Aspects of New Jersey Geology – 2009
The Jersey Shore

Looking towards Belmar at sunset. Photo from VisitUSA.com.

This calendar is available for free download from www.ganj.org, the website of the Geological Association of New Jersey. Karl Nordstrom of the Rutgers University Institute of Marine and Coastal Sciences, Stewart Farrell and Robert Koch of the Richard Stockton College Center for Marine Research, and Bill Graff, Zehdrah Allen-Lafayette and Ron Pristas of the NJ Geological Survey were helpful in assembling photographs and offering comments. Any peculiar interpretations are mine.

David Harper

Shoreline changes at Wildwood Crest between 1920 and 2002. Both air photos cover the same area. Turtle Gut Inlet, at the center of the 1920 air photo, closed in 1922 due to a combination of human and natural causes. The barrier island has expanded about three blocks seaward over the 82 year period. The 1920 photo is from a series in the care of Andrew Morang, US Army Corps of Engineers, Engineering Research and Development Center. The 2002 photo is from the NJ Office of Geographic Information Systems. Both were downloaded by Robert Koch, Richard Stockton Center for Marine Research.

The Jersey Shore: Like any shoreline, anywhere, anytime in geologic history, the Jersey Shore is a fleeting feature. 18,000 years ago, at the height of the most recent ice age, the shore stood near the edge of the continental shelf, about 80 miles east of where it is today. When the glaciers melted, sea level rose and the shoreline retreated, quickly at first, then, through the last 2,000 or so years when most of the ice was gone, more slowly. Even with the decreased sea level rise, our beaches are far from stable. Along the Monmouth County shoreline north of our barrier islands, beaches were eroding rapidly before aggressive shoreline stabilization began towards the beginning of the 20th century. Property records show as much as 2,000 feet of beach retreat since about 1650. In other places, the shoreline has receded less or even, as at Wildwood Crest, moved slightly seaward.

January 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4 First Quarter – Neap Tide	5	6	7	8	9	10 Full Moon – Spring Tide
11	12	13	14	15	16	17 Last Quarter – Neap Tide
18	19	20	21	22	23	24
25	26 New Moon – Spring Tide	27	28	29	30	31

Brant Beach after a winter storm, February 2006. Photo by Robert Koch.

The Winter Beach: The Jersey Shore in winter is not for the faint-of–heart. Native American and colonial visits were seasonal, and South Jersey's barrier islands remained largely abandoned through the winter months until winterization of summer homes became common beginning in the 1950s. Scarcity of people is not the only characteristic of winter beaches. High waves carve away at the beach and move sand offshore where it settles onto bars seaward of the breakers. Below the high tide line, the eroded winter beach can be steep and narrow. Above high tide, strong winter winds often carry away the fine sand beloved of beachgoers and leave a surface layer of coarse sand, shells, stones, and debris. In the calmer seasons, lower, less turbulent waves move sand onto the beach, making it wider and flatter. Some of the finer sand brought in by the waves blows landward across the coarse winter veneer, bringing the beach back to its summer greatness.

February 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2 First Quarter – Neap Tide	3	4	5	6	7
8	9 Full Moon – Spring Tide	10	11	12	13	14
15	16	17 Last Quarter – Neap Tide	18	19	20	21
22	23	24 New Moon – Spring Tide	25	26	27	28

Image © 2008 MapQuest Inc. Map Data © 2008 NAVTEQ or TeleAtlas
Poplar Beach, Deal, Monmouth County.

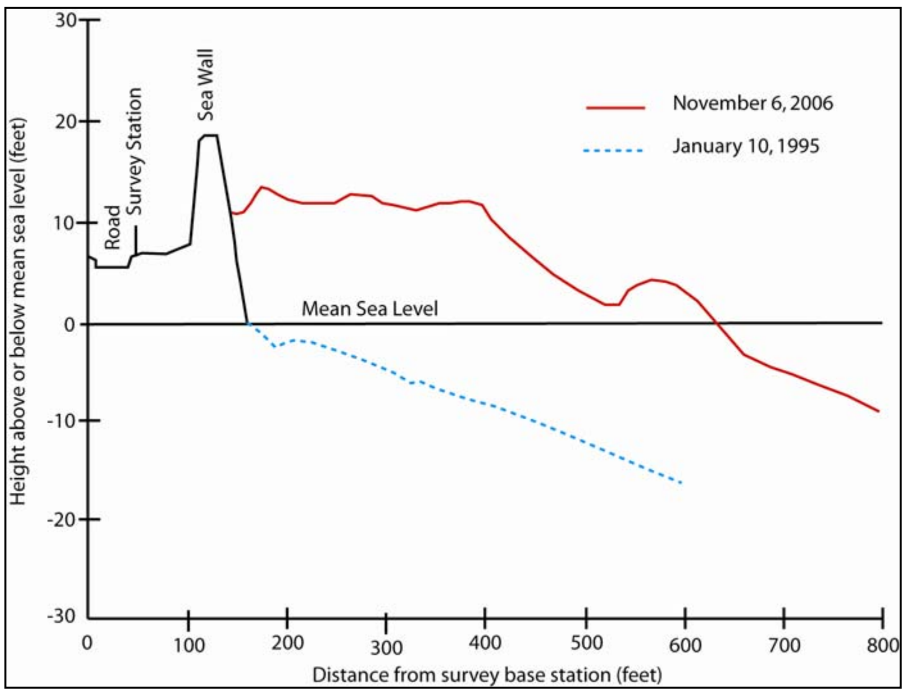
Beaches have been compared to rivers of sand propelled by coastal waves and currents. Unlike the water in a river, however, sand on a beach often reverses direction when wind and waves change. In New Jersey, summertime sand movement is most often to the north in response to waves from the southeast. In wintertime, waves from the northeast are the most effective sand movers, and average bulk movement is to the south. On most southern New Jersey beaches, waves from the northeast move the greatest amount of sand, and sand movement is, on annual average, south. To the north, along most of the Monmouth County shore, the beaches are sheltered by Long Island from fully developed waves from the northeast, and waves from the southeast move more sand in most years. Net sand transport is to the north.

At Poplar Brook in Deal, shown in the air photo to the left, waves from the northeast sometimes carry sand into the brook from the north and force its mouth southward (down). At other times sand carried by waves from the southeast force mouth of the brook north (up). In this photo, the brook bends south where it crosses onto the beach. This is from a time when waves were coming from the northeast and breakers progressed southward down the beach. By contrast, when the photo was taken waves can be seen breaking first to the south then moving northward. This change caused reversal of sand movement and Poplar Brook's hairpin turn to the north.

March 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	**2**	**3**	**4** First Quarter – Neap Tide	**5**	**6**	**7**
8	**9**	**10** Full Moon – Spring Tide	**11**	**12**	**13**	**14**
15	**16**	**17**	**18** Last Quarter – Neap Tide	**19**	**20**	**21**
22	**23**	**24**	**25**	**26** New Moon – Neap Tide	**27**	**28**
29	**30**	**31**				

With beach sand in constant motion, it is impossible to tell in any one year if a beach is growing or washing away. "Beach profiles" measured regularly for many years from a fixed base station are a better guide. Over the past 22 years, profiles of 100 beaches from Raritan Bay to Delaware Bay have been surveyed twice yearly by the Beach Profile Network of Richard Stockton College. Profiling on land is straightforward. Profiling seaward is less comfortable, and many older profiles have ended at low tide. They do not track sand from the time winter storms move it offshore until the storms die down and the sand returns to the beach. The Stockton profiles, by contrast, are measured past the offshore bars even if the water is cold and rough. They track sand through the entire annual cycle. One of the most reassuring findings of the Profile Network is that sand pumped onto beaches at great expense in beach nourishment projects has, by and large stayed on the beaches for years rather than, as some predicted, washing away in a few months.



Upper left: Profiling at Cape May Point. Photo by Stewart Farrell. Lower left: Profiles at Shrewsbury Way, Sea Bright, Monmouth County. The 1995 profile was measured before a beach nourishment project which ran from 1996 to 2000. For many years, as in 1995, there had been little or no beach in front of a seawall built early in the 20th century. After 2000, small amounts of sand were placed at nearby beaches, but not at Shrewsbury Way. The 2006 profile shows that the sand placed between 1996 and 2000 has remained on the beach for at least six years. The beach is public and has become a popular recreational spot. While this is encouraging, it must also be noted that there have been no direct hits by hurricanes or large northeast storms since the nourishment.

Profiles modified from "New Jersey Beach Profile Network: 20-Year Report on Shoreline Changes in New Jersey, Raritan Bay to Delaware Bay", Richard Stockton College Coastal Research Center, 2008.

April 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2 First Quarter – Neap Tide	3	4
5	6	7	8	9 Full Moon - Spring Tide	10	11
12	13	14	15	16	17 Last Quarter – Neap Tide	18
19	20	21	22	23	24 New Moon – Neap Tide	25
26	27	28	29	30		

Left: Air photo of Sandy Hook and Plum Island, courtesy U.S. Geological Survey. Above: Plum Island showing trees undermined and toppled by beach erosion. Photo by David Harper.

Like many of New Jersey's beaches, the ocean beach on the right in the photo to the left is crossed by a series of stone embankments known as "groins". Through much of the 20th century, groins, seawalls, and jetties were the favored means of stabilizing beaches. On this beach, the sand is going north (towards the top of the photo). The sawtooth pattern is from sand trapped behind groins until it reaches their seaward tip. Plum Island, attached to the bay side of Sandy Hook, is built from sand carried through inlets which periodically breached the narrow neck of Sandy Hook before a seawall was built in the early 1900s. The western side of Plum Island is eroding, and the sand is being carried to the sand spits growing north and south from the island. Beach processes on the bay are similar to those on the ocean, but on a much smaller scale. If Plum Island were on the ocean side, it would have been completely removed by erosion in just a few years.

May 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1 First Quarter – Neap Tide	**2**
3	**4**	**5**	**6**	**7**	**8**	**9** Full Moon – Spring Tide
10	**11**	**12**	**13**	**14**	**15**	**16**
17 Last Quarter – Neap Tide	**18**	**19**	**20**	**21**	**22**	**23**
24 New Moon – Spring Tide	**25**	**26**	**27**	**28**	**29**	**30** First Quarter – Neap Tide
31						

Beach nourishment at Avalon, spring 2008. Photo by Stewart Farrell.

Beach nourishment: Beginning in the 1960s and especially from the 1990s on, beach nourishment has come to be a major undertaking in New Jersey. Sand is pumped, barged, or trucked to the beach, leveled, and left to be redistributed by the waves. The process is expensive, and after an initial emplacement beaches need smaller nourishments every few years. Nourishments have, however, greatly improved the health of New Jersey's beaches and the dunes protecting shoreline communities. In this spring 2008 photo, hundreds of gallons per minute of sand slurry pumped from an offshore barge are discharging from the pipe on the right side of the photo.

June 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4	5	6
7 Full Moon - Spring Tide	8	9	10	11	12	13
14	15 Last Quarter – Neap Tide	16	17	18	19	20
21	22 New Moon - Spring Tide	23	24	25	26	27
28	29 First Quarter – Neap Tide	30				

Dunes at Ocean City. Photo by Karl Nordstrom.

These dunes did not exist in 1990. If you look carefully, you can make out four ridges. The oldest and furthest landward, just in front of the buildings, was built by bulldozing sand into a ridge, putting up sand trapping fences, and planting grasses to stabilize the dune. The three ridges in front formed successively closer to the water because beach nourishment provided an ample supply of sand and because sea wrack, the debris washed up at high tide, was not raked up as it is on many beaches. Beach grasses in the wrack took root, and dune growth began naturally when the grasses began trapping wind-blown sand.

July 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6	7 Full Moon - Spring Tide	8	9	10	11
12	13	14	15 First Quarter – Neap Tide	16	17	18
19	20	21 New Moon - Spring Tide	22	23	24	25
26	27	28 Last Quarter – Neap Tide	29	30	31	

Barnegat Inlet. Photo from NJ Office of Geographic Information Systems.
Downloaded by Robert Koch.

New Jersey's bays and tidal marshes are, on a geologic time scale, temporary features. Without further sea level change, they would fill with sediment and be gone within a few tens of thousands of years. In South Jersey the Pinelands rivers carry little sediment, and most of the sediment deposited behind the barrier islands comes from the ocean side. The air photo here shows a small part of the "flood-tide delta" at Barnegat Inlet. The delta is built of sand carried along beaches by waves and currents, then swept through the inlet by landward flow of rising waters during flood tides. Sand is also carried seaward from inlets by ebb tides, but this sand is more quickly dispersed by ocean waves. Ebb tide deltas are, therefore, seldom as dramatic on air photos as flood tide deltas.

August 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1
2	**3**	**4**	**5** Full Moon - Spring Tide	**6**	**7**	**8**
9	**10**	**11**	**12**	**13** Last Quarter - Neap Tide	**14**	**15**
16	**17**	**18**	**19**	**20** New Moon - Spring Tide	**21**	**22**
23/30	**24/31**	**25**	**26**	**27** First Quarter - Neap Tide	**28**	**29**

Aftermath of 1962 Ash Wednesday storm, Harvey Cedars Beach. Photo from Harvey Cedars Borough municipal website.

Sand is carried landward of our barrier islands by waves washing across the tops of the islands as well by tidal currents flowing through inlets. The islands stand, in most places, about 10 feet above high tide and block waves during all but the most intense hurricanes and northeast storms. When the islands are breached, a storm can leave a blanket of sand stretching hundreds of feet back into the bays and marshes. Before the 1962 Ash Wednesday storm, this barrier island was lined with houses.

Sediment layers from cores collected in marshes behind the barrier islands at Brigantine and Whale Beach in southern New Jersey have been dated using carbon-14, pollen changes associated with colonial settlement, and lead and copper increases from the industrial revolution. The cores include sand layers consistent with the 1962 Ash Wednesday storm and historically recorded storms in 1950, 1944, 1938, and 1821. There are more sand layers deeper in the cores left by storms which hit the beach before current records were being kept.

September 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	**2**	**3**	**4** Full Moon - Spring Tide	**5**
6	**7**	**8**	**9**	**10**	**11** Last Quarter - Neap Tide	**12**
13	**14**	**15**	**16**	**17**	**18** New Moon - Spring Tide	**19**
20	**21**	**22**	**23**	**24**	**25**	**26** First Quarter - Neap Tide
27	**28**	**29**	**30**			

Tidal marsh seen from Shad Island, Forsythe National Wildlife Refuge. Photo by Stewart Farrell.

Tidal marshes – In addition to the sand swept into bays and marshes, silt and clay suspended in ocean waters is carried inland by the tides. While much of the sand remains in deltas and sand sheets close behind the barrier islands, some sand and most of the finer sediment is repeatedly deposited and re-suspended until it settles out, or is filtered out by mussels and other "filter feeders", in the quiet waters and dense vegetation of tidal marshes. As sand and mud accumulate, the marshes build upward and outward into the bays. Because there is little way for sediment to be carried above water, the marshes build to a flat expanse at the high tide level. Over the past couple of thousand years, the tidal marshes of the mid-Atlantic states have been growing upward at about the two to three millimeter per year rate of local sea level rise.

October 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4 Full Moon - Spring Tide	5	6	7	8	9	10
11 First Quarter – Neap Tide	12	13	14	15	16	17
18 New Moon - Spring Tide	19	20	21	22	23	24
25 Last Quarter – Neap Tide	26	27	28	29	30	31

Reeds Beach, Delaware Bay. Photo by Karl Nordstrom

Bay Beaches: At some places along Delaware Bay, the beach ridge between the bay and the salt marshes is only a few yards wide and a couple of feet above high tide. Heavy weather easily overtops these beaches, washing sand from the shoreface onto the marsh behind. Only a small volume of sand is moved, but there is only a small volume of sand on the beach and the beaches are eroding quickly back across the marshes. Some Delaware Bay beaches are retreating at 12 feet per year. To the left of Bidwell Creek, Cape May County, at the center of the photo, the photo shows sand washed landward onto tidal marshes by an April 1984 storm. The jetty protects Bidwell Creek. It shelters houses along Reeds Beach by accumulating sand, but also prevents sand from nourishing beaches across the mouth of the creek.

November 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	**2** Full Moon - Spring Tide	**3**	**4**	**5**	**6**	**7**
8	**9** Last Quarter – Neap Tide	**10**	**11**	**12**	**13**	**14**
15	**16** New Moon - Spring Tide	**17**	**18**	**19**	**20**	**21**
22	**23**	**24** First Quarter - Neap Tide	**25**	**26**	**27**	**28**
29	**30**					

Summer at Island Beach – Photo from VisitUSA.com.

Sea level rise – Local sea level change is the sum of land elevation change and water elevation change. Tide gauges at Sandy Hook and Atlantic City both show sea level rising 3.8 millimeters per year, but neither is well placed to measure regional sea level change. Sandy Hook is on recently deposited sediment which may still be compacting, causing the station to sink. Atlantic City is additionally sinking because ground water is being pumped from deep-seated aquifers. A more realistic estimate for local sea level rise may be from a gauge at The Battery in New York City. The tide gauge at The Battery is on solid rock and shows sea level rising at 2.7 millimeters per year. For the near term, despite sea level rise, New Jersey's beaches and dunes are in improved shape thanks to beach nourishment and the absence of direct hits by major storms. Continuing rehabilitation of New Jersey's beaches, though, will be expensive. In addition, continuing development is increasing property vulnerability to storms and challenging the health of our bays and marshes. In the longer term, global warming and sea level rise threaten the entire coastal zone with storm flooding, wetland destruction, salt water intrusion into aquifers, and, in lower lying places, permanent submergence.

December 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	**2** Full Moon - Spring Tide	**3**	**4**	**5**
6	**7**	**8** Last Quarter - Neap Tide	**9**	**10**	**11**	**12**
13	**14**	**15**	**16** New Moon - Spring Tide	**17**	**18**	**19**
20	**21**	**22**	**23**	**24** First Quarter - Neap Tide	**25**	**26**
27	**28**	**29**	**30**	**31** Full Moon - Spring Tide		