



Shoreline Change Monitoring at Gateway National Recreation Area

2009-2010 Annual Report

Natural Resource Technical Report NPS/NCBN/NRTR—2011/500



ON THE COVER

Western portion of Breezy Point, Jamaica Bay Unit, Gateway National Recreation Area
Photograph by: Norbert P. Psuty

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Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Executive Summary

This annual report documents the collection of shoreline position data and describes the short-term variation that has occurred during the period from Spring 2009 to Spring 2010 in the Gateway National Recreation Area, as called for in the Northeast Coastal and Barrier Network's protocol on shoreline monitoring (Psuty, et al., 2010). The changes in shoreline position are generally descriptive of the seasonal contrasts (lower energetics in the summer period versus higher energetics in the winter period) that support sediment accumulation during summer and erosion during the winter. However, there are many natural variables and cultural events that affect the gains and losses of sediment and the displacements of the beach, especially along a coastal setting where sediment input and shoreline exposure are as varied as they are at Gateway National Recreation Area.

This was an unusually stormy period and the ocean-facing shorelines were displaced great distances, especially in the Fall 2009 – Spring 2010 season when Sandy Hook recorded a mean inland shift of -15.57 m and Breezy Point migrated inland a mean of 17.54 m. For the entire year, Sandy Hook had an average inland displacement of -7.24 m, Great Kills lost a mean of -2.11 m, Miller Field was relatively stable at +0.62 m, Fort Wadsworth lost an average of -0.46 m, Plumb Beach lost -0.68 m, and Breezy Point lost an average of -17.91 m.

This annual report on shoreline position change of the Gateway ocean shoreline does offer some insight into the areas of coastal dynamics and sediment budget. However, it is a report on only one year of observations and does not establish a trend. The protocols for shoreline monitoring created a comparable geodatabase that will lead to efficiencies in data assembly and analysis.

Acknowledgements

The field survey team is a critical component in the gathering of the field data and the subsequent processing of the data sets. The active members of the team included Peter Dennehy, Peter Shipton, Mark Christiano, Natalya Apostolou, and Barry Shafer. The shoreline monitoring could not have occurred without the able logistical assistance of Park personnel: Bruce Lane and Jeannie McArthur were consistent contributors at Sandy Hook, providing assistance with vehicles and with logistical support in the field at Sandy Hook. Tony Luscombe assisted in the data collection at Breezy Point. Lindsay Modugno assisted in reviewing and editing the final version of this report.

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Introduction

This is part of a series of Annual Monitoring Reports of the change in shoreline position along the ocean facing shorelines in Gateway National Recreation Area (Fig. 1). This report is a product of the shoreline monitoring protocols described in Psuty, et al. (2010) that were applied consistently starting in the spring of 2006. Subsequent surveys conducted in the spring of 2009, the fall of 2009, and in the spring of 2010 provide the temporal span for this annual report.

The goal of the annual report is to document the collection of shoreline position data and to describe the short-term variation that has occurred, as called for in SOP #7 (Change Calculation, Data Analysis, and Reporting) (Psuty, et al., 2010). The changes in shoreline position are generally descriptive of the seasonal contrasts (lower energetics in the summer period versus higher energetics in the winter period) that support sediment accumulation during summer and erosion during the winter. However, there are many other variables that affect the gains and losses of sediment and the displacements of the beach, especially along a coastal setting where sediment input and shoreline exposure are as varied as they are at Gateway National Recreation Area. Therefore, the short-term annual report is just a step in understanding the conditions that characterize the Park's ocean shoreline and is meant to establish a baseline of information for subsequent characterization and analyses. Discussions and analyses of vectors of shoreline change and likely associations will be the theme of the longer-term (5 years) trend reports to be produced by the Northeast Coastal and Barrier Network.



Figure 1. Shoreline areas of Gateway National Recreation Area considered in this report; including the location of the National Ocean Data Center (NOAA) Water Level Station at Sandy Hook as well as other sites mentioned in this report.

Site and Situation

The primary geomorphological components of the Gateway National Recreation Area ocean shoreline are the pair of barrier spits/islands, Sandy Hook and Breezy Point, extending towards and into New York Harbor (Fig. 1). In addition, the park incorporates several segments of an ocean facing shoreline on Staten Island, and a short segment of an ocean-facing shoreline at Plumb Beach. The segmentation of the shoreline, variable sediment input, and the wide range of exposure to the ambient wave and current conditions create differential responses to individual climatic events and to the net conditions at the shoreline.

The ocean shoreline position survey follows the Northeast Coastal and Barrier Network shoreline position monitoring protocol developed by Psuty, et al. (2010). Each survey records the position of the shoreline at that time, and subsequent surveys compare the changing position through time and space. The resulting data set is a measure of change for specific portions of the coast as well as for the segments of the Gateway ocean shoreline. In this report, the coastal segments are as follows: Sandy Hook Unit, Great Kills Park of the Staten Island Unit, Miller Field of the Staten Island Unit, Fort Wadsworth of the Staten Island Unit, Plumb Beach of the Jamaica Bay Unit, and the Riis Park-Fort Tilden-Breezy Point area of the Jamaica Bay Unit (hereafter referred to as Breezy Point).

Timing of Shoreline Position Surveys

Three surveys of the neap-tide, high-tide swash-line are included in this annual report (Table 1). They represent the positions monitored from the spring of 2009 to the spring of 2010. The three surveys were run during the predicted neap-tide period and had similar water level elevations, grouping around 1.45 m above MLLW.

Table 1. Date of shoreline survey and elevation of associated neap-tide, high-tide.

Season / Park	Date of survey	Previous High Tide	
		Height* (m)	Time
Spring 2006			
Sandy Hook	2 Apr 2009	1.666	12:36 AM
Great Kills	31 Mar 2009	1.419	11:06 AM
Plumb Beach	31 Mar 2009	1.419	11:06 AM
Breezy Point	31 Mar 2009	1.419	11:06 AM
Fall 2008			
Sandy Hook	13 Oct 2009	1.479	02:36 AM
Great Kills	30 Sep 2009	1.412	04:54 AM
Plumb Beach	30 Sep 2009	1.412	04:54 AM
Breezy Point	30 Sep 2009	1.412	04:54 AM
Spring 2009			
Sandy Hook	6 Apr 2010	1.510	01:06 AM
Great Kills	7 Apr 2010	1.541	01:30 AM
Plumb Beach	7 Apr 2010	1.541	01:30 AM
Breezy Point	8 Apr 2010	1.475	03:00 AM

*Tide heights relative to Mean Lower Low Water (MLLW), Sandy Hook tide gauge. Local Standard Time

There is a NOAA water level station located at the northern end of Sandy Hook (Fig. 1) (Station 8531680 (NOAA, 2009)). It is on the northern bay margin of Sandy Hook, but the entrance to New York harbor is so large that the station effectively records the water level in the adjacent ocean with very little elevational difference or temporal delay.

Natural and Cultural Events Affecting Shoreline Position

Natural Events

Storms are important elements of the environment that affect shoreline position by mobilizing and transporting beach and dune sediment. The existing protocol for shoreline monitoring is directed at identifying the seasonal, annual, and longer-term sediment balances at the ocean shoreline by recording changing positions of the water-land contact. Individual storms create short-term variations in the beach position and their occurrence and local effect can be accommodated by judicious planning of survey dates to avoid periods of short-term storm erosion and recovery, and to emphasize neap-tide swash positions independent of specific storms.

Storms are a condition at the ocean beach. They are important drivers of coastal change. The Sandy Hook water level station is a good resource for the determination of neap tide occurrence and elevation, as it responds to the full range of ambient wave directions and storm surges that approach and affect the Gateway National Recreation Area (NRA) ocean shoreline.

Wave data are often described by statistical values such as wave height, wave length, wave period, etc. These data are used in the calculation of wave dynamics in linear wave theory and they provide a basis for the establishment of local wave climatologies described by the U.S. Army Corps of Engineers in their Wave Information Studies (<http://frf.usace.army.mil/wis>). Another approach to describe storm dimension is the level of inundation on the beach profile and the effects on the upper beach. For Sandy Hook, storms that reach an elevation near or greater than 2.0 m above mean lower low water affect the upper beach and cause changes to the berm and potentially to the foredune. Whereas the effects of a particular storm are subject to accompanying conditions, a seasonal grouping of storm frequency and intensity provide a comparative evaluation of storminess and aspects of beach response to the events.

Using this approach to event-driven inundation, 23 storms have been identified as occurring between the beginning of January 2009 and the end of April 2010 (Fig. 2). Further, durations of the storm events were established by noting consecutive high tides with elevations near or greater than 2.0 m (Table 2). The greater the number of consecutive high tides operating on the upper beach, the more likely will the shoreline position represent erosion and displacement of the shoreline.

The combination of data in Figure 2 and Table 2 portrays the summer and fall 2009 and the late winter 2010 seasons as the times of numerous and severe storm events, with the October 15-19 2009 and November 12-14 2009 combination having water levels of 2.485 m and 2.395 m, respectively, and extending over 8 and 6 high tides, respectively. The combination of the February 27-March 4, March 13-16 and March 27-April 1 2010 storms was another major event. They had high water levels of 2.182 m, 2.541 m, and 2.390 m, respectively, and durations of 9, 6, and 8 high tides, respectively. Storm events were very common during this entire survey period and caused considerable shoreline displacement. The summer was mild only by comparison with the other seasons.

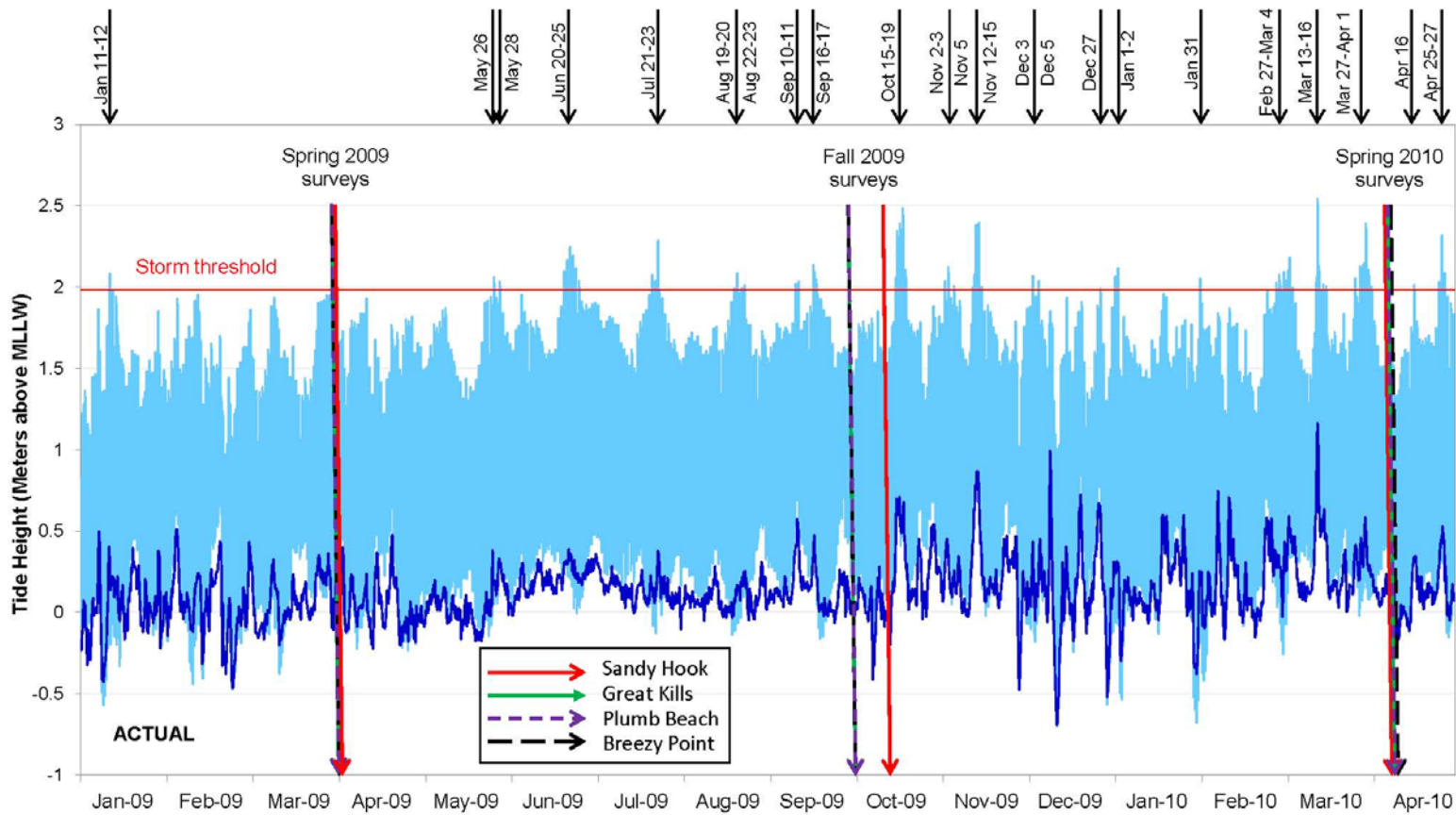


Figure 2. Distribution of water levels (light blue) from January 2009 through April 2010, incorporating storm threshold water level elevation, storm events; timing of shoreline surveys, and storm surges (actual elevation minus predicted elevation) (dark blue line). (Source: NOAA Ocean Data Center, Station 8531680).

Table 2. Storm events - January 2009 through April 2010. (NOAA,<http://tidesandcurrents.noaa.gov/>)

Storm	Number of tides higher than 1.98 m (Storm threshold)	Maximum Tide		
		Tide height (m)*	Date	Measured surge (m)
January 11-12, 2009	2	2.081	01/11/09	0.253
May 26, 2009	1	2.057	05/26/09	0.195
May 28, 2009	1	2.030	05/28/09	0.305
June 20-25, 2009	6	2.245	06/22/09	0.318
July 21-23, 2009	3	2.287	07/23/09	0.377
August 19-20, 2009	2	2.083	08/20/09	0.168
August 22-23, 2009	2	2.010	08/23/09	0.210
Sept 10-11, 2009	2	2.033	09/11/09	0.443
Sept 16-17, 2009	3	2.136	09/16/09	0.347
October 15-19, 2009	8	2.485	10/18/09	0.612
November 2-3, 2009	2	2.123	11/03/09	0.358
November 5, 2009	1	2.007	11/05/09	0.256
November 12-15, 2009	6	2.395	11/14/09	0.679
December 3, 2009	1	2.067	12/03/09	0.435
December 5, 2009	1	2.035	12/05/09	0.304
December 27, 2009	1	1.986	12/27/09	0.612
January 1-2, 2010	2	2.117	1/2/10	0.304
January 31, 2010	1	2.051	01/31/10	0.236
Feb 27 - March 4, 2010	9	2.182	03/03/10	0.472
March 13-16, 2010	6	2.541	03/13/10	1.164
Mar 27 - April 1, 2010	8	2.390	03/30/10	0.506
April 16, 2010	1	2.011	04/16/10	0.343
April 25-27, 2010	5	2.318	04/26/10	0.476

* Tide elevation values are referenced to Mean Lower Low Water (MLLW)

Shoreline Position Data Sets

Following application of the protocol, each surveyed shoreline is registered to a common base and distances are measured from an offshore baseline at 10 m intervals along the baseline following Digital Shoreline Analysis System (DSAS), a software program created and maintained by the U.S. Geological Survey (Thieler, et al., 2009) (see SOP # 7, Psuty et al., 2010) (Fig. 3). The product of the first part of the analysis is a plot of the shoreline positions, the offshore baseline, and transects (Fig. 3). The second part is a measure of the distances along the transects to each surveyed shoreline (Table 3). The complete table of measurements of distances from the baseline to the surveyed shoreline, spaced at 10 m intervals, is available from the NCBN data manager in GIS format.

The portrayal of the distribution of dimensions of change is created by an application called the Shoreline Change Mapper (Psuty, et al., 2010), a software application that works within the ArcGIS software from ESRI, and developed by Rutgers University for the purpose of this protocol. The application generates a new geographical data set that represents the distance of change as a bar-graph-type series of lines - corresponding to the location of a sampling transect - that can be overlaid on existing base maps. A running bar graph depicts the relative difference in shoreline position between surveys. Differences of less than 10 m of seaward or landward displacement (+ 10 m to -10 m) are shown as gray, whereas seaward displacement (accretion) greater than 10 m is shown as shades of blue and landward displacement (erosion) in shades of red. The length of each line represents the magnitude of change between two chosen dates. Additionally, the bar-graph portrayal adds information about the mean change values. These data sets (differences between surveys) are portrayed spatially in a series of panels (Figs. 4 - 17) that depict the seasonal changes from Spring 2009 to Fall 2009, Fall 2009 to Spring 2010, and annual change from Spring 2009 to Spring 2010. The panels include the traces of the surveyed shorelines, a plot of the measured differences between pairs of shorelines, and a depiction of the value of the mean change and an accompanying one standard deviation for each comparison. Together, these panels incorporate essential information on the measures and distributions of change through the span of one year, the basis of this annual report. Although the intent of the survey is to document the change in shoreline position produced by gains or losses in sediment, the shoreline position is also affected by other variables and thus there is a measure of uncertainty, or error, associated with the collected line position. There are three contributors to the variation in the estimate. Their character and dimension are: 1) the recording instrument is a GPS unit with sub-meter accuracy, its variation is about 0.3 m; 2) there is variation in the wave runup to create the neap high-tide swash line, it is 2-3 m; and 3) there is some small variation in the operator's tracking of the swash line on the beach face (0.25 m). Together, these contributors create an estimate in variation in position of ± 2.55 m. Therefore, any surveyed shoreline has an intrinsic estimation of ± 2.55 m. Further, any comparison between two survey lines would incorporate the estimates associated with each survey plus the variation in tidal level between the two surveys, up to 0.2 m, or an estimate of change of ± 5.66 m. However, the locations of the Great Kills Park and Plumb Beach shorelines are less exposed than Sandy Hook and Breezy Point, the beach face is steeper, and the wave run up is less, reducing the variation from this variable. For purposes of this monitoring effort, the estimation value for each of the surveys at Great Kills Park and Plumb Beach is judged to be ± 2.2 m; the comparison between any two surveys has an estimate of change of ± 4 m.

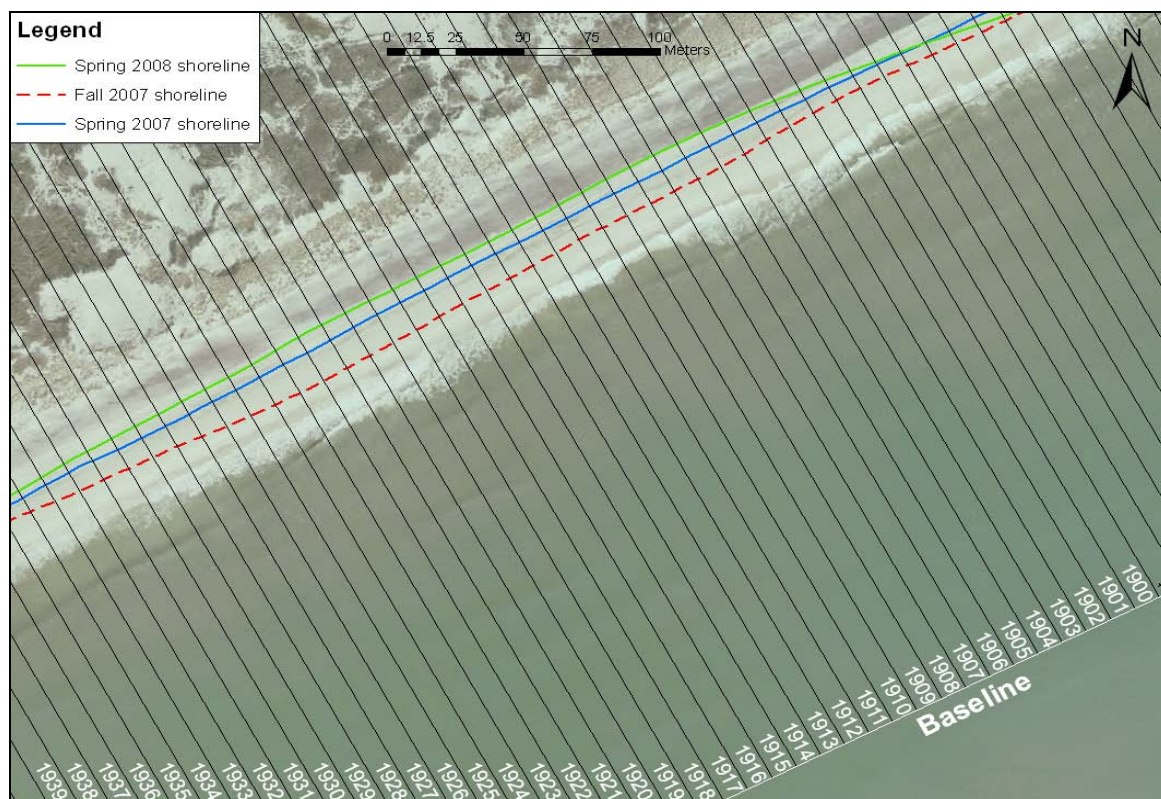


Figure 3. An example of surveyed shorelines intersecting with transects, and producing measures of distances from the baseline along each transect.

Table 3. Example of measured distances from the baseline for each transect on each survey, and comparative displacements of the shoreline between surveys.

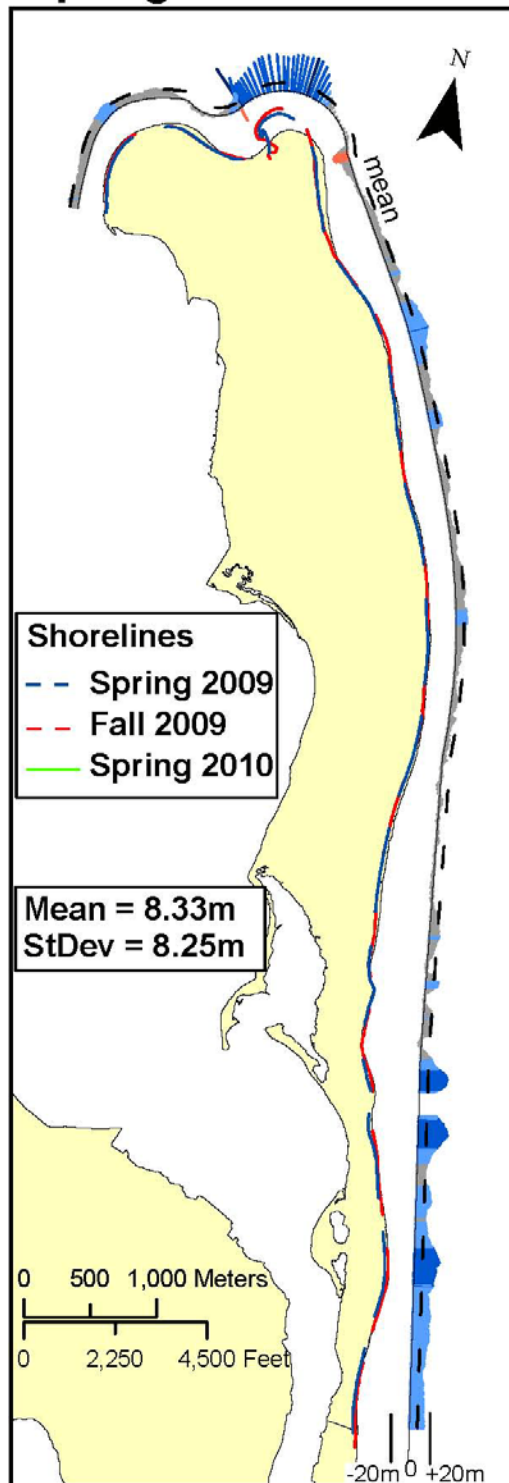
Transect Order	Distance to baseline (m)			Changes (m)		
	Spring 2007	Fall 2007	Spring 2008	Spring 2007 - Fall 2007	Fall 2007 - Spring 2008	Spring 2007 - Spring 2008
1900	241.78	235.92	244.99	5.86	-9.07	-3.22
1901	241.61	234.94	245.69	6.67	-10.75	-4.08
1902	241.39	234.07	246.34	7.32	-12.27	-4.95
1903	241.21	233.11	246.83	8.11	-13.72	-5.62
1904	241.03	231.96	247.05	9.07	-15.09	-6.02
1905	240.89	231.16	247.10	9.73	-15.94	-6.21
1906	240.43	230.50	247.12	9.94	-16.63	-6.69
1907	240.05	230.22	247.04	9.83	-16.82	-6.99
1908	239.78	229.77	246.78	10.01	-17.01	-7.00
1909	239.74	229.42	246.36	10.32	-16.93	-6.61
1910	239.32	229.10	245.76	10.22	-16.66	-6.44

Gateway Segments

Sandy Hook

The three seasonal surveys were conducted on April 2, 2009, October 13, 2009, and April 6, 2010. The Spring 2009 – Fall 2009 interval had a seaward displacement along most of the shoreline (Fig. 4, left panel). The Fall 2009 – Spring 2010 had major erosion along most of Sandy Hook (Fig. 4, right panel). The net condition for the year (Fig. 5) had two areas of considerable erosion (Critical Zone and Gunnison Beach), accumulation at the northern end, and an average inland displacement seaward of 1.2 m, with a standard deviation of 13.48 m (68 % of the measurements are within 1.0 standard deviation of the mean value). Greatest losses were at the east-facing portion of the northern tip of the Hook and at the northwest corner of the Hook. Greatest gains were at the Critical Zone and at the north-facing point of the Hook.

Spring 2009-Fall 2009



Fall 2009-Spring 2010

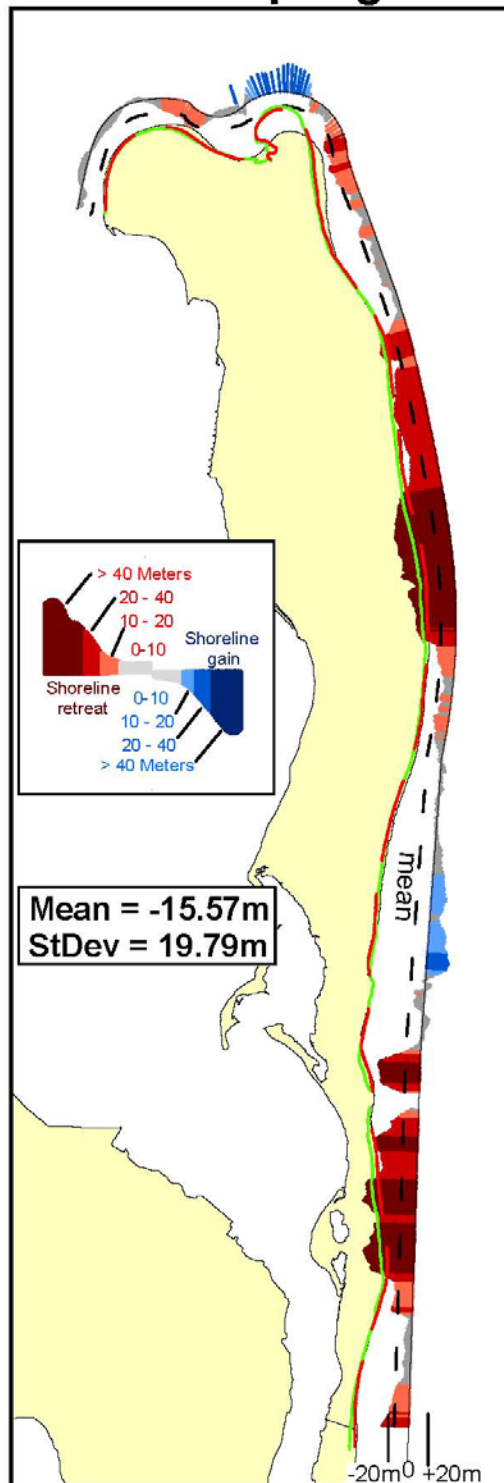


Figure 4. Net shoreline change at Sandy Hook Unit, Gateway National Recreation Area for the period Spring 2009 – Fall 2009 (left panel) and Fall 2009 – Spring 2010 (right panel), incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/- 1.0 standard deviation, all values in meters.

Spring 2009 - Spring 2010

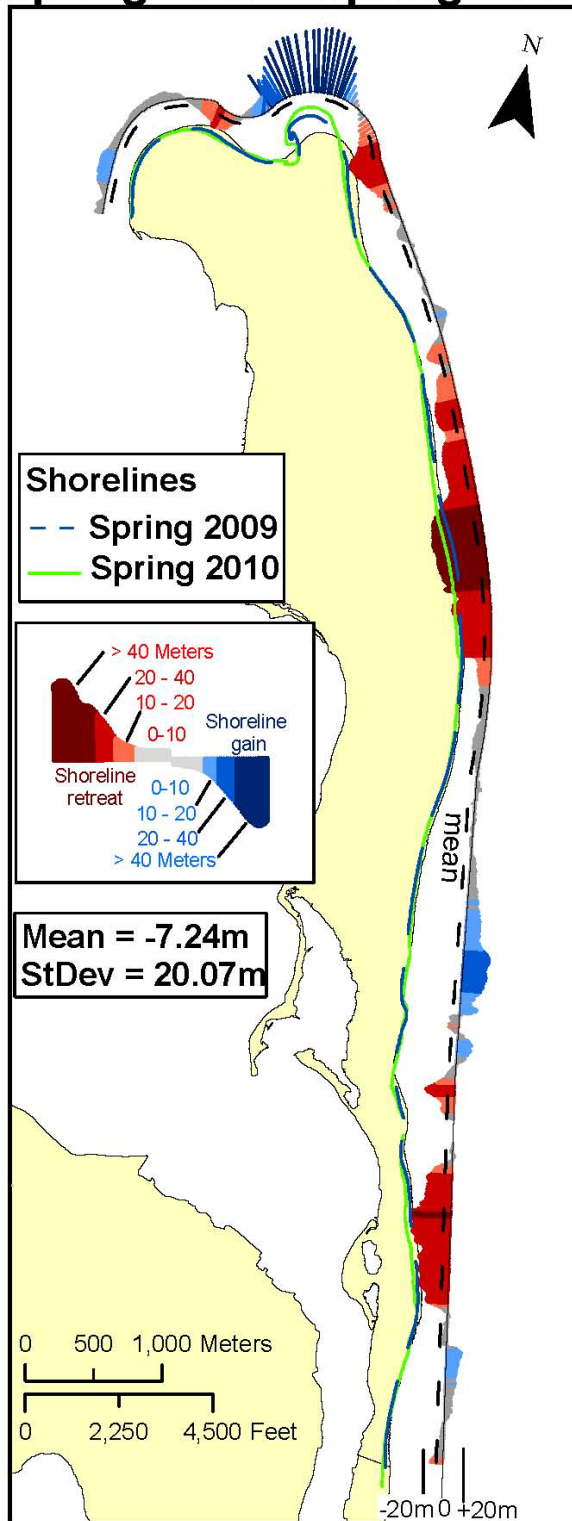


Figure 5. Net shoreline change at the Sandy Hook Unit, Gateway National Recreation Area for the period Spring 2009 – Spring 2010, incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/- 1.0 standard deviation (all values in meters).

Great Kills Park

The three seasonal surveys were conducted on March 31, 2009, September 30, 2009, and April 7, 2009. The shoreline change data indicate that erosion occurred along most of the shoreline during the first interval, with an average inland displacement of -2.75 m (Fig. 6, top panel). The Fall 2009 – Spring 2010 displacement had slight seaward shift of 0.68 m (Fig. 6, bottom panel). The net change during the year was an average inland displacement of slightly over 2 m (Fig. 7).

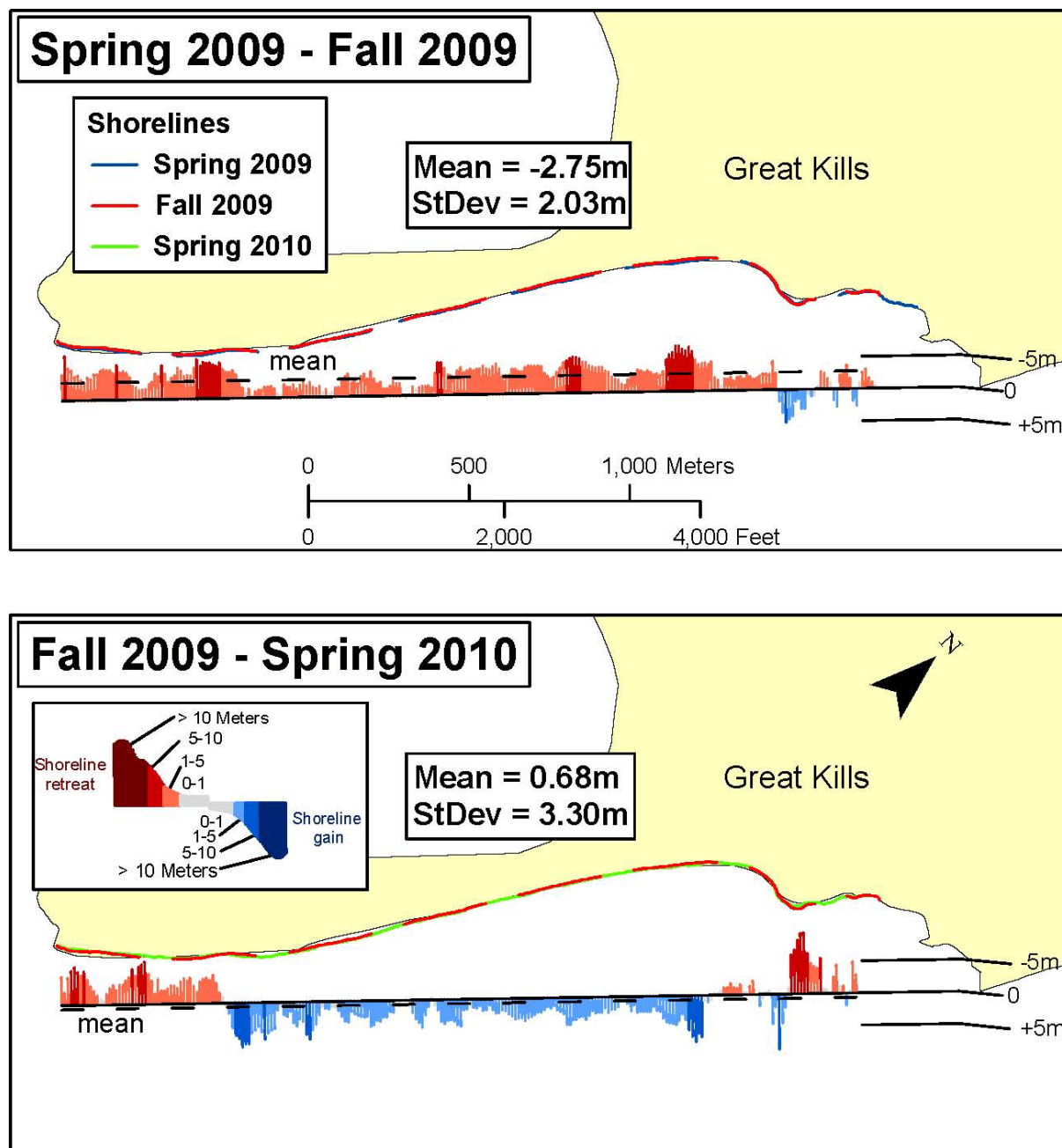


Figure 6. Net shoreline change at Great Kills Park, Staten Island Unit, Gateway National Recreation Area for the period Spring 2009 – Fall 2009 (top panel), Fall 2009 – Spring 2010 (bottom panel), incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/- 1.0 standard deviation (all values in meters).

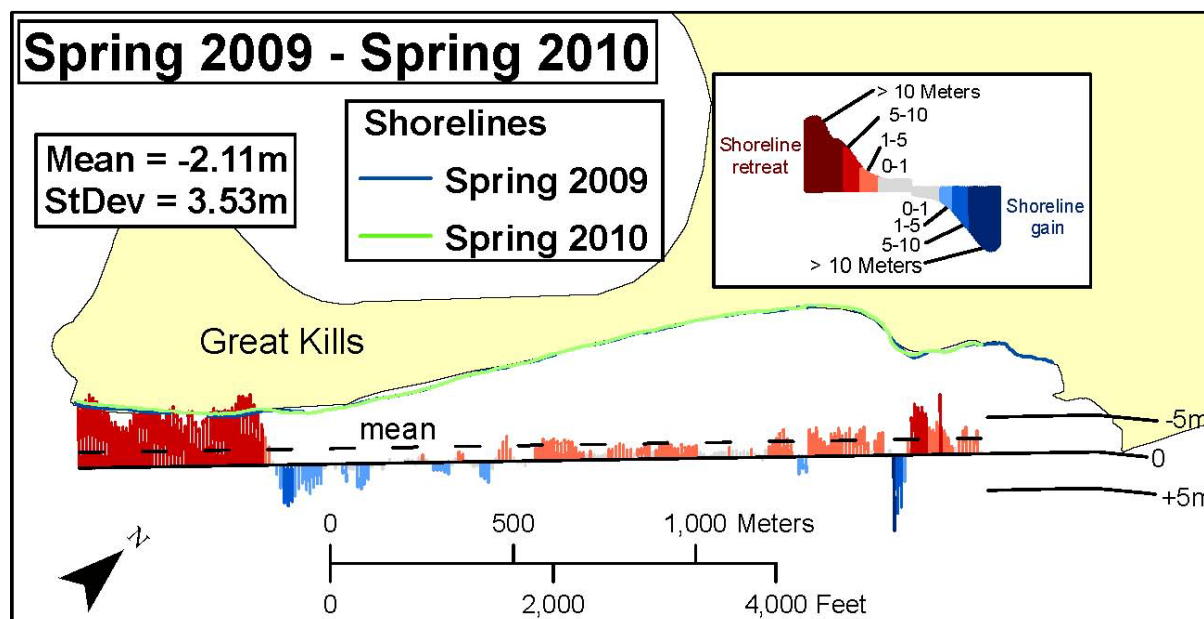


Figure 7. Net annual shoreline change at Great Kills Park, Staten Island Unit, Gateway National Recreation Area for the period Spring 2009 --- Spring 2010 incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/-1.0 standard deviation (all values in meters).

Great Kills Bay

This is the first annual report that identifies shoreline change downdrift of the jetty at Crooke's Point (Figs. 8-9). This location has been accumulating sediment that drifts beyond the jetty. It is creating a point that projects toward the dredged boat channel and it is also creating a shoal at the entrance to Great Kills Marina.

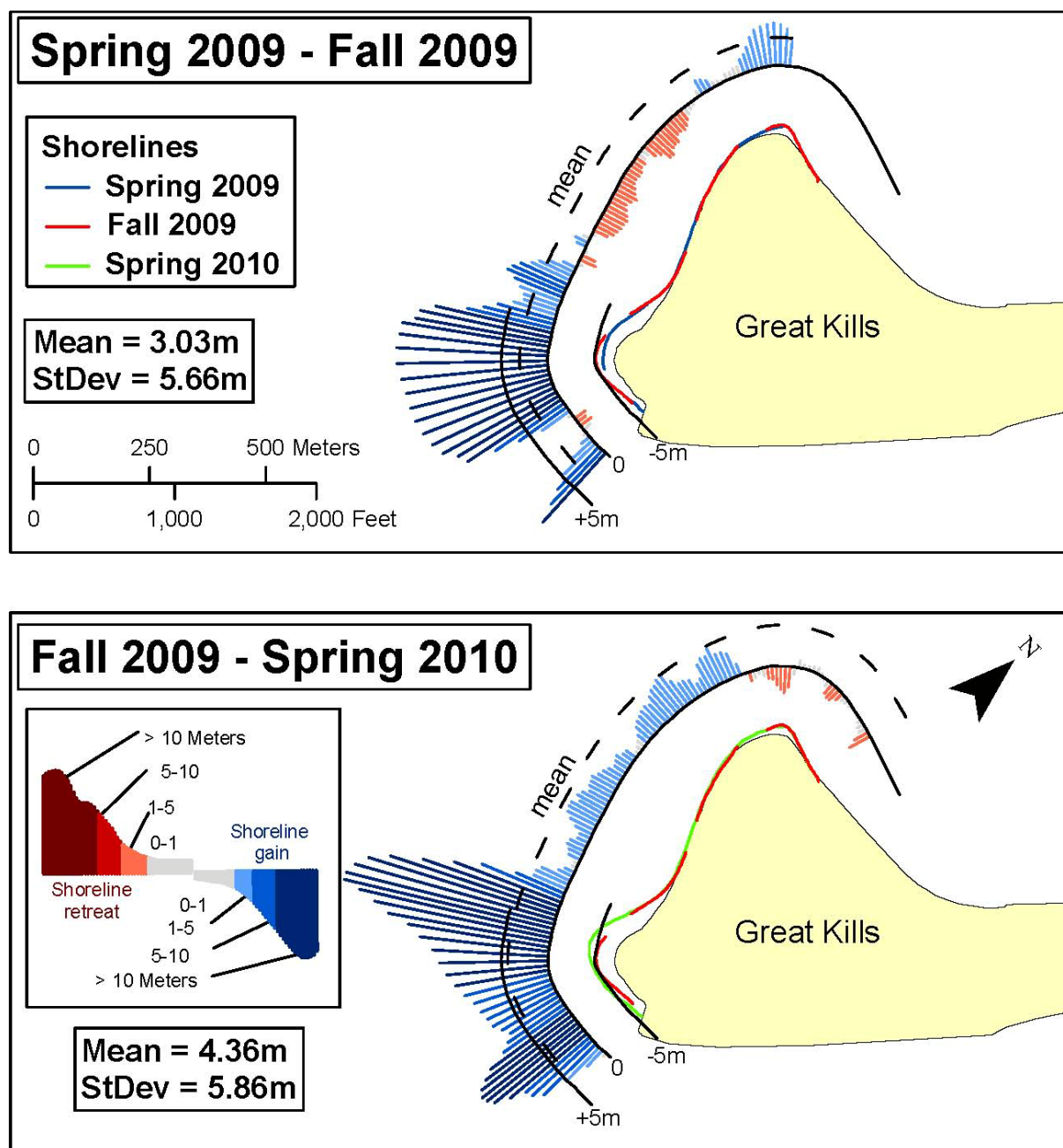


Figure 8. Net shoreline change at Bayside, Great Kills Park, Staten Island Unit, Gateway National Recreation Area for the period Spring 2009 – Fall 2009 (top panel), Fall 2009 – Spring 2010 (bottom panel), incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/- 1.0 standard deviation (all values in meters).

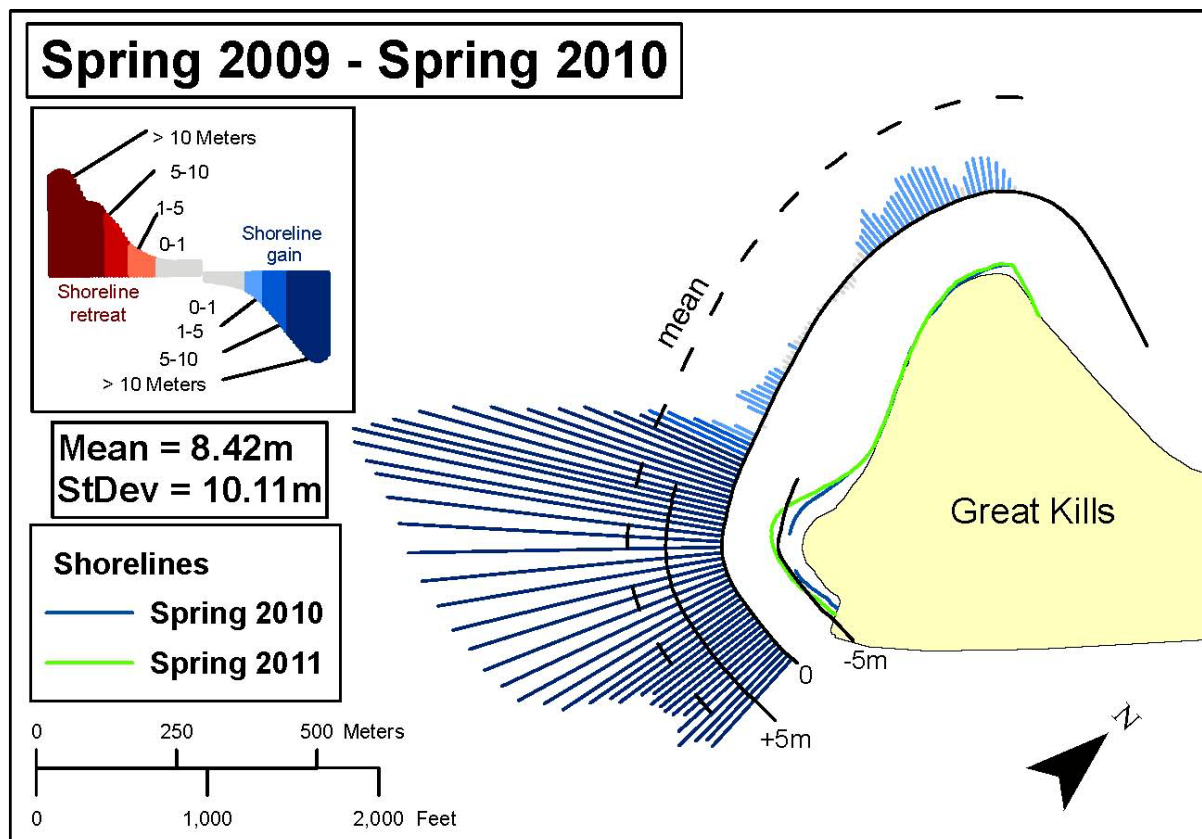
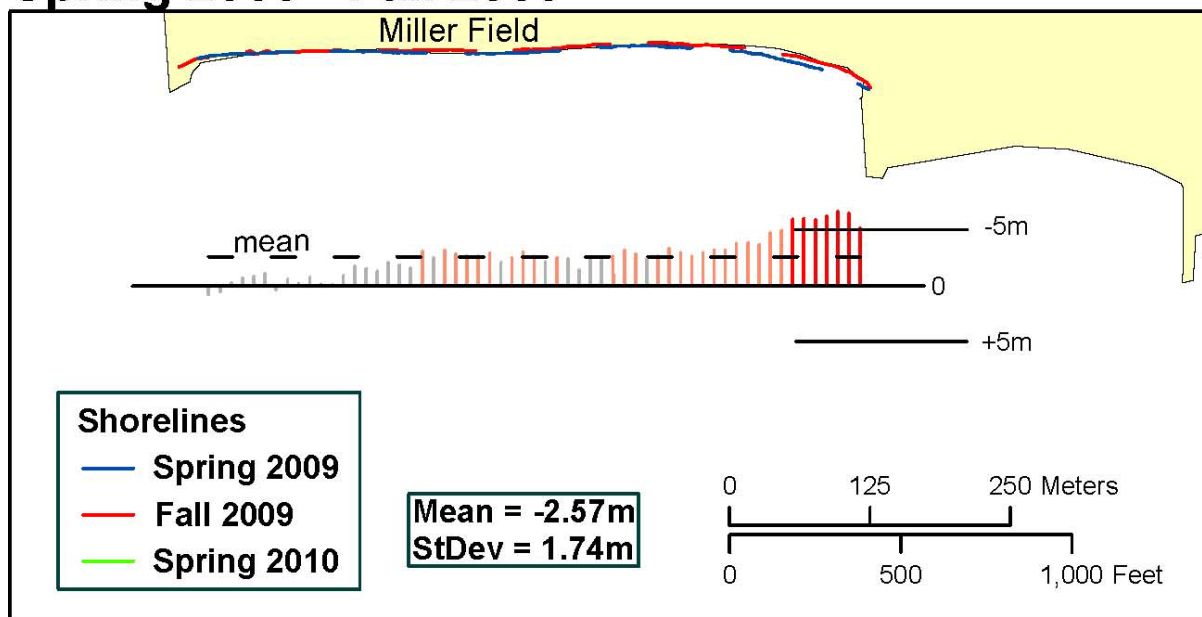


Figure 9. Net annual shoreline change at Bayside, Great Kills Park, Staten Island Unit, Gateway National Recreation Area for the period Spring 2009 – Spring 2010 incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/-1.0 standard deviation (all values in meters).

Miller Field

This is the first annual report on shoreline changes at Miller Field (Figs. 10-11). This location is a short beach segment between two groins. It will tend to have an alongshore gradient from one groin to the other.

Spring 2009 - Fall 2009



Fall 2009 - Spring 2010

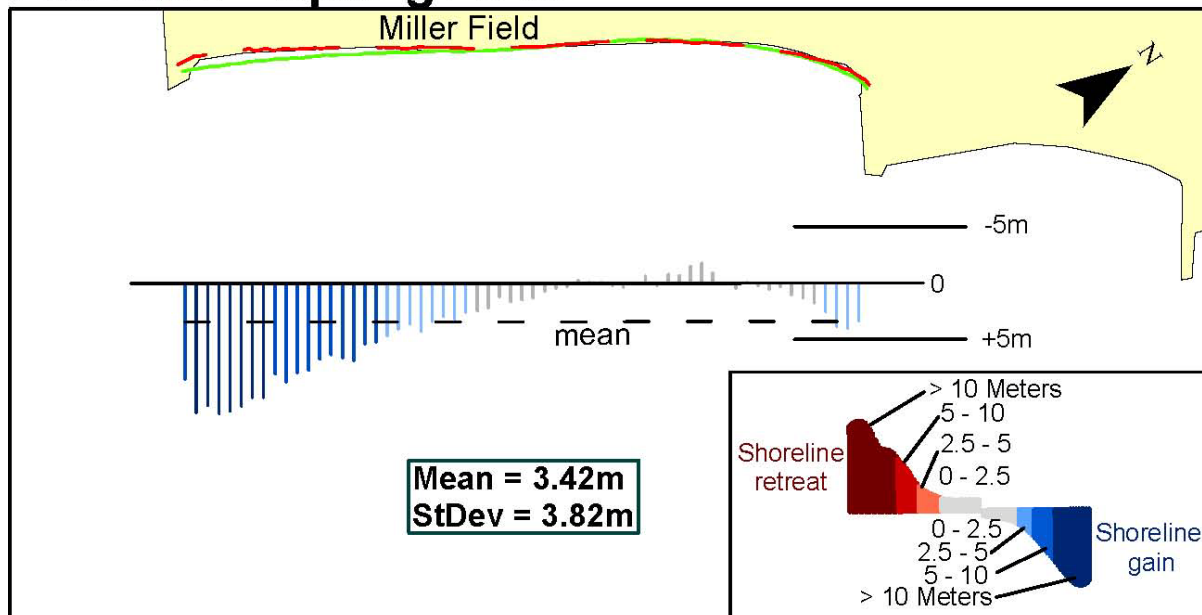


Figure 10. Net shoreline change at Miller Field, Staten Island Unit, Gateway National Recreation Area for the period Spring 2009 – Fall 2009 (top panel), Fall 2009 - Spring 2010 (bottom panel), incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/- 1.0 standard deviation (all values in meters).

Spring 2009 - Spring 2010

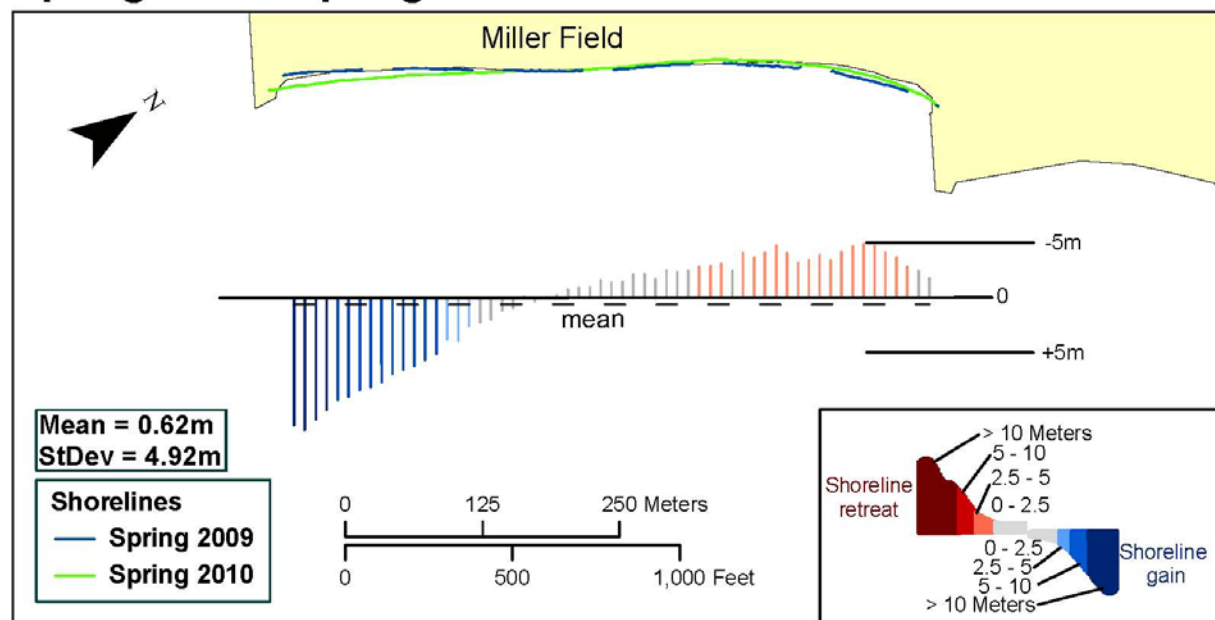
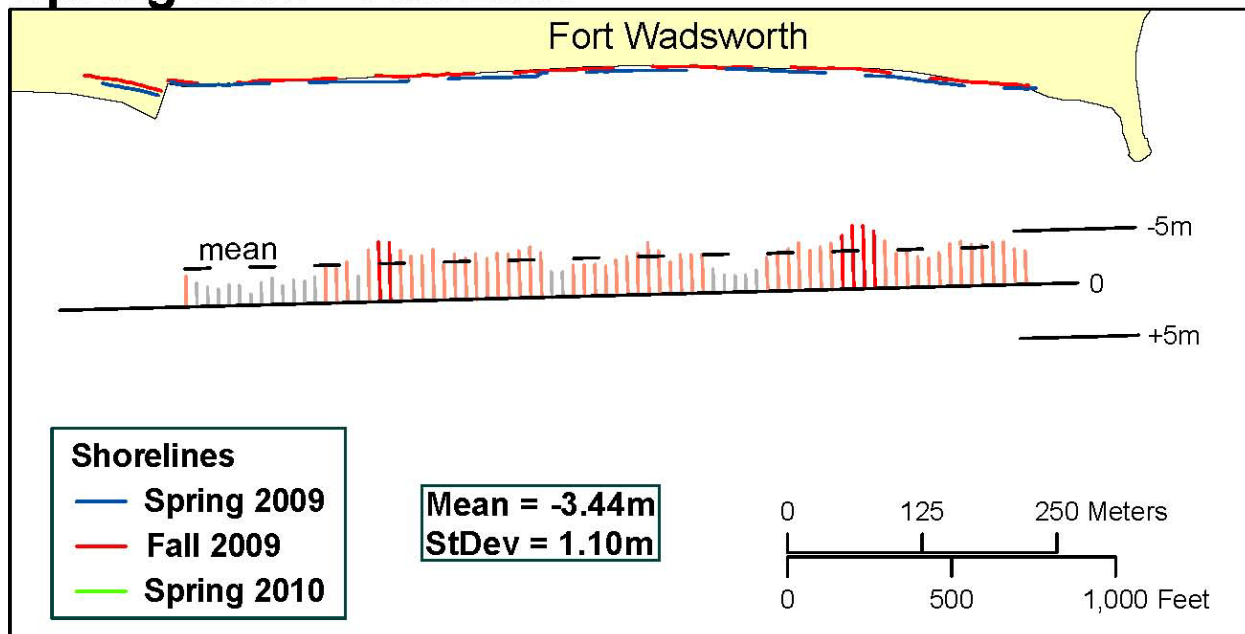


Figure 11. Net annual shoreline change at Miller Field, Staten Island Unit, Gateway National Recreation Area for the period Spring 2009 – Spring 2010 incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/-1.0 standard deviation (all values in meters).

Fort Wadsworth

This is the first annual report that includes information for the Fort Wadsworth shoreline (Figs. 12-13). This segment extends from a groin at the western margin to the rock revetment at the eastern end.

Spring 2009 - Fall 2009



Fall 2009 - Spring 2010

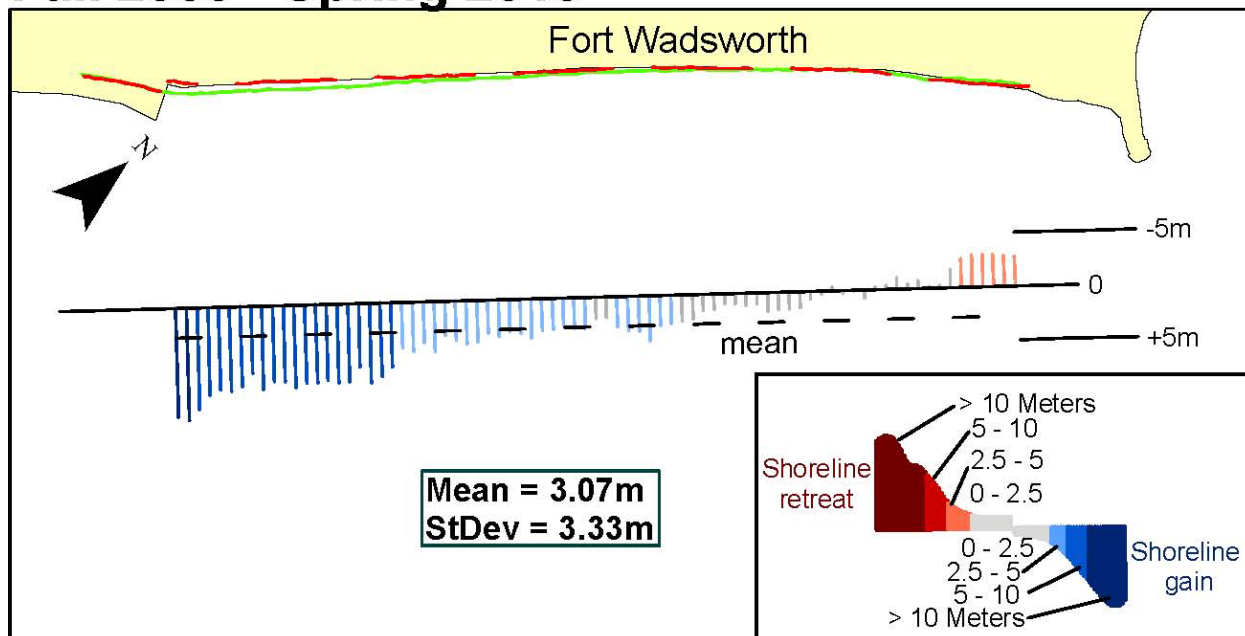


Figure 12. Net shoreline change at Fort Wadsworth, Staten Island Unit, Gateway National Recreation Area for the period Spring 2009 – Fall 2009 (top panel), Fall 2009 – Spring 2010 (bottom panel), incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/- 1.0 standard deviation (all values in meters).

Spring 2009 - Spring 2010

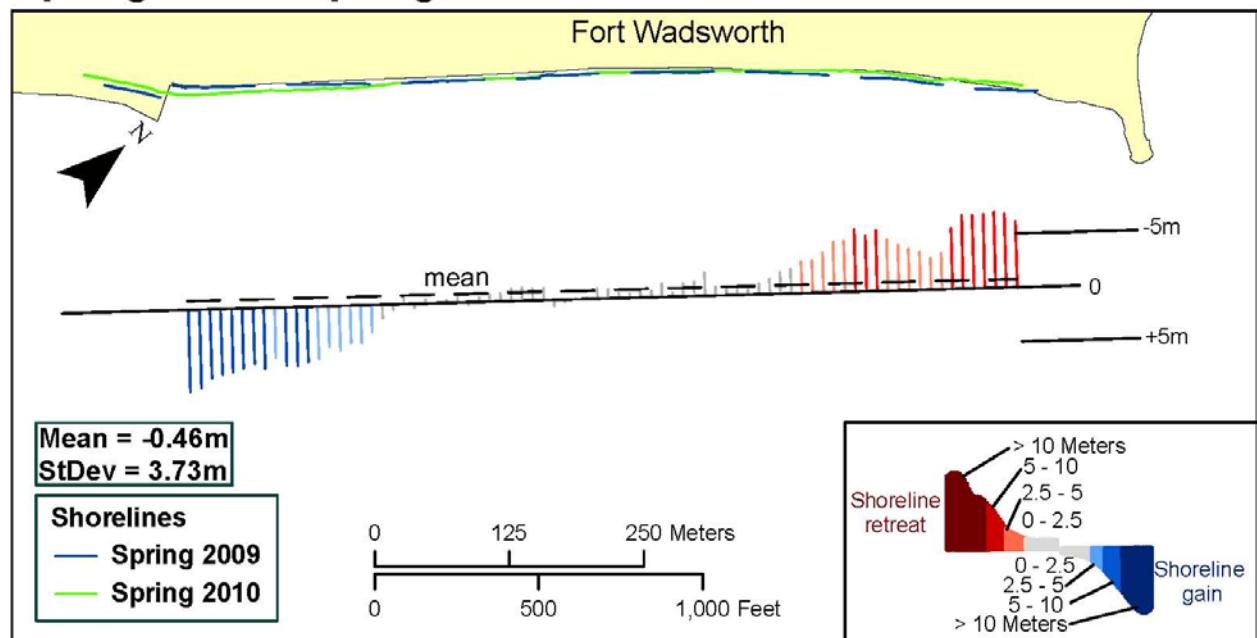
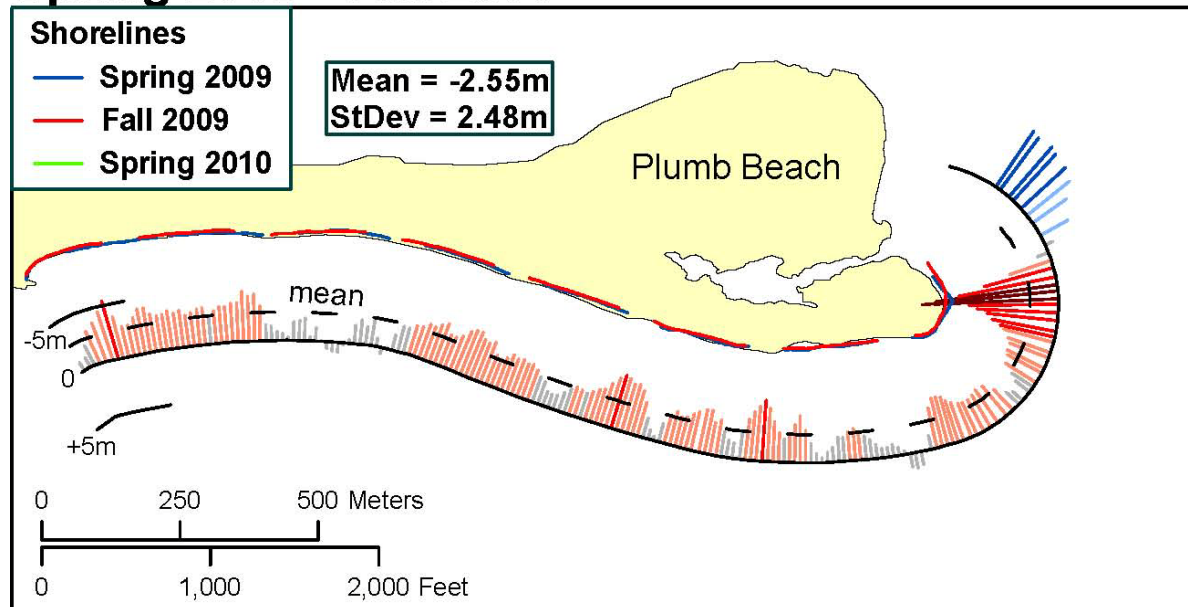


Figure 13. Net annual shoreline change at Fort Wadsworth, Staten Island Unit, Gateway National Recreation Area for the period Spring 2009 – Spring 2010 incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/-1.0 standard deviation (all values in meters).

Plumb Beach

The three seasonal surveys were conducted on March 31, 2009, September 30, 2009, and April 7, 2010. There was severe erosion and displacement of the entire shoreline in the spring period, (Fig 14, top panel), with shoreline recovery at the eastern and western ends because of displaced sediment in the latter period (Fig. 14, bottom panel). The net condition was inland displacement in the central portion of Plumb Beach and some accumulation toward the east (Fig. 15).

Spring 2009 - Fall 2009



Fall 2009 - Spring 2010

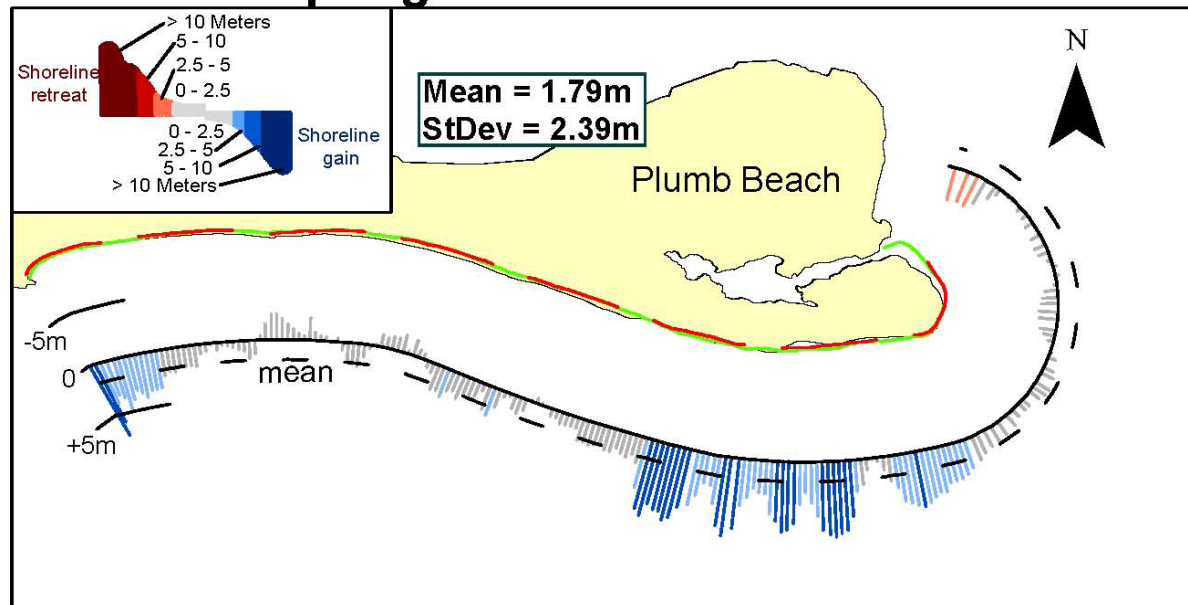


Figure 14. Net shoreline change at Plumb Beach, Jamaica Bay Unit, Gateway National Recreation Area for the period Spring 2009 – Fall 2009 (top panel), Fall 2009 – Spring 2010 (bottom panel), incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/- 1.0 standard deviation (all values in meters).

Spring 2009 - Spring 2010

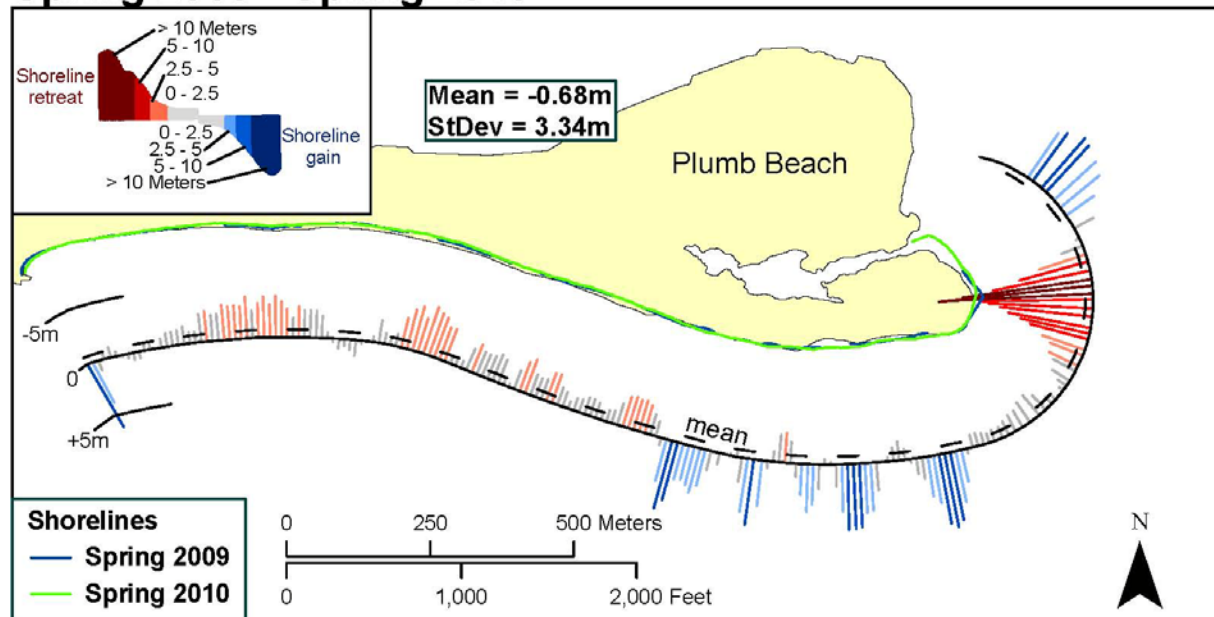


Figure 15. Net annual shoreline change at Plumb Beach, Jamaica Bay Unit, Gateway National Recreation Area for the period Spring 2009 – Spring 2010 incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/-1.0 standard deviation (all values in meters).

Breezy Point

The three seasonal surveys were conducted on March 31, 2009, September 30, 2009, and April 9, 2010. The shoreline change data indicate minimal change along most of the shoreline during the Spring 2009 – Fall 2009 interval (Fig. 16, top panel). The Fall 2009 – Spring 2010 displacement was considerable erosion along the western half of the area (Fig. 16, bottom panel), averaging -17.54 m. The net change during the year (Fig. 17) was an average seaward displacement of -17.91 m.

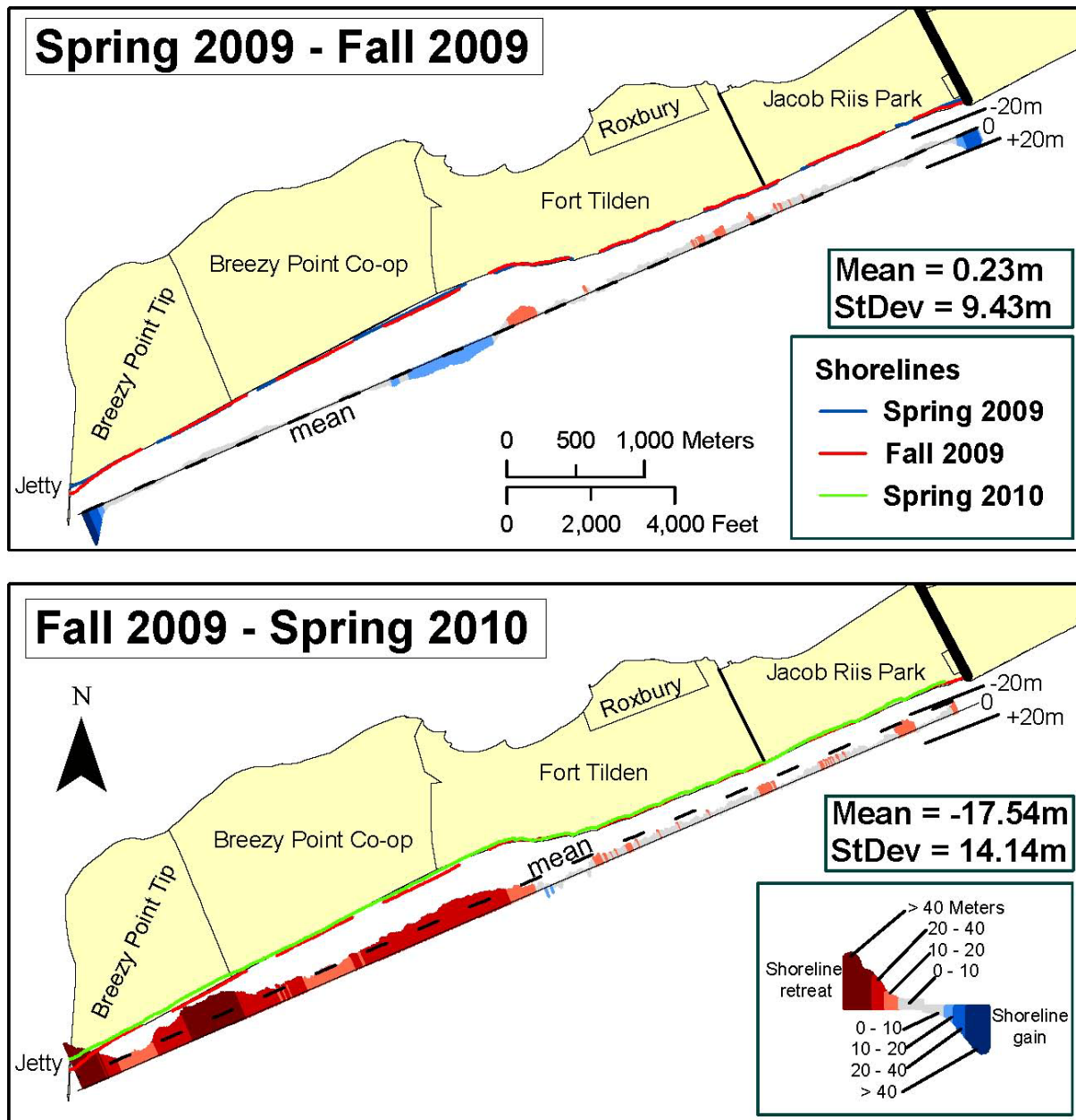


Figure 16. Net shoreline change at Breezy Point, Jamaica Bay Unit, Gateway National Recreation Area for the period Spring 2009 – Fall 2009 (top panel) and Fall 2009 – Spring 2010 (bottom panel), incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/- 1.0 standard deviation (all values in meters).

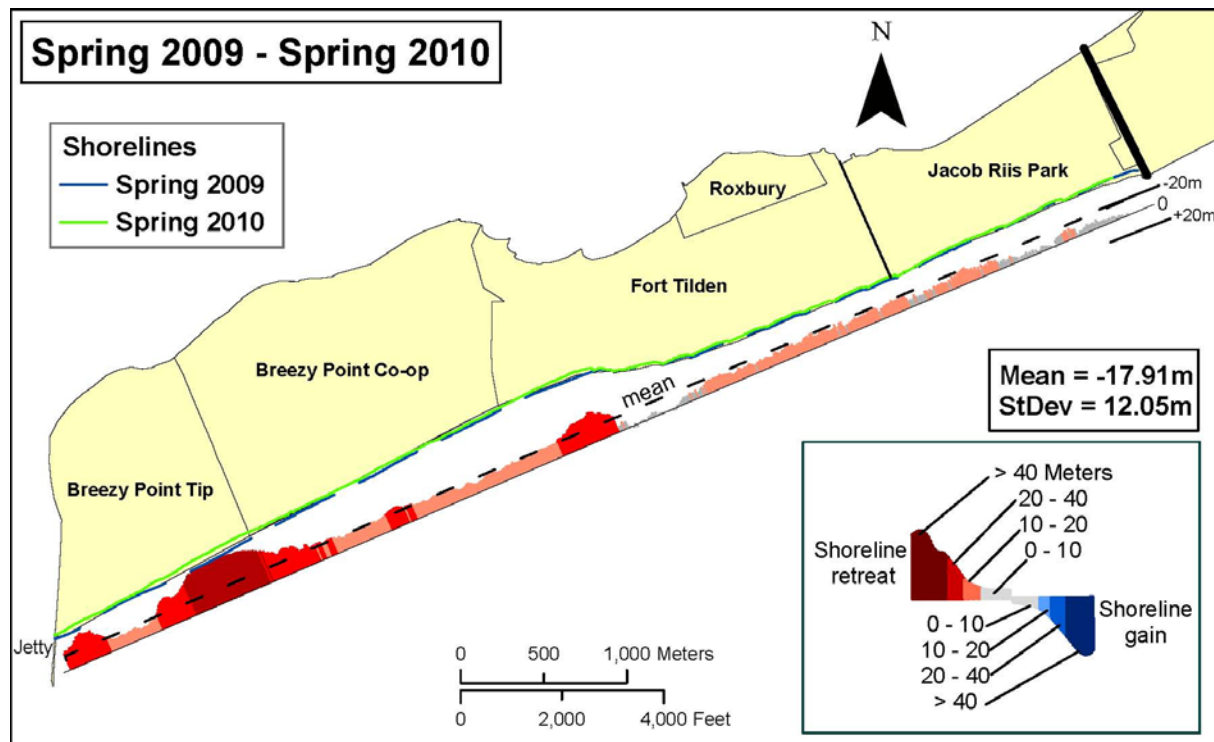


Figure 17. Net shoreline change at Breezy Point, Jamaica Bay Unit, Gateway National Recreation Area for the period Spring 2009 – Spring 2010, incorporating surveyed shoreline positions, dimensions of shoreline change, mean change, mean change line, and +/- 1.0 standard deviation (all values in meters).

Spatial Evaluation

The totality of the difference measurements is also subjected to very simple statistical analysis to determine the mean and standard deviation values for the seasonal and annual comparisons. These outcomes are incorporated in Figures 18 – 39. Each of the panels in these figures has a dashed black line depicting the mean difference value, and a text box with the values of the mean change and the 1.0 standard deviation. Thus, through the incorporation of mean and standard deviation values, the spatial portrayal of change is reported relative to all other changes on the segment of Gateway NRA for the same temporal span. It is a means to provide a visual perspective on the magnitude and direction of the change (vectors) on a localized basis.

Summary Statistics and Tables of Change

The outcomes of the difference measurements are represented as histograms of the frequency of changes (Figs. 18 - 39). In the instances of the seasonal comparisons, there is a near normal distribution that depicts a marked central tendency in the assembled measurements and a general decline of frequency of change away from the mean values. Some of the annual comparisons have a bi-modal distribution of the change values because one of the seasonal trends was erosional whereas the other was depositional. Further, each of the comparisons is tempered by the uncertainty values that accompany the methodology of defining the shoreline (± 4 -5.5 m). The uncertainty is low, but it exists and it is necessary to view all changes in the context of the accuracy of the defined shoreline position. However, this is one year and it is not prudent to ascribe longer-term changes and interpretations based on this limited data set. In general, the unimodal seasonal distributions have a smaller standard deviation value than the bimodal annual comparisons.

Sandy Hook

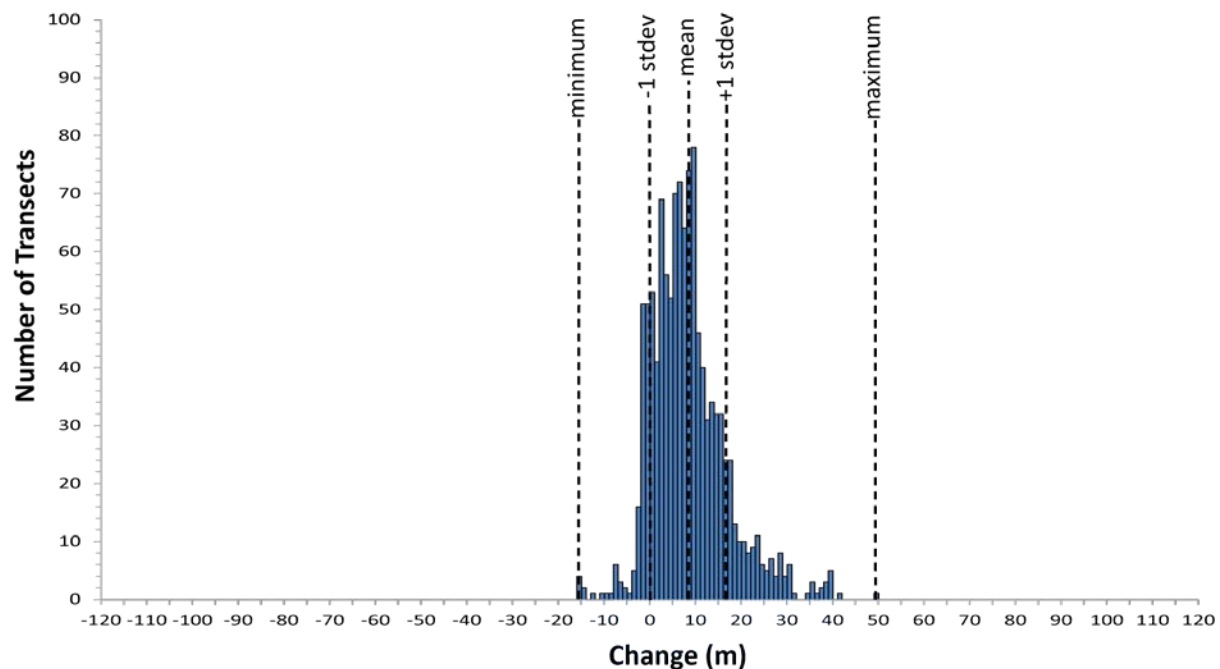


Figure 18. of difference measurements at Sandy Hook Unit, Gateway National Recreation Area, for the seasonal shoreline change between Spring 2009 and Fall 2009, incorporating the mean change value (8.33 m), standard deviation (8.25 m), maximum, and minimum values.

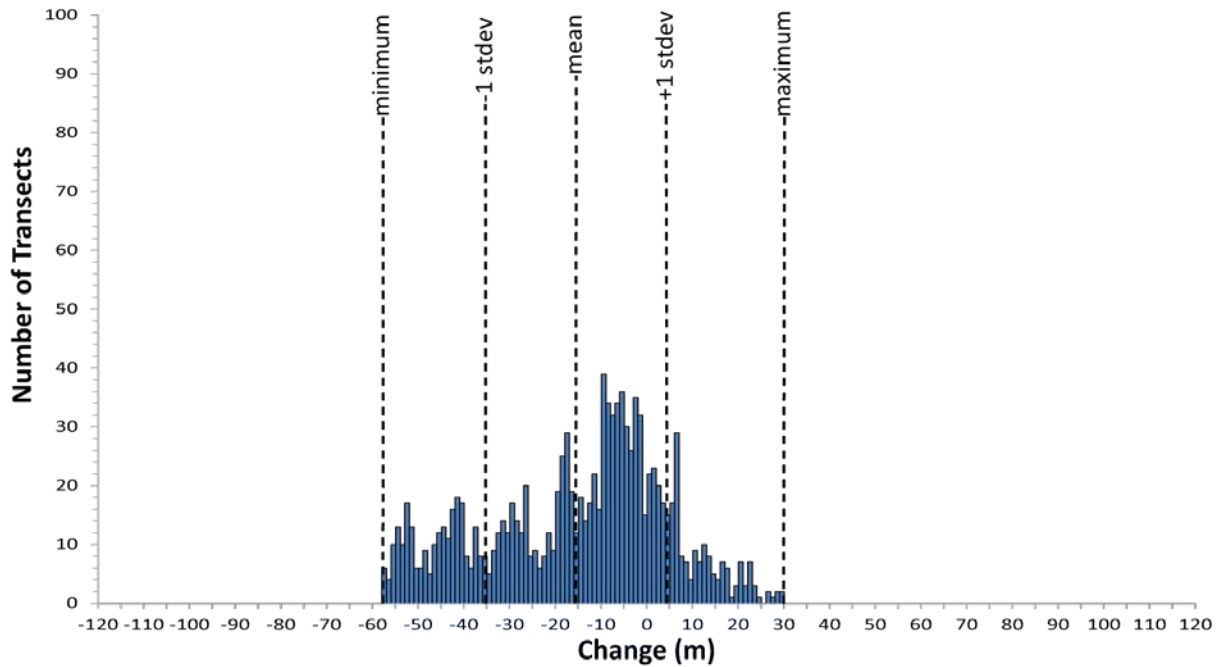


Figure 19. Distribution of difference measurements at Sandy Hook Unit, Gateway National Recreation Area, for the seasonal shoreline change between Fall 2009 and Spring 2010, incorporating the mean change value (-15.57 m), standard deviation (19.79 m), maximum, and minimum values.

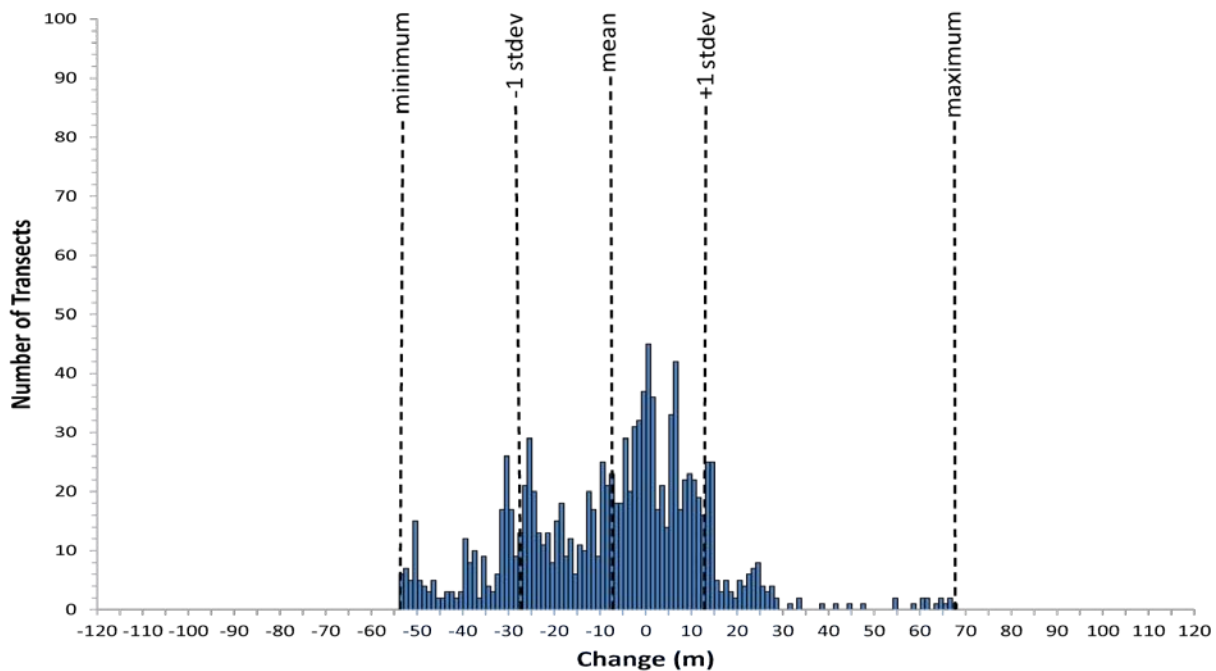


Figure 20. Distribution of difference measurements at Sandy Hook Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Spring 2010, incorporating the mean change value (-7.24 m), standard deviation (20.07 m), maximum, and minimum.

Great Kills Park

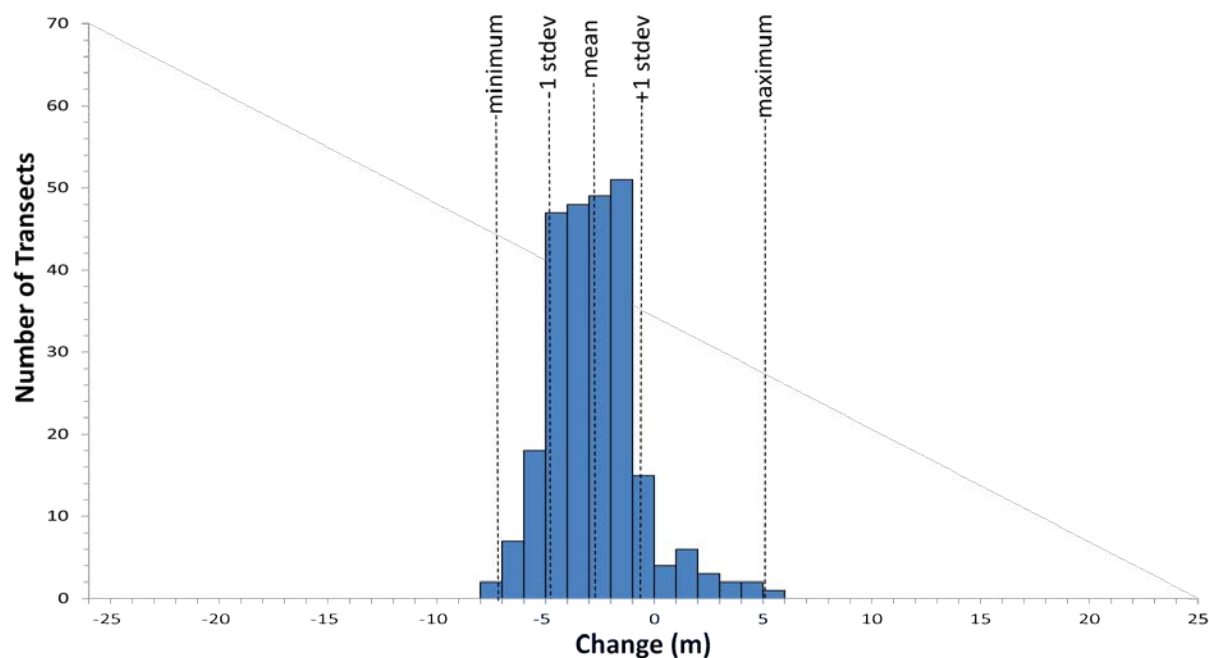


Figure 21. Distribution of difference measurements at Great Kills Park, Staten Island Unit, Gateway National Recreation Area, for the seasonal shoreline change between Spring 2009 and Fall 2010, incorporating the mean change value (-2.75 m), standard deviation (2.03 m), maximum, and minimum.

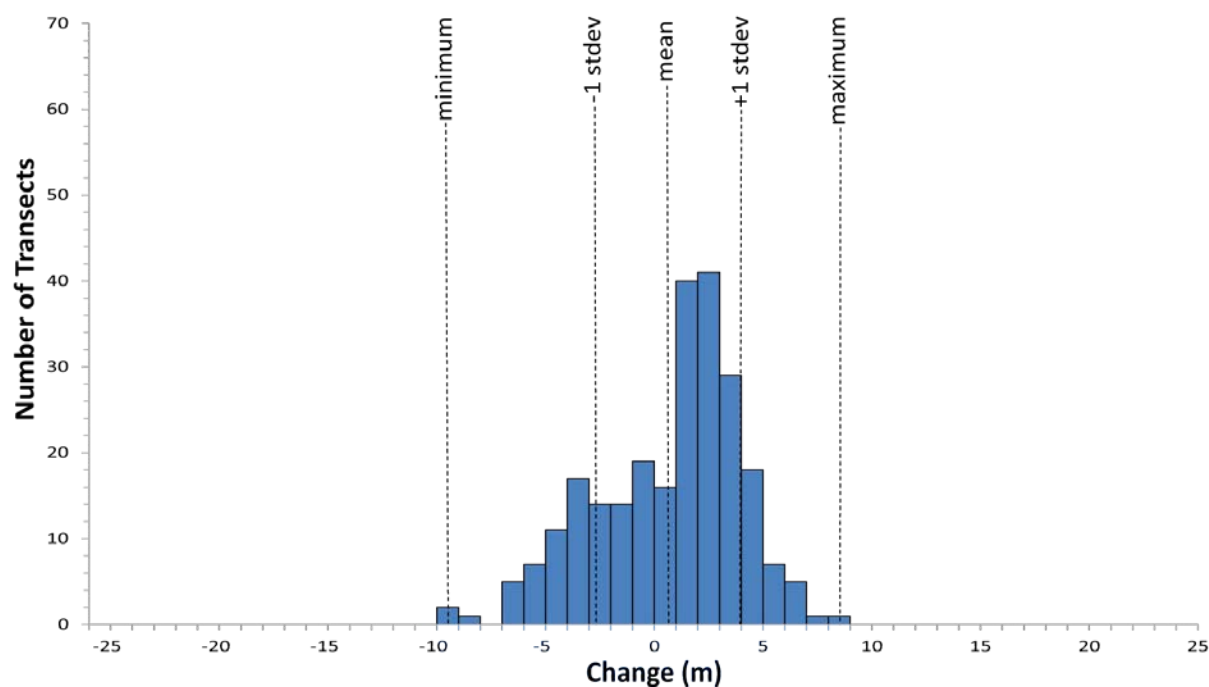


Figure 22. Distribution of difference measurements at Great Kills Park, Staten Island Unit, Gateway National Recreation Area, for the seasonal shoreline change between Fall 2009 and Spring 2010, incorporating the mean change value (0.68 m), standard deviation (3.30 m), maximum, and minimum.

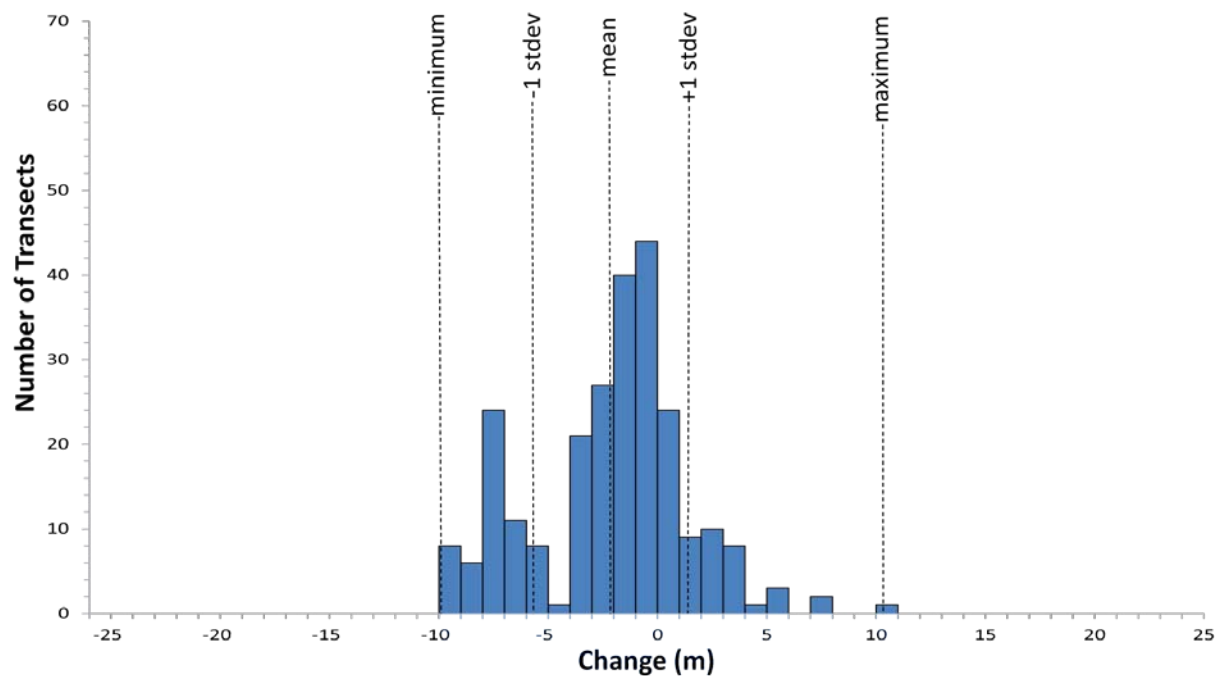


Figure 23. Distribution of difference measurements at Great Kills Park, Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Spring 2010, incorporating the mean change value, (-2.11 m) standard deviation (3.53 m), maximum, and minimum.

Great Kills Bay

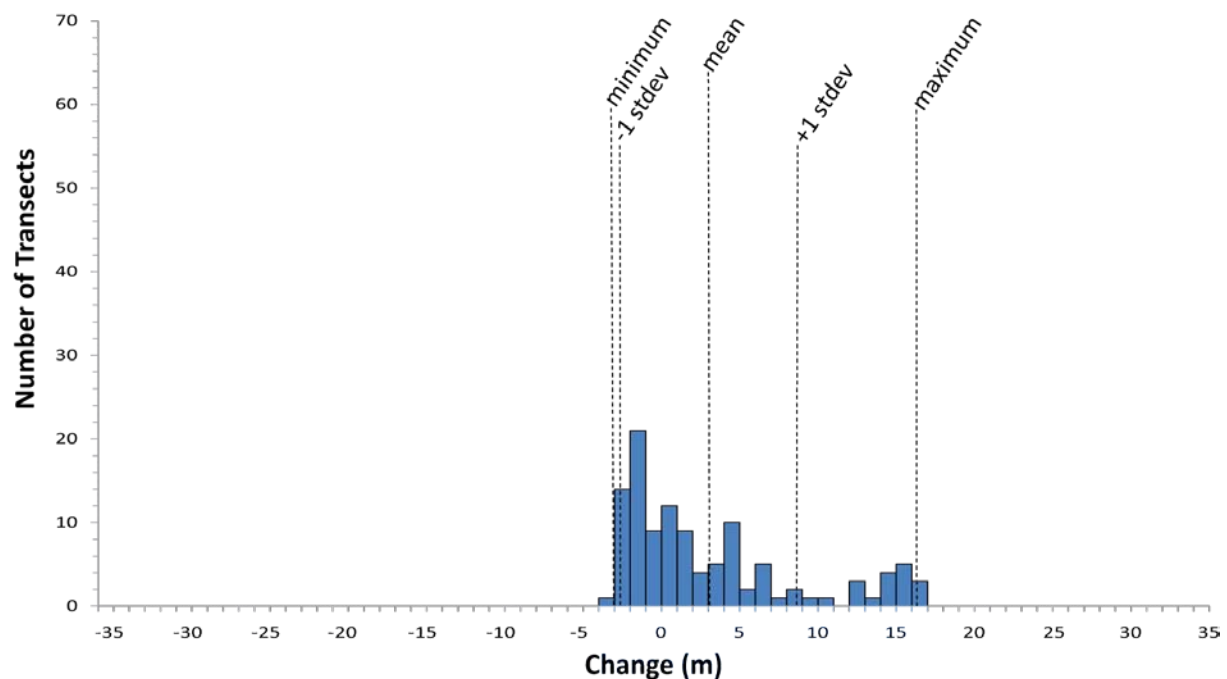


Figure 24. Distribution of difference measurements at Bayside, Great Kills Park, Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Fall 2009, incorporating the mean change value, (3.03 m) standard deviation (5.66 m), maximum, and minimum.

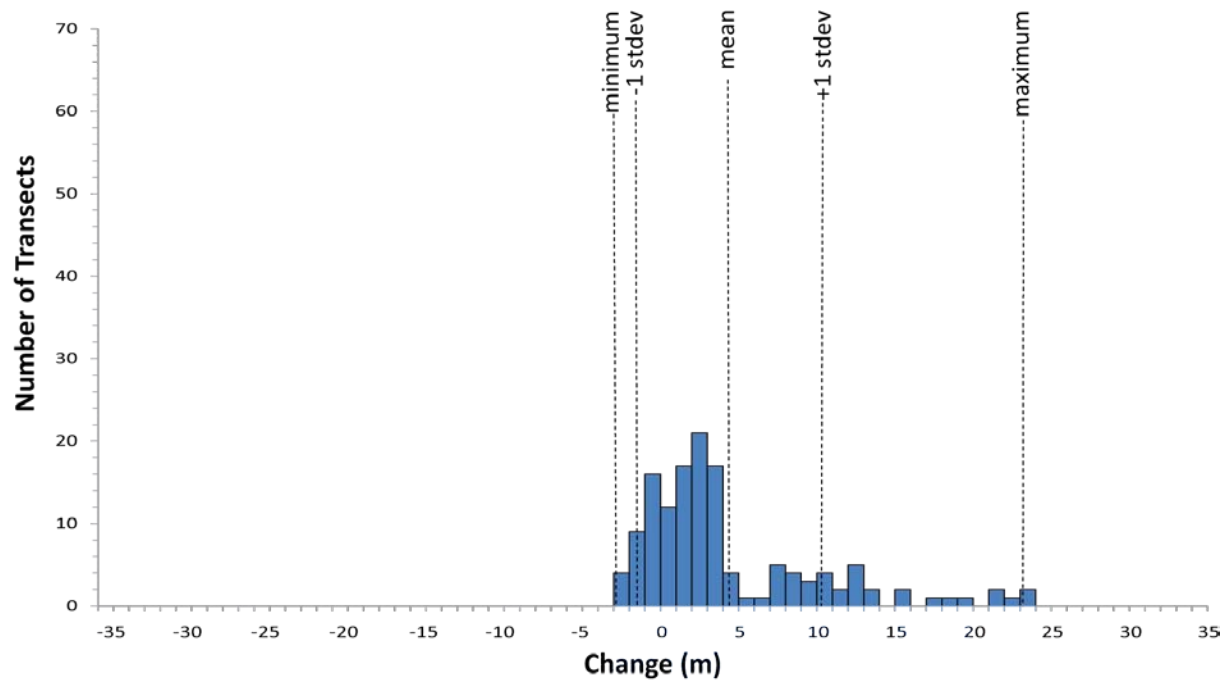


Figure 25. Distribution of difference measurements at Bayside, Great Kills Park, Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Fall 2009 and Spring 2010, incorporating the mean change value, (4.36 m) standard deviation (5.86 m), maximum, and minimum.

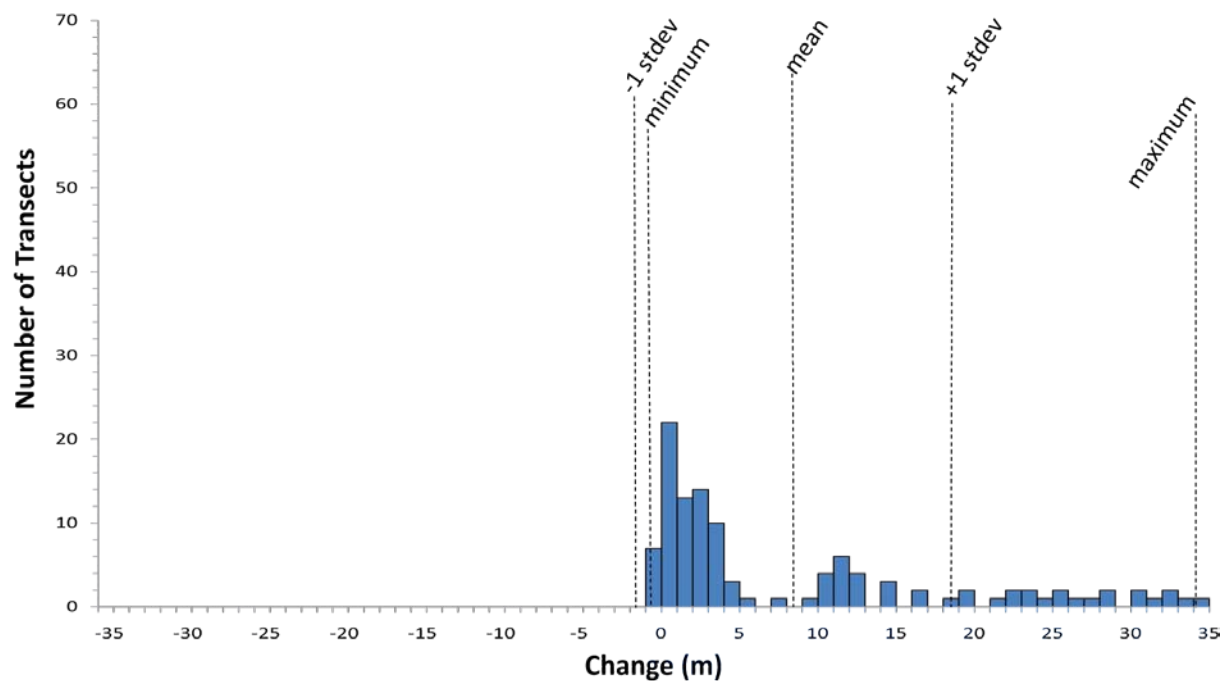


Figure 26. Distribution of difference measurements at Bayside, Great Kills Park, Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Spring 2010, incorporating the mean change value, (8.42 m) standard deviation (10.11 m), maximum, and minimum.

Miller Field

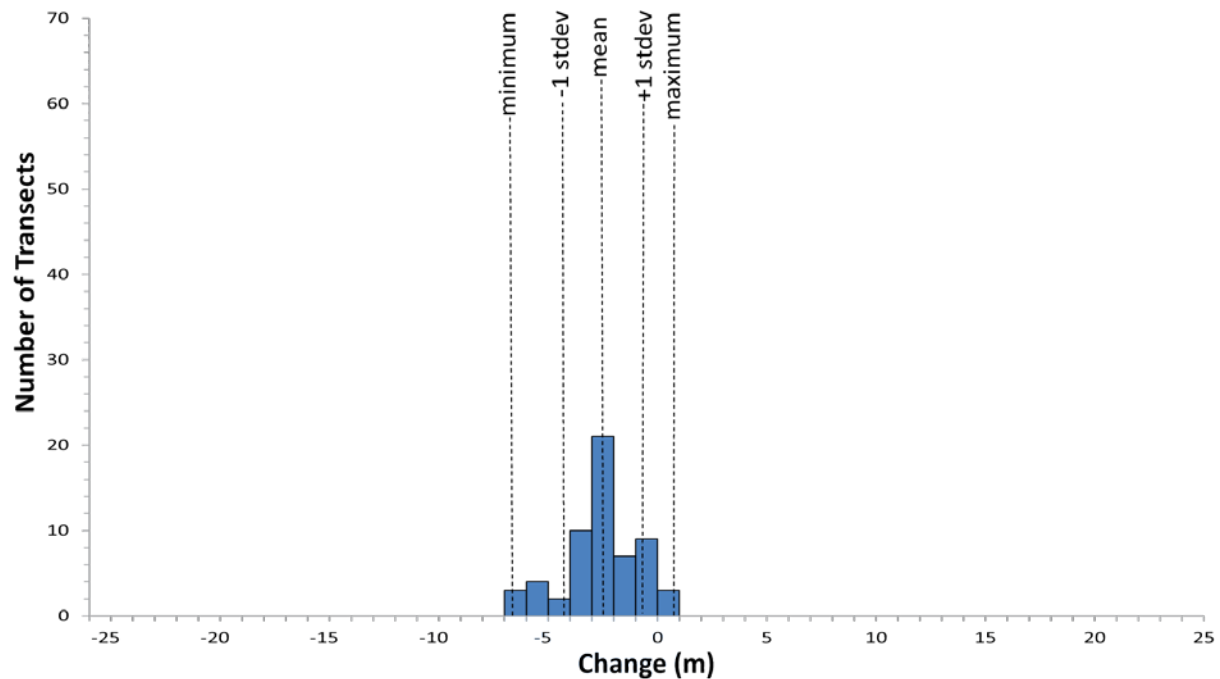


Figure 27. Distribution of difference measurements at Miller Field Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Fall 2009, incorporating the mean change value, (-2.57 m) standard deviation (1.74 m), maximum, and minimum.

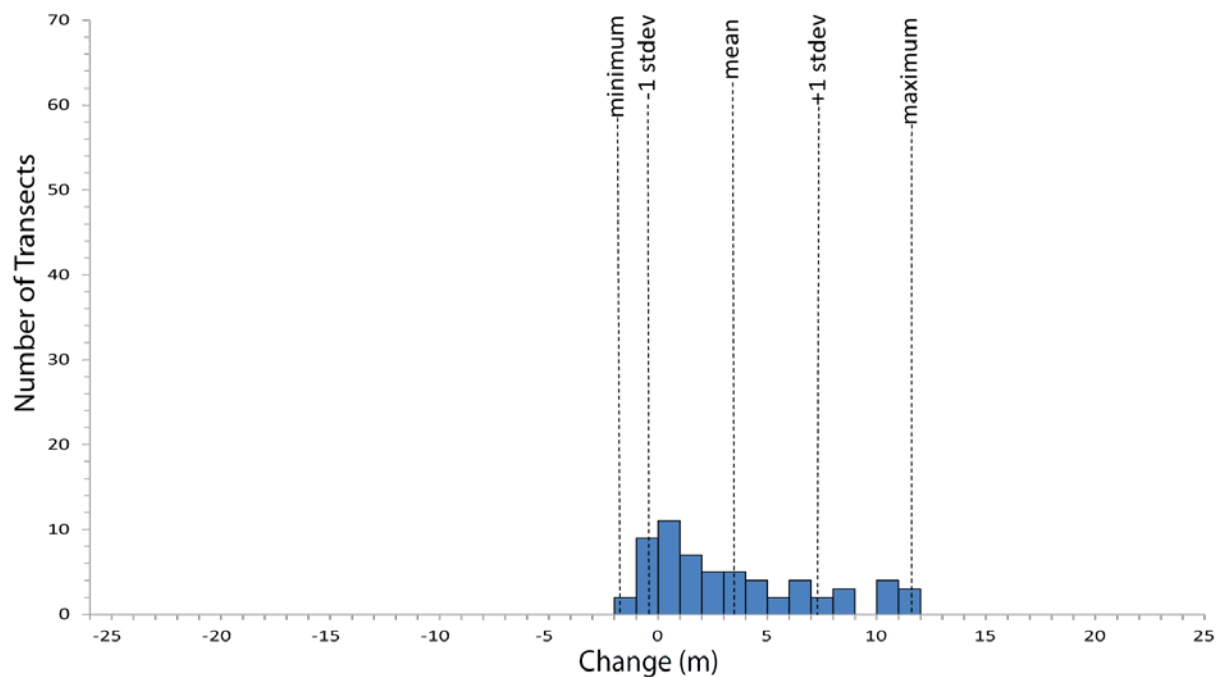


Figure 28. Distribution of difference measurements at Miller Field, Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Fall 2009 and Spring 2010, incorporating the mean change value, (3.42 m) standard deviation (3.82 m), maximum, and minimum.

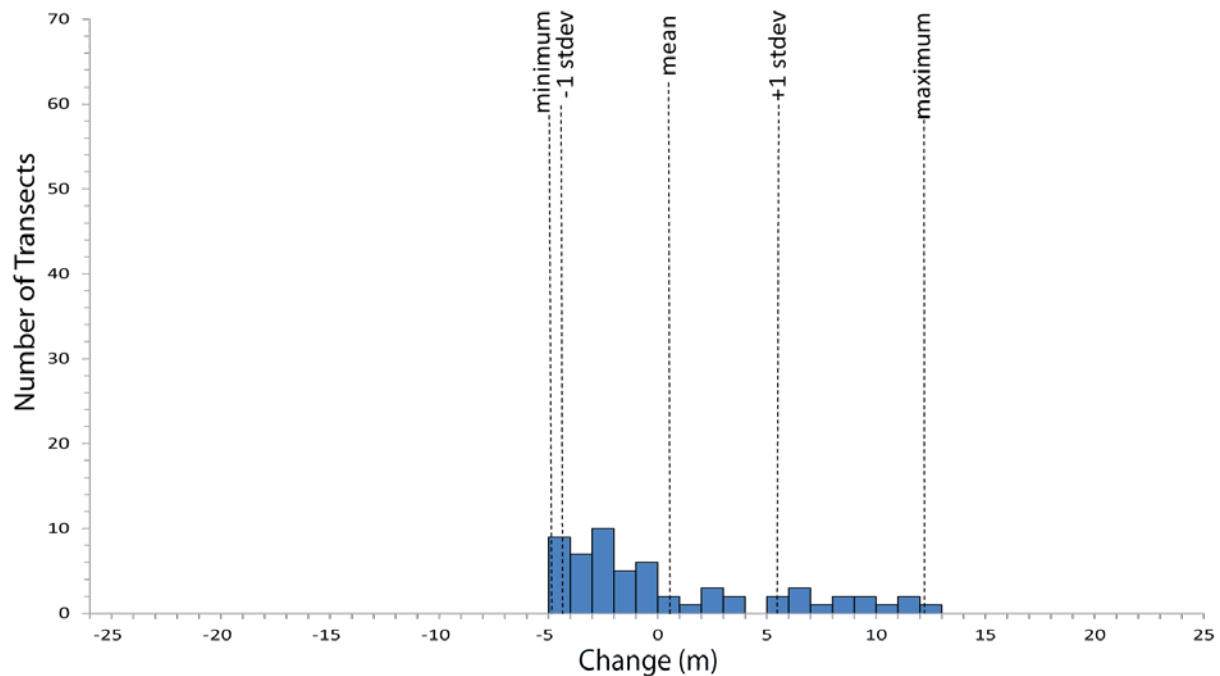


Figure 29. Distribution of difference measurements at Miller Field, Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Spring 2010, incorporating the mean change value, (0.62 m) standard deviation (4.92 m), maximum, and minimum.

Fort Wadsworth

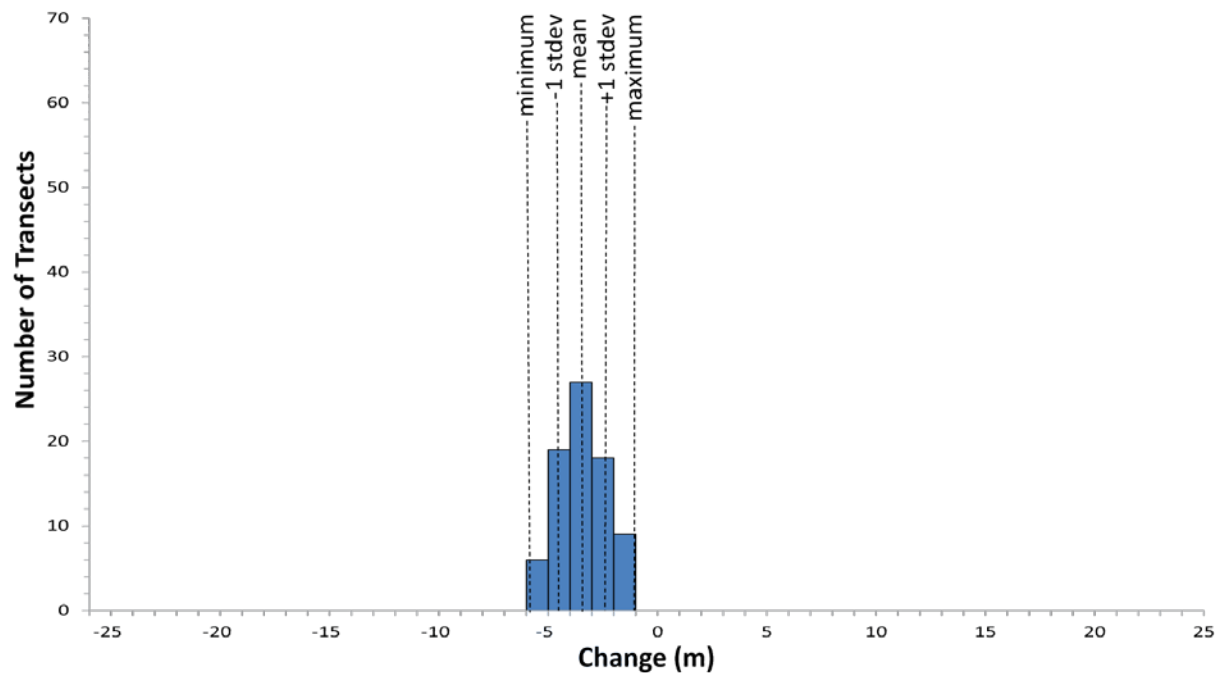


Figure 30. Distribution of difference measurements at Fort Wadsworth, Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Fall 2009, incorporating the mean change value, (-3.44 m) standard deviation (1.10 m), maximum, and minimum.

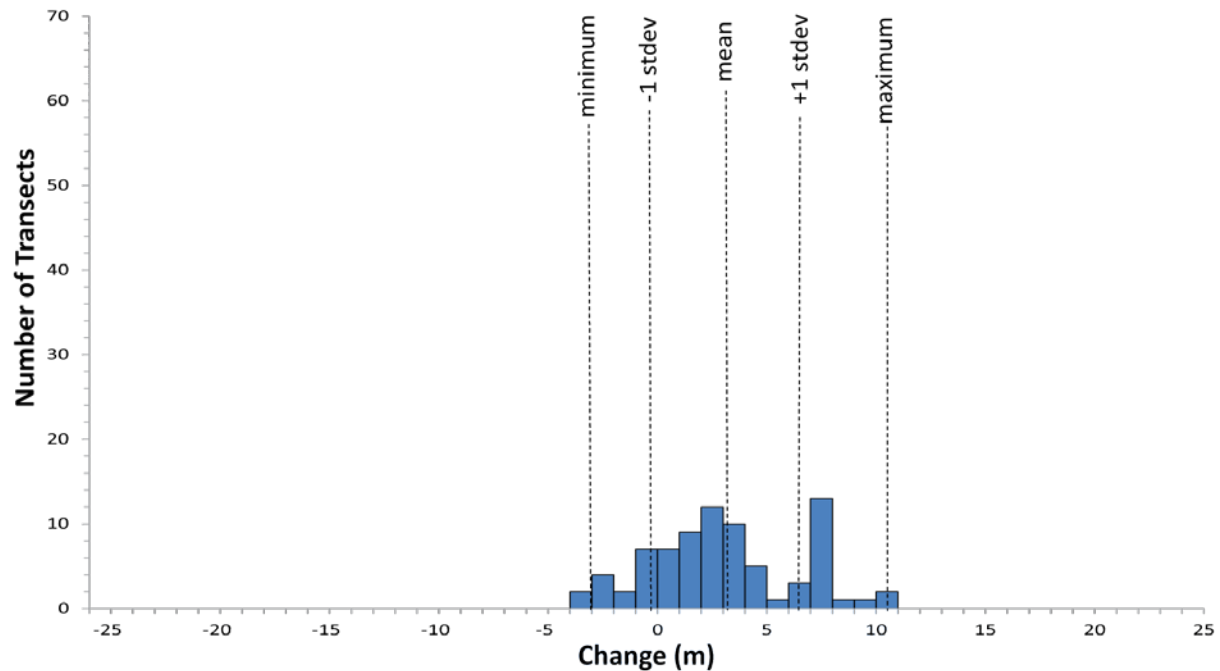


Figure 31. Distribution of difference measurements at Fort Wadsworth, Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Fall 2009 and Spring 2010, incorporating the mean change value, (3.07 m) standard deviation (3.33 m), maximum, and minimum.

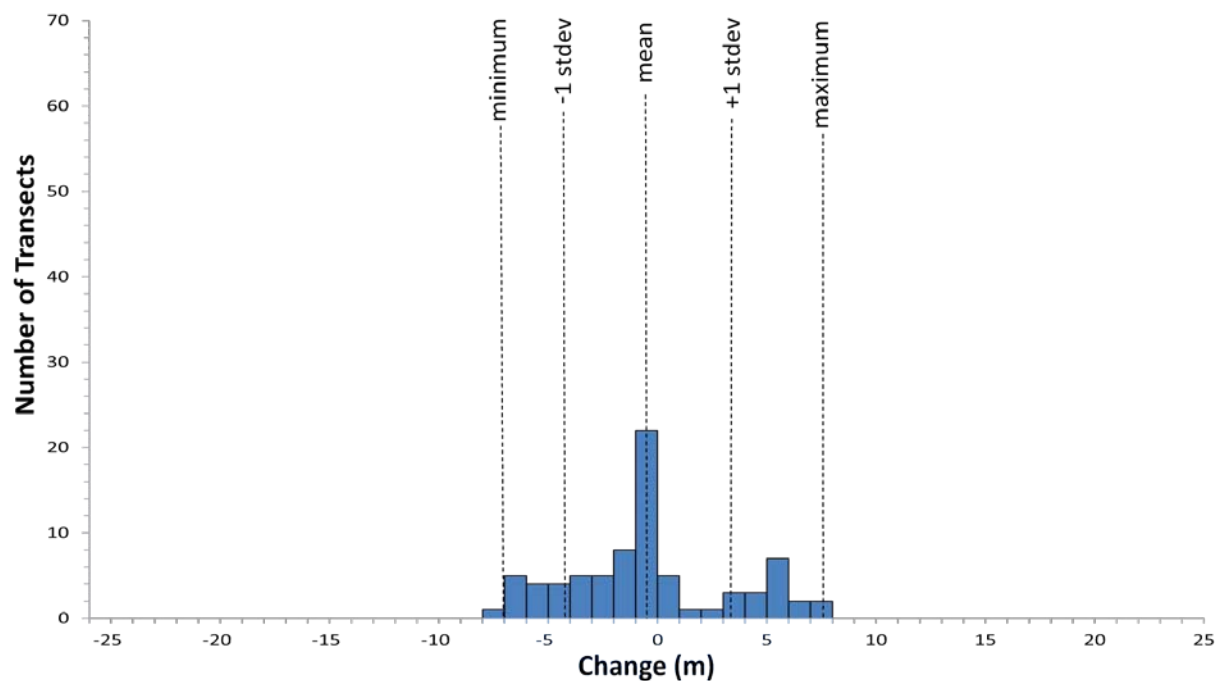


Figure 32. Distribution of difference measurements at Fort Wadsworth, Staten Island Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Spring 2010, incorporating the mean change value, (-0.46 m) standard deviation (3.73 m), maximum, and minimum.

Plumb Beach

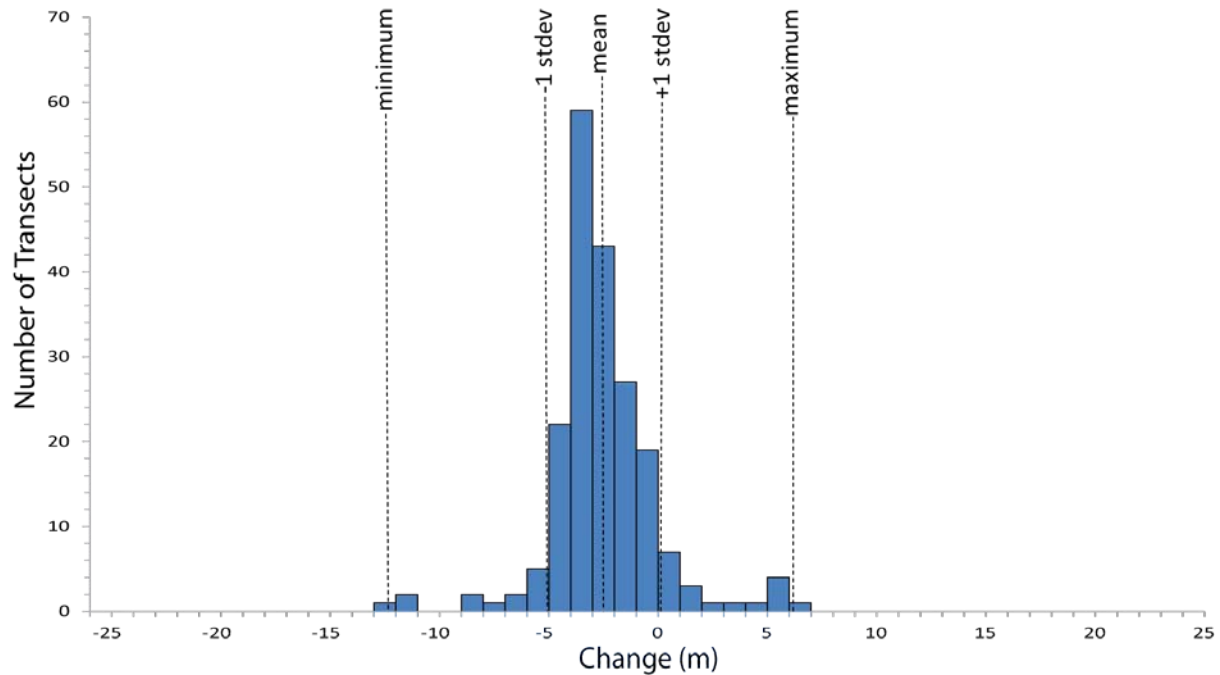


Figure 33. Distribution of difference measurements at Plumb Beach, Jamaica Bay Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Fall 2009, incorporating the mean change value, (-2.55 m) standard deviation (2.48 m), maximum, and minimum.

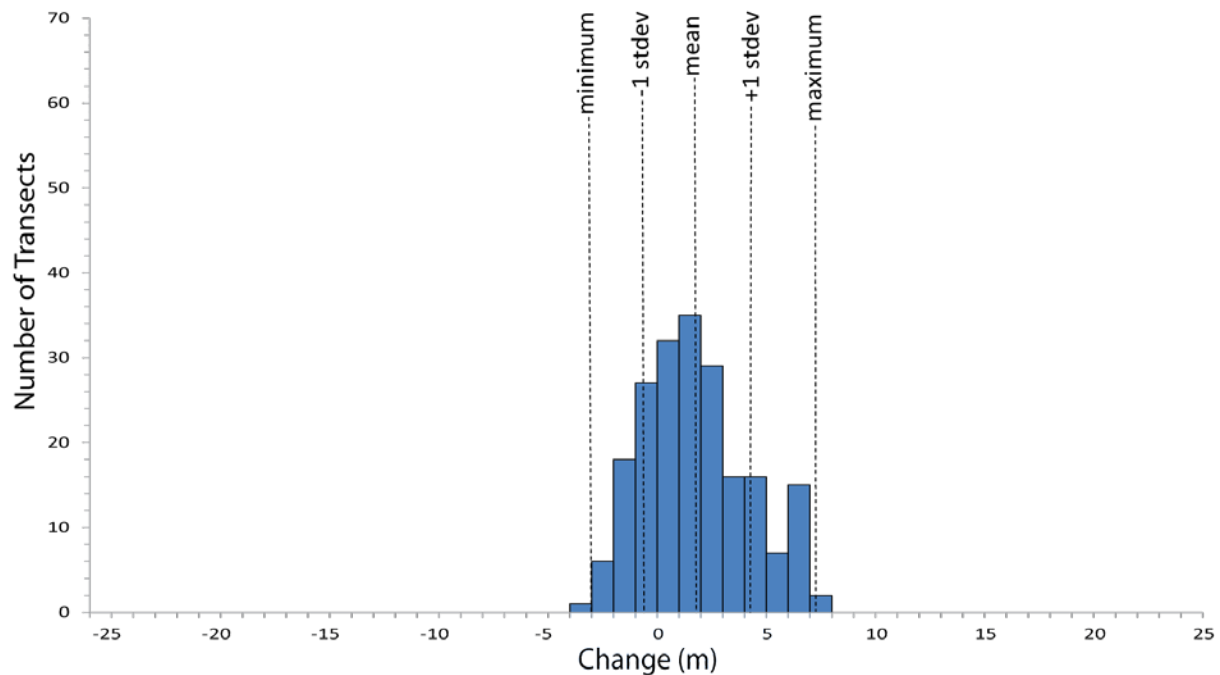


Figure 34. . Distribution of difference measurements at Plumb Beach, Jamaica Bay Unit, Gateway National Recreation Area, for the annual shoreline change between Fall 2009 and Spring 2010, incorporating the mean change value, (1.79 m) standard deviation (2.39 m), maximum, and minimum.

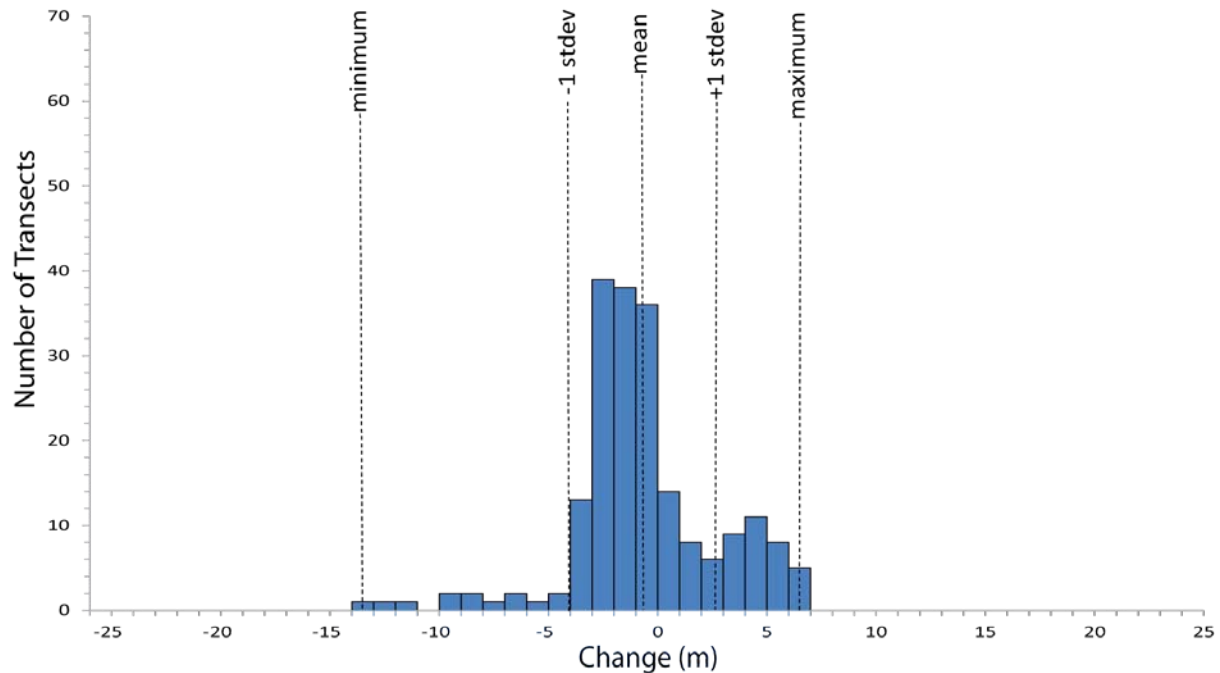


Figure 35. Distribution of difference measurements at Plumb Beach, Jamaica Bay Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Spring 2010, incorporating the mean change value, (-0.68 m) standard deviation (3.34 m), maximum, and minimum.

Breezy Point

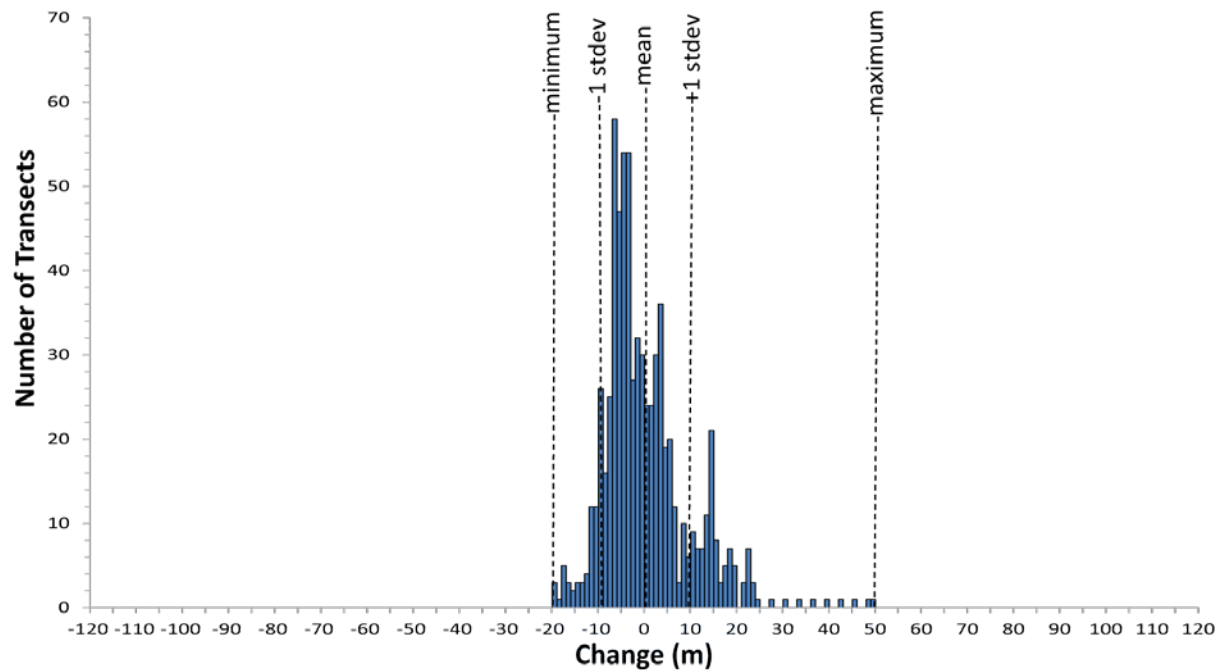


Figure 36. Distribution of difference measurements at Breezy Point, Jamaica Bay Unit, Gateway National Recreation Area, for the seasonal shoreline change between Spring 2009 and Fall 2009, incorporating the mean change value (0.23 m), standard deviation (9.43 m), maximum, and minimum.

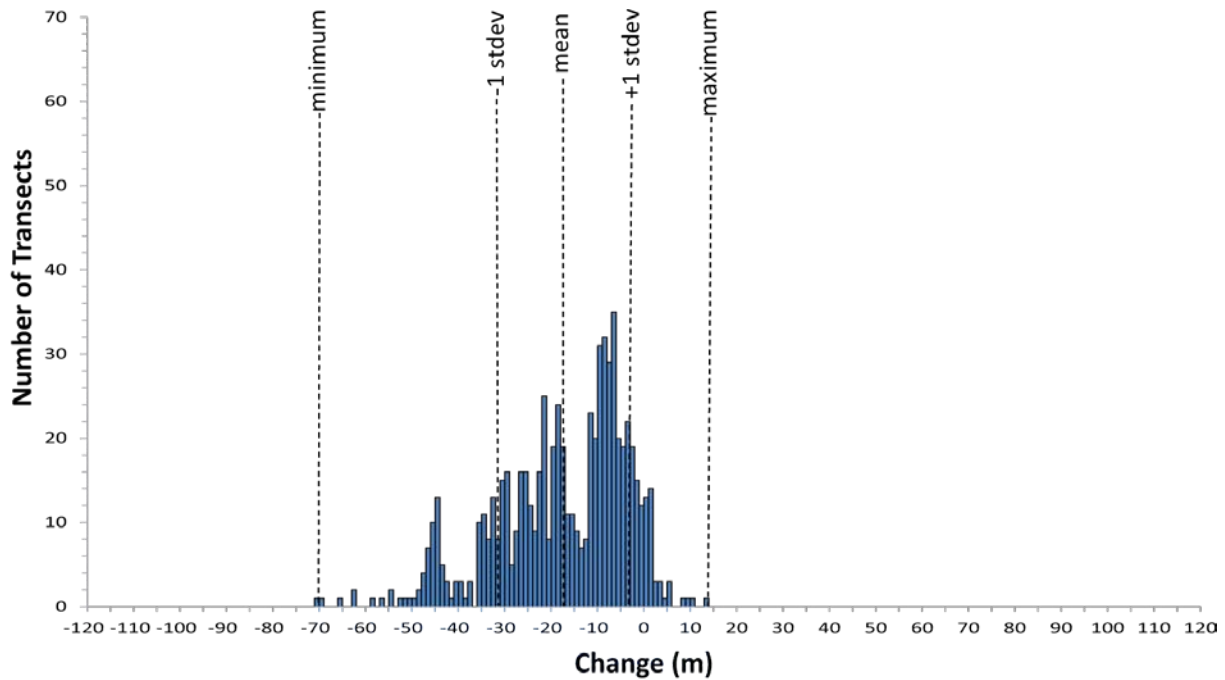


Figure 37. Distribution of difference measurements at Breezy Point, Jamaica Bay Unit, Gateway National Recreation Area, for the seasonal shoreline change between Fall 2009 and Spring 2010, incorporating the mean change value (-17.54 m), standard deviation (14.14 m), maximum, and minimum.

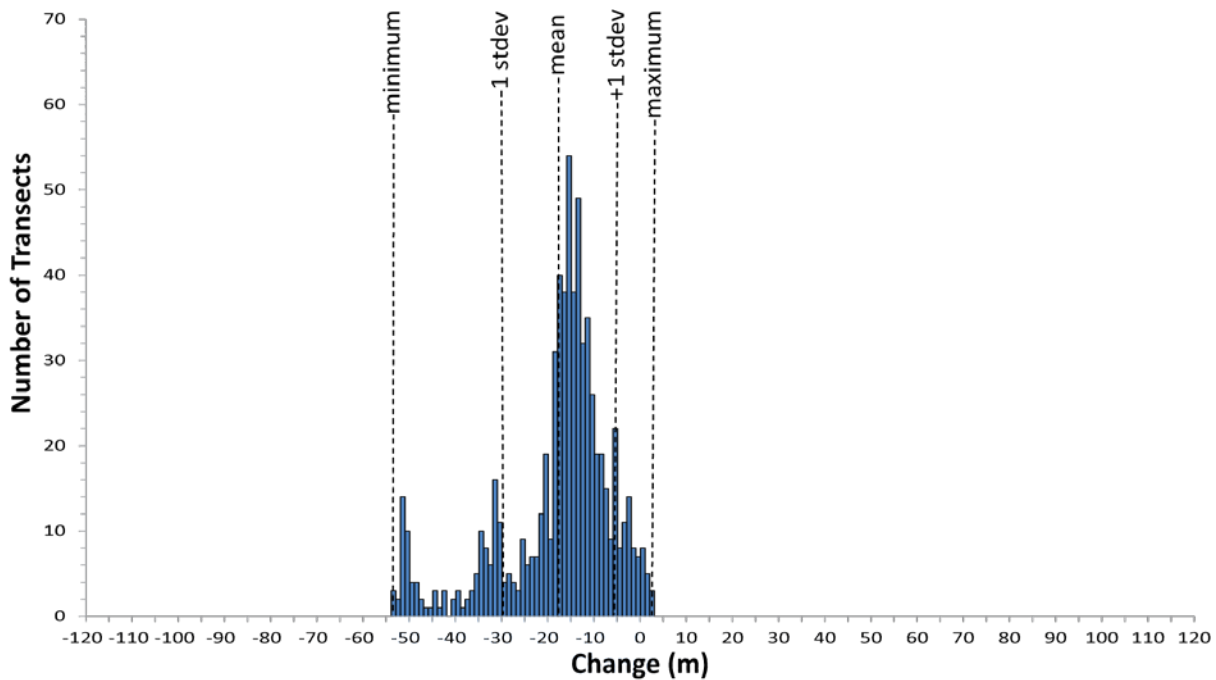


Figure 38. Distribution of difference measurements at Breezy Point, Jamaica Bay Unit, Gateway National Recreation Area, for the annual shoreline change between Spring 2009 and Spring 2010, incorporating the mean change value (-17.91 m), standard deviation (12.05 m), maximum, and minimum.

Areas of Interest

Specific areas of interest have not been highlighted in this annual report. The temporal scale is too short to describe a condition that may be influenced by a few storms or non-stormy period. The data will be incorporated in a longer term, trend report, where there is much more perspective on the sequence and vectors of change.

Conclusions and Information for Management

With the caveat that the data presented only apply to a one-year period, there are many locations that have changes greater than ± 5.6 m measure of uncertainty (± 4 m at Staten Island and Plumb Beach) and a few that are greater than the one-standard-deviation. It is difficult to determine whether these changes are local perturbations or some larger negative displacement with this limited data set. Longer term tendencies of shoreline change will be analyzed and presented in the NCBN 5-year trend reports.

Problems / Concerns

There were no issues that arose in this period that constituted problems or concerns in the application of the protocol.

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Thieler, E.R., E.A. Himmelstoss, J.L. Zichichi, and A. Ergul. 2009. Digital Shoreline Analysis System (DSAS) version 4.0—An ArcGIS extension for calculating shoreline change: U.S. Geological Survey Open-File Report 2008-1278.
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U.S. Army Corps of Engineers, Wave Information Studies: <http://frf.usace.army.mil/wis>
(accessed October 2010).

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 646/111500, November 2011

National Park Service
U.S. Department of the Interior



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