The Impact on Great South Bay of the Breach at Old Inlet

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The previous report provided a detailed look at the conditions in Bellport Bay as a result of the Oct. 29 super-storm Sandy through November, 2012. Since then a sensor has been deployed on the dock at Old Inlet, the Bellport sensor's real-time data have been put online, and we have retrieved the sensors from the US Coast Guard base at Fire Island Inlet and from Tanner Park Figure 1. These new records, combined with the wind data from the GSB1 buoy, provide more information about the response of the Bay to Sandy as well as the subsequent behavior of water level and salinity throughout the Bay as the Old Inlet breach has evolved.

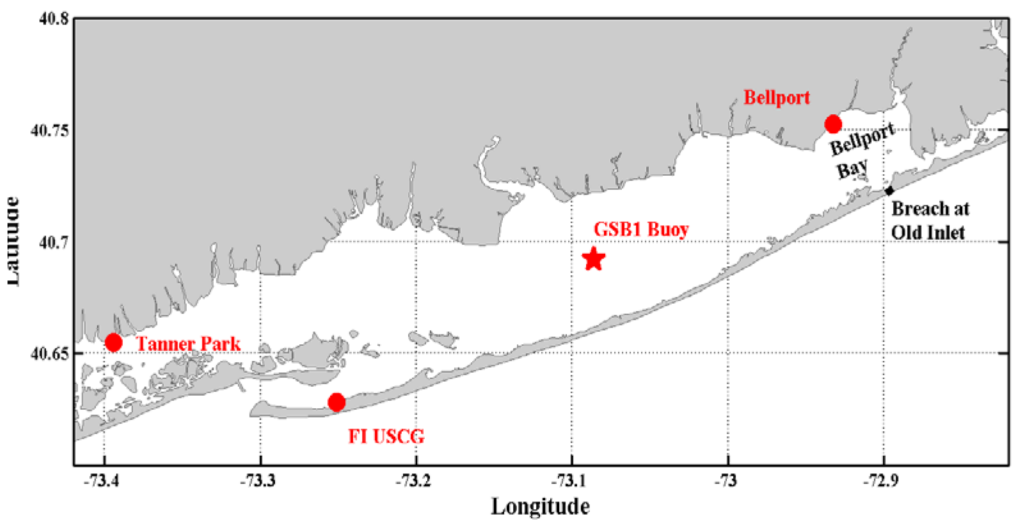

Figure1. Map showing the location of the breach at Old Inlet, GHSB1 buoy and the sensors deployed around the perimeter of the Bay included in this report.

Aerial Surveys

As part of the breach project, we and interested collaborators collected a series of aerial photographs covering the inlet's development, and a brief report describing those observations has just been completed. A short synopsis of those photographs indicates that the inlet evolution continues, punctuated by high wind events that sometimes produce marked changes. Such was the case during December, 2012. For most of December, the inlet morphology altered little but that situation changed abruptly during two stormy periods in late December. By the end of December, the eastern edge of the inlet had accreted a good deal of sand while the western edge had eroded quite noticeably along the ocean front. This change was accompanied by the closure of the eastern channel with the ocean, as an offshore bar moved onshore creating a ridge and runnel system along the reach between the inlet and Smith Point. As part of this process, the ebb-shoal, which was quite evident previously due to breaking waves, disappeared and the western channel seemed to have enlarged and moved into the center of the inlet. In the back bay, the extensive area of sand bars and shallows remains pretty much as earlier without any obvious opening of a deep channel to the rest of the Bay.

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Available Water Level and Water Property Data

Figure 2 shows a plot of the available water level records from Bellport, Tanner Park, Fire Island Inletand the Old Inlet dock from August 2012 through the first week of January, 2013. : The Fire Island (USCG FI) record extends to December 19th, the Tanner Park record to early on December 25th, and the Bellport record to January 8th. The sensor at the Old Inlet dock was deployed on December 5th and available data were downloaded on January 5th. All the water level records are given relative to

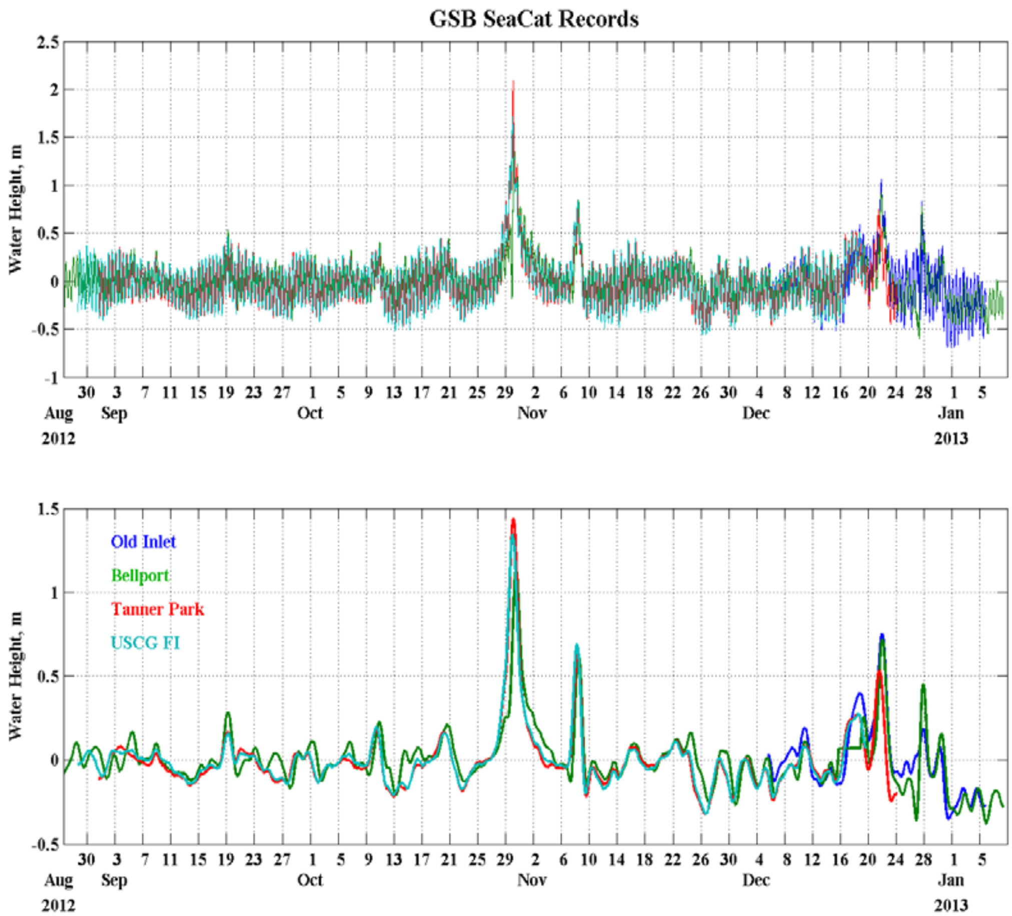

Figure 2. Water level records from the Old Inlet area, Bellport, Fire Island USCG base and Tanner Park. The lower panel shows the low-passed height records using a 33 hour half-power symmetric filter.

their record means, as we do not have the NAVD88 offsets for any location other than Bellport at this point. The records track each other rather well, although the tidal ranges at Fire Island Inlet and Tanner Park are somewhat larger than at Bellport.

The low-passed water levels also track one another, although there are some differences in terms of height and phasing during the storms. First, the height records during super-storm Sandy will be discussed below, followed by the other lesser events in early November and late December.

Tidal Analysis

Table 1 presents tidal analyses for Bellport, Fire Island Inlet and Tanner Park before and after the breach. There has been little change in tidal range at any of the locations, but the phase of the tide at Bellport has moved forward by about 20 minutes, based upon the M2 tidal constituent (frequency 0.0805114 cycles/hr).

Table 1. M2 tidal analyses before and after the formation of breach at Old Inlet

	Before Sandy		**After Sandy**	
	Amplitude, m	**Phase, Deg**	**Amplitude, m**	**Phase, Deg**
Bellport	**0.16**	**102.8**	**0.16**	**93.8**
Fire Island Inlet	**0.23**	**11.7**	**0.22**	**12.4**
Tanner Park	**0.20**	**63.1**	**0.19**	**62.6**

Super-storm Sandy Revisited

Figure 3 shows the available water level records during Sandy from Bellport (discussed in the previous report), Fire Island inlet and Tanner Park, plus the wind record from the Observatory's buoy south of Sayville. On Oct. 29th, Bellport shows the characteristic initial drop in water level as a result of strong east winds, followed by a quick rise in water level of more than 2 m to 1.5 m above MWL as the ocean setup against Fire Island flooded into the Bay. Note that the water levels at both Fire Island inlet and Tanner Park increased well before Bellport and reached their peak between 6 and 2 hours earlier. The storm surge at Tanner Park was 0.5 m higher than that at Bellport while the Fire Island Inlet surge height was just a little bit more than Bellport's. These records show three things. The first is the characteristic response of the Bay to east winds during which Bay waters are blown down wind, piling up against the western Bay while lowering water levels in the east. The second point is that the response of the Bay to the ocean setup was felt more or less equally throughout the Bay and was not limited to Bellport Bay, the differences being due to local wind responses. And lastly, the slow rate at which the waters receded from the Bay was the same everywhere. So it would seem that the breach at

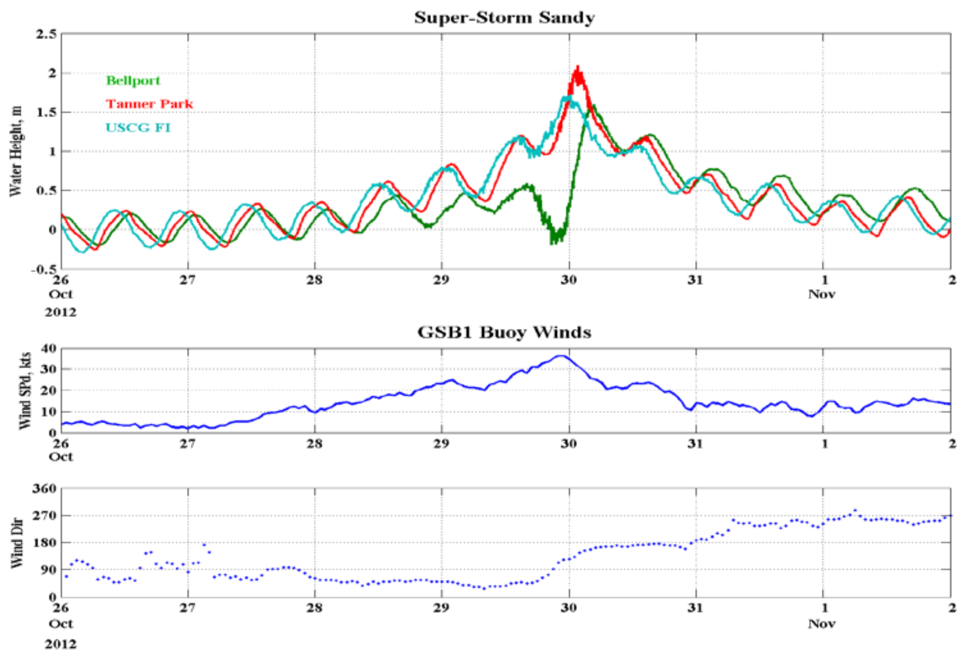

Figure 3. Water level records from Bellport, Tanner Park and the Fire Island Coast

Old Inlet did not produce a clearly different response than one would expect from a storm of Sandy's magnitude.

Post-Sandy Nor'easter

About a week after Sandy passed by, a nor'easter hit the area causing significant flooding in the Bellport Bay area, Figure 4. So the question is, to what extent was Bellport Bay's response to this early November storm different from what might be expected, as a result of the new inlet. Figure 4 again shows the water height records from Bellport, Tanner Park and Fire Island Inlet, which together show the overall behavior of the Bay. Before and after the storm, the mean sea level and tidal ranges at the three sites were quite similar. At the onset of the storm winds, the water levels at Bellport fell below those at the western end of the Bay but then caught up after the peak winds and the wind direction rotated counter-clockwise, from northeast to north, to northwest. The maximum water levels were only marginally higher at Bellport than at the other locations with slight delays related to the local times of high tide. Thus, while the post-Sandy nor'easter produced significant high water levels it does not appear that the response in Bellport Bay was unusual when compared to the water levels elsewhere in Great South Bay.

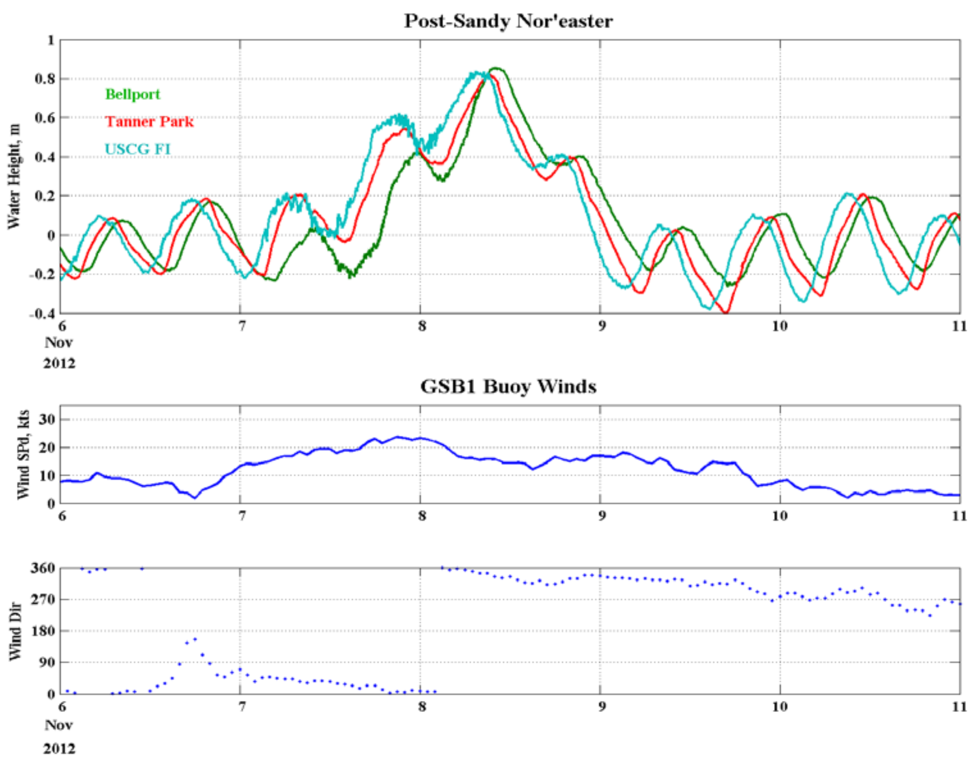

Figure 4. Water level records from the same stations as in Figure 3 with the winds from the GSB1 buoy.

Old Inlet Record and Late December Storms

On December 5th 2012 an internally recording SeaCat was deployed from the Old Inlet dock just to the northeast of the breach, and data from that instrument were downloaded a month later on January 5th 2013. Water level and salinity records from the Old Inlet dock and Bellport are shown in Figure 5. The

Old Inlet salinity record shows ocean salinities of 32 psu or slightly higher during flood tide and Bellport Bay salinities generally around 28 psu on ebb tide. Generally, Bellport salinities are less than the ebb salinities at the inlet, but that is not always the case reflecting the complex circulation patterns within the Bay and the incomplete mixing of water types.

There were two significant wind events during the month of December, one on the 21st with winds predominately from the west and another on the 27,th which started out as a classic nor'easter with a substantial amount of rain. These events will be discussed below, but for the moment it is of interest to point out the difference in tidal ranges at the inlet and Bellport before and after the storms. Prior to the first storm on the 21,st the tide ranges at the two locations were very similar with high tide at Bellport lagging that at the inlet by about three hours. After that storm, the tide range in the inlet nearly doubled relative to that at Bellport, and this change is even more evident after the second storm on the 27th . Why did the relative change take place? Without a thorough modeling and bathymetric study of the inlet and back bay area, it is not possible to say for certain what happened. However, looking at the change in morphology of the inlet shown in the January 5 aerial photographs, it appears that the exposure of the Old Inlet dock area to the ocean was increased without a concomitant increase in exposure of Bellport Bay. Thus, the shallows surrounding the inlet produced by the breaching process seem to isolate the Bay to some extent from what is going on in the inlet, at least under normal tidal conditions. It will be interesting to see whether this difference remains as the inlet undergoes further deposition and erosion.

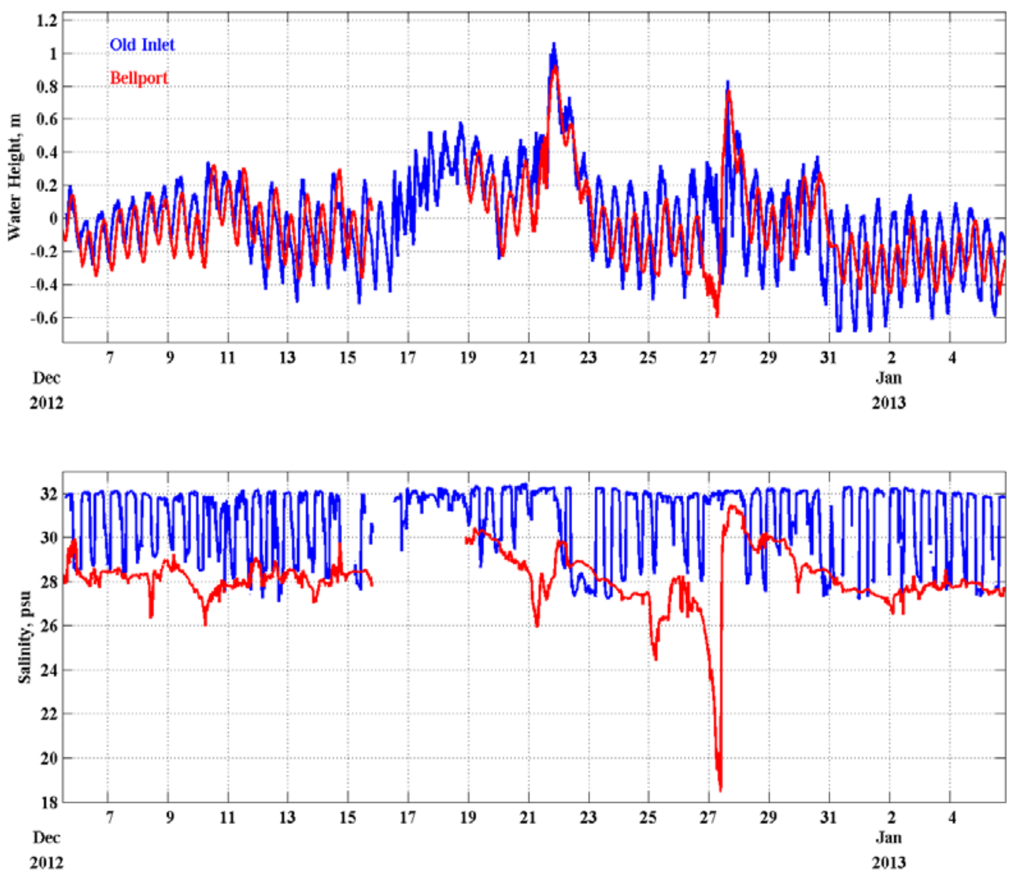

Figure 5. Bellport and Old Inlet water levels and salinities during the month of December.

The storm on December 21st, Figure 6, started out with winds out of the southeast, increasing to ~20kts. This caused water levels at Bellport to initially fall below those at the inlet, while water levels in the western end of the Bay at Tanner Park increased. With the frontal passage, there was a sudden near reversal of winds while at the same time they increased to nearly 30kts by mid-day on the 21st This had the effect of pushing water into Bellport Bay, increasing water levels there while lowering them at Tanner Park. Water levels at Bellport were only slightly less than those in the inlet after the change in wind direction, while Tanner Park water levels were about 0.4 m lower until the west winds subsided on the 23rd. The salinity record of Figure 5 shows that starting late on the 21,st there was an extended period, , of low salinity Bay waters in the inlet. This shows that during this westerly event, the high waters in Bellport Bay were exiting the area through the inlet as well as their more usual exit path through Smith Point Channel and Moriches Bay.

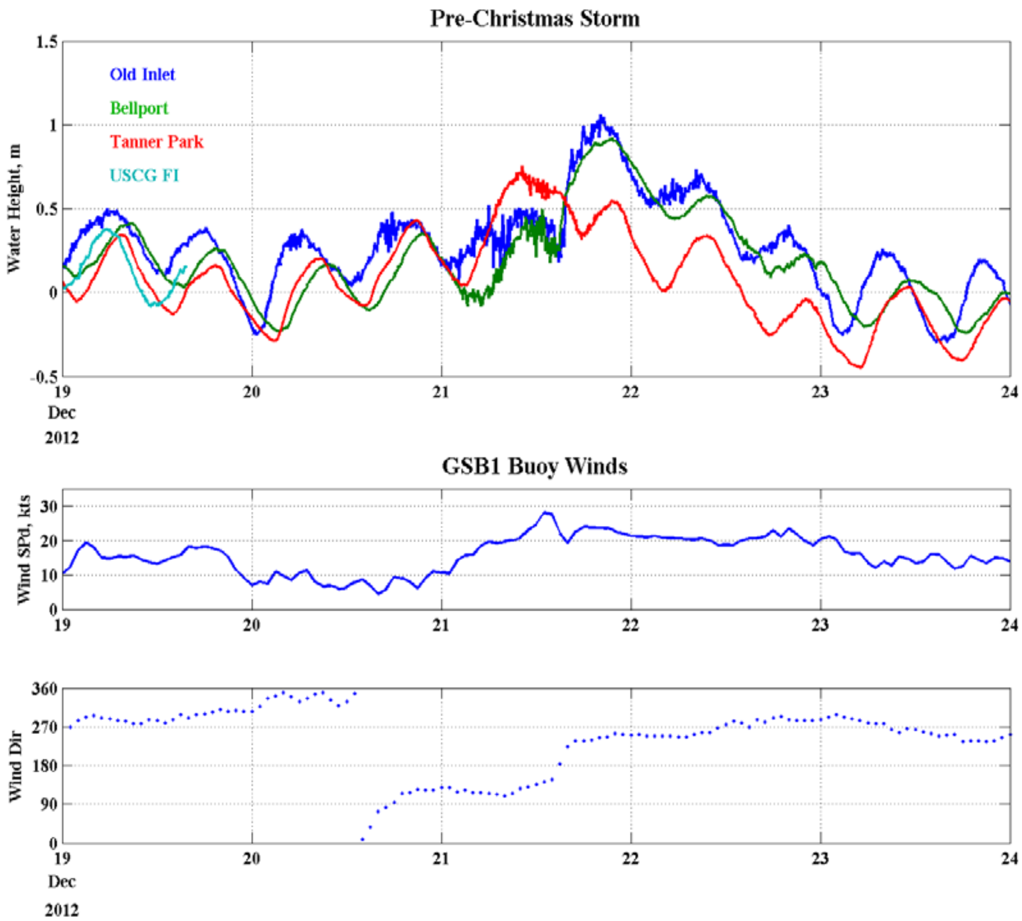

Figure 6, Responses at Bellport, Old Inlet and Tanner Park to the first December storm.

The storm of December 27th started out as a classical nor'easter with a buildup of winds to 30 kts from the northeast to east, producing the usual drop in water levels at Bellport, Figure 7. This water level drop was accompanied by a large runoff directly from the coast as well as fresh water discharged from the upwind river and creek. Together, these fresh water sources lowered the salinity at Bellport by nearly 10 psu, Figure 5, which is probably the largest salinity decrease we have seen since deploying instruments there. Even though there were low salinities along the Bellport waterfront, waters with ocean salinities were flowing in through the inlet because of the water level height differences between the inlet and Bellport. Eventually, those high salinity ocean waters reached Bellport causing an even larger salinity change of about 12 psu over a period of about one hour. Under normal circumstances, one would expect the winds from the east to cause a setup along Fire Island that would eventually cause water levels in the inlet and entire Bay to rise. And this seemed to happen atBellport, but the puzzling thing was what was happening to the inlet water levels, Figure 7. The inlet waters continued to decrease in height even as Bellport's water levels were rising through mid-day on Dec. 27th . However, salinities were high at the inlet indicating the presence of ocean waters throughout this event. Then there was just a brief period of high water in the inlet before the relative water levels and tidal phase between the two sites was re-established. Was the delayed water level response in the inlet a result of a period of substantial morphological changes in the inlet ? Or was there some instrumentation problem? The sensor at the Old Inlet dock is suspended by a pair of chains, and it is possible that some debris, of which there is a good deal in the area, temporarily elevated the instrument. We cannot know for sure, but this seems to be the most likely cause for the observed behavior.

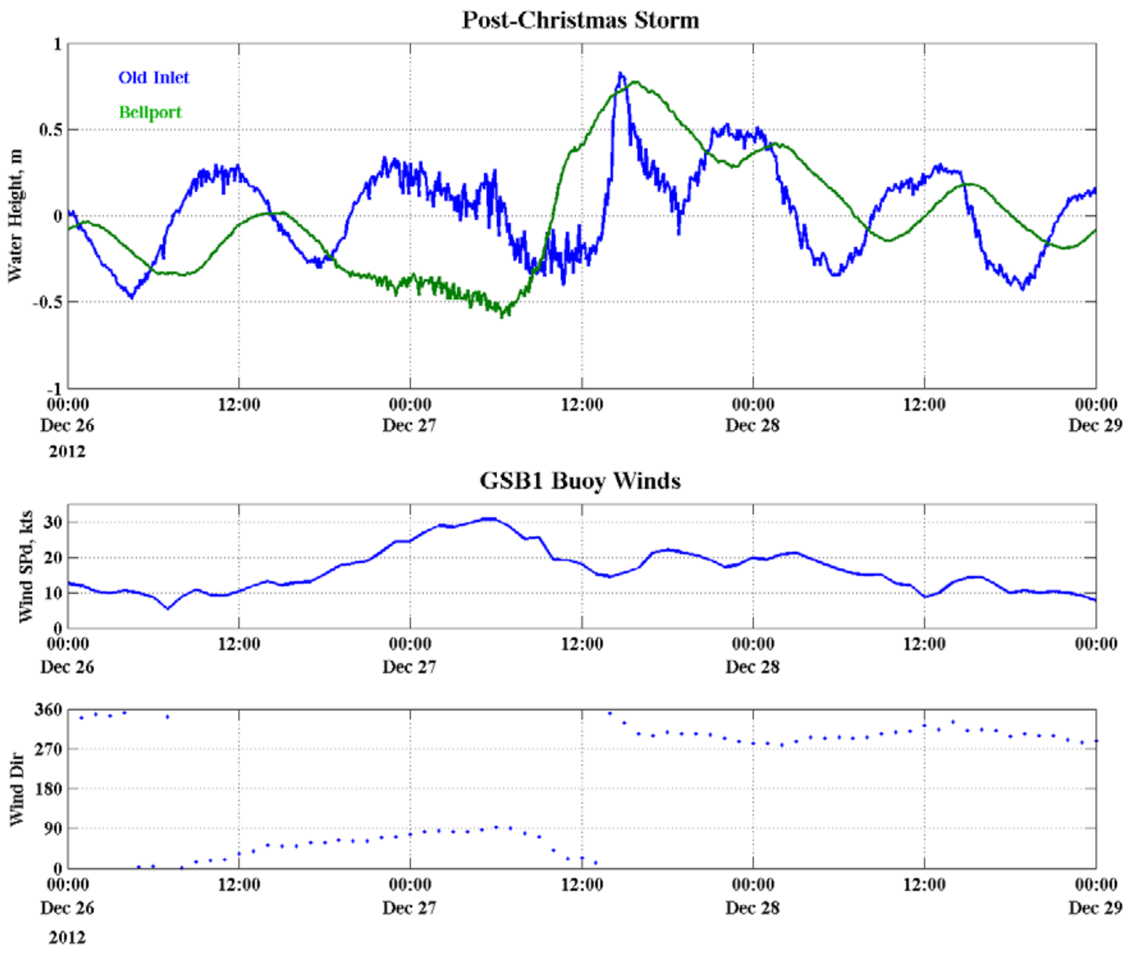

Figure 7. Water levels and Bellport and Old Inlet, and winds from the GSB1 buoy during the December 27th storm

Discussion

The conditions in Bellport Bay and Great South Bay as a result of the breach at Old Inlet are continually evolving as the morphology of the inlet is altered by erosion and deposition. At this point, it appears that the inlet is relatively stable within its own parameters without any obvious sign of growth toward a major inlet. In that regard, it is difficult to conceive of a situation under which a major inlet could occur at this location primarily because of the huge amount of sand in the back bay that would need to be removed. And where would that sand go?

As for the inlet's impact on flooding in neighboring areas, the relative size of the inlet compared to Moriches and Fire Island Inlets needs to be considered. The width of the Fire Island Inlet from Google Earth ranges from 590 m at Democrat Point to 1150 m under the Robert Moses Causeway. If we estimate the mean depth at the Democrat Point section as about 6 m and the depth under the Causeway as about 4 m, the cross-sectional area of Fire Island Inlet ranges somewhere between 3500 and 4500 m^2. If we do the same thing at Moriches Inlet where the width is about 220 m and perhaps the water depth after the recent dredging is 4 m, then the cross-sectional area there would be about 880 m^2. The bathymetric survey of the inlet breach on December 20, 2012, showed that the minimum inlet cross-sectional area was about 100 m^2. Thus, the transmittance of the Old Inlet breach is around 12% of that at Moriches inlet, 2.5% of that at Fire Island inlet, and just 2% of the combined major inlets, not counting either of the inlets farther west. The relative sizes of the inlets certainly suggest that the impact of the inlet on local flood should be small, perhaps not negligible, but small. A definitive answer about the added risk of flood would require some detailed circulation modeling, but so far we have not seen any clear evidence of added flooding in the eastern Great South Bay as a result of the breach at Old Inlet. Salinity and perhaps water quality are a different matter. The extra salinity clearly indicates an increased exchange between the eastern Bay and the ocean, although the high salinity also shows the lack of exchange between Bellport Bay and the rest of Great South Bay.

There are three other sensors deployed in Great South Bay which cover this period of interest and which have yet to be recovered for data analysis. The results from those sensors will be incorporated in the next installment.

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