorded this past winter (red) with the long- term average (grey) at NOAA buoys 44009 (off Delaware Bay) and 44025 (off Sandy Hook). The average wave height recorded this winter exceeded the long term average every month (and by a significant margin) with the exception of April. The buoy off the southern NJ coast (44009)

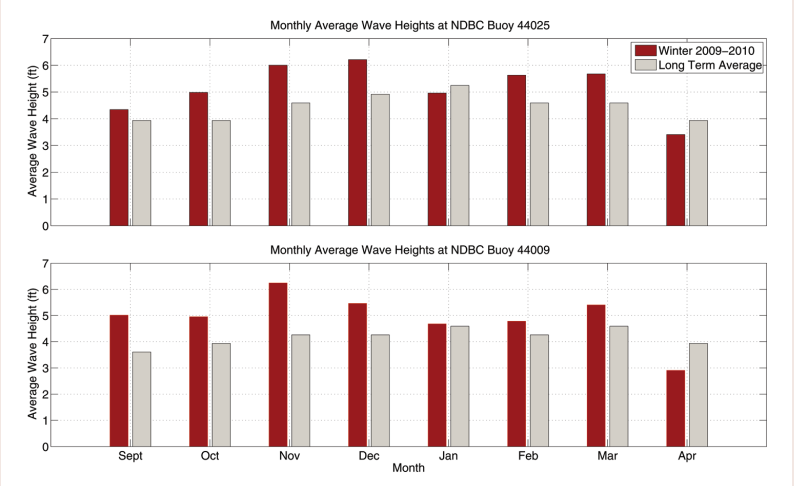


Figure 2: Comparison of the monthly average wave heights at NDBC Buoys 44025 and 44009 observed during the winter of 2009/2010 with the long term historical averages.

actually recorded the largest wave ever measured during the months of October, November, December, and February, as well as the largest wave height ever measured at the station (, 26.6 ft). Through analogy with the Accumulated Cyclone Energy (ACE) parameter used by NOAA to measure the relative strength of tropical cyclone seasons, two parameters the Storm Erosion Index (SEI) and the Accumulated Storm Wave Energy (ASWE) were used to compare storm seasons (July through June) over the period for which wave and water level data are available. Figure 3 shows the comparison, where the values have been normalized by the maximum value. Even though the 2010 dataset is still incomplete, both the ACE and ASWE are already significantly larger than in any other given year, and in most cases are nearly double that measured in previous years.

Coastal Assessment

This "winter of despair" was undoubtedly one of the worst with respect to beach erosion and storm damage in New Jersey's recent past. One has to go back to historic storms such as the Hurricane of 1944, the Ash Wednesday Storm of 1962, and the December 1992 Nor'easter to find storms of similar magnitude and destructive potential. Fortunately, several factors helped to mitigate the impacts somewhat. First of all the two largest storms of the season were concentrated along different sections of the coast. While both were big enough to impact the entire state, the nature of the November storm was such that the beaches in the southern part of the state received more damage, while during the March storm the northern beaches fared worse. In addition, many of New Jersey's beaches, if not its residents, were optimally prepared to absorb Mother Nature's blow. The combination of the abnormal lull in storm activity over the past decade combined with the robust nature of New Jersey's beach nourishment program; resulted in beaches that were generally wider and much healthier than they otherwise would have been.

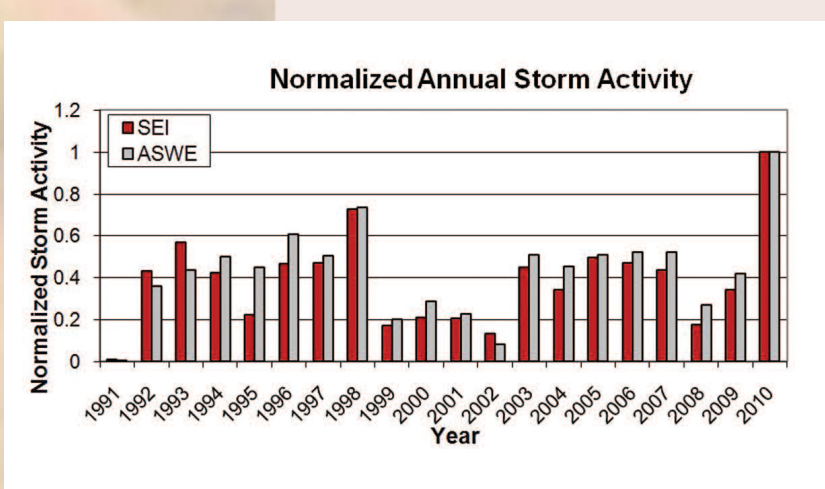


Figure 3: Annual values of accumulated Storm Erosion Index (SEI) and Accumulated Storm Wave Energy (ASWE) based on data collected at NOAA buoy 44025 and the Atlantic City tide gauge.

Summer Storm Outlook

The most recent (April 7, 2010) extended range forecast released by the Colorado State University, Tropical Meteorology Project calls for an above average 2010 hurricane season, with a total of 15 named storms, 8 hurricanes, and 4 intense (Category 3 or higher) hurricanes. These numbers are significantly higher than the long term averages of 9.6 named storms, 5.9 hurricanes, and 2.3 intense hurricanes, and represent the fourth time in the last five years the April forecast has called for an above average tropical storm season. This season, an anomalous warming of Atlantic tropical sea surface temperatures, combined with weakening El Niñno conditions over the Pacific are considered the major contributing factors. The probability of an intense hurricane strike along the U.S. east coast is given as 69%, significantly larger than the decadal average of 52%. While a direct impact from an intense hurricane remains highly unlikely in New Jersey (<0.1%), there is a realistic chance that New Jersey could be impacted by damaging tropical storm or hurricane force (40-75 mph) winds. Based on the latest forecast, the probability of New Jersey's coastal counties being impacted by tropical storm force winds is 6.6%, with a 1.9% chance the winds could reach hurricane force.

Future Outlook

Lower than average wave conditions, and the lack of any significant storm activity through the better part of April, gives New Jersey's residents hope that we are now entering "the Spring of hope.". Undoubtedly, the beaches will look different this summer than last ; however but the good news is that most communities have a strategy and have already begun preparing for the summer season. Since the natural beach recovery process can be agonizingly slow, particularly for coastal communities that rely heavily on revenues generated during the summer tourism season, many communities are attempting to accelerate the process. Some communities are promoting the recovery of the back beach and dune system by scraping newly deposited material near the shoreline up into the dune. In other cases communities are simply moving sand from locations where it has piled up during the storms to locations that have become exposed. In still others, sand is being trucked in to shore up weak spots. The appropriateness or effectiveness of each technique varies depending upon the setting. An important lesson that can be taken away from this past winter is that coastlines are dynamic landscapes and if we are to continue to successfully live in and enjoy these environments, we must find a way to plan with resiliency in mind to reduce the impacts from future storm events.

Don't miss Dr. Miller's feature article on the Winter 2010 storm impacts on New Jersey beaches in the new online issue of the Jersey Shoreline magazine at jerseyshoreline.org.