The Continuing Evolution of the New Inlet

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It is now a year plus since super storm Sandy pushed through Fire Island forming a new inlet near the historic Old Inlet and much has changed during that period. The initial fears of increased flooding have not materialized while changes in the water quality within the immediate area have been clearly beneficial. The new inlet itself and the back-bay shoals underwent major modifications during the stormy winter months of 2012-2013 before reaching a sort of stasis during the late spring and summer. Now that fall is upon us with increasing chances of nor'easters, we are likely to see further changes in the shape and location, if not the size, of the inlet in the coming months. What follows is a brief review of the major changes that we have seen based upon data collected in the inlet, in Bellport Bay and in Great South Bay, leading to the current state of the inlet.

Since the June report there have been six overflights of the inlet through early December. All the photos of the inlet are available from the project web site (http://po.msrc.sunysb.edu/GSB).

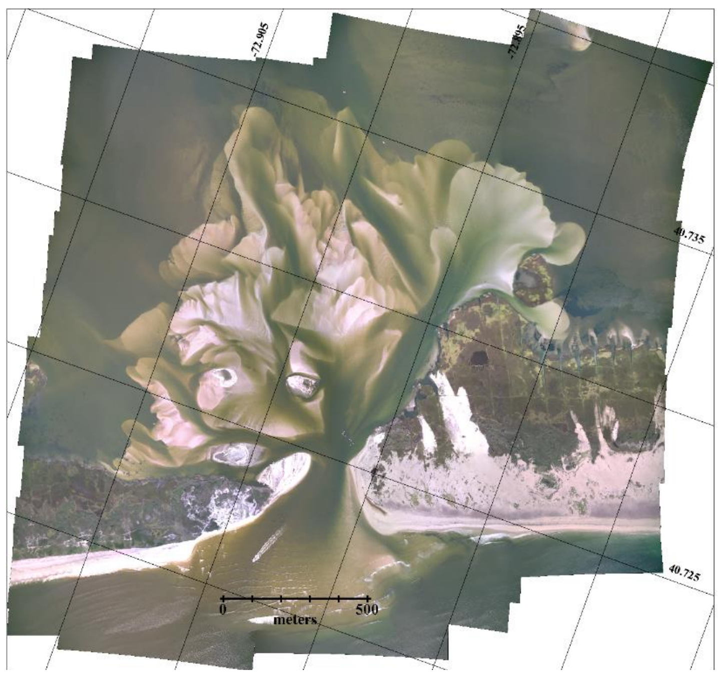

Figure 1. September 15, 2013 photo-mosaic of the New Inlet.

The main feature of this series of observations is that the inlet has been remarkably stable through the summer months and into September. From March through early May, sand was deposited along the eastern shoreline causing a narrowing of the inlet. In late May the eastern shore eroded back to essentially its present position but left behind a shallow area that is still present. Along the western shore, there was some minor erosion during the summer which further opened the mouth of the inlet to the ocean. At the same time the western sand spit gradually grew northward toward Pelican Island. This latest version of the sand spit formed in early May, shrank some through July, before growing larger again through August and early September. Figure 1 shows the configuration of the inlet at the end of the summer from the September 15, 2013 overflight.

Things began to change in the early fall when there was a six day period of moderate winds from the northeast between October 6 and 13, Figure 2. The winds were not particularly strong during this storm, between 15 and 20 kts. What was different was the several day duration and the northeasterly direction of the winds. As is clear from the photo mosaic produced on October 19, 2013, Figure 3, this period of easterly winds caused significant erosion to the western shore and a major change in the character of the sand spit off the northwest corner. During the storm, the spit lost about half its width through erosion from both the front and back sides while at the same time it extended another 100 meters or so farther north toward Pelican Island. The spit later extended a further 50 meters or so northward, Figure 4, possibly due to a period of high winds from the south on November 1st, Figure 2.

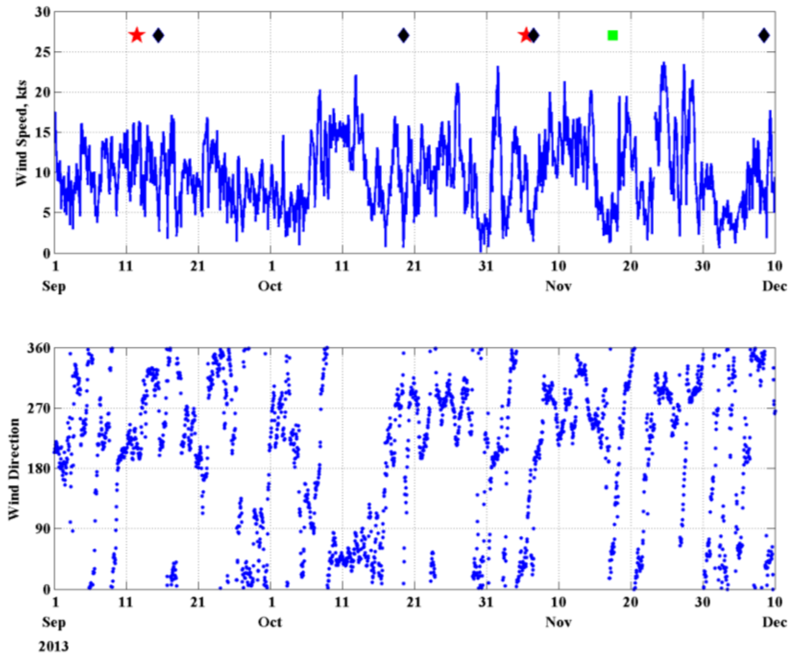

Figure 2. Time series plot of winds from the GSB1 buoy for the fall 2013 period. The lower panel indicates the direction from which the wind is blowing. In the top panel stars are times of bathymetry surveys, diamonds indicate overflights and the square is the date of the velocity survey discussed below.

As a result of the growth of the spit, most of the old west channel had been cut off by November 6th. Shortly after the inlet was formed, a large sand spit connected Fire Island to Pelican Island but that barrier to flow from the west was breached within a month. So the longevity of the current western sand spit, which is much narrower than the earlier one, might be rather short. An important aspect of the northward extension of the spit is that it changed the flow in the inlet. Thus, the inlet throat, generally the narrowest spot with the highest flow rates, has moved north well into the east channel area ending up northeast of the remains of the Old Inlet dock. This is more evident in the discussion about the bathymetric data below.

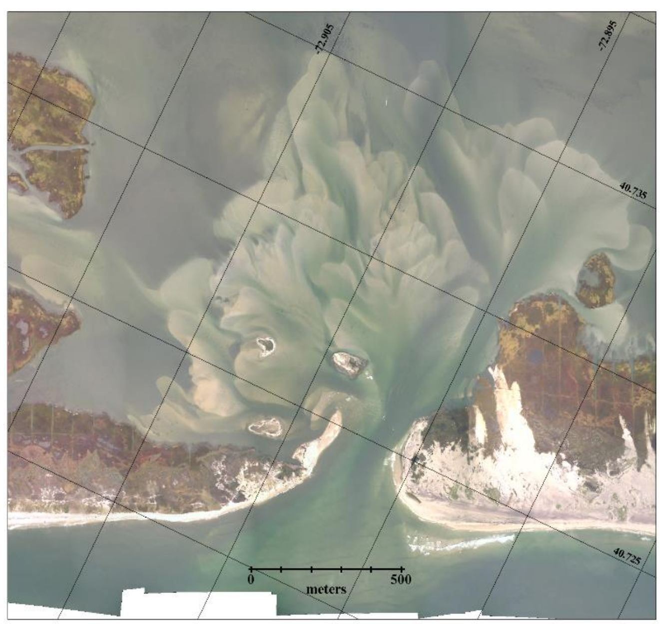

Figure 3. Photo-mosaic from the October 19, 2013 overflight.

In addition to the aerial overflights, we have conducted a series of bathymetric surveys to define the evolution of the underwater shape of the inlet. To date we have conducted eleven such surveys which have yielded some interesting features of the inlet. The surveys are generally restricted to the area between Pelican Island to the north and the ebb shoal delta to the south. That leaves the large and very prominent flood delta to the north of the inlet unmapped by boat as it is mostly too shallow even for the small skiff we have been using. To the south we are restricted by the seas breaking over the ebb shoal. Bathymetric surveys offshore of the ebb shoal delta have been carried out by Professor Flood through an NSF grant and by the USGS.

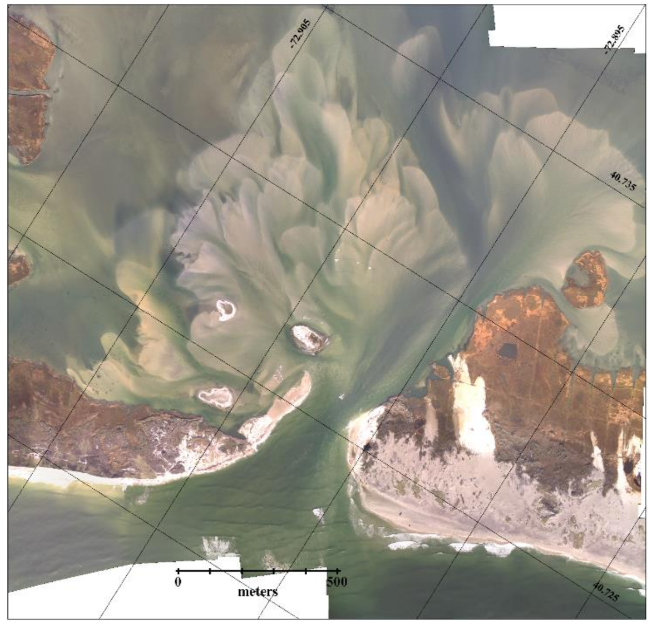

Figure 4. Photo-mosaic from the November 6, 2013 overflight.

Figure 5 shows all eleven bathymetric surveys with the observed depths, shown as colored dots, relative to NAVD88 elevation datum. The datum represents a “level” surface that is close to mean water level and takes into account local changes in gravity. Each panel covers the same area so that the inlet’s westward progression, shape changes and rotation are clearly evident. In these panels, north is straight up while the angle of the Fire Island shoreline is approximately 25^o counter-clockwise relative to east-west. Initially the inlet cut directly across Fire Island at around 72.894 ^{o}W. However, over time the inlet migrated west, the offshore portion widened, the location of the deepest area moved north and the whole inlet rotated clockwise. Most of this evolution was completed by the end of May and the underwater portion was pretty stable through the summer.

Then, in concert with the extension of the western sand spit northward in early October, there was a similar northward displacement of the deepest portion of the inlet. Prior to the October nor’easter, the deepest part of the inlet had been 50 to 100 meters south of the old dock and south of 40.725^oN, although it had been creeping slowly northward. With the northward extension of the sand spit in October, the location of the deepest part of the channel also moved northward to where it is now, north and east of the dock as shown by the “+” in the November 5^{th} panel in Figure 5. This change has reinforced the dominance of the east channel in the transport of water through the inlet. At the time of the November survey, the deepest depth recorded was about 6.2 meters. The west channel, which at one time had been at least equal to the east channel, is now constricted to a ~75 meter stretch south of Pelican Island with depths ranging from 1 to 1.5 meters. Pelican Island is now about one third of its original size.

Another way to monitor the evolution of the inlet has been to look at the bottom profile and cross-sectional area of the narrowest portion of the inlet. This narrow throat portion has always been the location of the deepest water because this is the area where the current speeds are a maximum and thus the erosion is also greatest. It is not clear whether the constriction of the throat area is what limits the flow through the inlet or whether there are other factors such as the flood shoals to the north and/or the ebb shoals to the south that constrain the access of the ocean to the bay. Regardless, the dimensions of the narrowest portion of the inlet reflect the ability of the overall inlet system to act as a conduit. Figure 6 shows the temporal changes to the profiles through the throat and the cross-sectional areas. The cross-sectional area is defined as the area between the bottom and the zero elevation according to the NAVD88 datum. The zero elevation datum is not, in general, coincident with the instantaneous water surface but it provides a consistent reference for all the surveys. The location of these bottom profiles is shown as the black lines across the inlet in Figure 5.

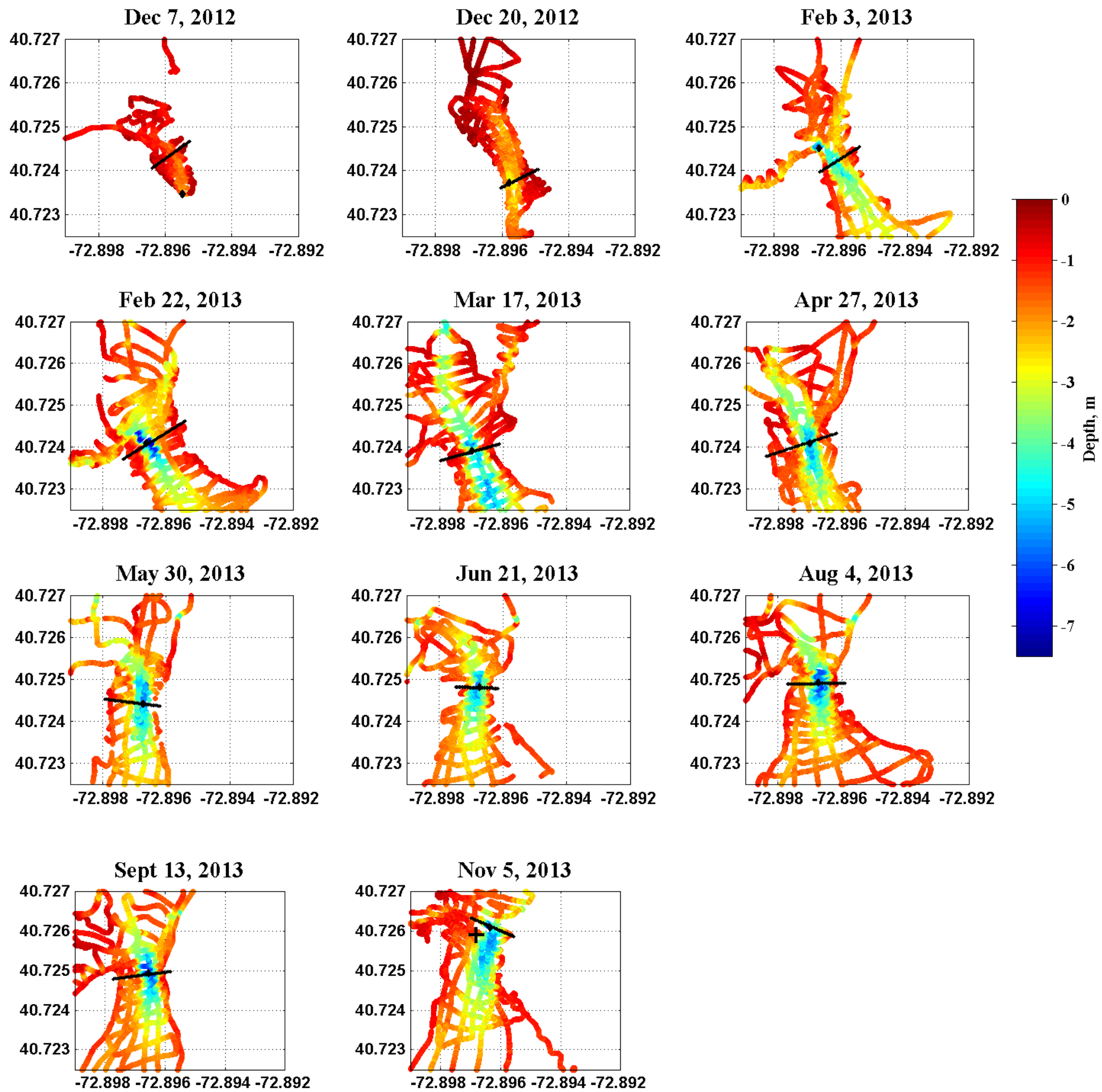

Figure 5. Composite of all the bathymetric surveys of the inlet. Each panel covers the same area so as to illustrate the relative changes in the inlet's configuration. The position of the remnants of the Old Inlet dock is given by the cross plotted on the November 5, 2013 survey plot.

The left panel in Figure 6 is rather busy but it shows the development of the inlet over time. Initially the inlet was rather shallow with depths less than 2 meters and located ~75meters east of its location during the recent summer months. The inlet then migrated west about 120 meters before settling at a middle location through the summer. By mid September the center of the inlet had moved slightly east. The eastward progression continued as a result of the October nor-easter because of the northward shift of the main channel.

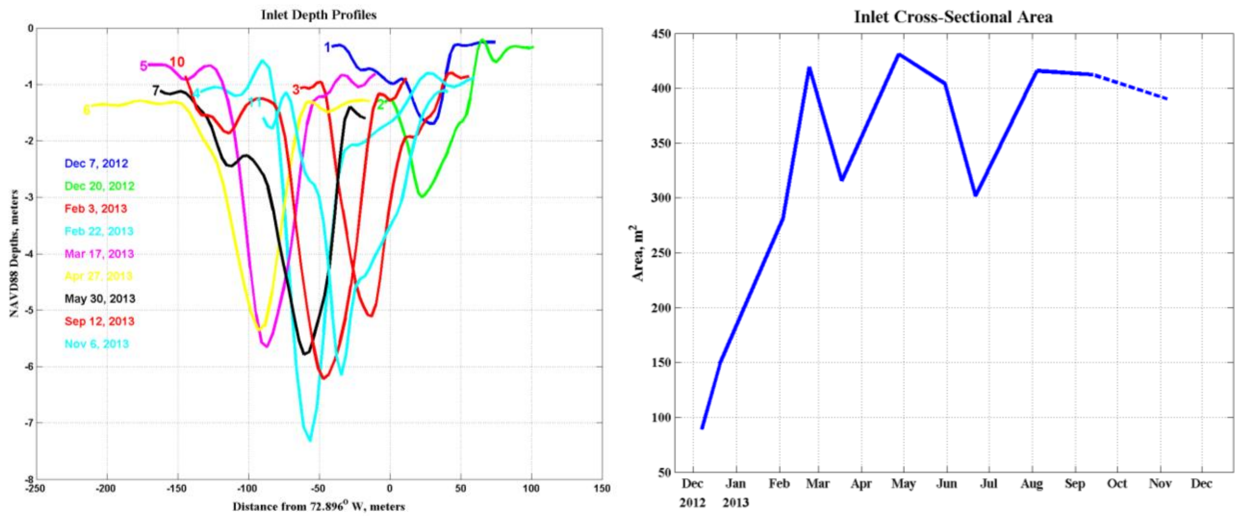

Figure 6. In the left panel are shown the bottom profiles from west to east across the throat area for each survey of the inlet while the right panel shows the cross-sectional area through time. (The profiles from July and August are similar to May and are not shown for clarity.) The dashed portion of the right panel indicates the results for the November 5 survey where the boundaries of the throat area are less well defined.

In the right panel is shown the changes in cross-sectional area of the inlet. From that figure it is apparent that the inlet increased in size quickly before reaching a rather stable size of around 400 m^2 by late February. Prior to the November survey, the shore boundaies of the throat section were well defined. However, in November with the shift in the location of the throat area, the left or west end of the section was less constrained, So, somewhat arbitraily, the left end was stopped at a shoal between the dock and Pelican Island. If that forms an appropriate end of the section, then the cross sectional area remains about 400 m^2. It thus appears that despite the changes in the shape and location of the inlet that its relationship to and potential impact on Great South Bay has been constant over the last 9 months or so. That does not gaurantee that this situation will continue

Figure 7. ADCP survey track from November 17, 2013.

indefinitely but it does suggest that the overall dynamics of the Bay, inlet, ocean system is currently in some sort of balance.

On November 17, 2013 we conducted a survey of currents in the inlet with the intent of determining how much water passes through the inlet during each tidal cycle. An acoustic Doppler current profiler (ADCP) was mounted on our skiff together with a precise RTK GPS tracking system. Combined, these units allow us to determine the current speed and direction from near the surface to the bottom. Using these data along a single track from one side of the inlet to the other, we can compute the total amount of water that flows through the inlet during a tidal cycle.

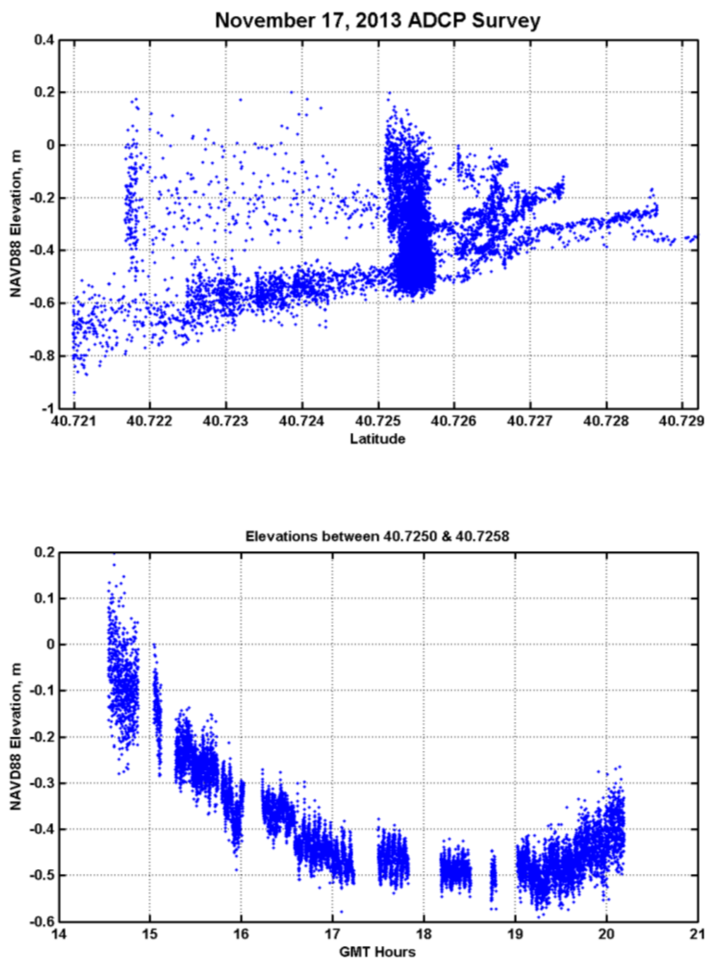

Figure 8. RTK GPS water levels during the November 17, 2013 velocity survey.

For this survey we arrived at the inlet at slack water after high tide in the ocean and continued the survey until just short of slack water after the ocean's low tide. The tidal cycles in the Bay and ocean have different ranges and are not in phase. Slack water in the inlet occurred at about 9:30 AM EDT (14:30 GMT), or 3 hours after high tide at Democrat Point and close to the time of high water at Bellport. The ADCP survey track is shown in Figure 7. There were 70 round-trips across the center area to monitor the flow through the inlet during the ebb portion of the tidal cycle.

The RTK GPS system on the skiff gave us not only horizontal position data, it also provided very precise data about the elevation of the boat during the survey. As a result, we have direct evidence about the water levels in the inlet during the survey. In addition to showing the tidal cycle these data also provide information about the hydraulic head driving the flow. The hydraulic head refers to the water level difference between the Bay and the ocean. Figure 8 shows two views of the water level, the upper panel shows all the elevation data while the lower panel shows the elevation just along the main transect. Although we may not have recorded the water level at its highest level, it appears that the tidal range in the inlet is about 0.45 meters (1.48 ft). It might be a little more if there was more water in the inlet during the last part of the flood just before slack water when we arrived.

During the survey, we made a couple of excursions north and south of the main transect to see how the currents and water levels varied elsewhere as shown in the track lines of Figure 7. The upper panel of Figure 8 reflects those excursions. The first of the forays to the north and south occurred between 14:50 GMT and 15:15 GMT at a time when the flow through the inlet was accelerating. The data from that period in the upper panel shows that there was a 0.45 meter height difference between the Bay and the ocean over a distance of about 850 meters. As is shown in Figure 9 below, these data were collected about an hour before maximum ebb which would suggest that the hydraulic head had not reached its maximum. A couple of swings later to the south between 17:50 and 18:50 GMT occurred at a time of minimum water levels and when the flow rate was clearly slowing down. The elevations then show that water levels to the south were highly variable but with a much reduced elevation difference north to south through the inlet.

The primary purpose of the velocity survey was to measure the total flow through the inlet during at least one complete phase of the tide. The results from velocity profiles across the main transect are shown in Figure 9. We completed about 70 complete round trips during the survey but not all of them returned useable data because of bubbles and sand in the water. The maximum recorded near surface velocity was about 2.2 m/sec, or 4.3 kts. The good transects in Figure 9 showed a very consistent progression of volume transports through the inlet and a hand-drawn fit to those points is shown as the red line.

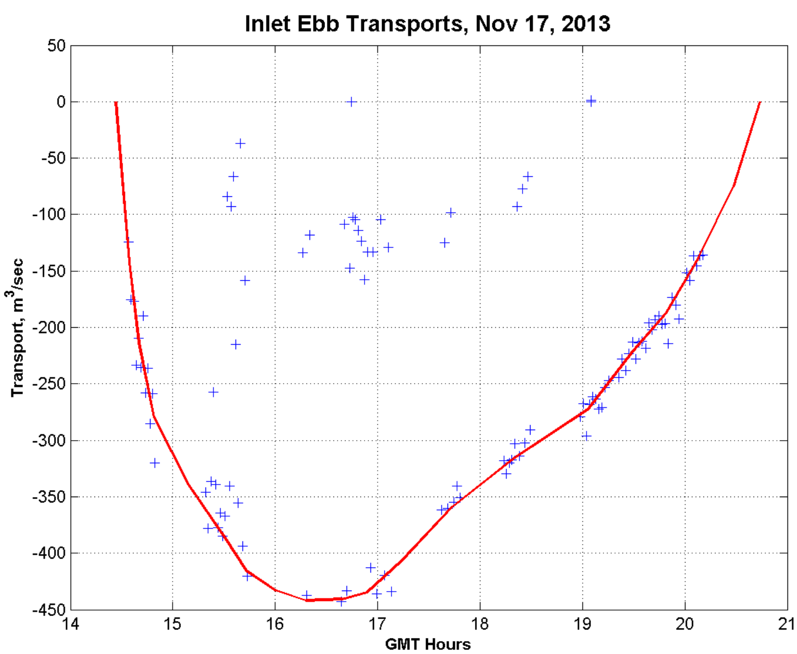

Figure 9. Transport estimates through the inlet during ebb on November 17, 2013.

The maximum flow rate during ebb was about 450 m^3/sec and the total transport of water out of the Bay during ebb was 6.89×10^6 m^3. Given the complex nature of the Bay with now five openings to the ocean, it is not clear that it is a completely justified assumption that the flood and ebb tidal transport are the same. However, at this point we have to assume that the flood tidal transport would be equal to this ebb tidal estimate.

To put this transport result in context, we can estimate the area of Great South Bay directly affected by this transport by assuming that the flow through the inlet is responsible for supplying the water needed over some area to account for the Bay's observed tide range. During the period of the survey, the Bellport station reported a 0.39 m tide range. For this tide range, the flow through the inlet could supply enough water to cover an area of 17.6 km^2 (6.8 square miles). The area of Bellport Bay between Smith Point and Howells Point is 18.1 km^2 while the area of Great

South Bay west to Lindenhurst is about 220 km^2. Thus, the inlet can supply enough water to meet Bellport Bay's tidal needs but only about 8% of the needed water for the entire Great South Bay. This estimate of the limited reach of the tidal flow through the inlet corresponds fairly well with the observations from this past summer of the area of increased water clarity and reduced impact of nitrogen pollution with the attendant minimal brown tides, all of which were clearly apparent in Bellport Bay but less so farther west.

At this point the inlet has survived winter storms and summer doldrums – neither getting so large as to irrevocably change the character of Great South Bay nor filling with sand and closing on its own. The breach seems to have developed into a small, semi-stable inlet that has not endangered the nearby communities while it has markedly reduced the residence time of the waters within the relatively remote Bellport Bay area. (Remote in the sense of being far from Fire Island Inlet.) The improvement in water quality is quite evident in this eastern region and there are now fish species and sizes that have not been seen here in decades. It is much too early to say that the ecology of the area has recovered, it will take years for the sea grass beds and hard clams to re-establish themselves. And it is important to keep an eye on this evolving system, as we and others are doing, to support science-based decision-making. But it does appear at this point that the gamble the Park Service made by leaving open the breach in the wilderness area, has paid off.