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Shoreline Change Monitoring at Assateague Island National Seashore

2005-2010 Trend Report

Natural Resource Technical Report NPS/NCBN/NRTR—2011/509

ON THE COVER
Fence border between Assateague Island National Seashore and Chincoteague National Wildlife Refuge.
Photograph by: Norbert P. Psuty

Shoreline Change Monitoring at Assateague Island National Seashore

2005-2010 Trend Report

Natural Resource Technical Report NPS/NCBN/NRTR—2011/509

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Executive Summary

This Trend Report documents the collection of shoreline position data and describes the variation that has occurred during the period from Spring 2005 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 at the northern and southern termini of the Assateague Barrier Island. Periodic dredging of the Ocean City Inlet alters the natural supply of sediment reaching the island and also deposits sediment in the nearshore environment to augment the sediment budget.

Over the 5-year period, the Maryland portion of Assateague Island had an average inland displacement of -6.38 m, with the northern area experiencing persistent erosion. Seasonal average displacements varied from -17.32 m (Spring 2006-Fall 2006) to +13.58 (Fall 2005-Spring 2006). Mean changes for the entire barrier island were affected by the lengthy southerly extension at Tom's Cove Hook that tempered the general loss to create a -5-year mean of -2.26 m and seasonal displacements that varied from -18.24 m (Spring 2006-Fall 2006) to +13.43 m (Fall 2007-Spring 2008).

Persistent erosion downdrift of Ocean City Inlet and along the ocean shoreline at Tom's Cove are areas of special concern because of washover and breach potential. That said, this is a short-term data set that has a lot of temporal and spatial variation. Continued monitoring of the shoreline position is providing a basis for identifying vectors of change along Assateague barrier island.

Acknowledgments

The Assateague Island National Seashore park personnel conducted all the field surveys. Carl Zimmerman, Courtney Schupp, and Neil Winn provided additional information and data used in the completion of this report. Gregory Bass of the U.S. Army Corps of Engineers, Philadelphia District, provided information on the Ocean City Inlet bypass volumes. Robin Baranowski of the NCBN provided valuable assistance in the production of this report.

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Introduction

This is the first Trend Report of the change in shoreline position along the ocean side of Assateague Island, extending from Ocean City Inlet to Tom's Cove Hook. This first report follows the protocols described in Psuty, et al. (2010) to track the neap tide high tide swash line (see cover photos) and that were applied for the first time on Assateague Island National Seashore in Spring 2005. Subsequent surveys were conducted semi-annually in the spring and fall until Spring 2010; they provide the temporal span for this trend report.

The goal of the Project Trend Report is a summary of the full database of shorelines, with an emphasis on the previous five years. It is a comprehensive compilation of analyses that synthesize the shoreline change data, and provide scientific interpretation of the trends revealed in the numerical analyses. The longer term comparisons of trend of shoreline positions reveal changes created by differences in sediment availability and intensity of formational processes.

Site and Situation

Assateague Island is a barrier island along the eastern coast of Maryland and Virginia (Fig. 1). The barrier is approximately 58 km alongshore from Ocean City Inlet to Tom's Cove Hook. The primary geomorphological component of the Assateague Island National Seashore is a Holocene age barrier island that is a continuation of the barrier island system that extends southward from the headland in Delaware (Walker and Coleman 1987) (Figure 1). The modern-day configuration of Assateague Island is a product of a 1933 hurricane that breached the ancestral Fenwick Island and created Ocean City Inlet. Construction of jetties in 1934-35 maintained the inlet and resulted in the establishment of Assateague Island. The combination of the very long jetties and the sequestering of sediment in the flood-tide and ebb-tide deltas adjacent to the inlet greatly altered the sediment supply reaching Assateague Island and extensive shoreline displacement ensued (Underwood and Hiland 1995). The effects of the inlet are still in place but are ameliorated by periodic transfers of sediment, part of the North End Restoration Project, sponsored by the U.S. Army Corps of Engineers (Schupp et al. 2007). Beginning in January 2004, sediment has been dredged from the navigation channel and from portions of the tidal deltas and placed in the nearshore of Assateague Island twice a year.

Assateague Island National Seashore includes the northernmost 35 km of the barrier island (Fig. 1). Assateague Sate Park has jurisdiction over a 3 km stretch along the NPS land, and Chincoteague National Wildlife Refuge occupies the southernmost 23 km of the barrier island. The data included in this report correspond to the portrayal of the shoreline position along the entire length of Assateague Island from Ocean City Inlet to Tom's Cove Hook.

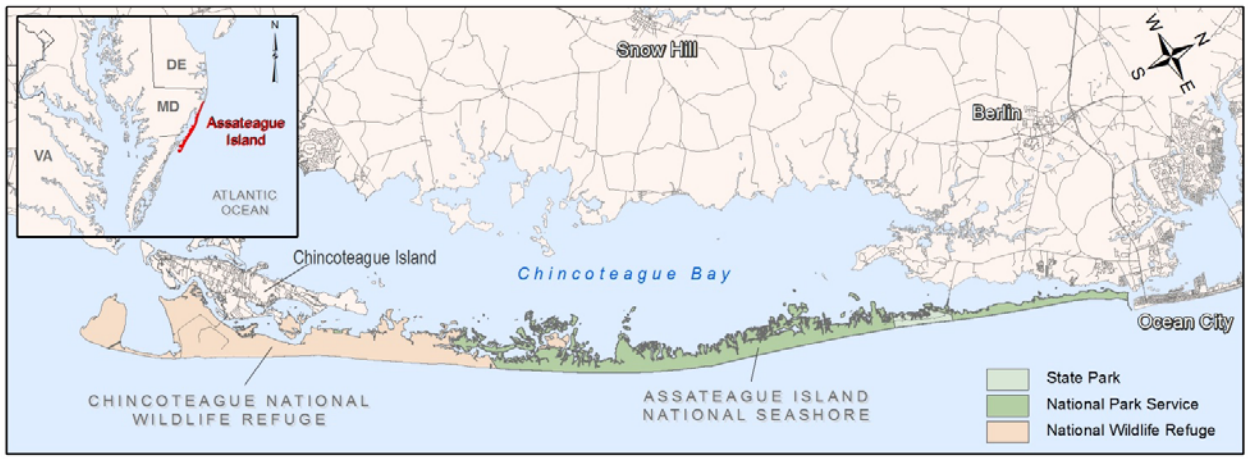

Figure 1. Assateague Island and the administrative units present on the barrier island.

Timing of Shoreline Position Surveys

Eleven surveys of the neap-tide, high-tide swash-line are included in this trend report (Table 1). They represent the positions monitored from Spring 2005 to Spring 2010. The eleven surveys were run during the predicted neap-tide period, sometimes over a period of 2-4 days, and had similar water level elevations. The closest tide gauge that portrays the ocean condition at Assateague Island is located at the Ocean City Inlet, MD. However, this gauge is in the estuary and tidal range and timing is constrained by the narrow inlet. Thus, to represent the conditions at the ocean shoreline, data from the gauge at Lewes, Delaware, NOAA National Ocean Data Center, Station #8557380 (NOAA, 2010) are used to reference water level positions and the timing of the water levels in this report. This is not a perfect solution because historical records indicate that high water at the Lewes gauge is about 1.0 hr later than at the ocean shoreline at Ocean City (Station #8570280, NOAA, accessed 9/10/2010).

Table 1. Date of shoreline survey and elevation of previous high tide. Source: NOAA tide gauge (#8557380) Lewes, MD. (http://tidesandcurrents.noaa.gov/geo.shtml?location=lewes%2C+delaware)

Season	**Date**	**Previous High Tide Height** (Meters rel. Mean Lower Low Water)	**Previous High Tide Time** (Local)
Spring 2005	30 March 2005	1.285	11:36 am
Fall 2005	21 November 2005	1.259	12:06 am
Spring 2006	16 March 2006	1.001	09:24 am
Fall 2006	16 November 2006	1.401	05:24 am
	17 November 2006	1.313	06:12 am
	20 November 2006	1.562	07:54 am
	21 November 2006	1.574	08:42 am
Spring 2007	27 March 2007	1.149	04:36 am
	28 March 2007	1.263	05:42 am
	30 March 2007	1.300	07:42 am
Fall 2007	19 November 2007	1.347	03:18 am
	20 November 2007	1.422	04:06 am
	21 November 2007	1.499	05:00 am
Spring 2008	29 May 2008	1.187	03:54 am
	30 May 2008	1.099	04:54 am
Fall 2008	7 October 2008	1.000	02:54 am
	8 October 2008	0.940	03:42 am
Spring 2009	7 April 2009	1.423	07:36 am
	8 April 2009	1.278	08:24 am
Fall 2009	30 September 2009	1.137	06:48 am
	2 October 2009	1.389	07:54 am
Spring 2010	5 April 2010	1.371	01:54 am
	6 April 2010	1.354	03:06 am
	13 April 2010	1.286	08:48 am
	14 April 2010	1.195	09:30 am

Natural and Cultural Events Affecting Shoreline Position

Storms are a condition at the ocean beach. They are important drivers of coastal change and affect shoreline position by mobilizing and transporting beach and dune sediment. Because the shoreline position surveys are scheduled at six-month intervals, they are not meant to represent the outcomes of specific storms, but instead they provide insight into the comparison of times of high energy levels and considerable sediment transport relative to those times of lower energy levels and more opportunity for sediment retention. Yet, the results may not be so simple. There are other variables at work that affect the outcomes, such as the local sites of sediment accumulation and loss associated with the structures at the inlets and along the shoreline; human manipulation of sediment; inshore circulation cells that add the dimensions of current patterns to the sediment mobility equation, alongshore transfers of pulses of sediment, etc.

Natural Events

The existing protocol for shoreline monitoring is directed at identifying the seasonal, annual, and longer sediment balances at the ocean shoreline by recording changing positions of the water-land contact. Storms are important drivers of the shoreline change and the protocol is attempting to monitor the results of stormy and non-stormy periods as net conditions, or seasonal contrasts. A measure of storminess is garnered by the water level data collected at the Lewes, Delaware tide gauge (Fig. 2 and Table 2).

A storm threshold of 1.98 m (6.5 ft) above mean lower low water (MLLW) is chosen that represents an elevation on the berm surface (above the beach face). The absolute value of the threshold is not diagnostic in itself, but it represents an elevation that is reached occasionally and when it is reached, the upper beach and potentially the foredune undergo erosion and sediment redistribution, and overwash may occur. All of the daily water levels are depicted in Figure 3 with a solid blue line that represents the maxima and minima of that date. Cyclonic storms (nor'easters and hurricanes) tend to be represented by several days of high water levels and frequently have a combination of very high waters during the periods that the winds are onshore followed by very low water levels during the succeeding periods when the winds are offshore. The patterns of water levels tend to depict the more frequent occurrence of storms during the winters and springs versus the less stormy summers. Alternate survey periods are markedly stormier, with the first year of this report, Spring 2005-Spring 2006, incorporating frequent and relatively high magnitude storms. However, the Spring 2009-Spring 2010 period has the greatest water level, the greatest number of storms, and the longest storm durations of the entire 5 years.

The number of storms listed in Figure 2 is higher than in Table 2 because it is referring to water levels at or above 1.828 m (6 ft) above MLLW. Nonetheless, the same pattern of storminess is evident.

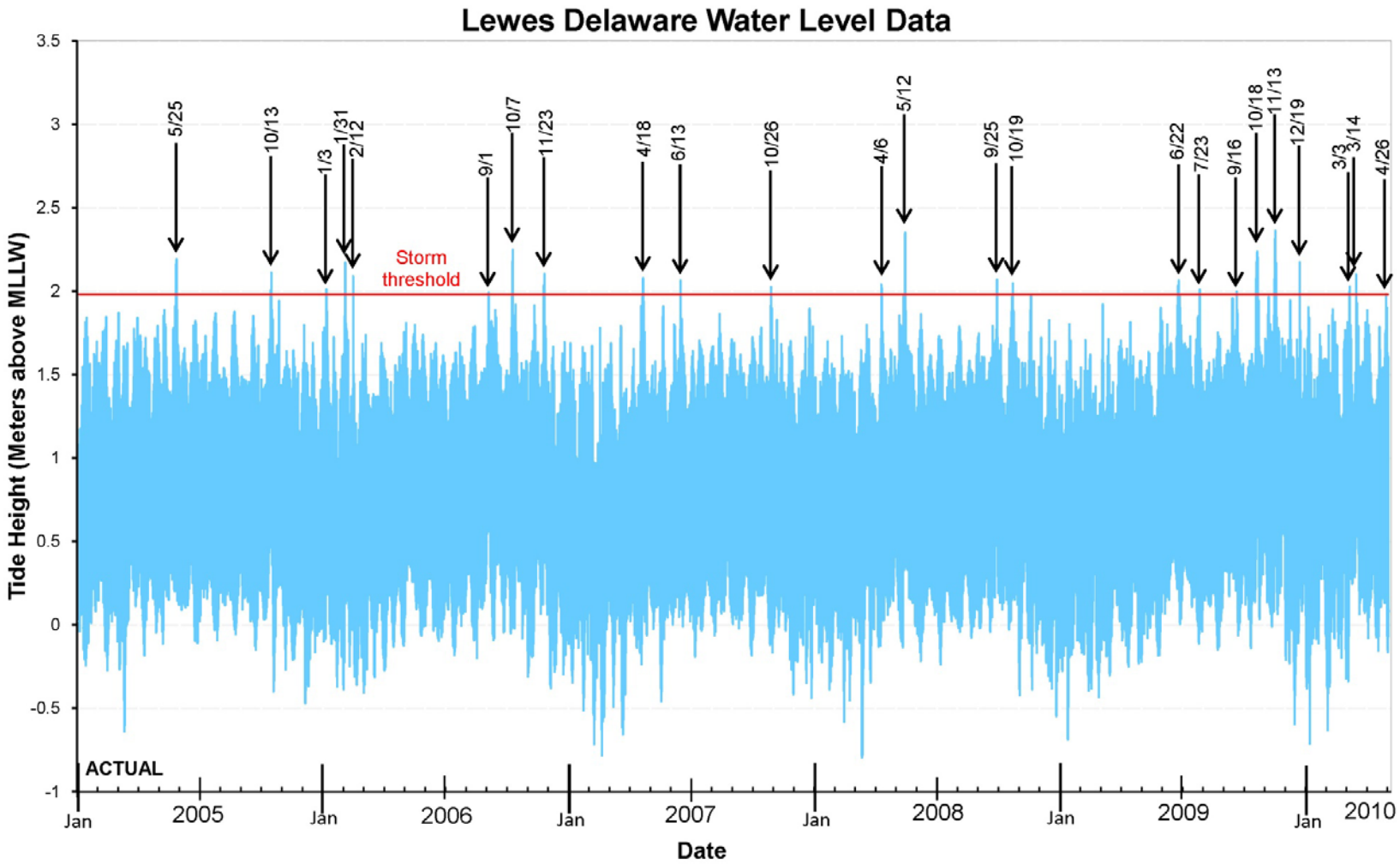

Figure 2. Water level variation at Lewes, Delaware, tide gauge, with storm surges surpassing threshold value of 1.98 m above Mean Lower Low Water. Dates of the maximum water levels during storm events are noted. Source: NOAA tide gauge (#8557380) Lewes, MD (http://tidesandcurrents.noaa.gov/geo.shtml?location=lewes%2C+delaware)

Table 2. Frequency and magnitude of water levels at or above 1.828 m, 2005 - 2010, Lewes, Delaware.

Year	Storm	Number of tides higher than 1.83m (6ft Storm threshold)	Maximum Tide		
			Tide height (m)	Date	Measured surge (m)
2005	May 6-7	2	1.888	05/07/05	0.33
	May 23-26	4	2.190	05/25/05	0.52
	July 21-22	2	1.867	07/22/05	0.14
	August 18-19	2	1.878	08/19/05	0.15
	September 16	1	1.850	09/16/05	0.20
	October 12-15	5	2.111	10/13/05	0.62
	October 25	2	1.942	10/25/05	0.97
2006	January 3-4	2	2.011	01/03/06	0.46
	January 30-31	2	2.172	01/31/06	0.55
	February 12	1	2.090	02/12/06	0.80
	September 1	1	1.991	09/01/06	0.66
	September 11-12	2	1.888	09/11/06	0.26
	October 6-8	5	2.248	10/07/06	0.58
	October 11	1	1.919	10/11/06	0.32
	November 8	1	1.915	11/08/06	0.28
	November 22-23	3	2.103	11/23/06	0.62
2007	April 15	1	1.910	04/15/07	0.40
	April 17-19	3	2.078	04/18/07	0.35
	May 17-18	2	1.908	05/18/07	0.22
	June 13	1	2.064	06/13/07	0.39
	June 15	1	1.888	06/15/07	0.16
	August 10	1	1.862	08/10/07	0.32
	October 25-27	4	2.025	10/26/07	0.29
	November 3	1	1.829	11/03/07	0.53
	December 22	1	1.895	12/22/07	0.30
2008	April 6-7	2	2.039	04/06/08	0.40
	May 3	1	1.855	05/03/08	0.28
	May 10	1	1.974	05/10/08	0.42
	May 12-13	3	2.351	05/12/08	0.98
	June 4	1	1.860	06/04/08	0.11
	September 25	1	2.069	09/25/08	0.58
	October 17-20	4	2.048	10/18/08	0.31
	November 14-15	2	1.975	11/15/08	0.26
2009	March 1	1	1.921	03/01/09	0.54
	May 26	1	1.901	05/26/09	0.21
	June 20-24	5	2.064	06/22/09	0.36
	July 20-21	2	1.849	07/21/09	0.13
	July 23	1	2.009	07/23/09	0.32
	September 10-11	2	1.957	09/10/09	0.50
	September 16-17	3	1.998	09/16/09	0.40
	October 15-19	8	2.237	10/17/09	0.65
	November 3	1	1.967	11/03/09	0.36
	November 11-15	7	2.362	11/13/09	0.94
	December 5	1	1.945	12/05/09	0.34
	December 19	1	2.173	12/19/09	0.80
2010	January 1-2	2	1.904	01/01/10	0.24
	February 6	2	1.892	02/06/10	0.96
	March 3	2	2.027	03/03/10	0.51
	March 13-14	3	2.100	03/13/10	0.76
	March 29	1	1.886	03/29/10	0.30
	April 26-27	2	1.981	04/26/10	0.40

Cultural Events– Artificial Emplacement of Sediment

As described earlier, Ocean City Inlet has a downdrift effect on the shoreline of Assateague Island through the combination of the very long jetties as well as the sediment storage in the tidal deltas. The navigation channel in the inlet and portions of the tidal deltas are periodically dredged and some of the dredged sediment is discharged downdrift of the jetty in the nearshore of Assateague Island. This material adds to the local sediment supply and partially offsets the negative effects of the controlled inlet. During the period of this trend report, there have been 10 episodes of dredging and emplacement of sediment off of Assateague, totaling approximately 530,000 m^3 (Table 3).

Table 3. Dates and quantities (in cubic meters) of sediment dredged and placed offshore of Assateague Island. (source: US Army Corps of Engineers, Baltimore District)

Time Period	Total Dredged Sediment	Total Placed Sediment at Assateague
3/29/05 to 4/28/05	25528	25108
9/18/05 to 11/13/05	61761	53140
4/3/06 to 5/11/06	36389	34978
8/11/06 to 10/29/06	86226	79498
4/22/07 to 6/7/07	56688	59481
9/23/07 to 12/5/07	86949	86322
4/1/08 to 5/14/08	43446	40885
10/5/09 to 11/14/08	44080	40793
3/15/09 to 4/23/09	40953	37610
9/6/09 to 10/19/09	76368	74647

Areas of Special Interest

There are several areas of special interest identified by Park management (incorporated in Figs. 31 and 37). They consist of: 1) the shoreline downdrift from Ocean City Inlet because of the interruption of alongshore sediment transport related to the jettied inlet; 2) an area about midway along the island that is low and prone to overwash events; and 3) the narrow barrier at Tom's Cove at the southern margin of the island. As the data sets are assembled and analyzed, additional information may be incorporated to provide more perspective on the dimensions of changes in these three areas.

Changes to the Protocol

Although there are no documented changes to the protocol used in the data gathering cited in this report, much of the archived data were collected prior to publication of the final version of the protocol. However, the early work on the protocol was in collaboration with the data collecting team at Assateague and was strongly influenced by the methodology employed at Assateague. Therefore, the trend report is presuming that, except as noted in the subsequent discussion of the data sets, the general application of the 1-D protocol was followed and the comparisons are reasonable. Further, this first Trend Report is following the format described in the protocol and is generating a model for reporting as well as an interpretation of the archived data.

Shoreline Position Data Sets

Following application of the field collection protocol for each of the shoreline surveys in this Trend Report, 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 a program created and maintained by the U.G. Geological Survey (Thieler et al. 2009) (see SOP # 7, Psuty et al. 2010). The product of the first part of this procedure is a plot of the shoreline positions, the offshore baseline, and transects. The second part of the procedure is a measure of the distances along the transects to each surveyed shoreline. The complete table of measurements of distances from the baseline to the surveyed shoreline, spaced at10 m intervals, is available from the NCBN data manager in GIS format.

The change in shoreline position is derived from a comparison of surveyed lines and is conveyed as a measure of differences between distances for each transect location. 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 estimation, 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 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 (rounded to 6n m).

The portrayal of the distribution of dimensions of change is created by the application of the Shoreline Change Mapper, 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 dimension 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 (incorporated in a succession of applications, beginning with Figure 9). A running bar graph depicts the relative difference in shoreline position between any two surveys. Differences of less than 10 m of seaward or inlandward 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 inland displacement (erosion) in shades of red. The length of each line represents the magnitude of change between two chosen dates. Additionally, the bar-graph adds information about the mean change as well as lines of +/- one standard deviation. These data sets (differences between surveys) are portrayed spatially in a series of panels that depict the seasonal changes from Spring 2005 to Fall 2005, for example, as well as annual changes, from Spring 2005 to Spring 2006, for example. 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. The annual comparisons also include the locations of sediment by-passing events (dredging and placement) associated with the North End Restoration Project, at the Maryland portion of Assateague Island.

Together, these panels incorporate the essential information on the measures and distributions of change through the succession of seasons, and through the series of five years.

The sequence establishes the seasonal, annual and 5-year conditions in the ASIS Maryland section, followed by the totality of Assateague Island (Maryland and Virginia). The Maryland portion of Assateague Island is further subdivided to portray, with higher resolution, the geotemporal pattern of shoreline change occurring in the land under the jurisdiction of NPS (Fig. 3).

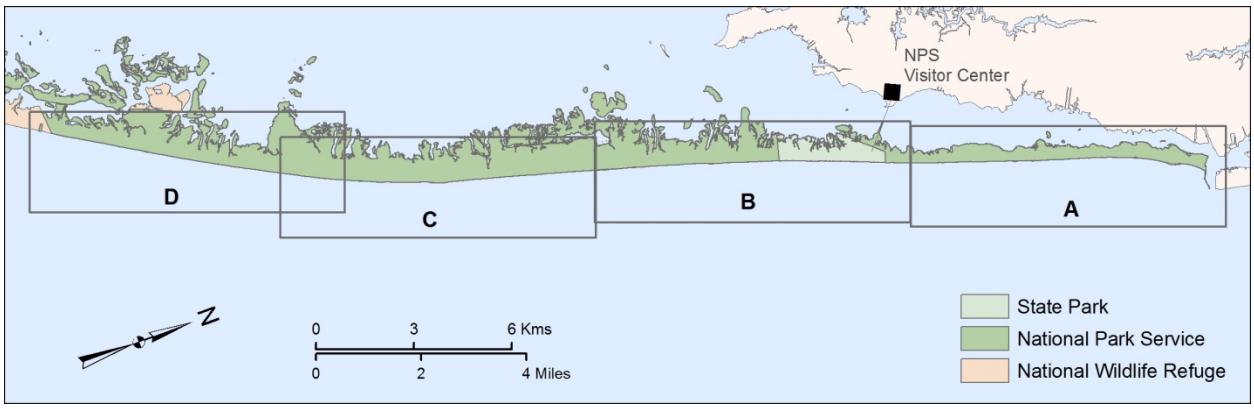

Figure 3. Subdivision of the Maryland portion of Assateague Island used to portray the shoreline change patterns in higher resolution.

Seasonal Shoreline Change

Shoreline changes between successive surveys (Figs. 6-15 and 16-25) are short-term portrayals of the relative storminess, the sediment budget, and the effects of local conditions such as attachment of sediment transport features and inshore circulation cells. Patterns of general displacement for the entire length of the shoreline tend to be related to levels of storminess whereas patterns of shoreline oscillation (considerable variation within short distances) tend to be the product of circulation cells (Fig. 4). Magnitudes associated with the Spring 2006 survey are probably inaccurate. All other values are reasonable and fit the potential outcomes of the drivers functioning in this location. The patterns of shoreline change are driven by the same variables at the entire island level as in the Maryland portion with the addition of the effects of the downdrift terminus of the barrier island. A combination of erosion immediately updrift of the terminus, downdrift extension of the terminus, and erosion of the westerly-trending end of the island produce larger shoreline change values in these locations than at any other portion of the island.

Annual Shoreline Change

The patterns of annual shoreline change are driven by the same variables as those affecting the seasonal displacements, but they represent the net conditions following the sequence of seasonal weather contrasts. Locations of sediment attachment and the effects of circulation cells continue to influence the local displacements (Figs. 26-31 and 32-37).

5-Year Shoreline Change

The net change for the 5-year period amalgamates the variety of weather factors, circulation cells, natural sediment inputs, and dredge spoil additions (Figs. 31 and 37). The small zone of positive change downdrift of the inlet is a location of natural sediment transport from the large ebb-tide delta where it attaches to the shore (Fig. 5). The area immediately downdrift from the attachment is likely the erosion zone caused by the inlet and jetties at the Ocean City Inlet.

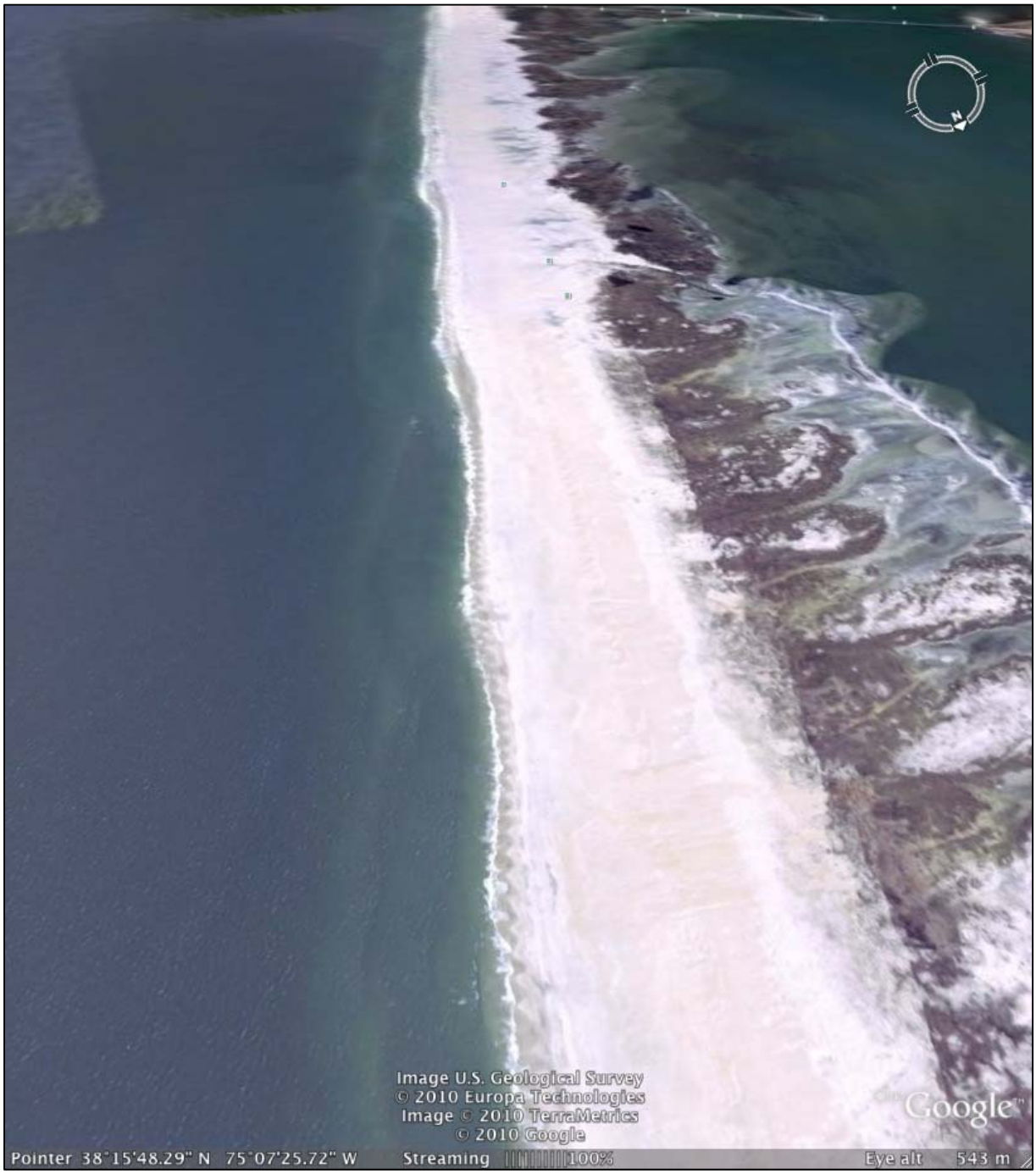

Figure 4. Aerial photo of a portion of Assateague Island depicting the effect of circulation cells.

Figure 5. Aerial photo of the northern end of Assateague Island, Ocean City inlet, showing the location of the large ebb-tide delta attachment to the shore.

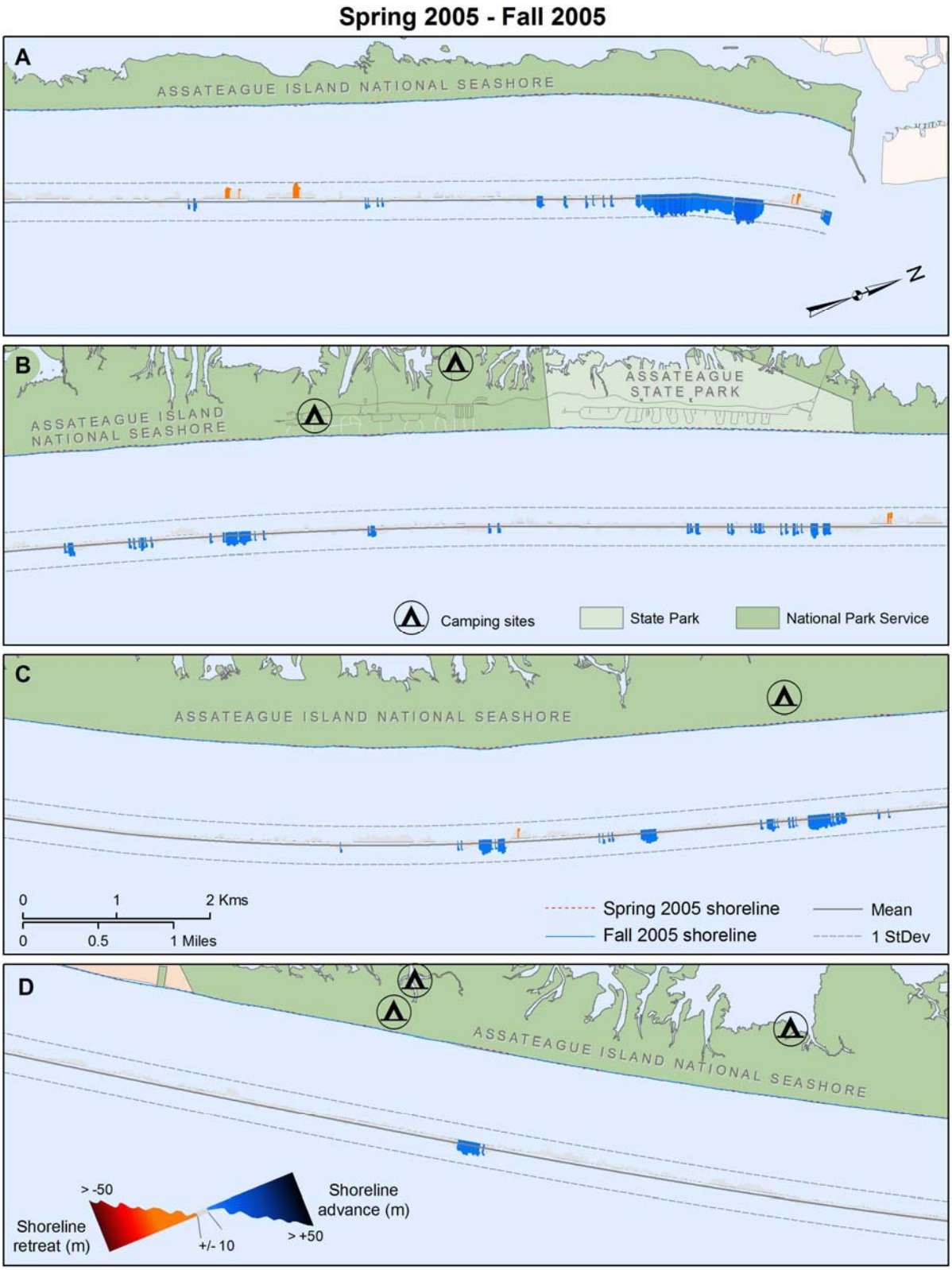

Figure 6. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Spring 2005 – Fall 2005.

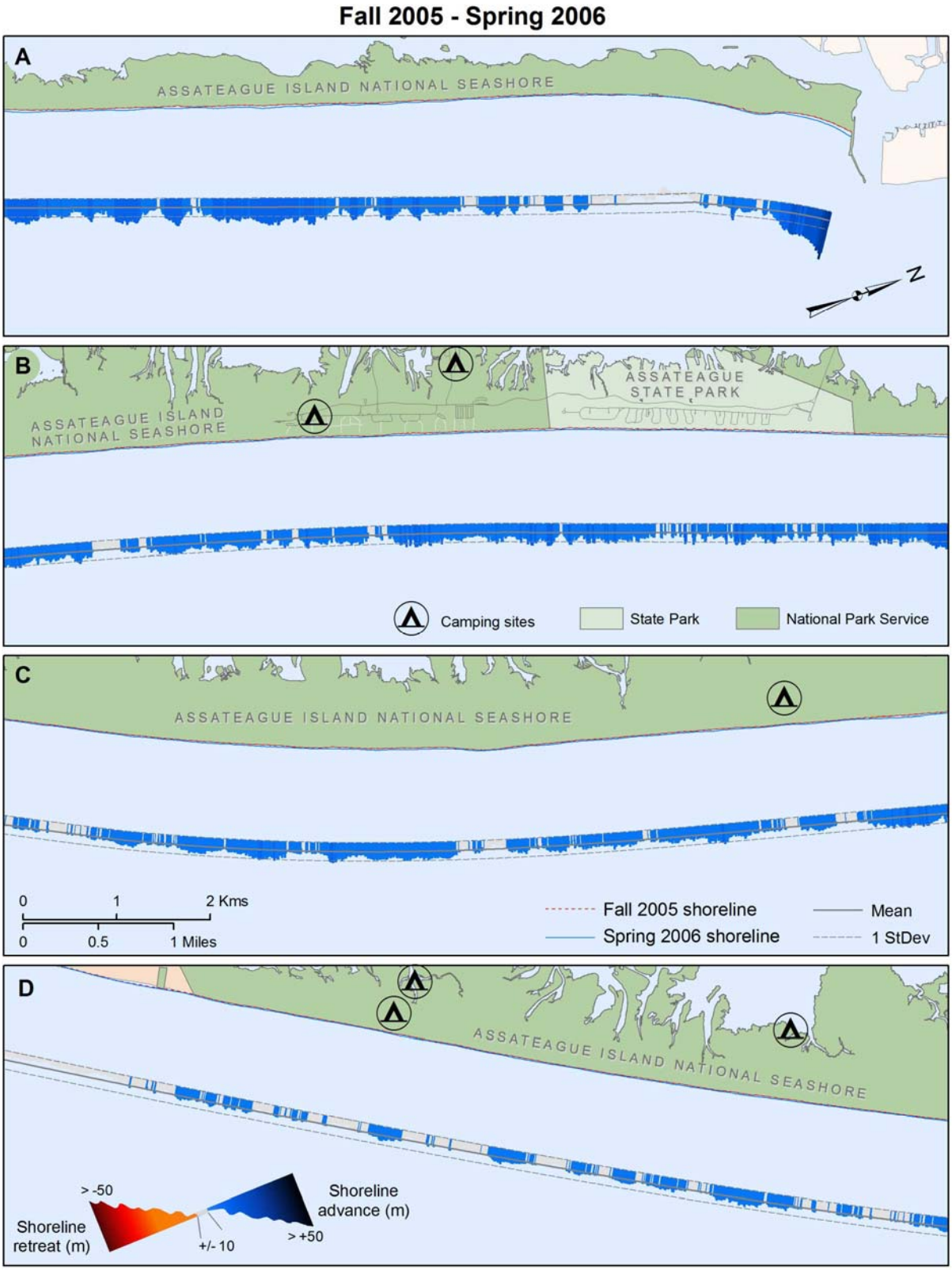

Figure 7. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Fall 2005 – Spring 2006.

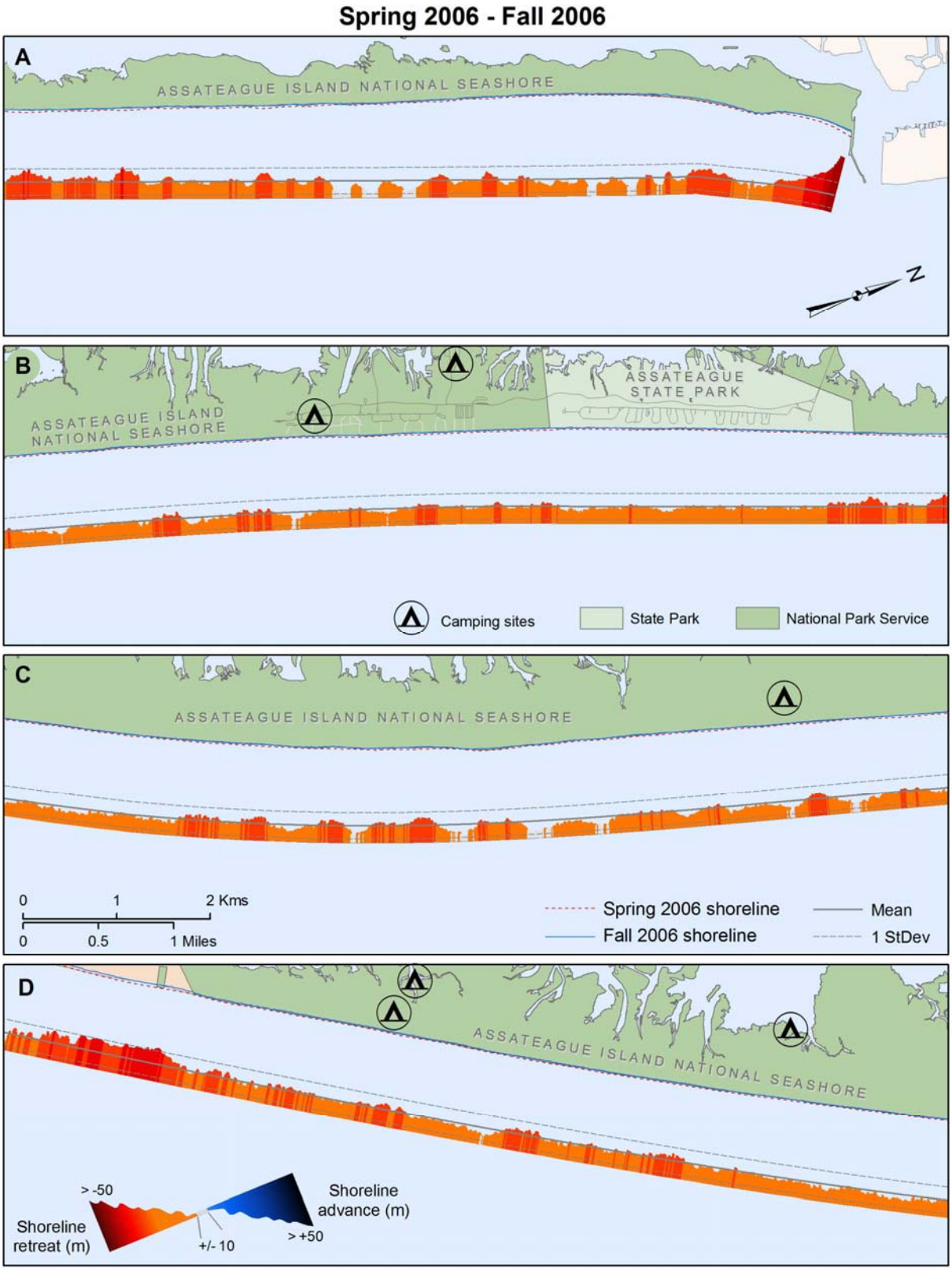

Figure 8. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Spring 2006 – Fall 2006.

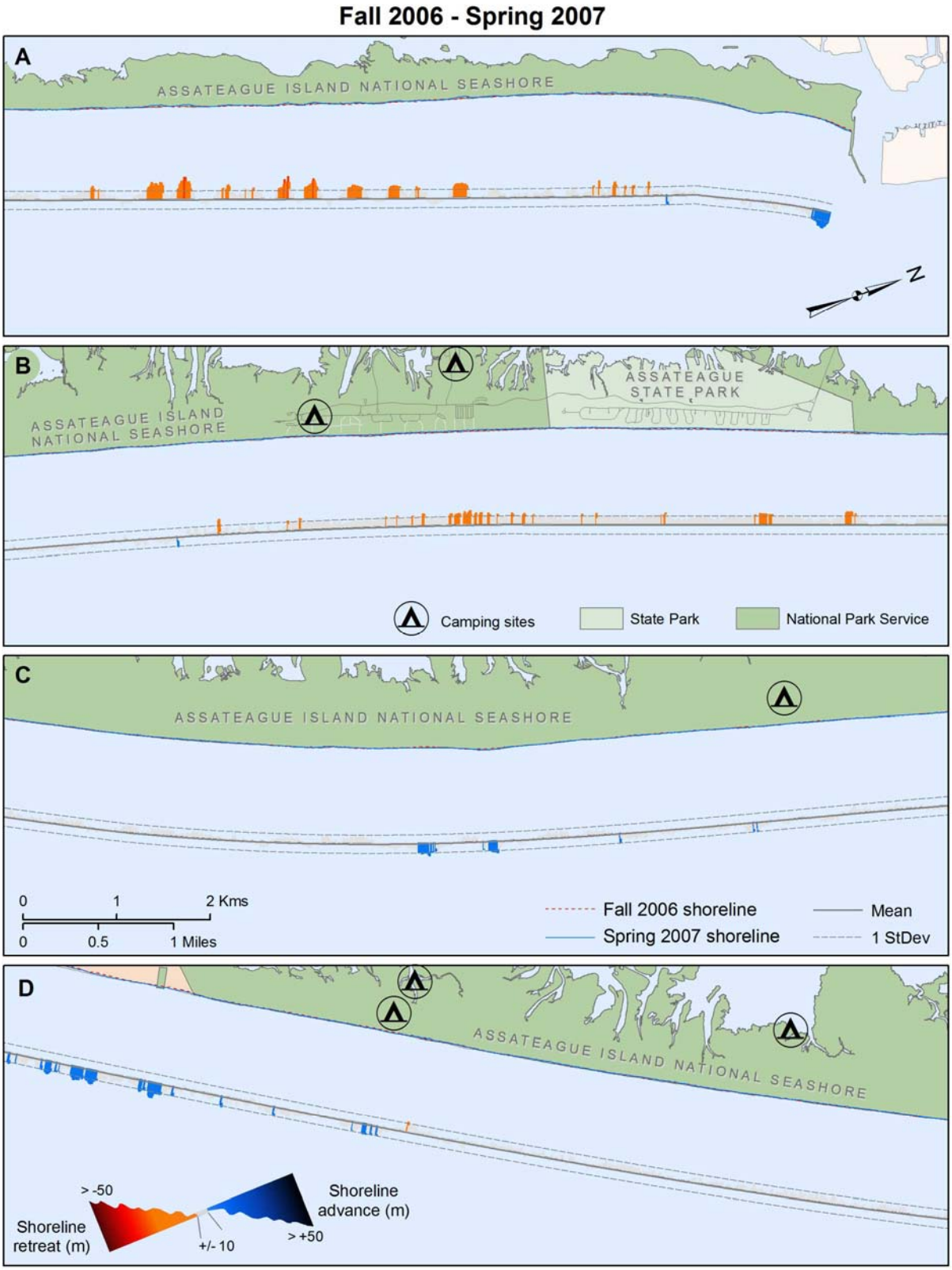

Figure 9. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Fall 2006 – Spring 2007.

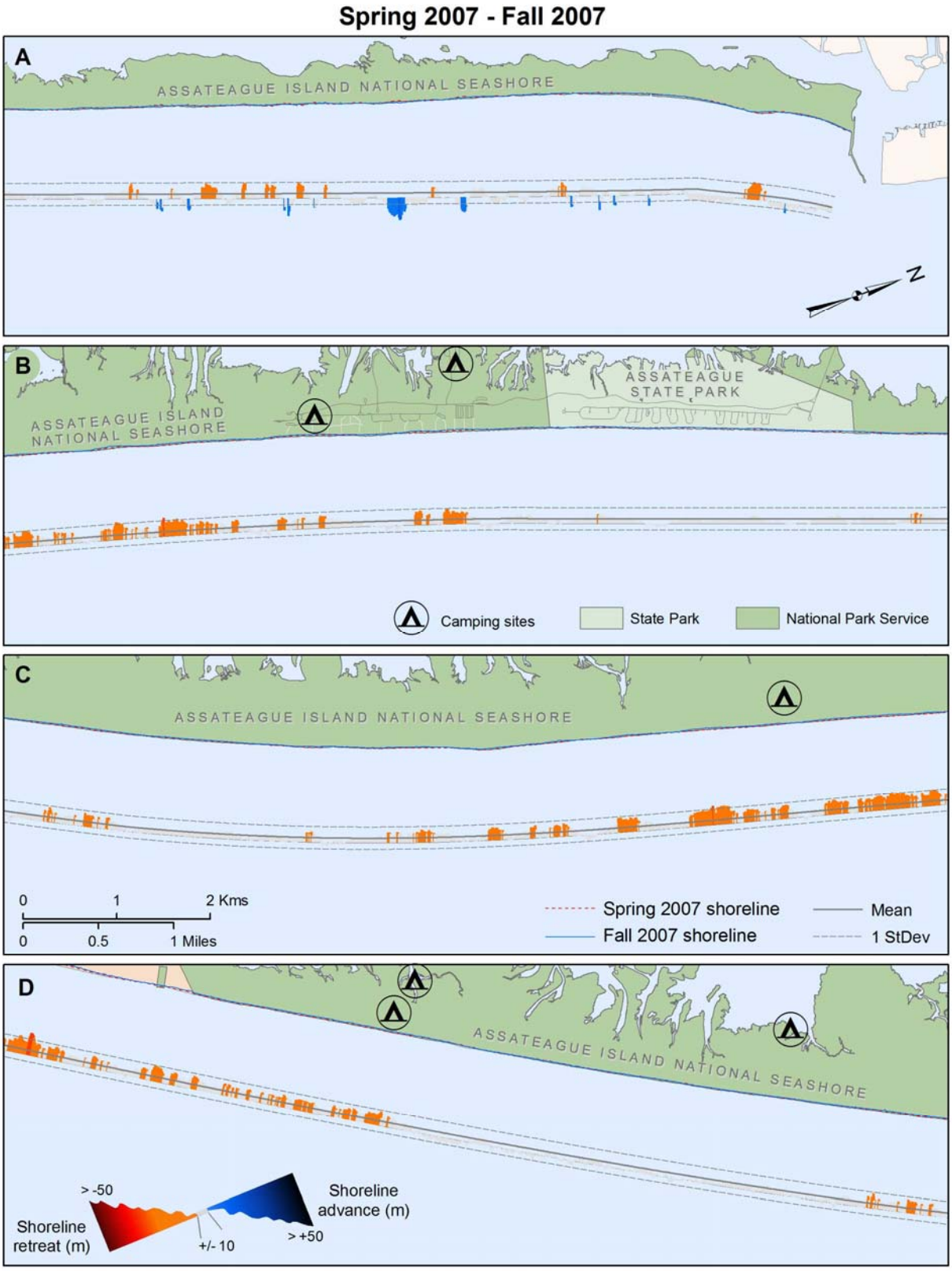

Figure 10. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Spring 2007 – Fall 2007.

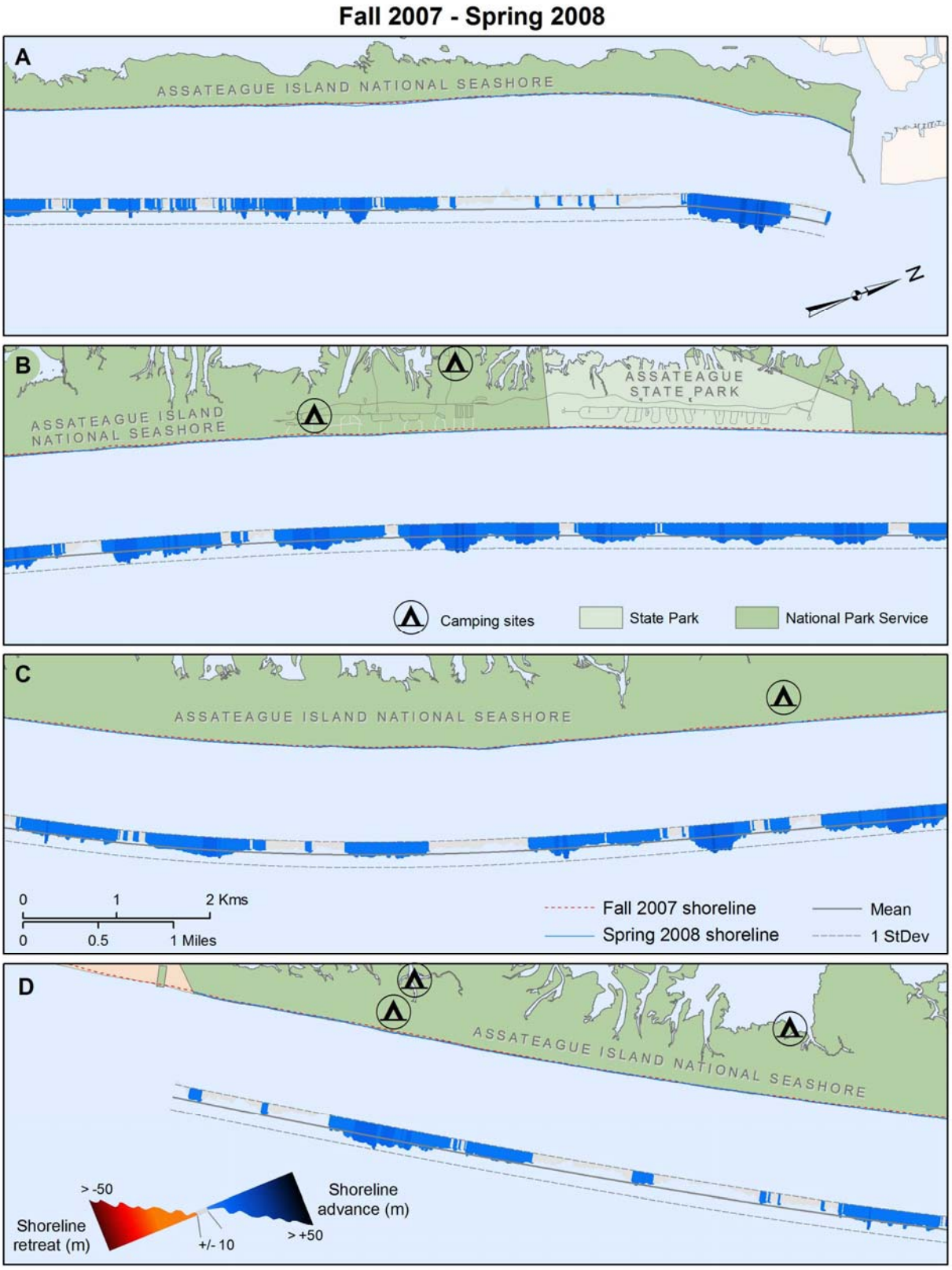

Figure 11. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Fall 2007 – Spring 2008.

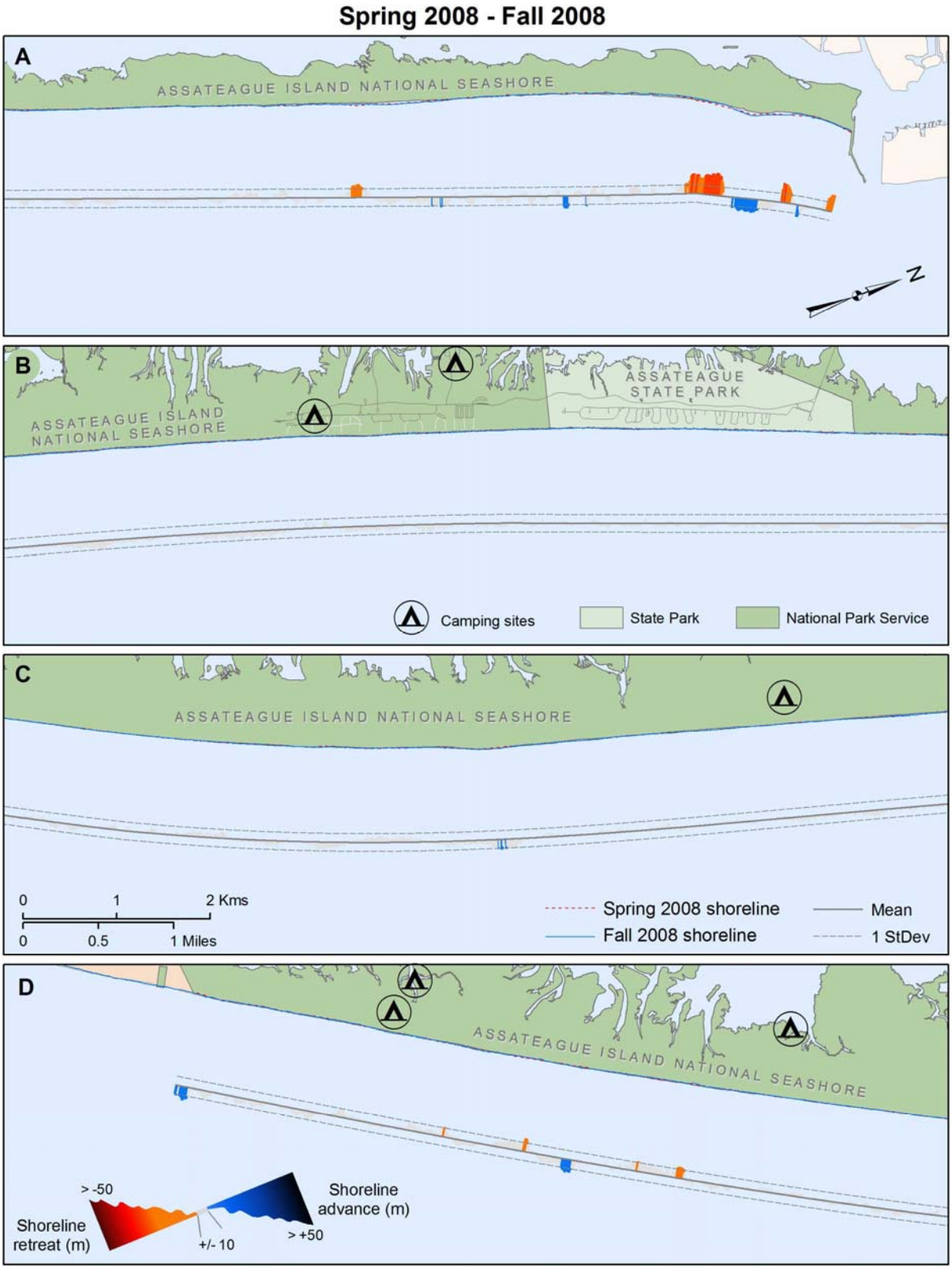

Figure 12. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Spring 2008 – Fall 2008.

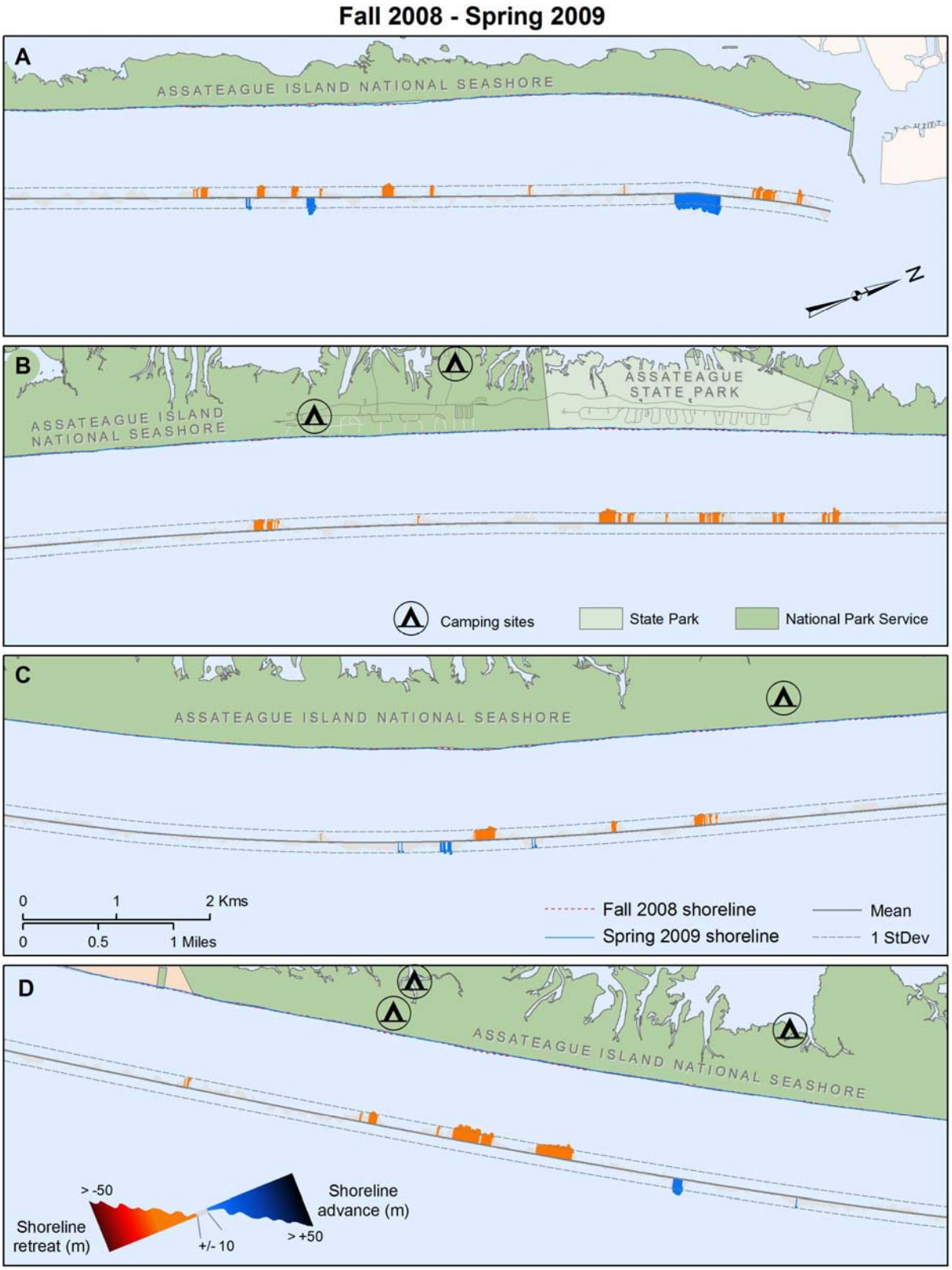

Figure 13. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Fall 2008 – Spring 2009.

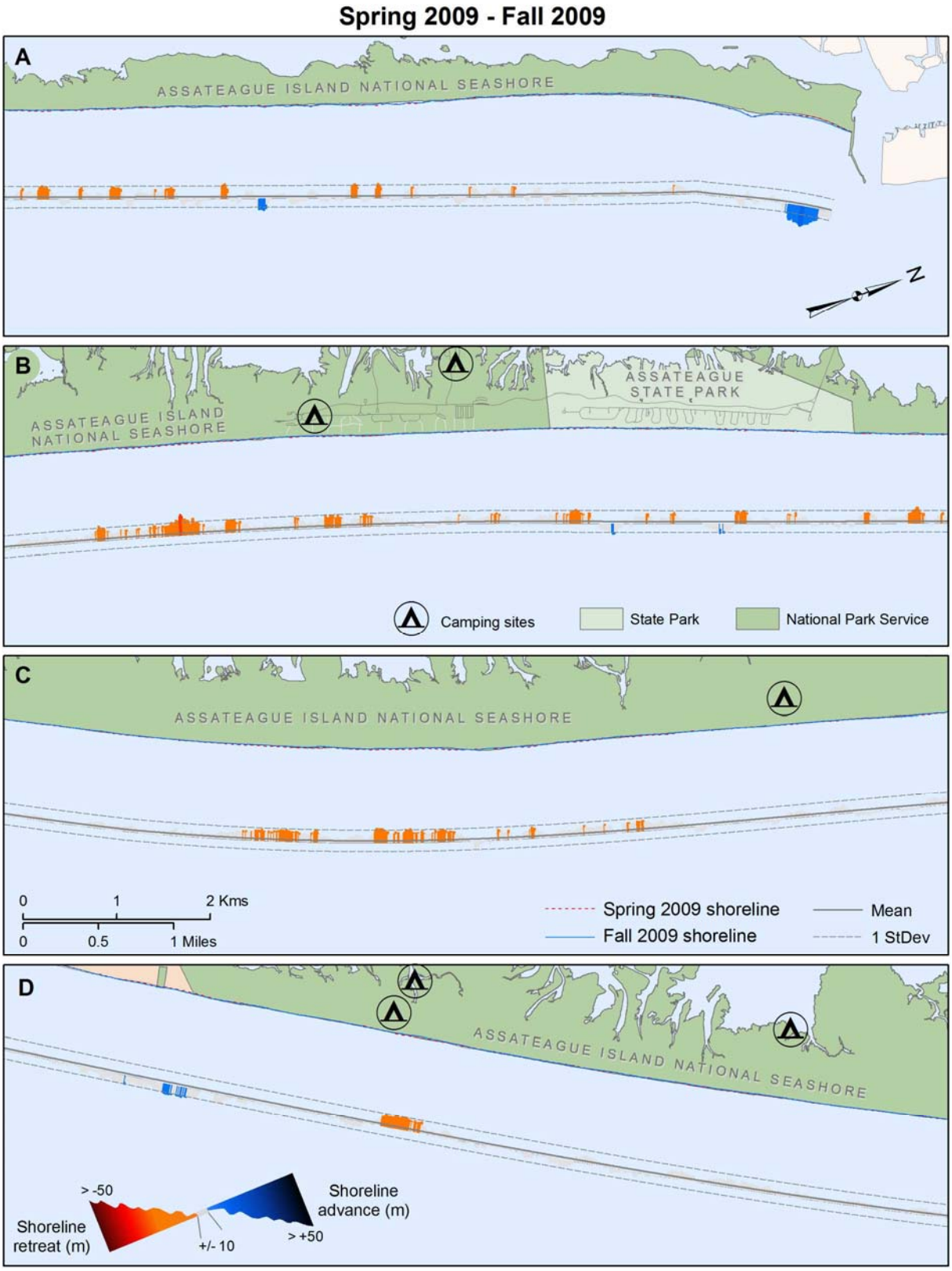

Figure 14. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Spring 2009 – Fall 2009.

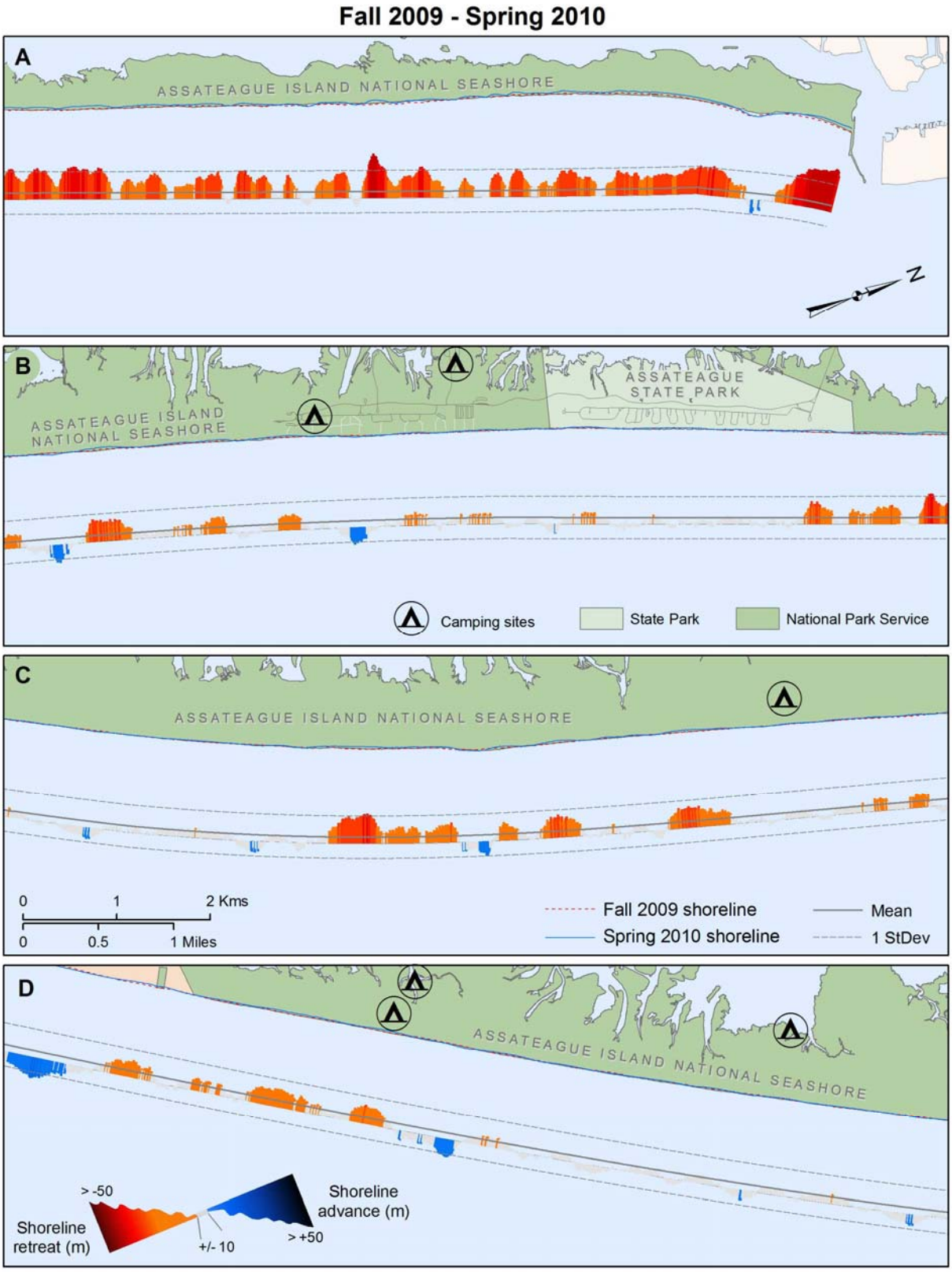

Figure 15. Distribution of seasonal shoreline change along the Maryland portion of Assateague Island, Fall 2009 – Spring 2010.

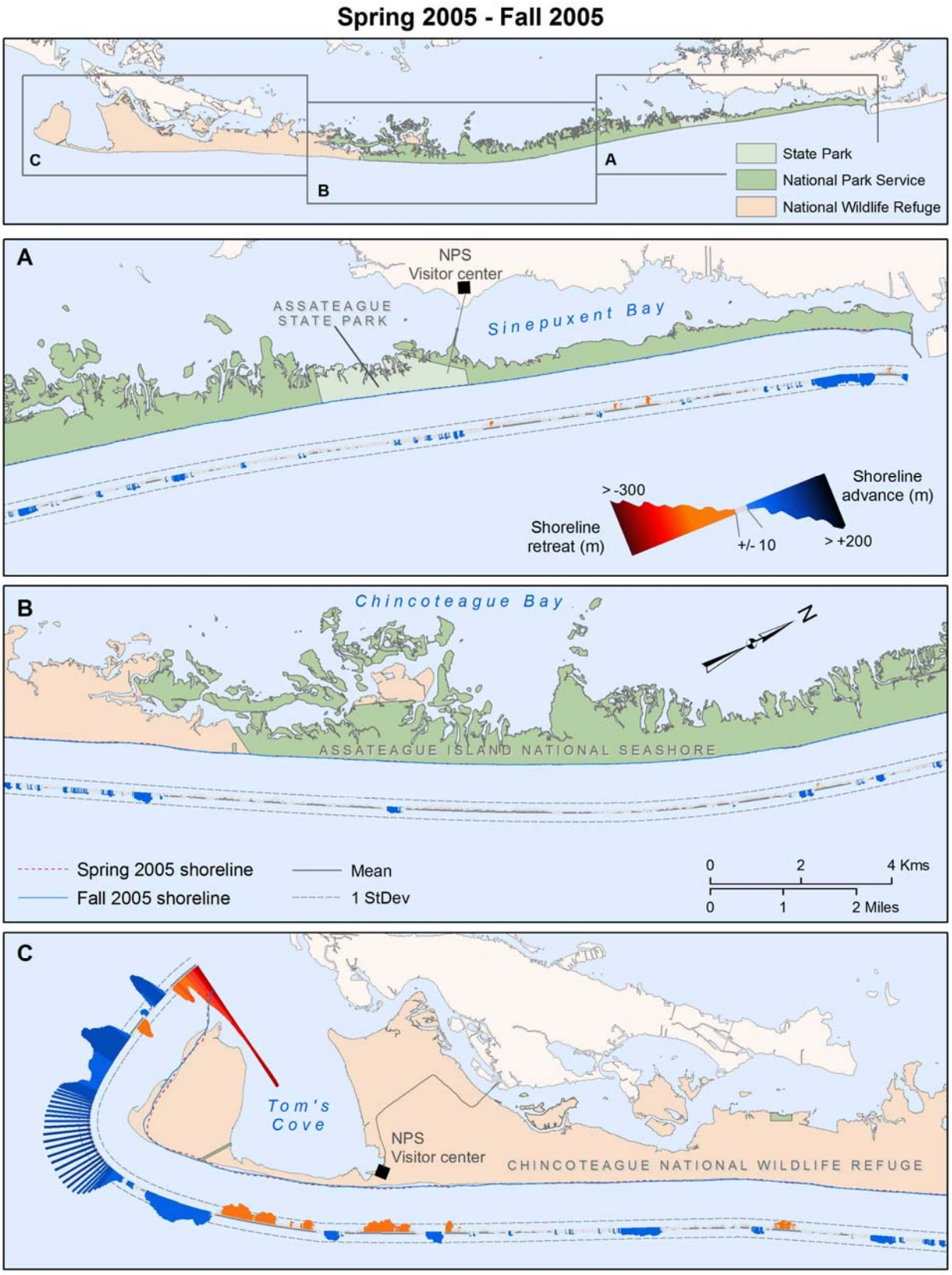

Figure 16. Distribution of seasonal shoreline change along Assateague Island, Spring 2005 – Fall 2005.

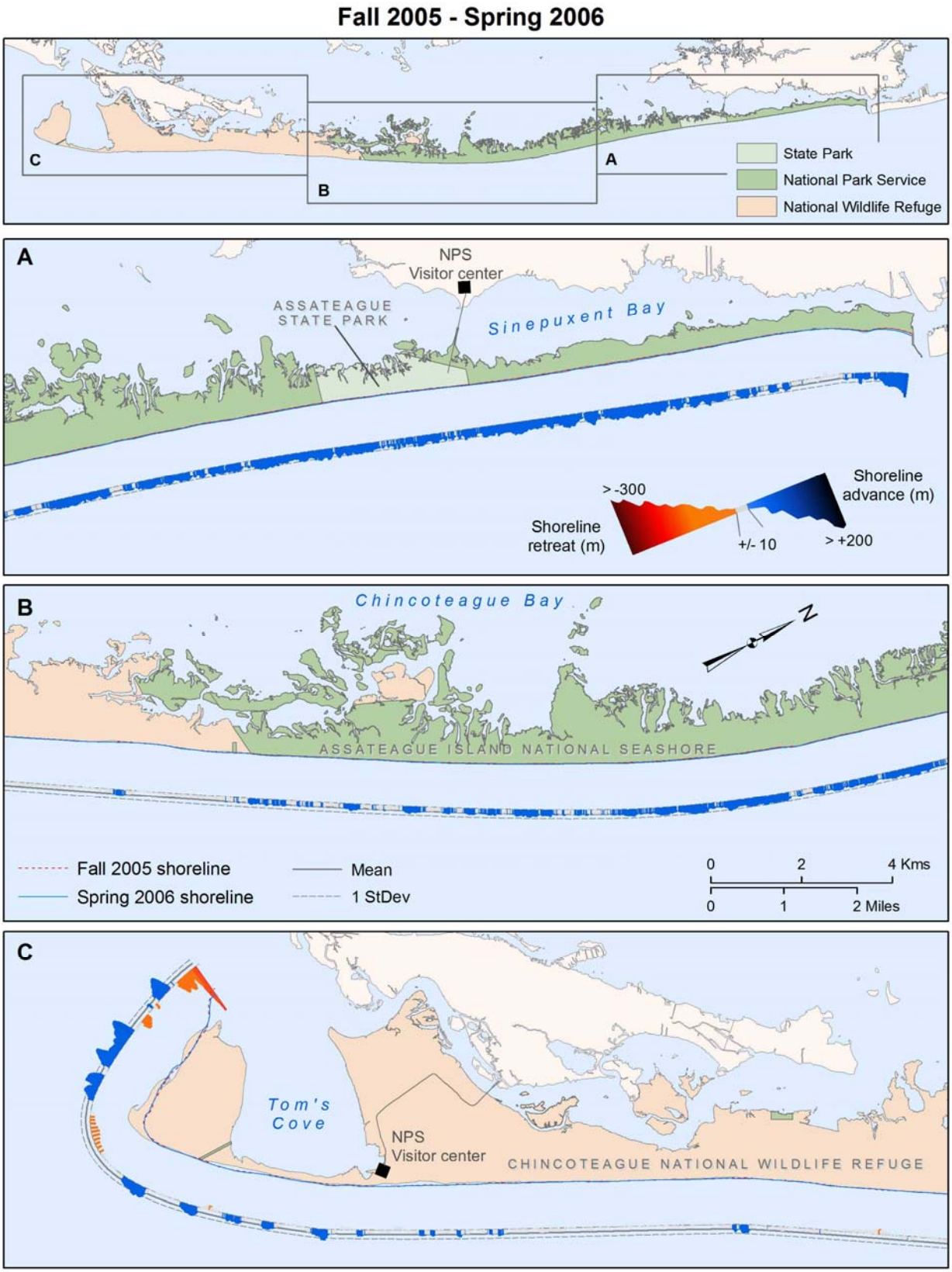

Figure 17. Distribution of seasonal shoreline change along Assateague Island, Fall 2005 – Spring 2006.

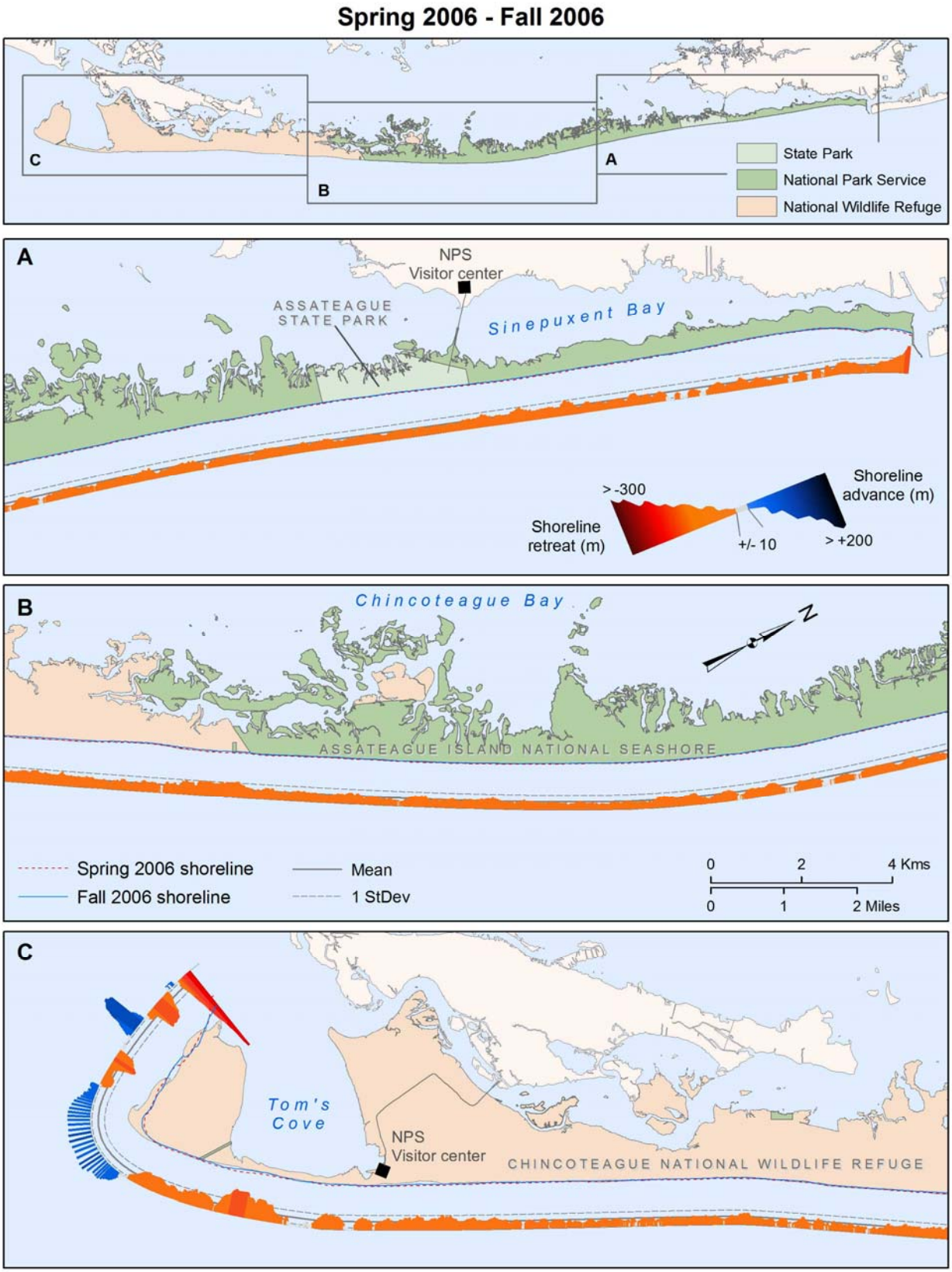

Figure 18. Distribution of seasonal shoreline change along Assateague Island, Spring 2006 – Fall 2006.

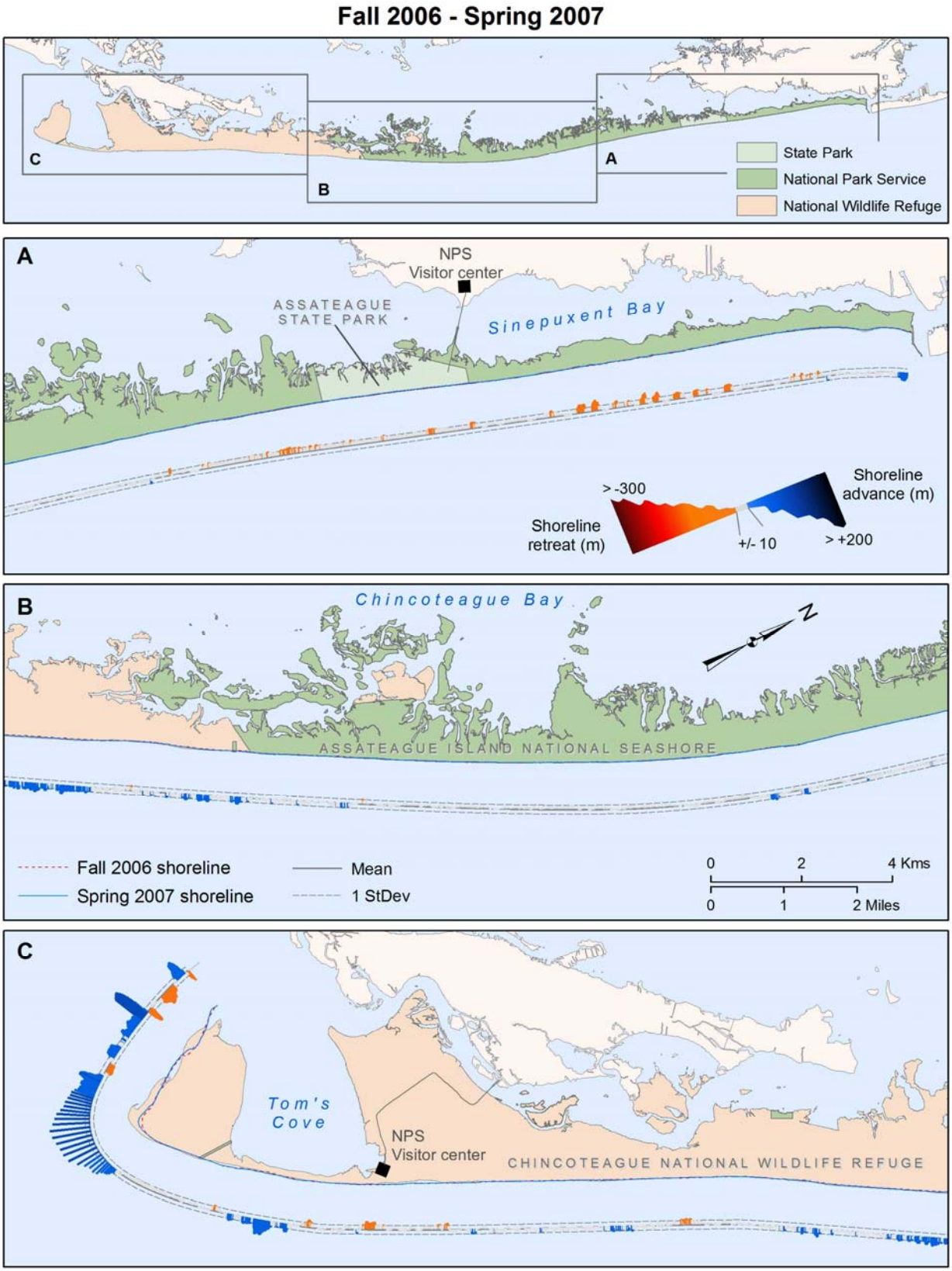

Figure 19. Distribution of seasonal shoreline change along Assateague Island, Fall 2006 – Spring 2007.

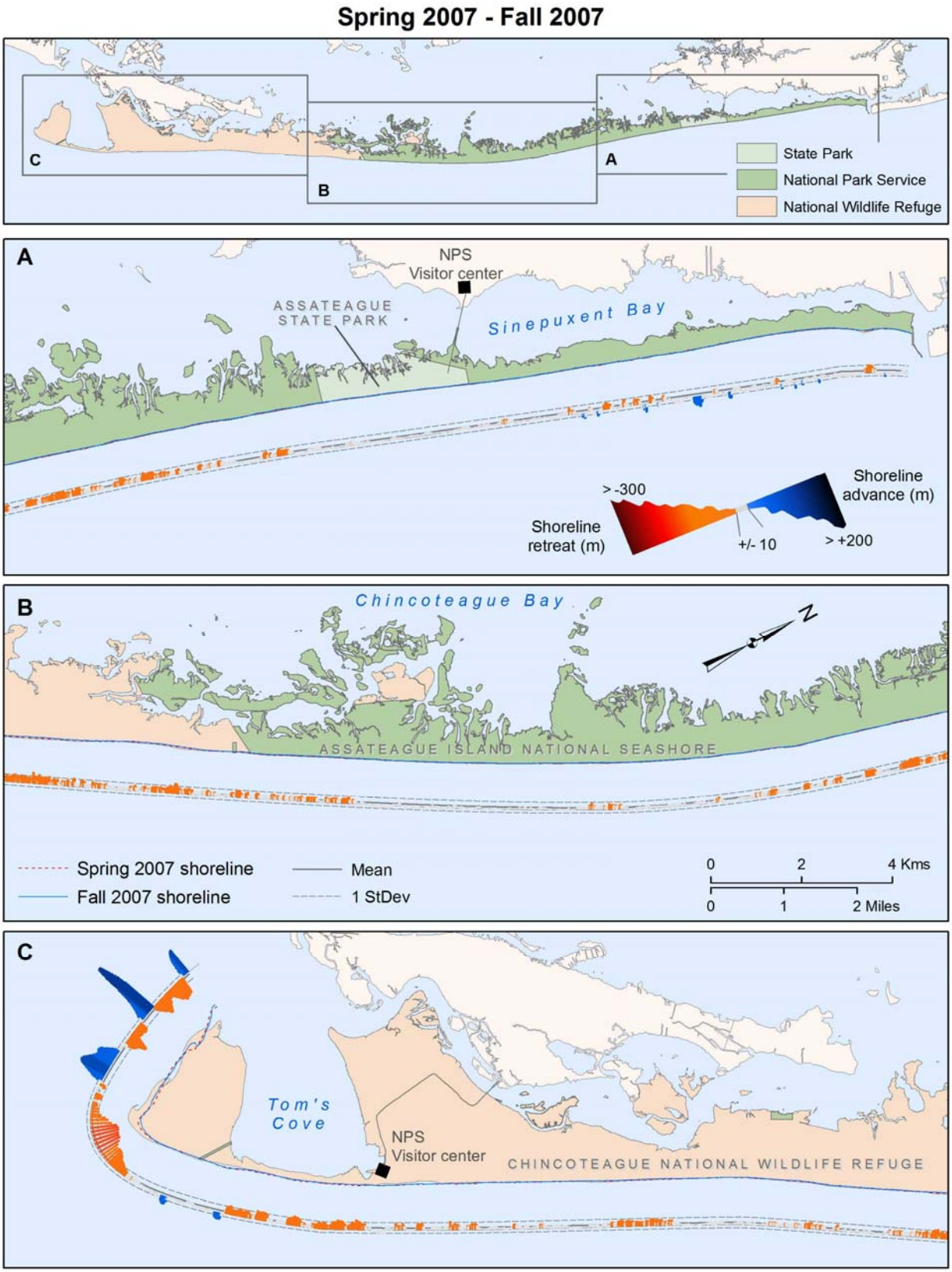

Figure 20. Distribution of seasonal shoreline change along Assateague Island, Spring 2007 – Fall 2007.

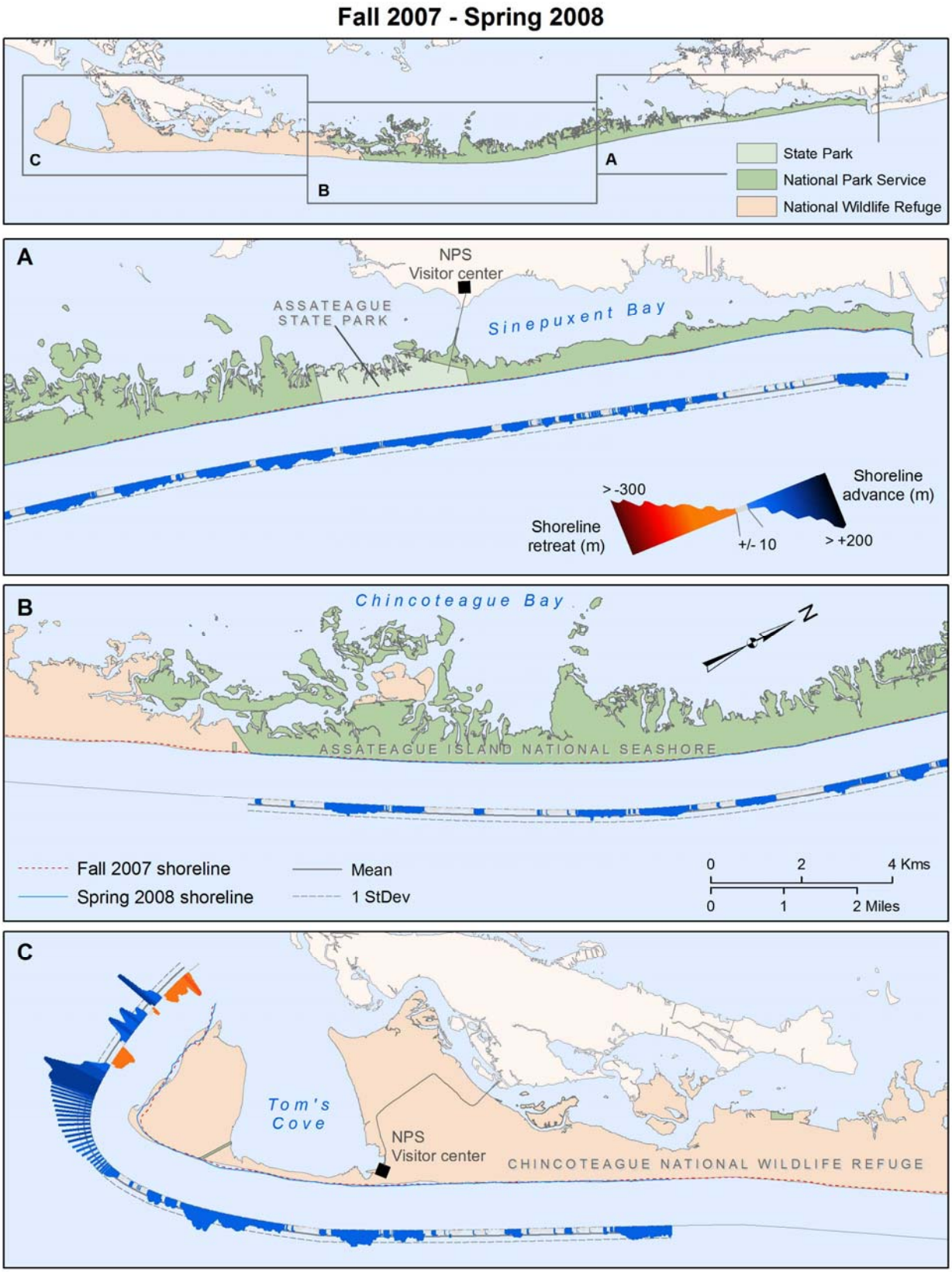

Figure 21. Distribution of seasonal shoreline change along Assateague Island, Fall 2007 – Spring 2008.

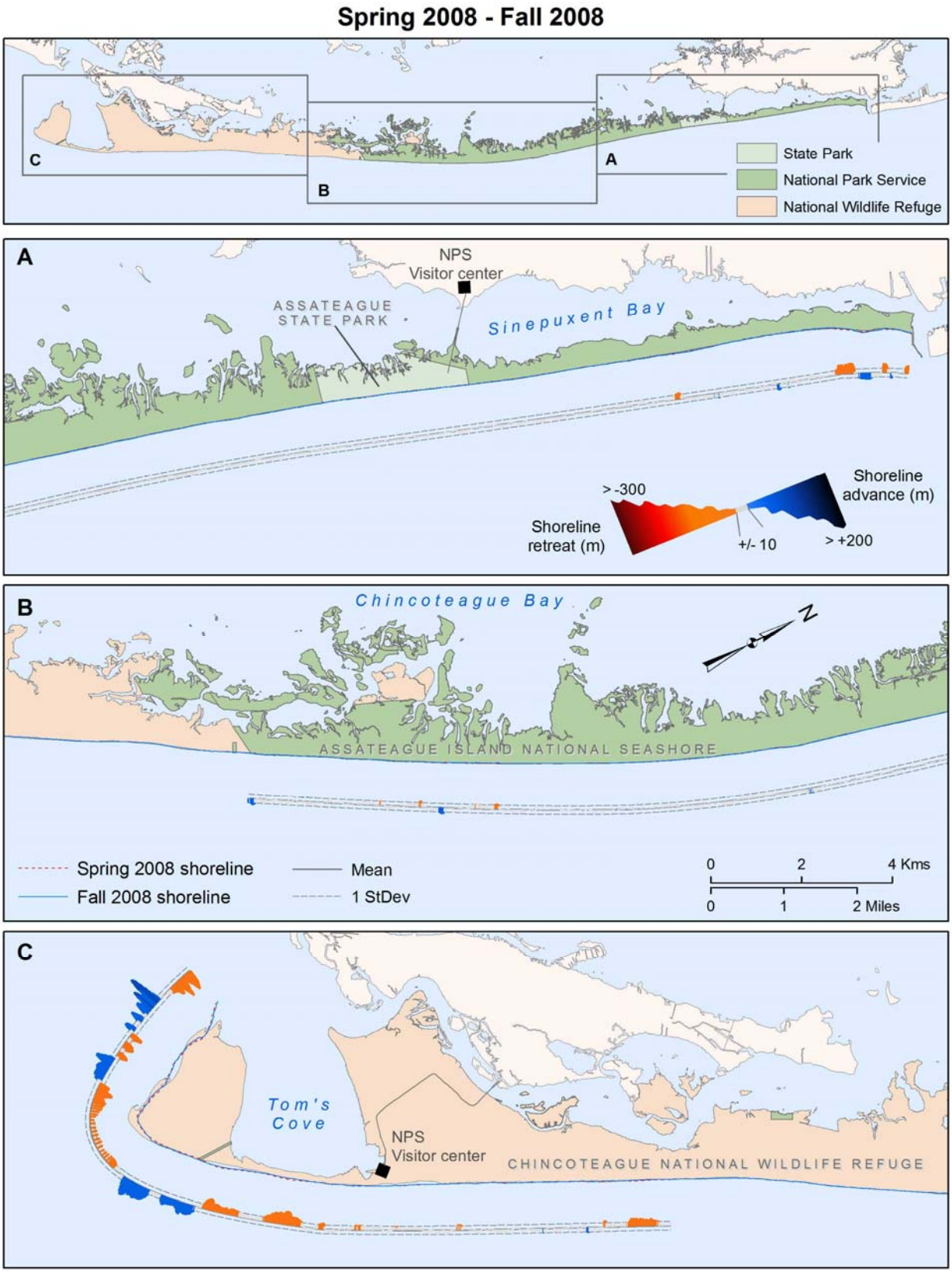

Figure 22. Distribution of seasonal shoreline change along Assateague Island, Spring 2008 – Fall 2008.

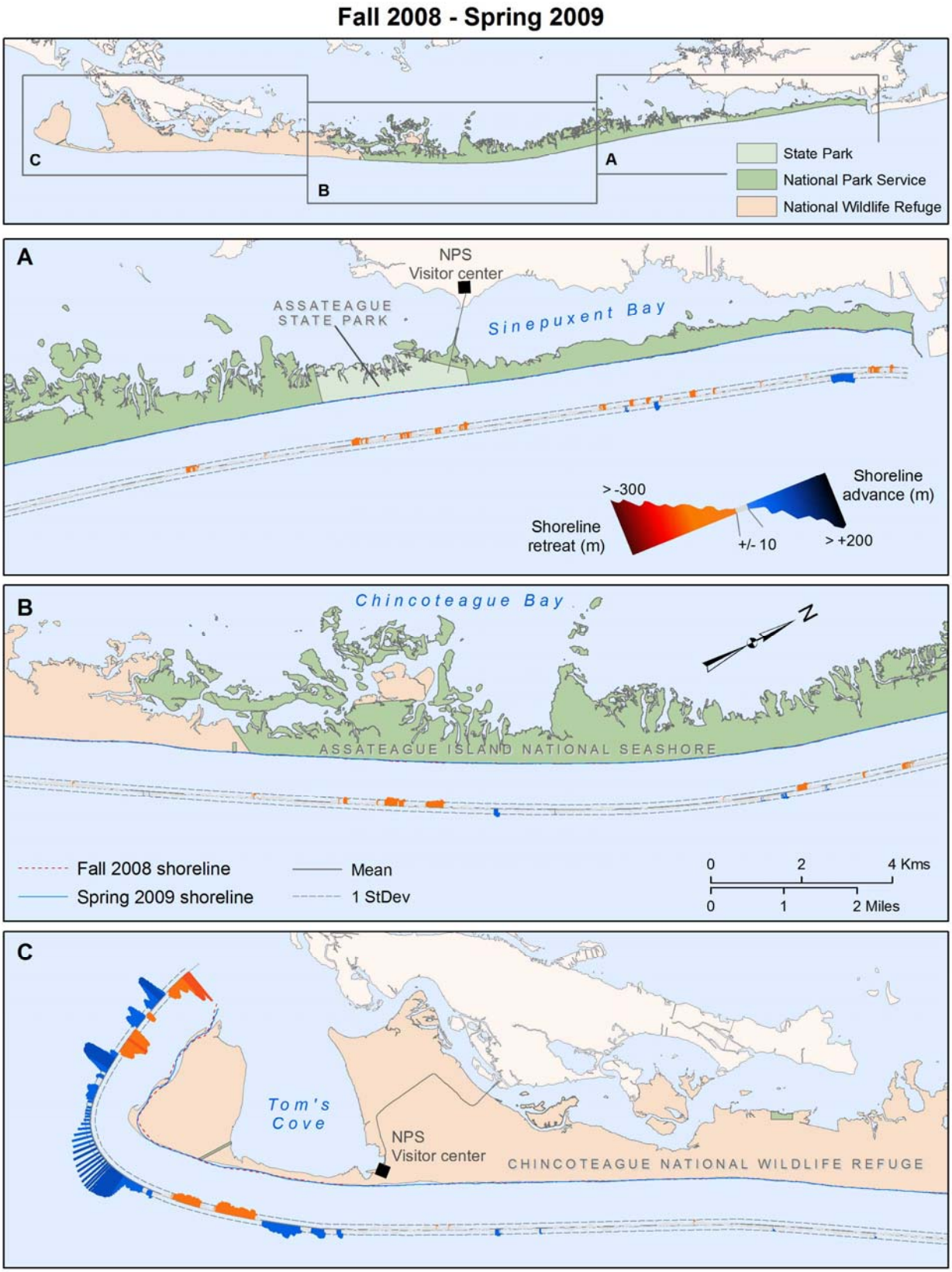

Figure 23. Distribution of seasonal shoreline change along Assateague Island, Fall 2008 – Spring 2009.

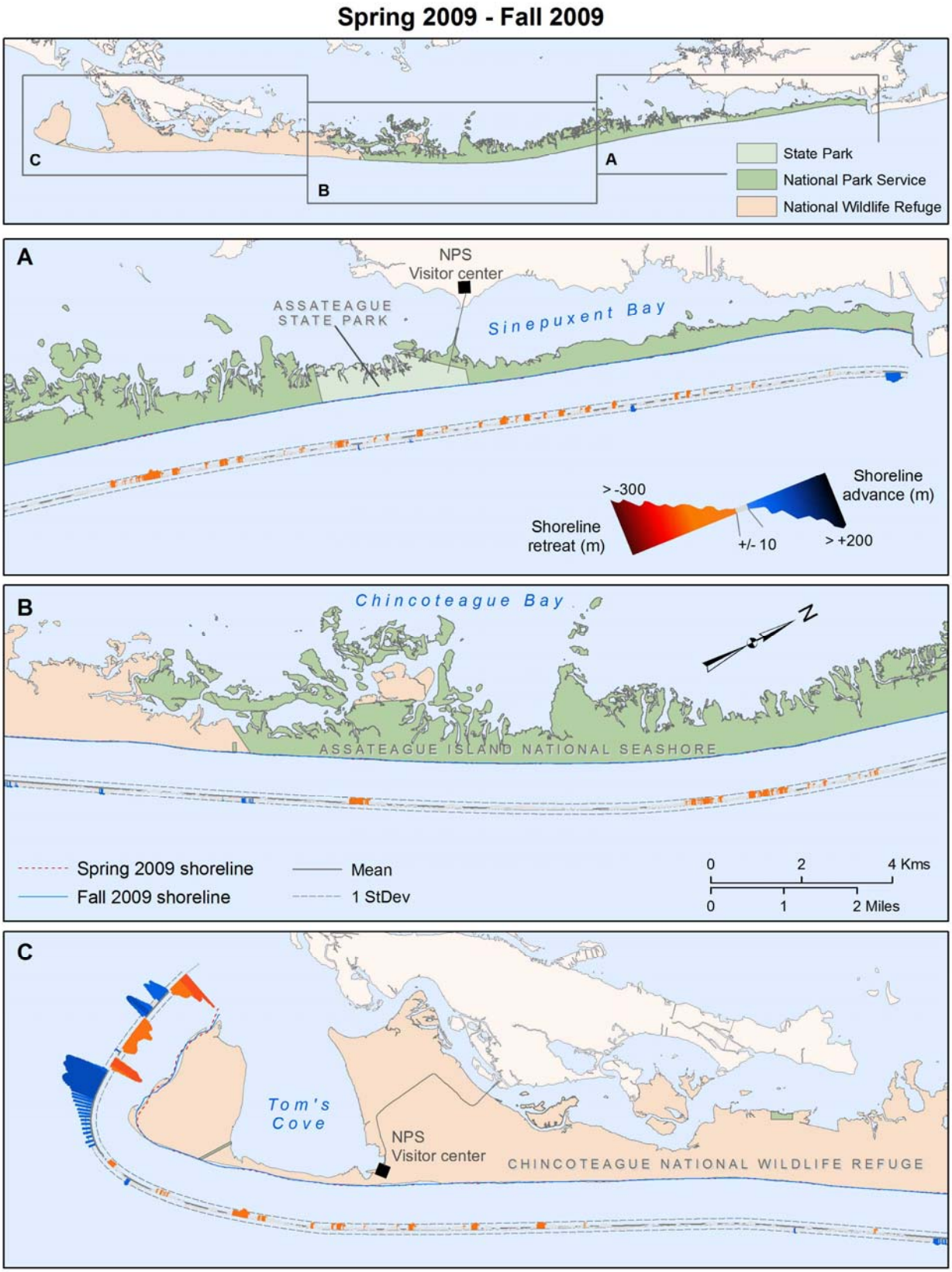

Figure 24. Distribution of seasonal shoreline change along Assateague Island, Spring 2009 – Fall 2009.

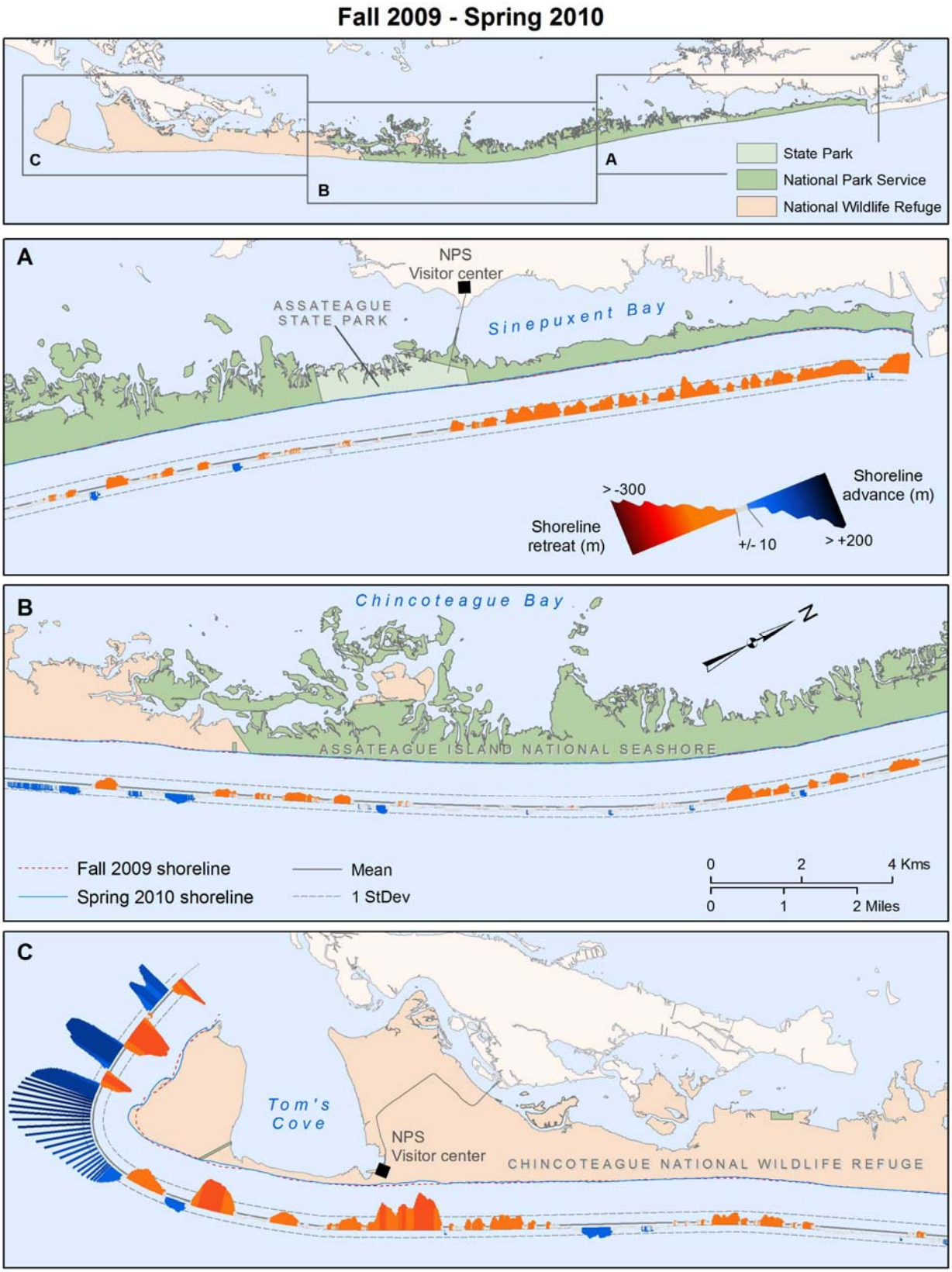

Figure 25. Distribution of seasonal shoreline change along Assateague Island, Fall 2009 – Spring 2010.

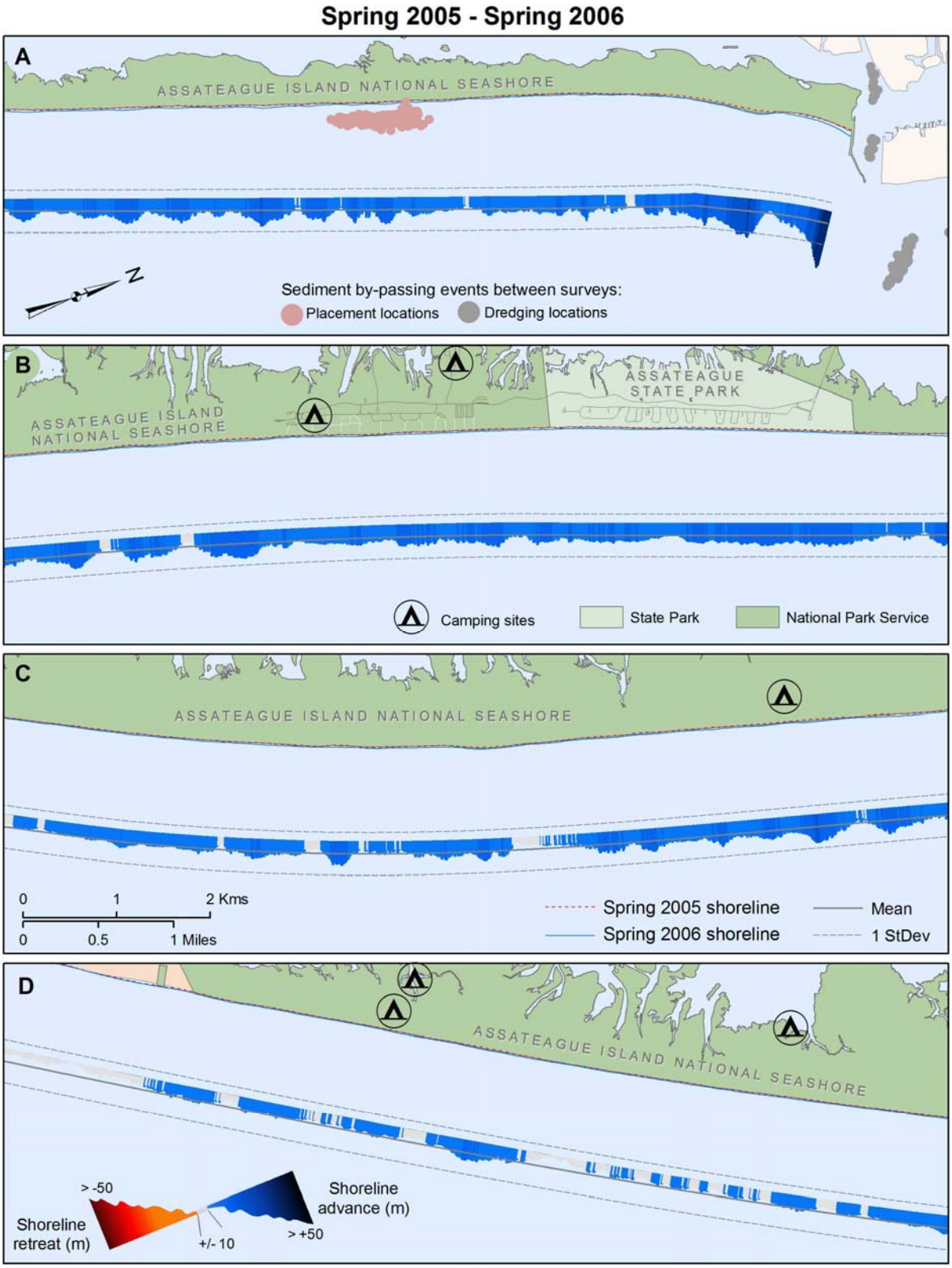

Figure 26. Distribution of annual shoreline change along the Maryland portion of Assateague Island, Spring 2005 – Spring 2006. Sediment by-passing events related to the North End Restoration Project.

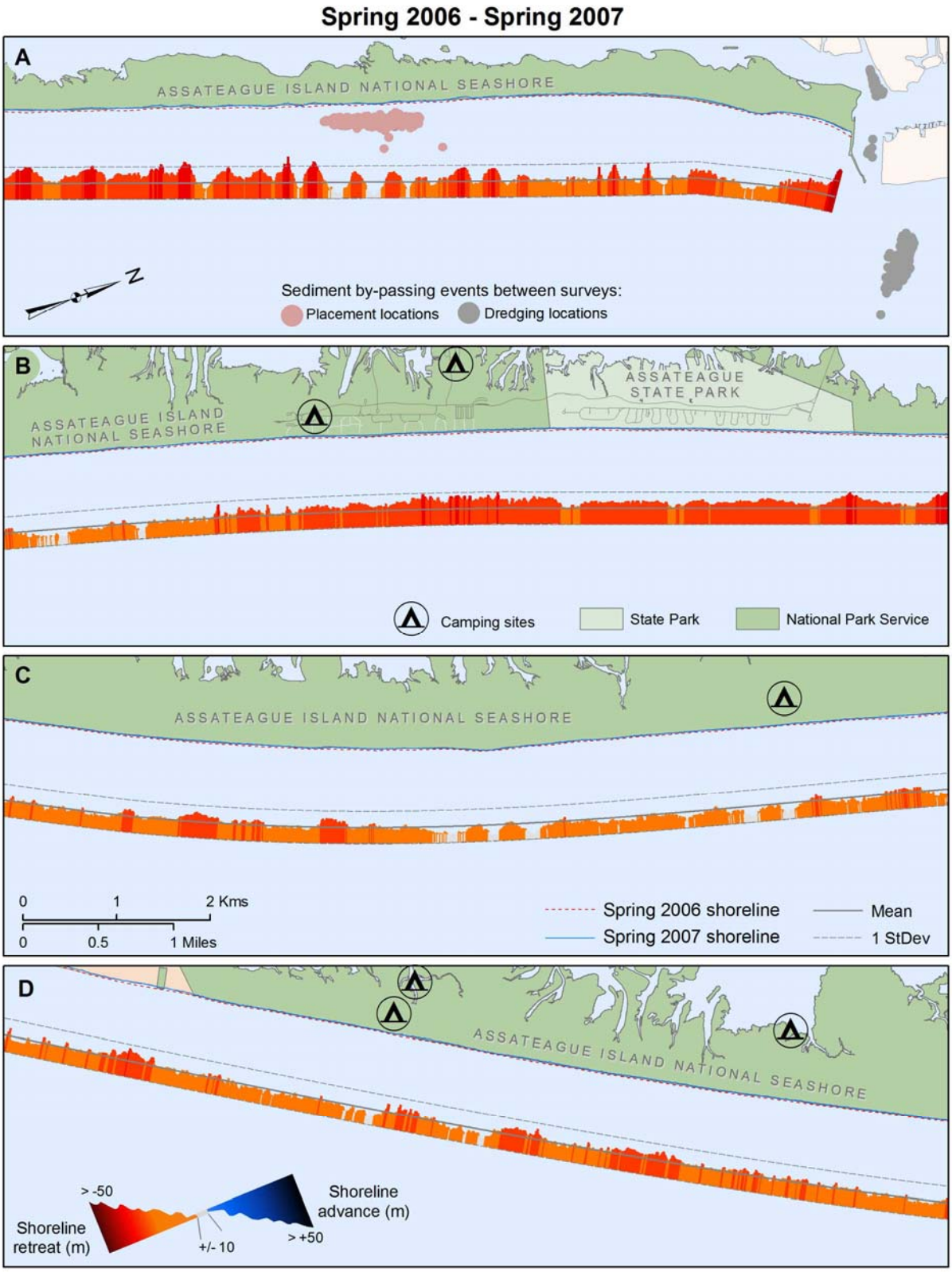

Figure 27. Distribution of annual shoreline change along the Maryland portion of Assateague Island, Spring 2006 – Spring 2007. Sediment by-passing events related to the North End Restoration Project.

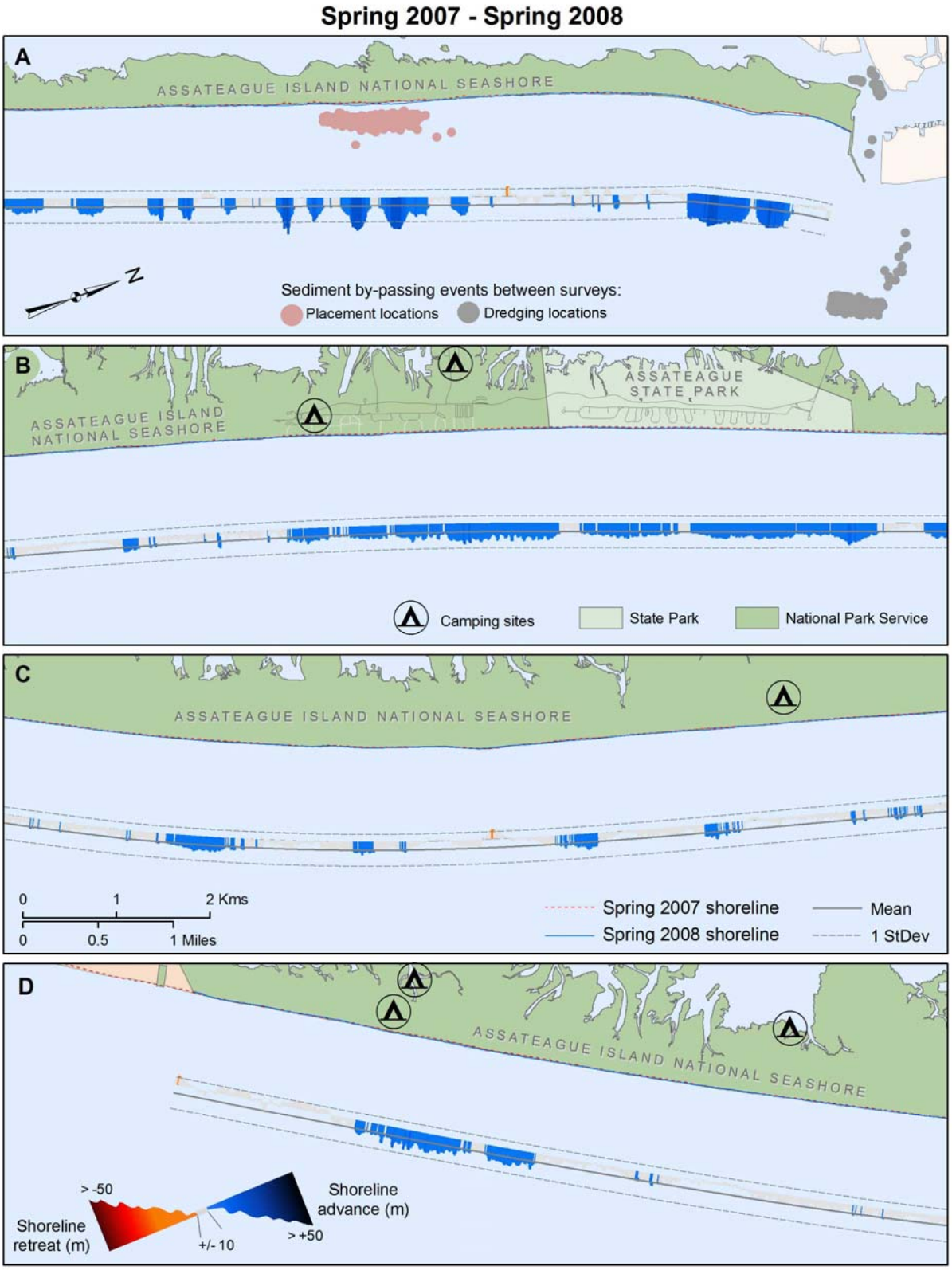

Figure 28. Distribution of annual shoreline change along the Maryland portion of Assateague Island, Spring 2007 – Spring 2008. Sediment by-passing events related to the North End Restoration Project.

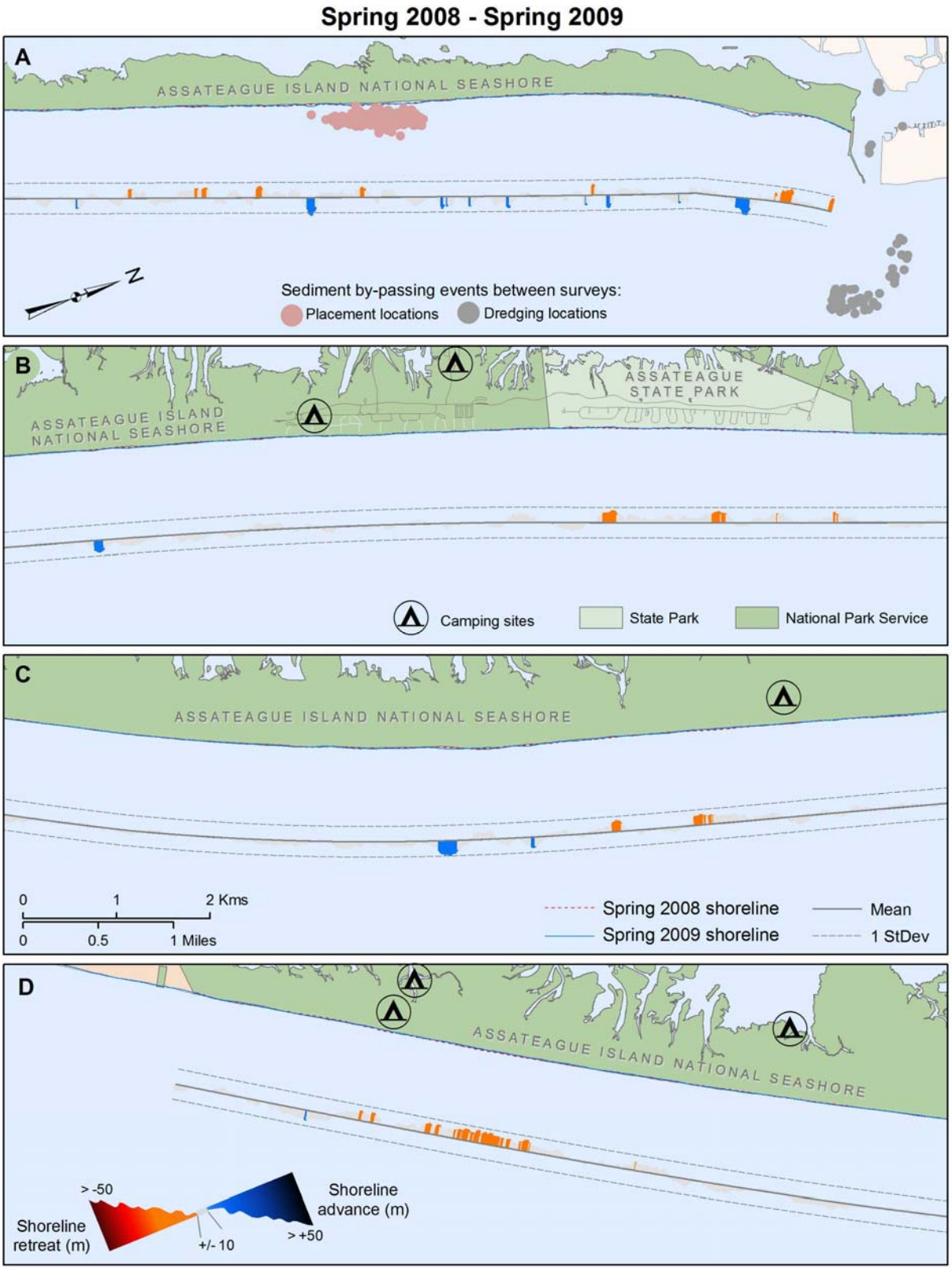

Figure 29. Distribution of annual shoreline change along the Maryland portion of Assateague Island, Spring 2008 – Spring 2009. Sediment by-passing events related to the North End Restoration Project.

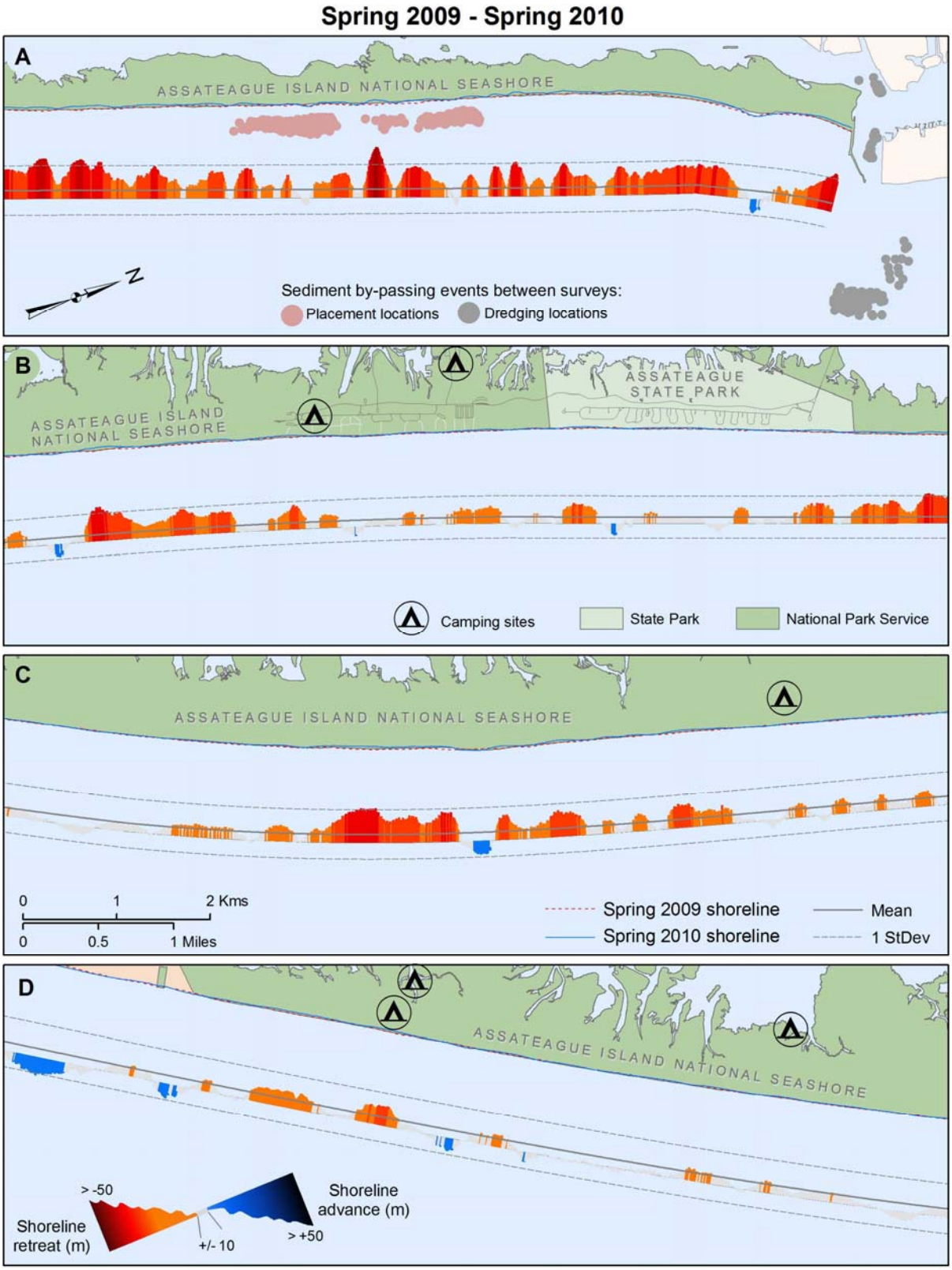

Figure 30. Distribution of annual shoreline change along the Maryland portion of Assateague Island, Spring 2009 – Spring 2010. Sediment by-passing events related to the North End Restoration Project.

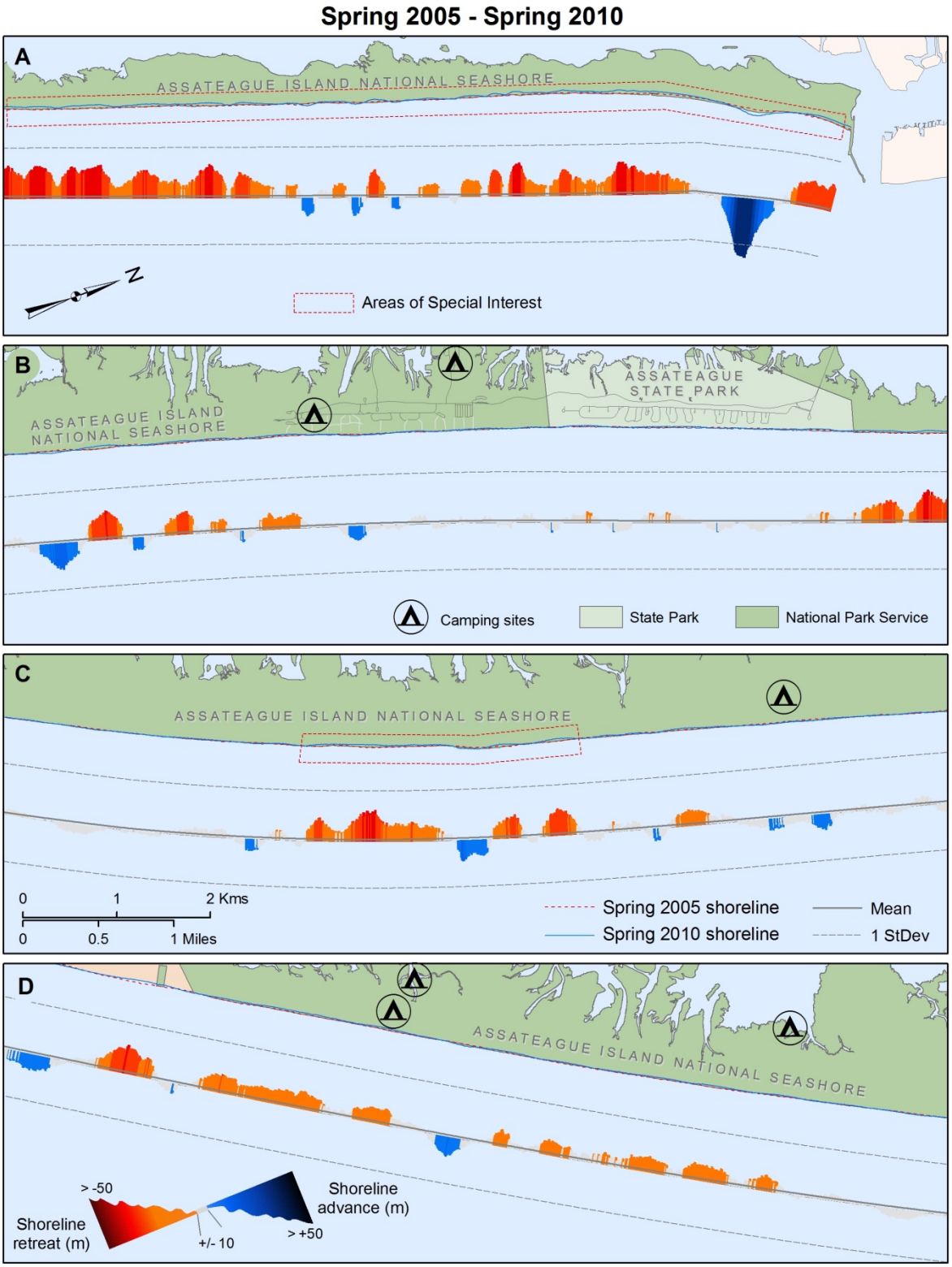

Figure 31. Distribution of annual shoreline change along the Maryland portion of Assateague Island, Spring 2005 – Spring 2010. Areas of special concern in Panel A (downdrift of inlet) and Panel C (washover zone).

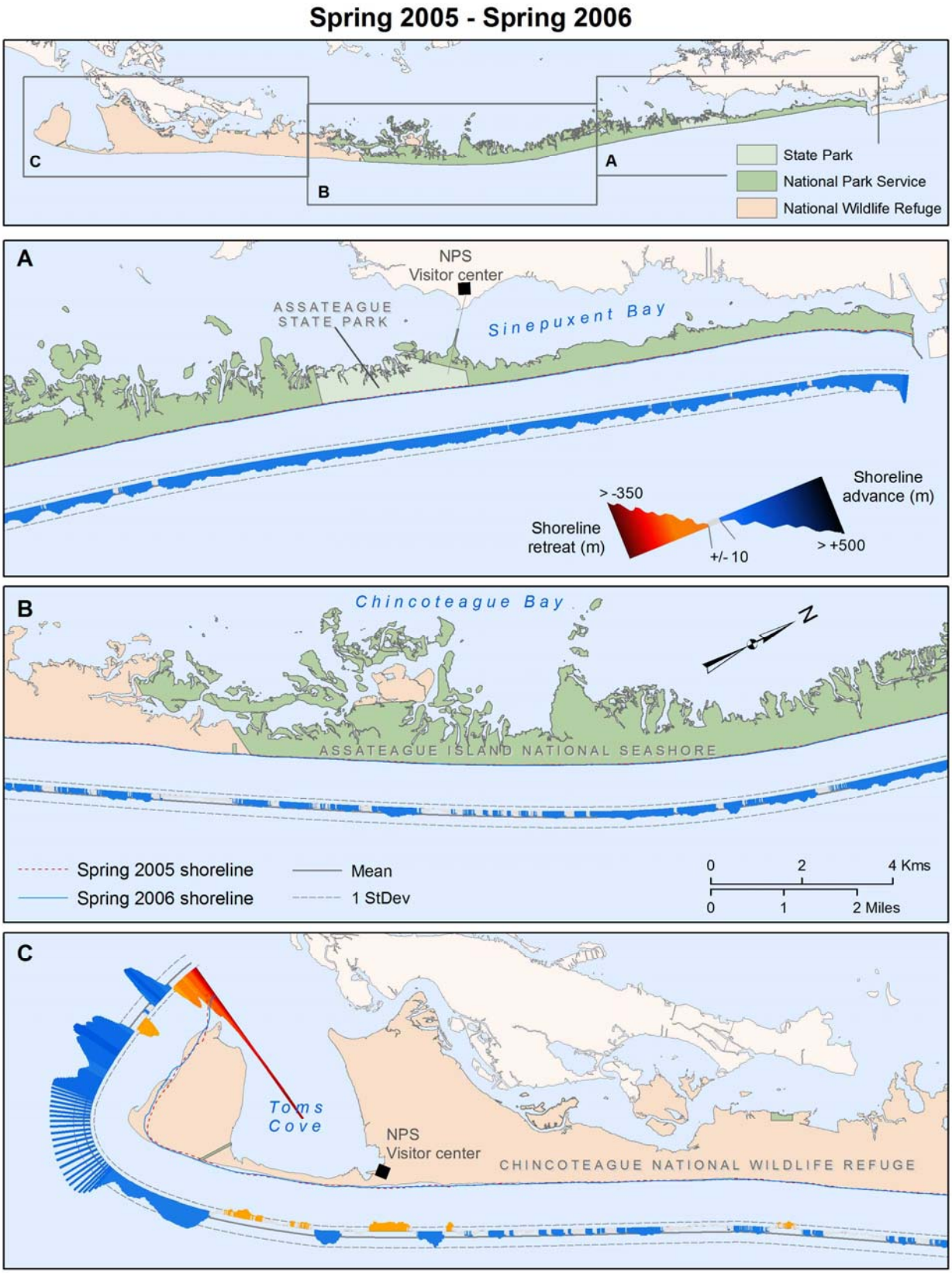

Figure 32. Distribution of annual shoreline change along Assateague Island, Spring 2005 – Spring 2006.

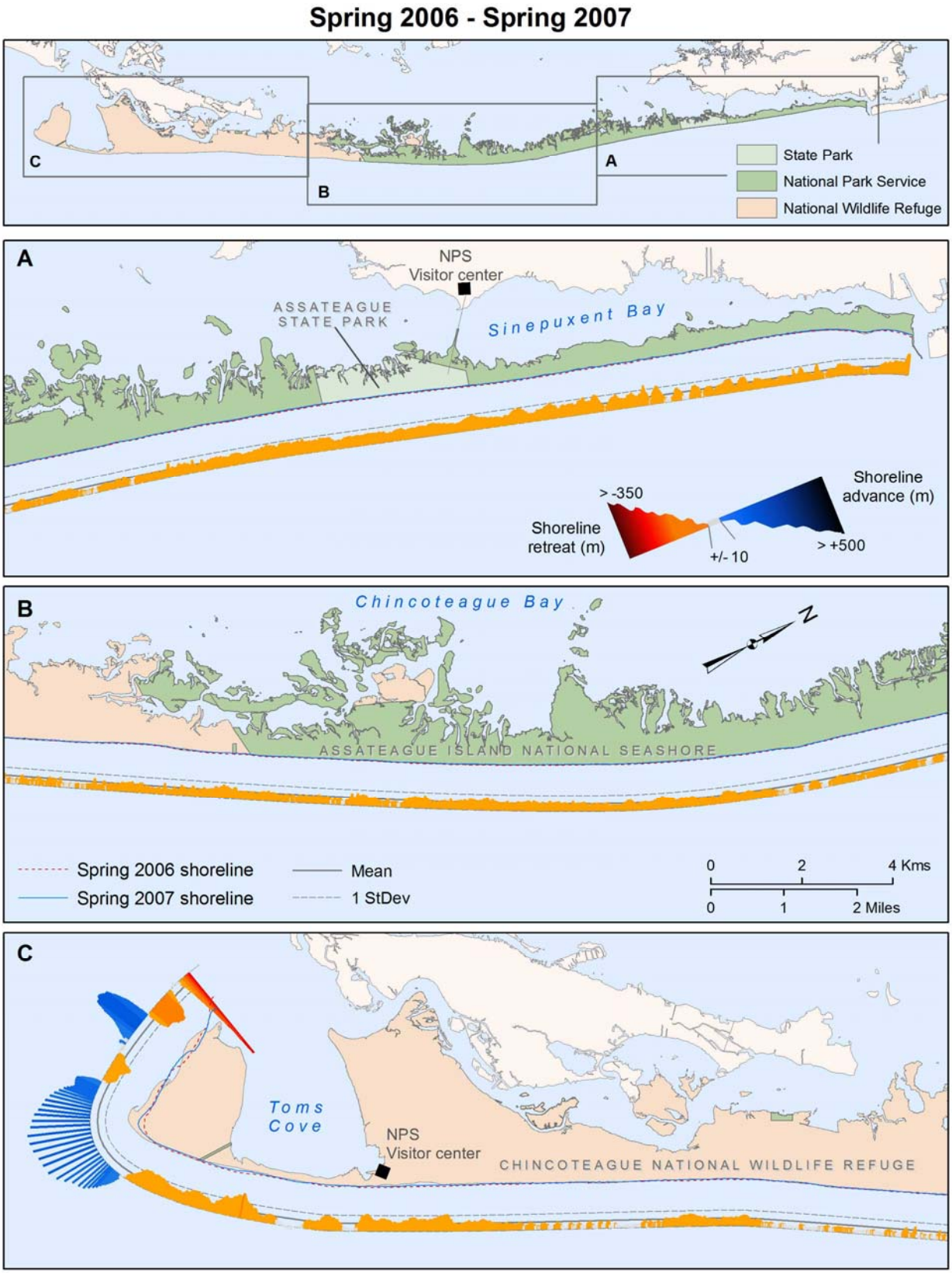

Figure 33. Distribution of annual shoreline change along Assateague Island, Spring 2006 – Spring 2007.

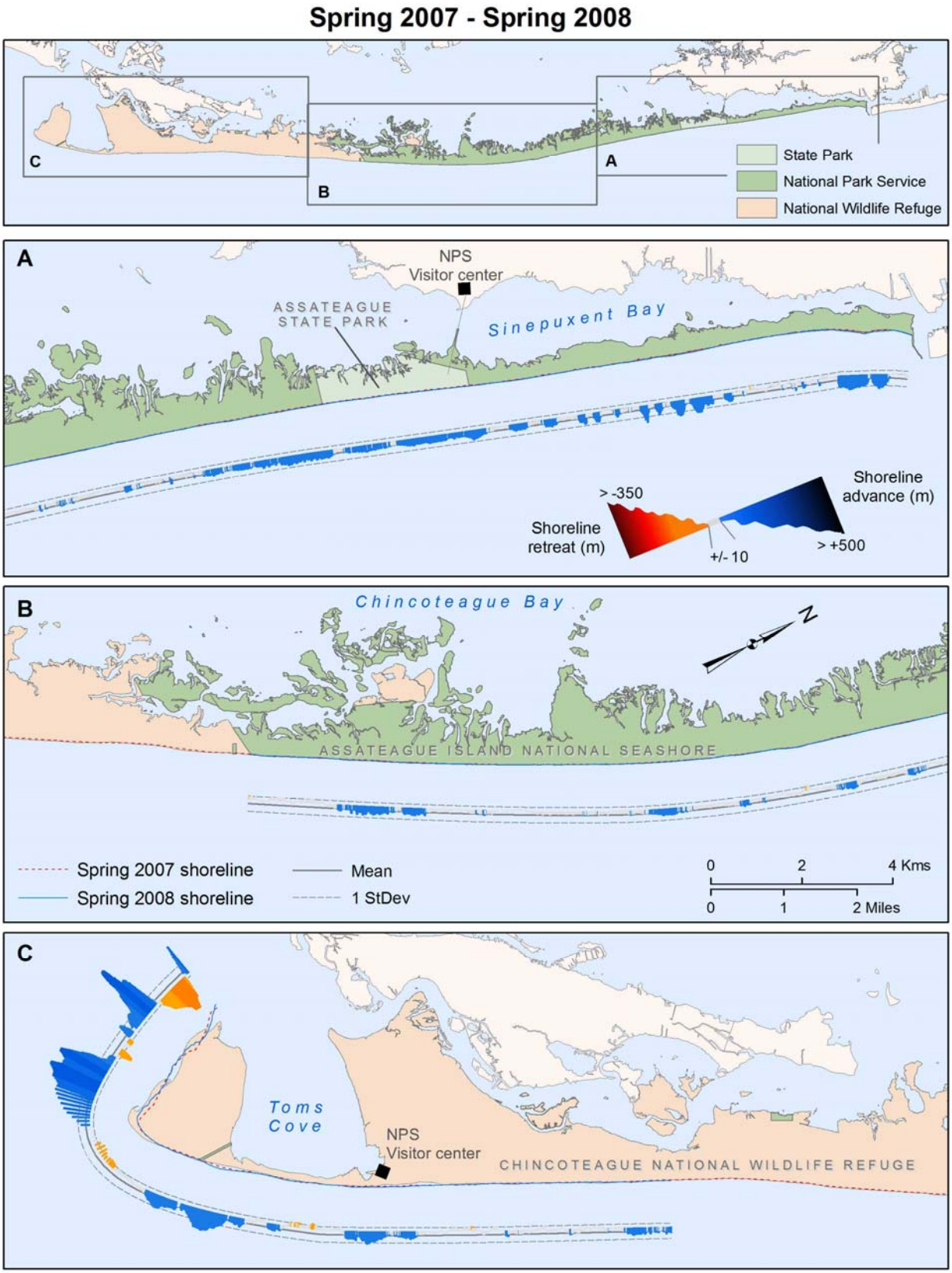

Figure 34. Distribution of annual shoreline change along Assateague Island, Spring 2007 – Spring 2008.

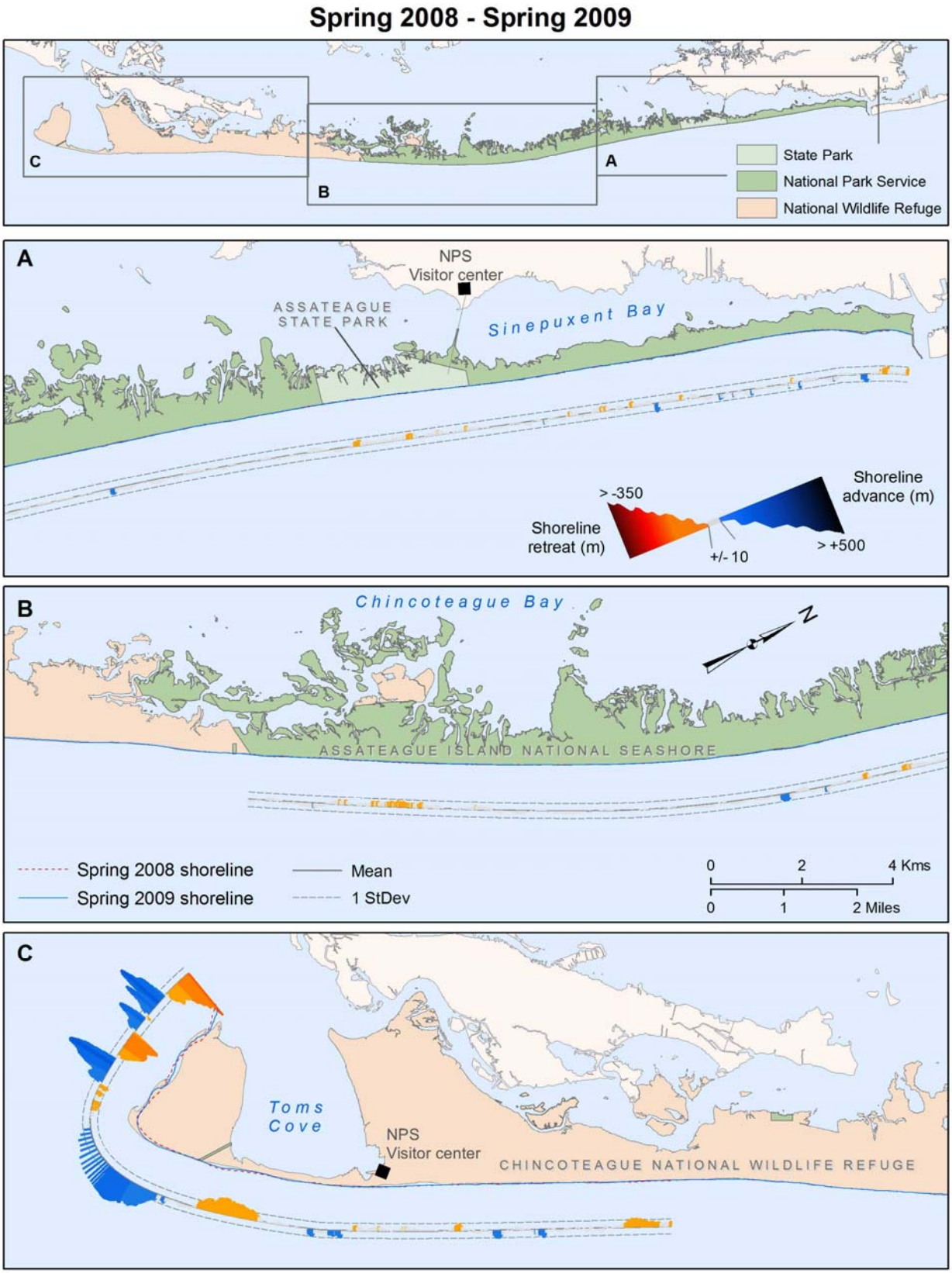

Figure 35. Distribution of annual shoreline change along Assateague Island, Spring 2008 – Spring 2009.

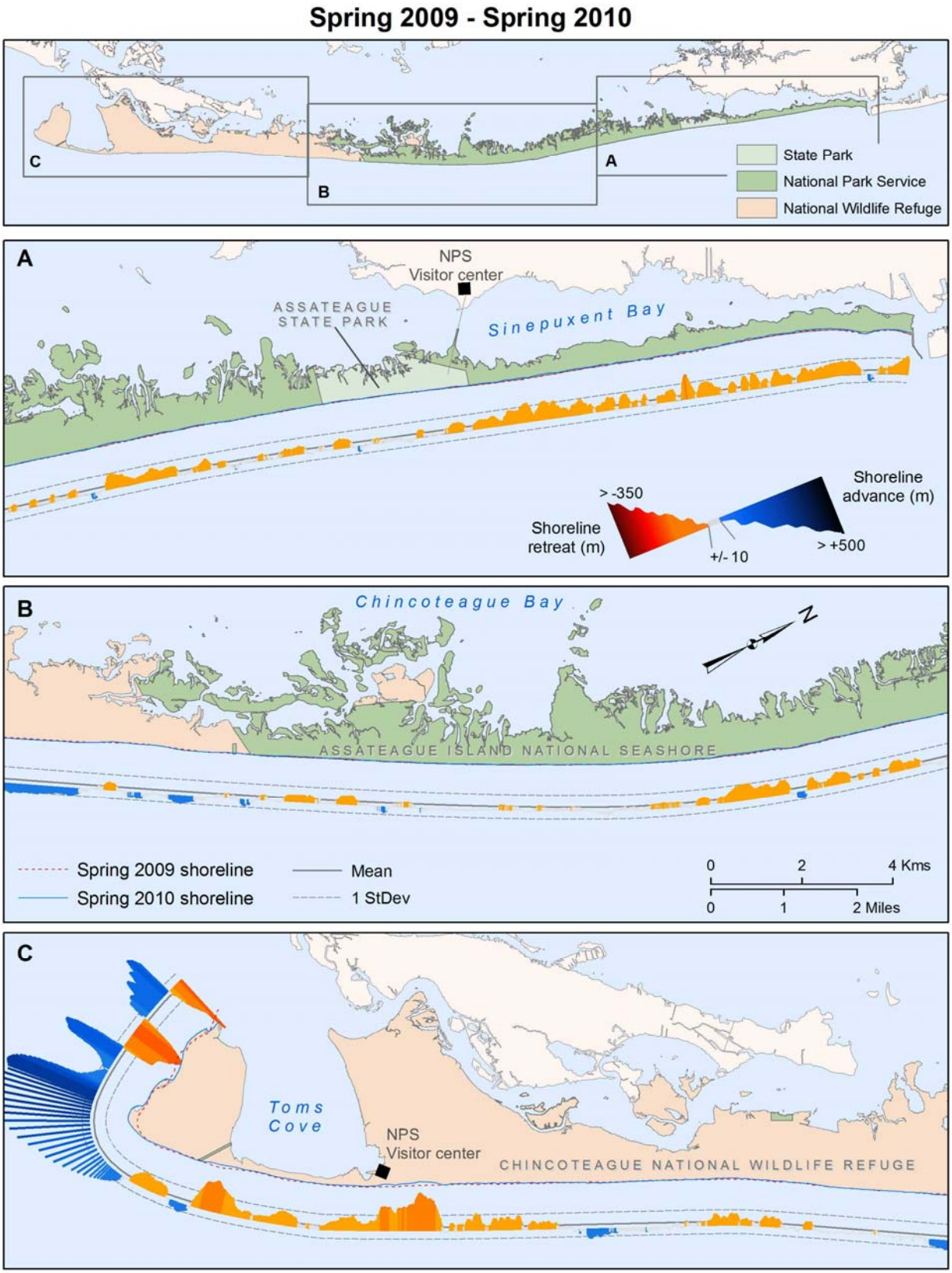

Figure 36. Distribution of annual shoreline change along Assateague Island, Spring 2009 – Spring 2010.

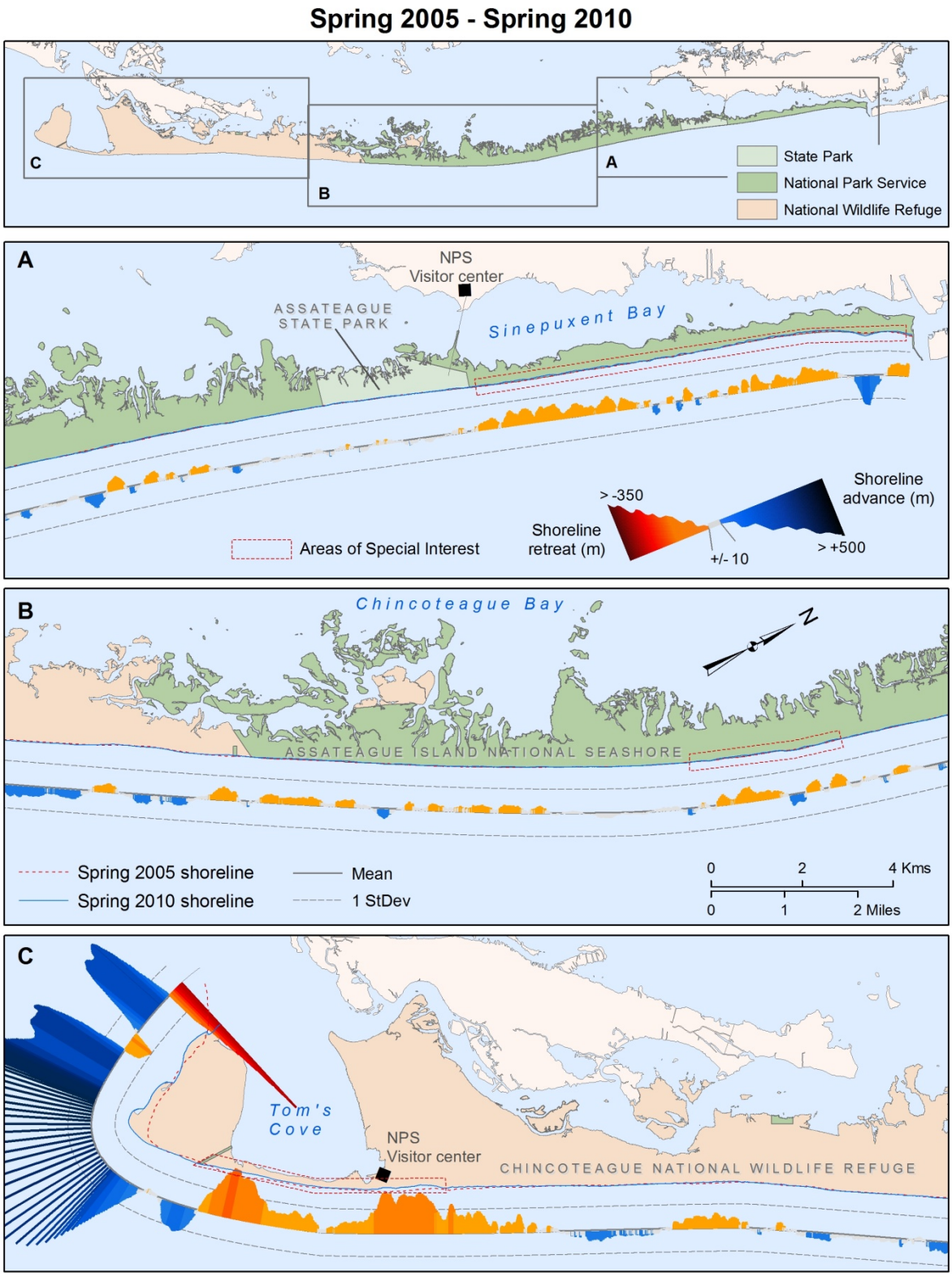

Figure 37. Distribution of shoreline change along Assateague Island between Spring 2005 and Spring 2010, incorporating areas of special concern in Panels A (downdrift of inlet), B (overwash area), and C (narrow strip at Tom's Cove).

Summary Statistics and Tables of Change

The shoreline change data are presented in their seasonal, annual, and 5-year data comparisons, as histograms incorporating the totality of measures of the site. The sequence establishes the conditions in the ASIS Maryland section (Figs. 38-47, 58-62, and 68), followed by the totality of Assateague Island (Maryland and Virginia) (Figs. 48-57, 63-66, and 69). All of the histograms depict a +/- 10 m zone (lighter blue) related to the categories applied in the Shoreline Change Mapper. In addition, the mean value of shoreline change, the standard deviation, and the maximum and minimum values for the period are on the histogram. Measurements associated with the Spring 2006 survey may have a survey error because there is such a systematic displacement.

Seasonal Changes

Seasonal displacements of the shoreline along the entire Assateague barrier island are influenced by the large values of erosion and deposition at the downdrift terminus of the island (Figs. 48-57). The histograms incorporate very large maximums and minimus while preserving a near-normal distribution around a central tendency (Figs. 38-47 and 48-57). Each of the histograms incorporates a mean value, a standard deviation value (large because of the multimodal distribution), and maximums and minimums. The Spring 2006 survey may be in error and influence any comparative measure.

Annual Changes

The shoreline displacements that occur over the span of a year tend to amalgamate the seasonal contrasts and tend to more closely resemble the effects of the sediment budget (reductions in sediment leading to inland shoreline displacement, and vice versa) (Figs. 58-62 and 63-66). The histograms tend to have smaller spreads and tighter fits, with the exception of comparisons based on the Spring 2006 surveys. Similar to the data in the seasonal change matrix, the large changes at the Tom’s Cove section produce large maximums and minimums and alter means and standard deviations of the histograms portraying the entire island.

5-Year Data Distribution

A comparison of the shoreline position over the 5-year period tends to be more representative of the trend, although it remains a very short time span and is subject to many natural variations in the driving forces and availability of sediment supply. The histogram for the Maryland section of Assateague Island (Fig. 68) has a very broad spread of shoreline change measurements (a diffused central tendency), a broad spread of extreme values, and a relatively large standard deviation. However, there are also a large number of measurements that are greater than the measure of uncertainty and there is a statistical validation of the tendency of the displacement. The histogram for all of Assateague Island (Fig. 69) has a much larger range of values because of the erosion and deposition at Tom’s Cove Hook, and a much larger standard deviation. However, there is a more pronounced central tendency (stronger peak) that is representing the condition of the entire island.

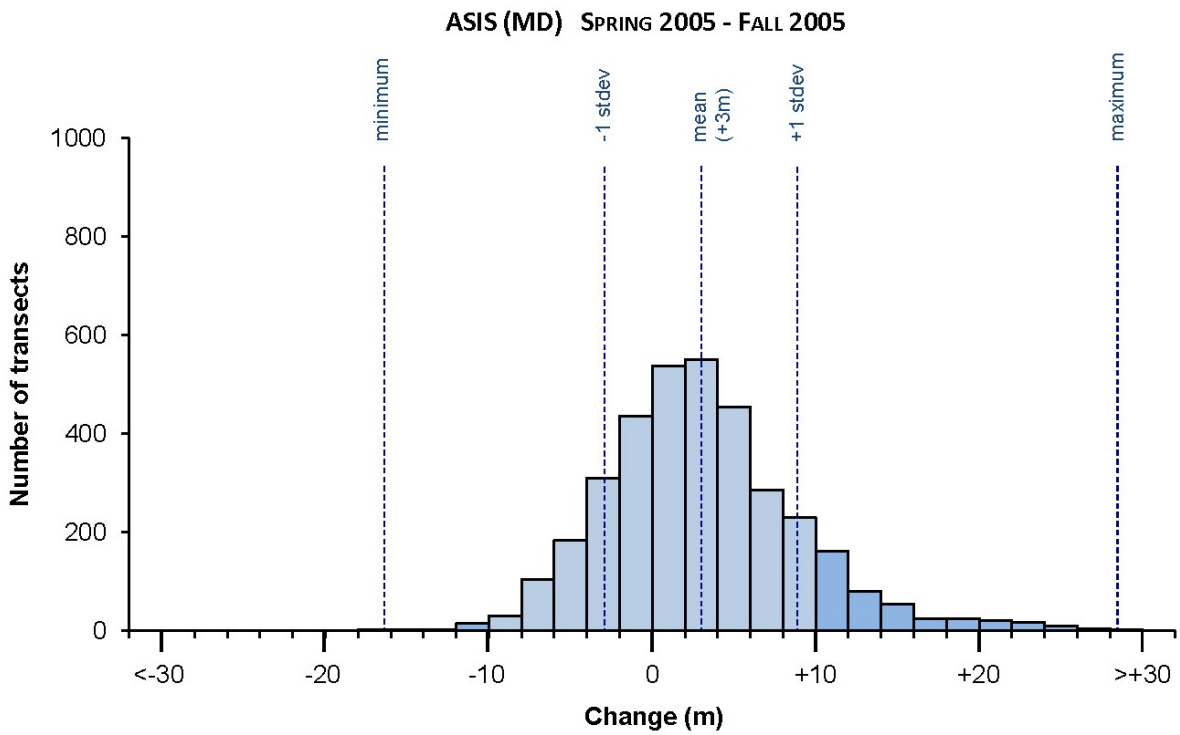

Figure 38. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Spring 2005 – Fall 2005.

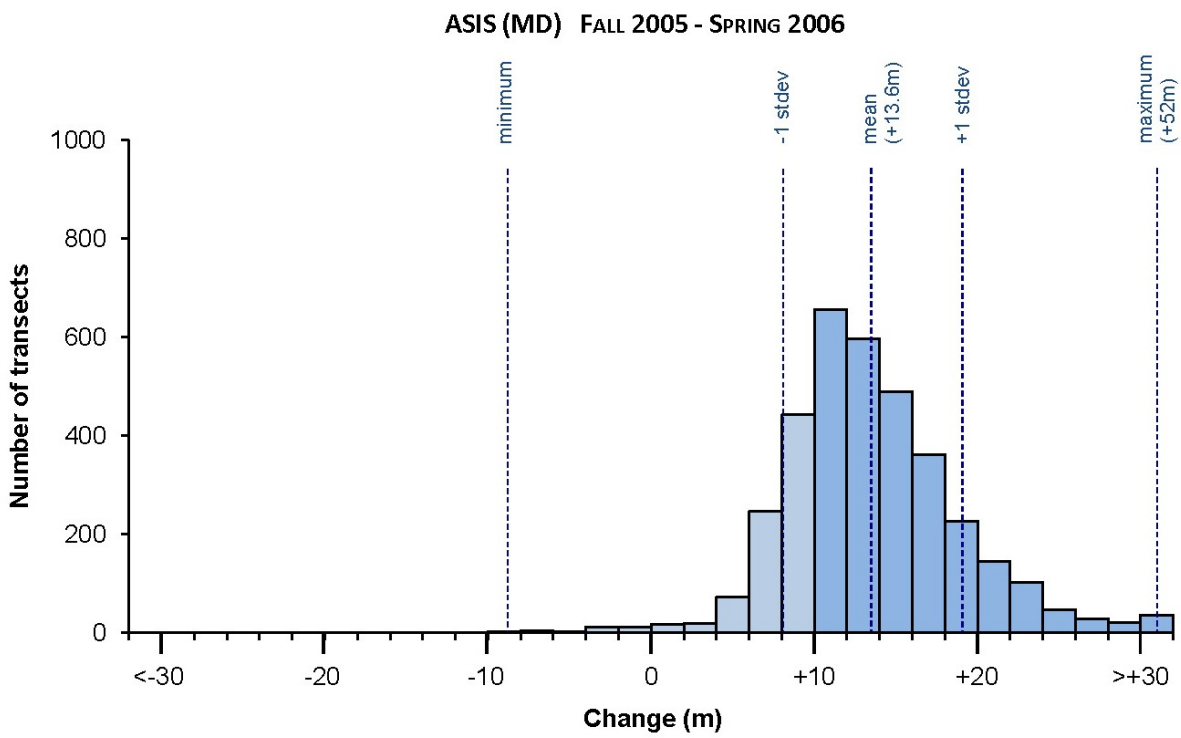

Figure 39. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Fall 2005 – Spring 2006**.**

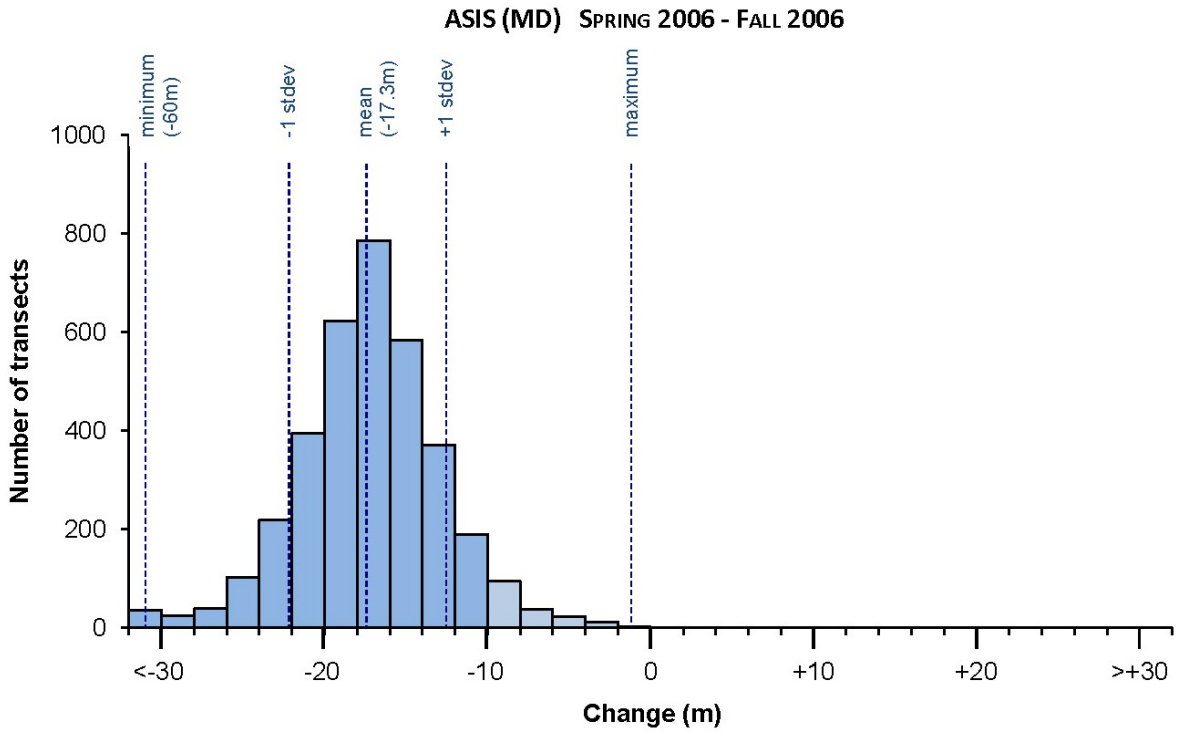

Figure 40. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Spring 2006 – Fall 2006.

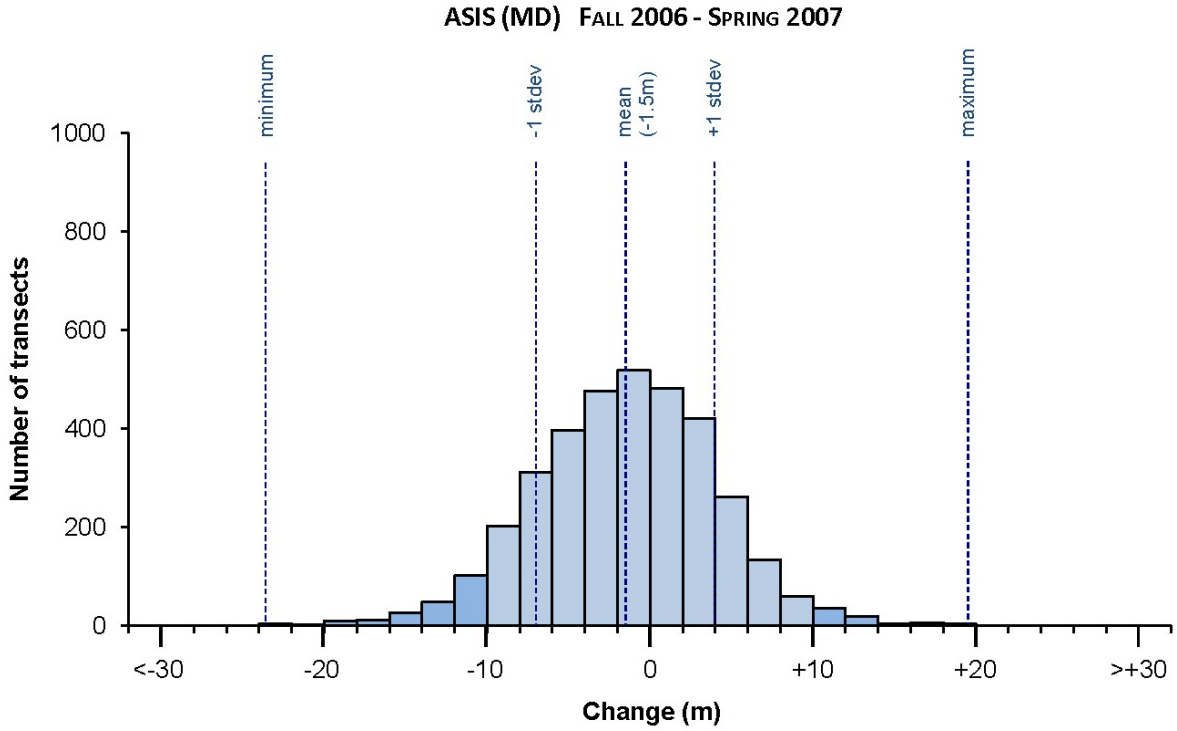

Figure 41. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Fall 2006 – Spring 2007.

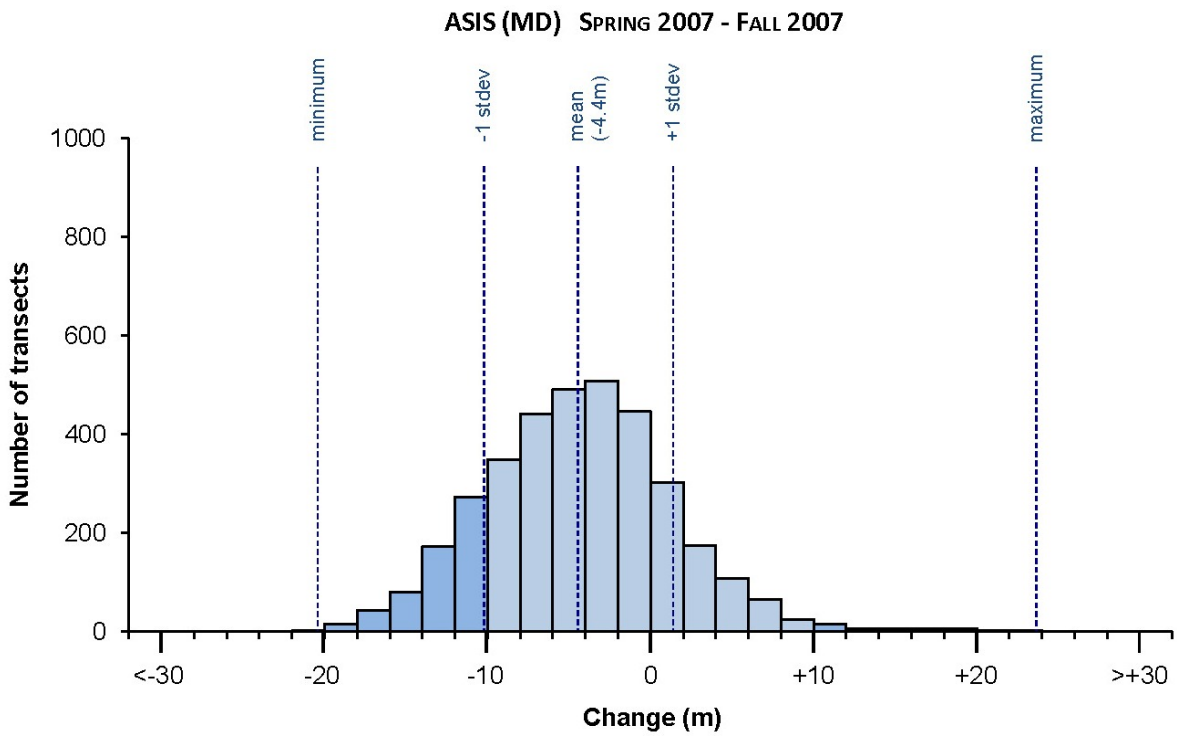

Figure 42. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Spring 2007 – Fall 2007.

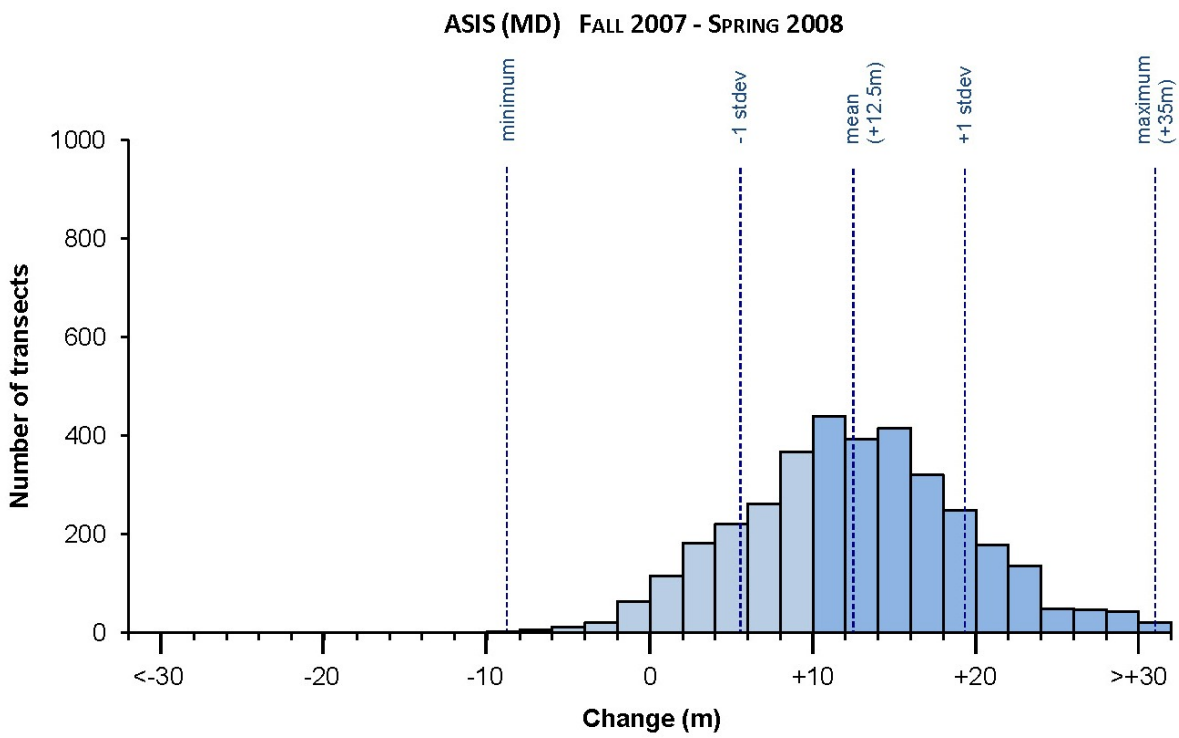

Figure 43. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Fall 2007 – Spring 2008.

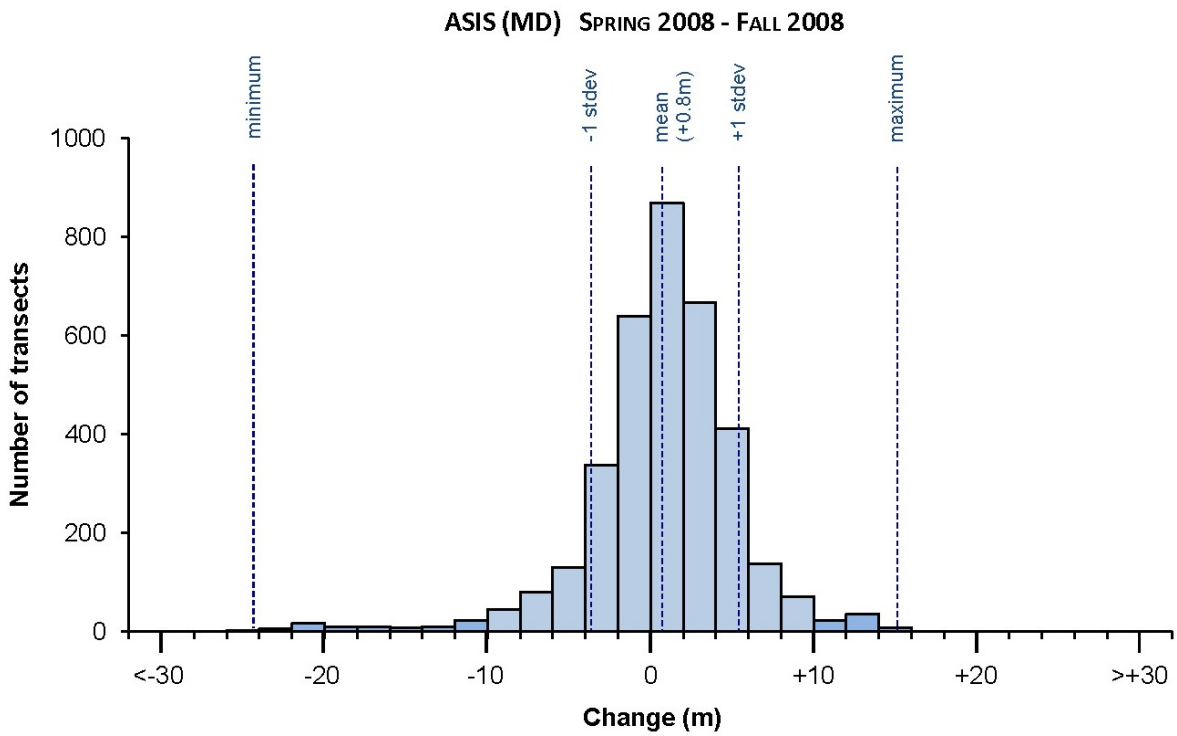

Figure 44. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Spring 2008 – Fall 2008.

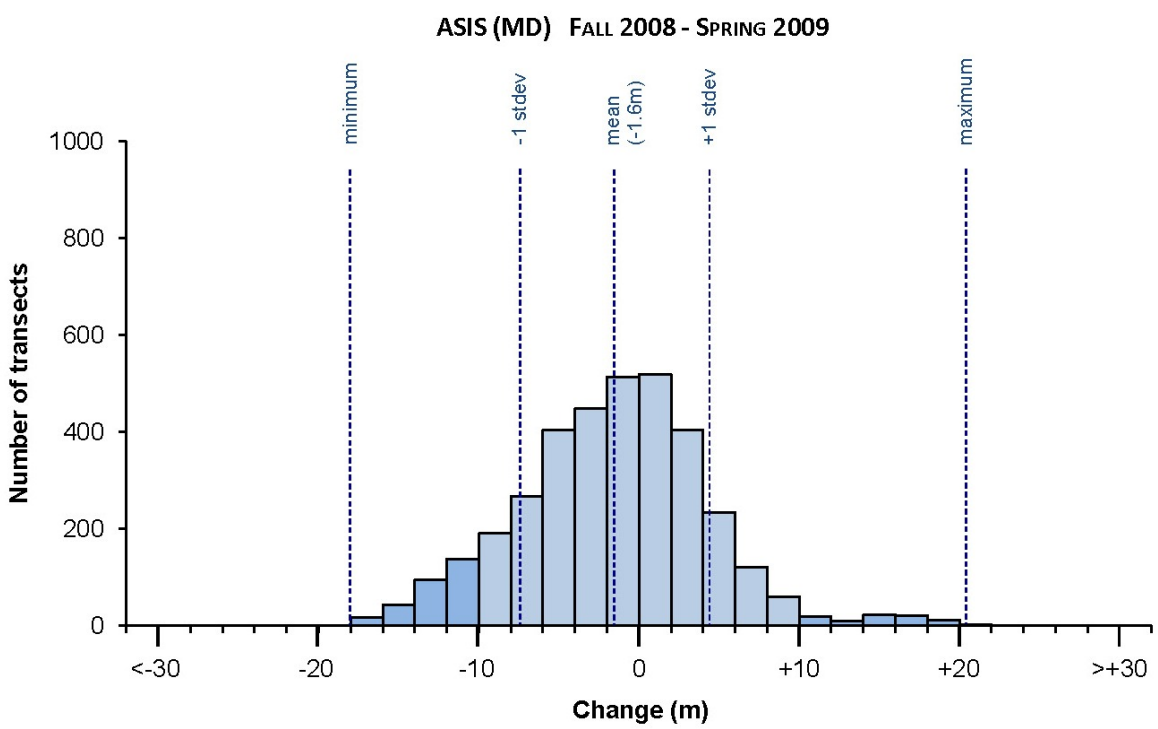

Figure 45. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Fall 2008 – Spring 2009.

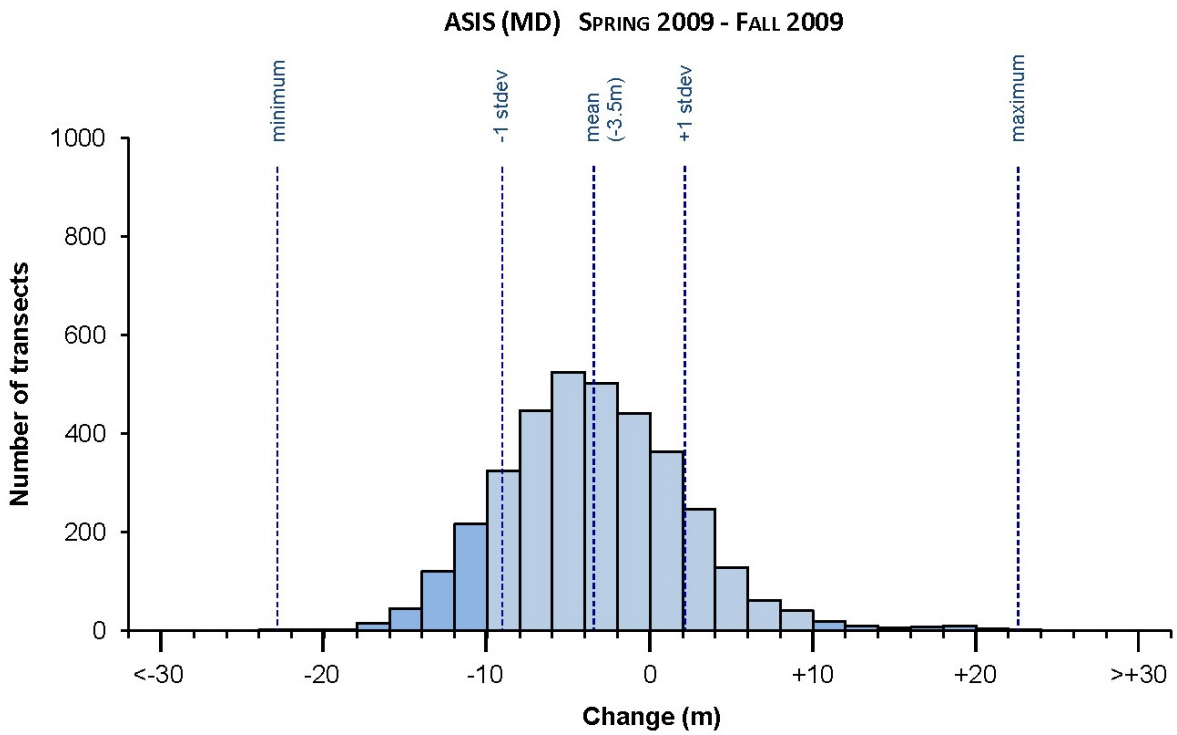

Figure 46. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Spring 2009 – Fall 2009.

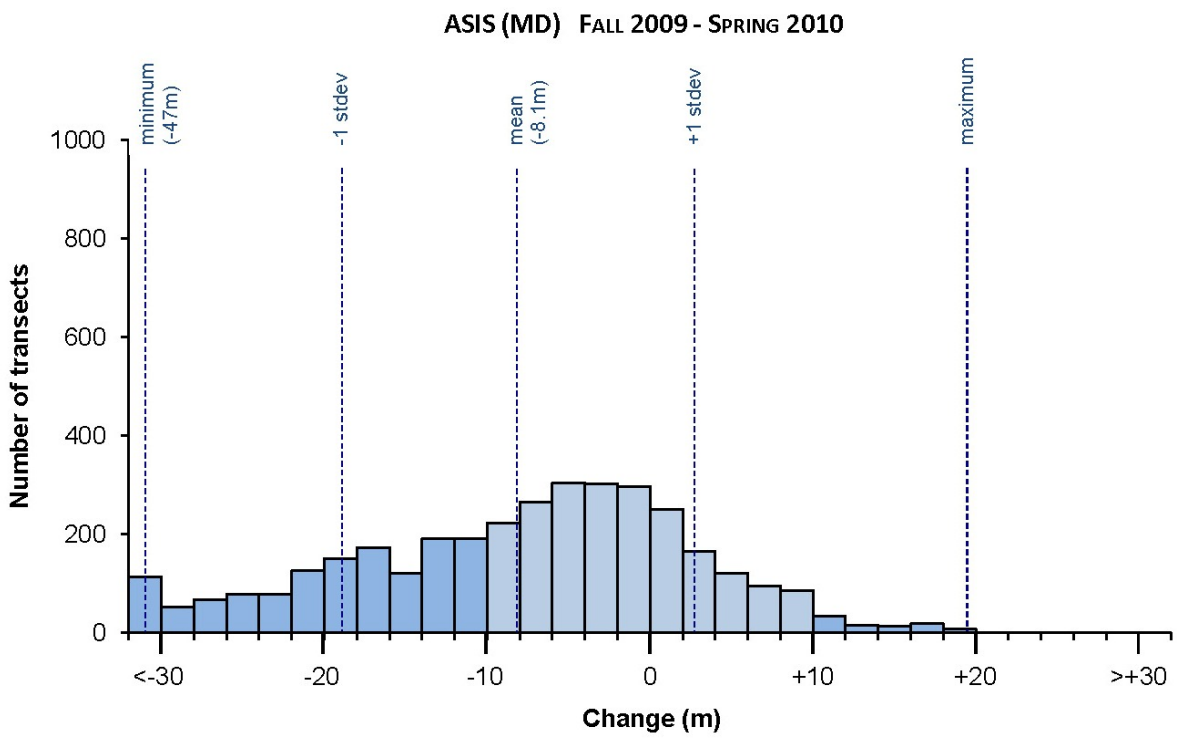

Figure 47. Distribution of seasonal shoreline change values for the Maryland portion of Assateague Island, Fall 2009 – Spring 2010.

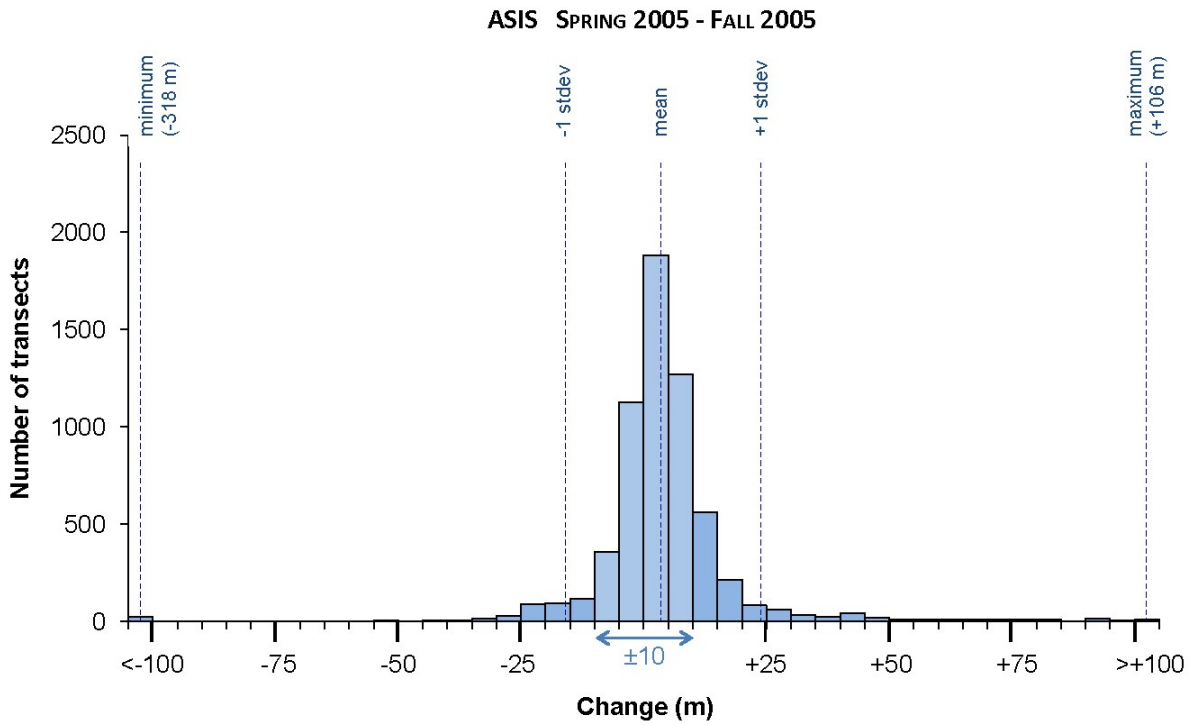

Figure 48. Distribution of seasonal shoreline change values for Assateague Island, Spring 2005 – Fall 2005.

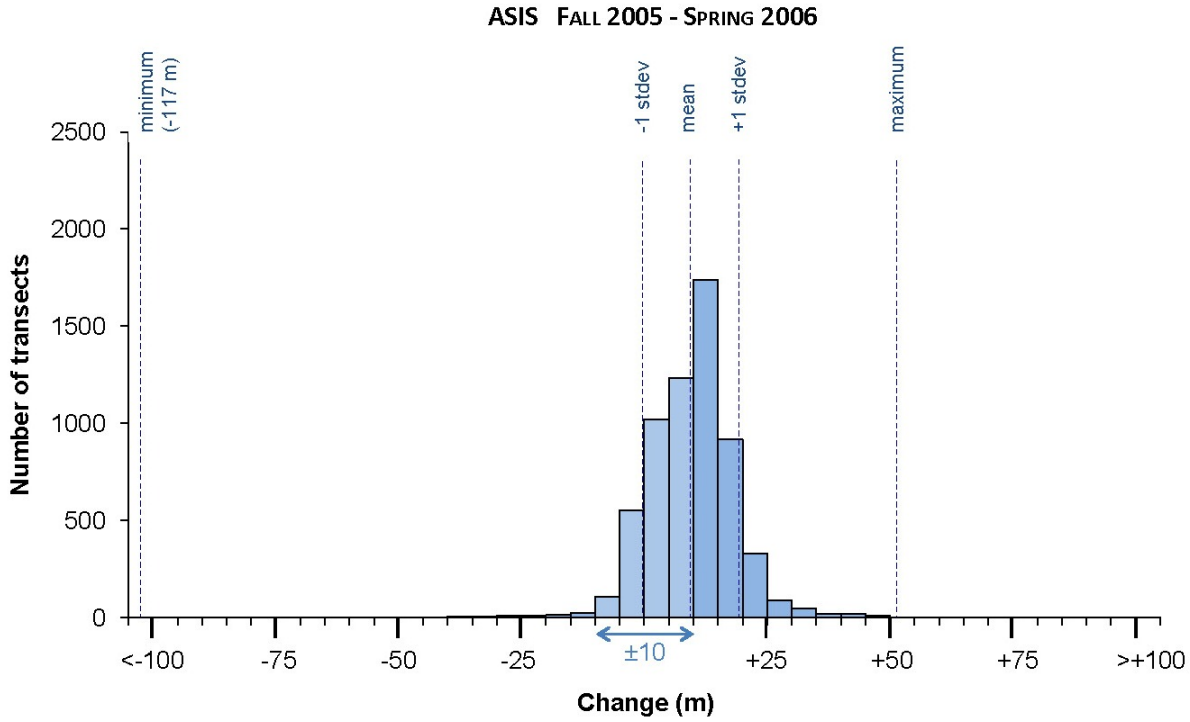

Figure 49. Distribution of seasonal shoreline change values for Assateague Island, Fall 2005 – Spring 2006.

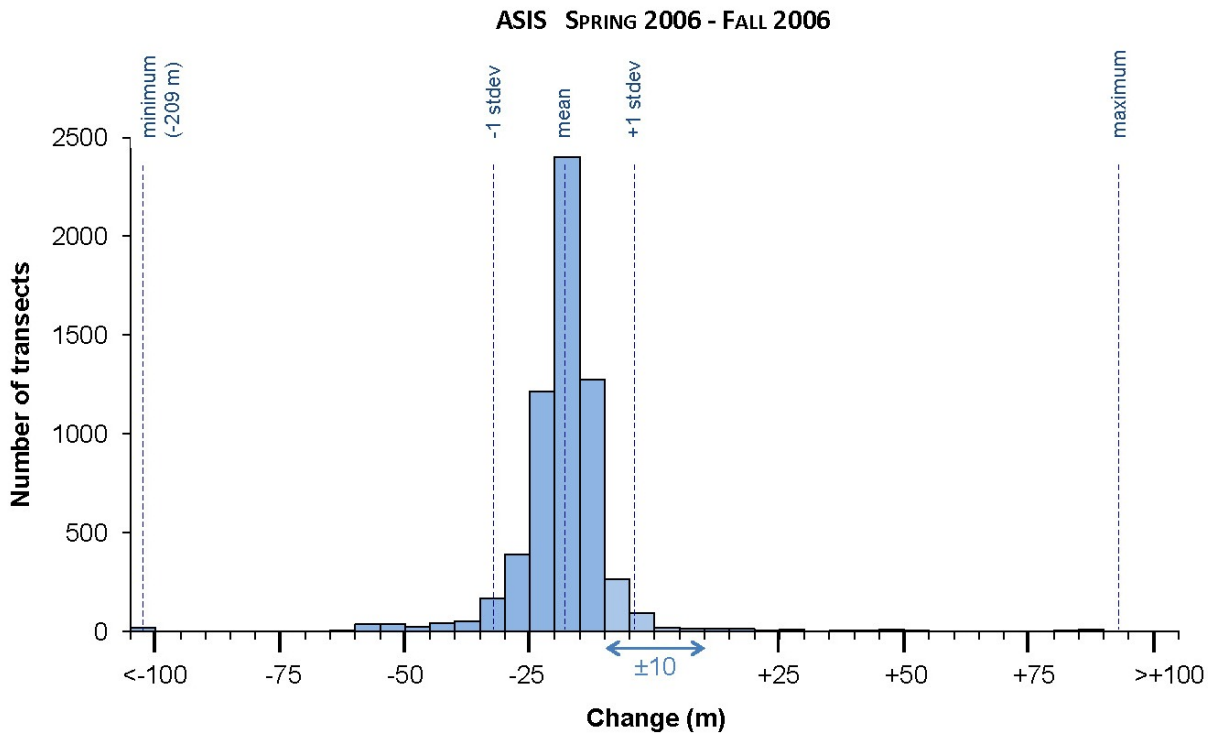

Figure 50. Distribution of seasonal shoreline change values for Assateague Island, Spring 2006 – Fall 2006.

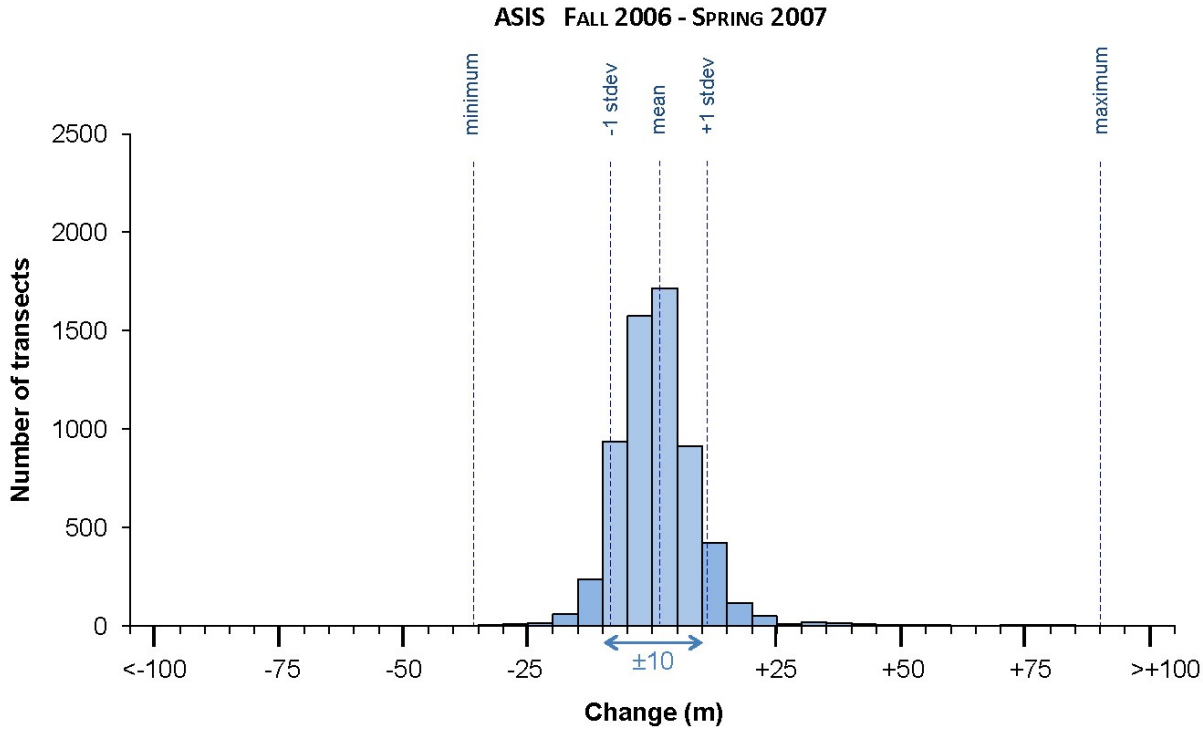

Figure 51. Distribution of seasonal shoreline change values for Assateague Island, Fall 2006 – Spring 2007.

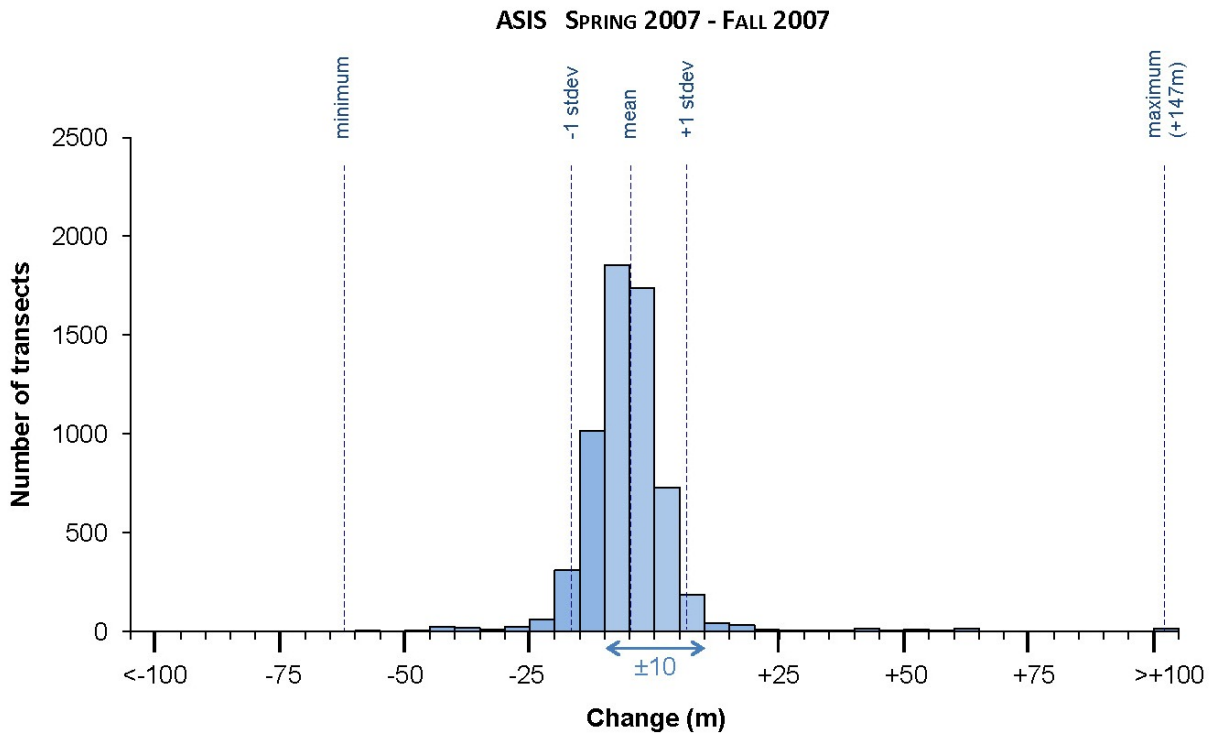

Figure 52. Distribution of seasonal shoreline change values for Assateague Island, Spring 2007– Fall 2007.

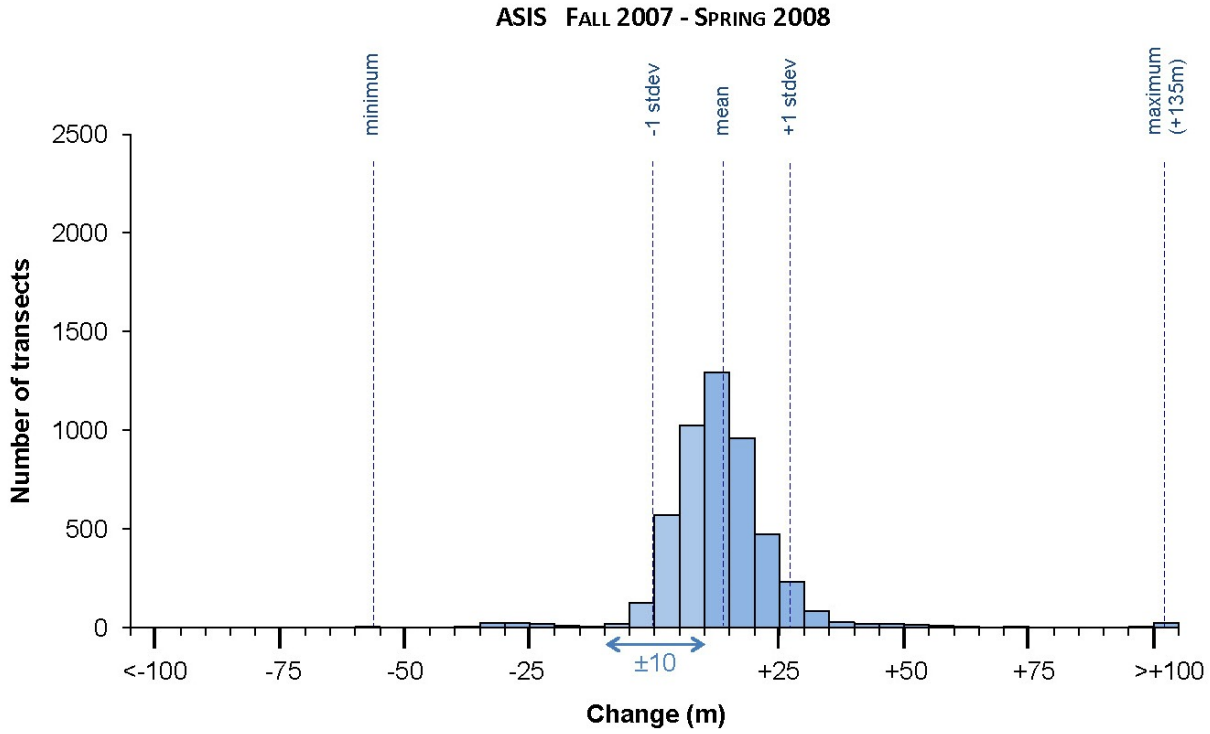

Figure 53. Distribution of seasonal shoreline change values for Assateague Island, Fall 2007 – Spring 2008.

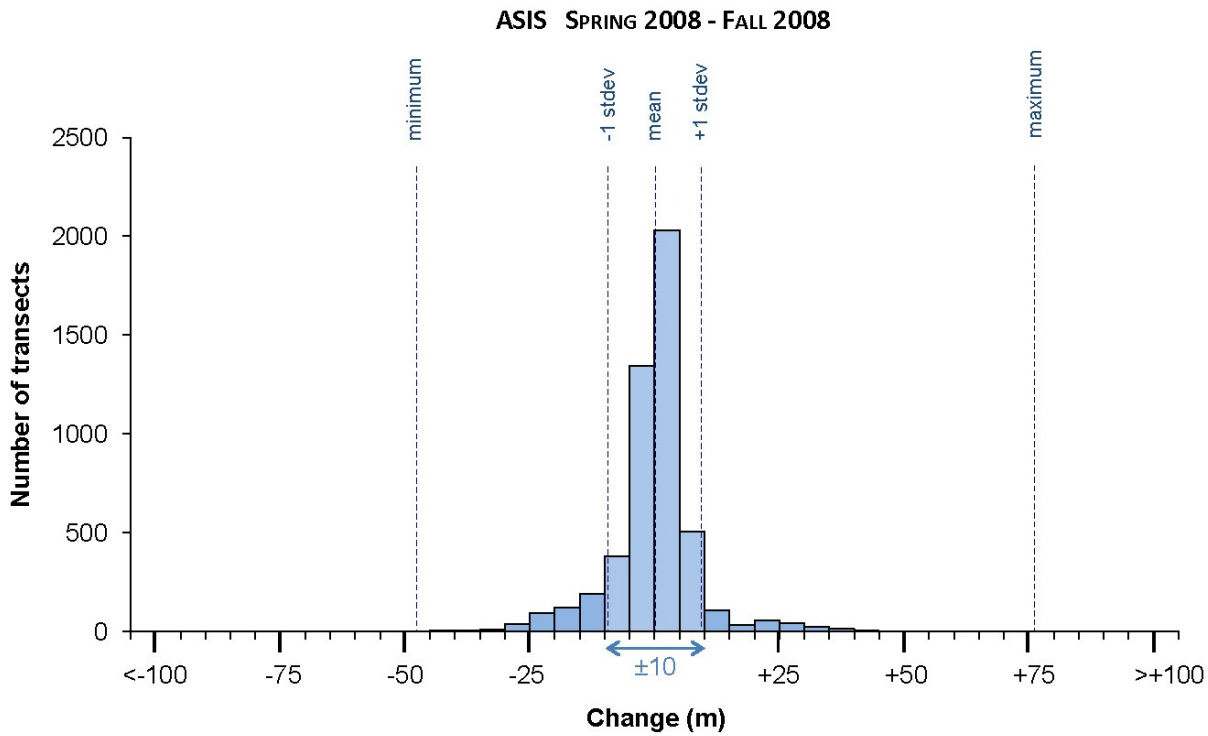

Figure 54. Distribution of seasonal shoreline change values for Assateague Island, Spring 2008 – Fall 2008.

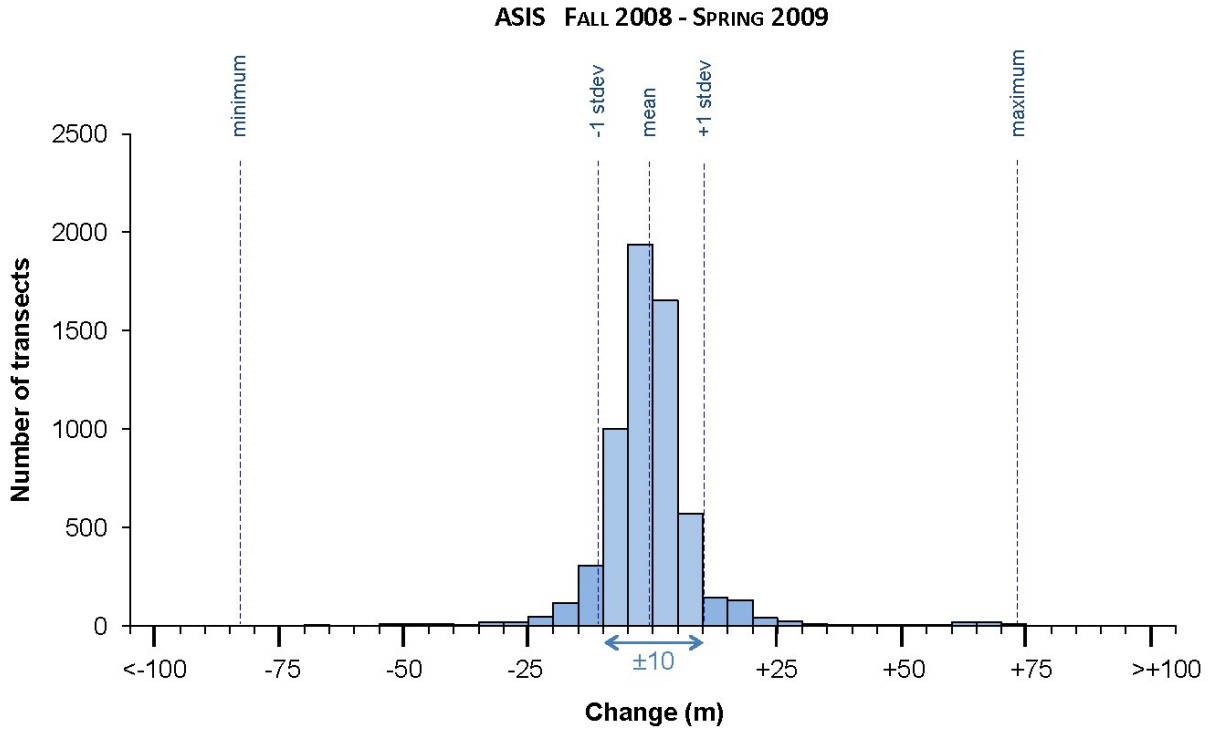

Figure 55. Distribution of seasonal shoreline change values for Assateague Island, Fall 2008 – Spring 2009.

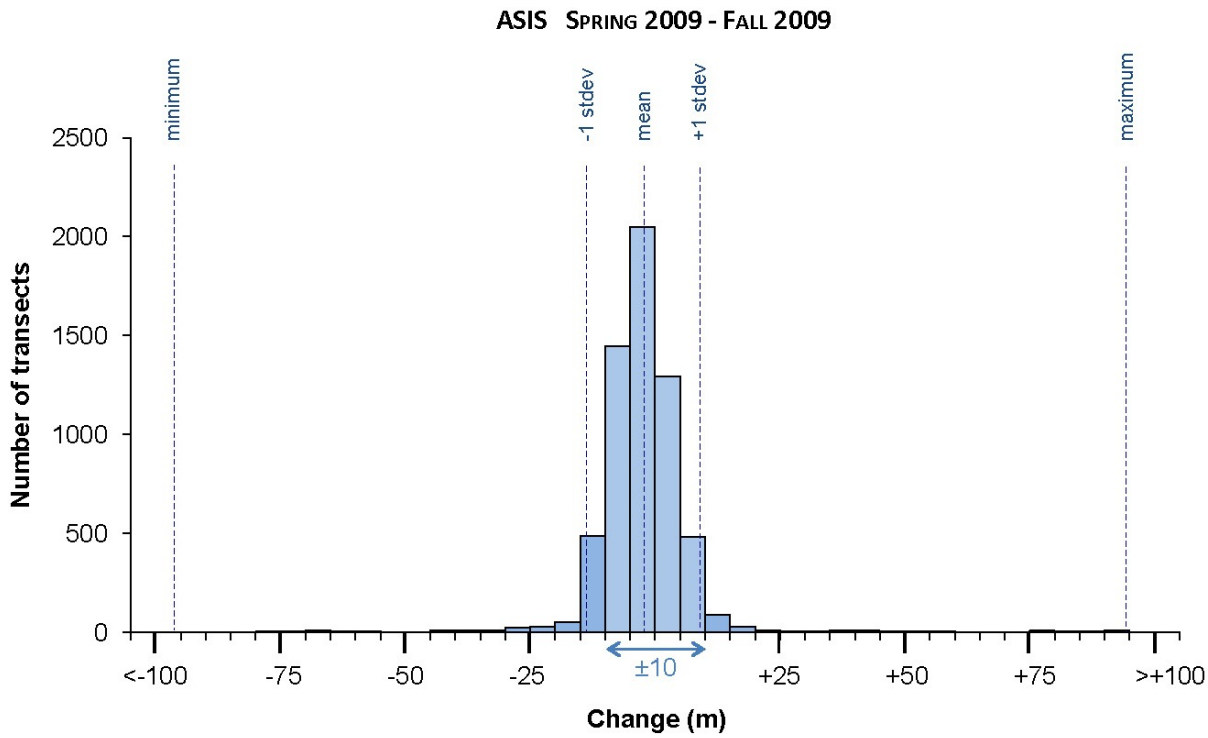

Figure 56. Distribution of seasonal shoreline change values for Assateague Island, Spring 2009 – Fall 2009.

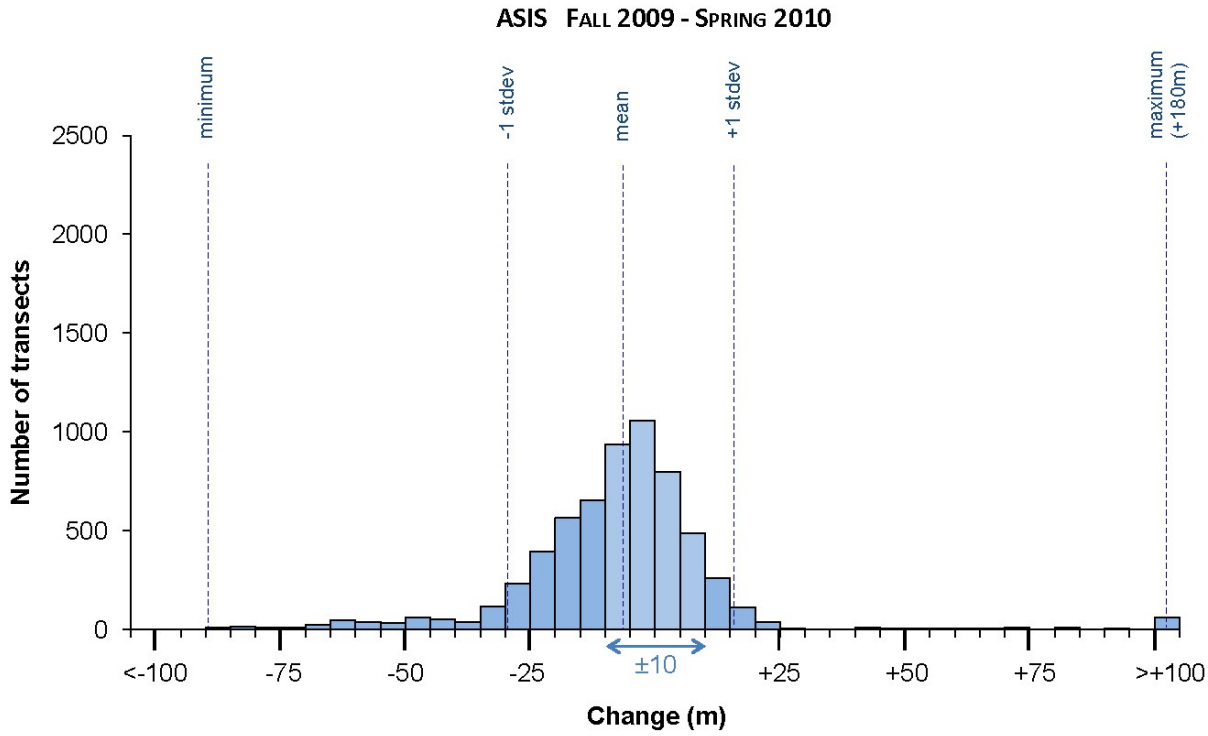

Figure 57. Distribution of seasonal shoreline change values for Assateague Island, Fall 2009 – Spring 2010.

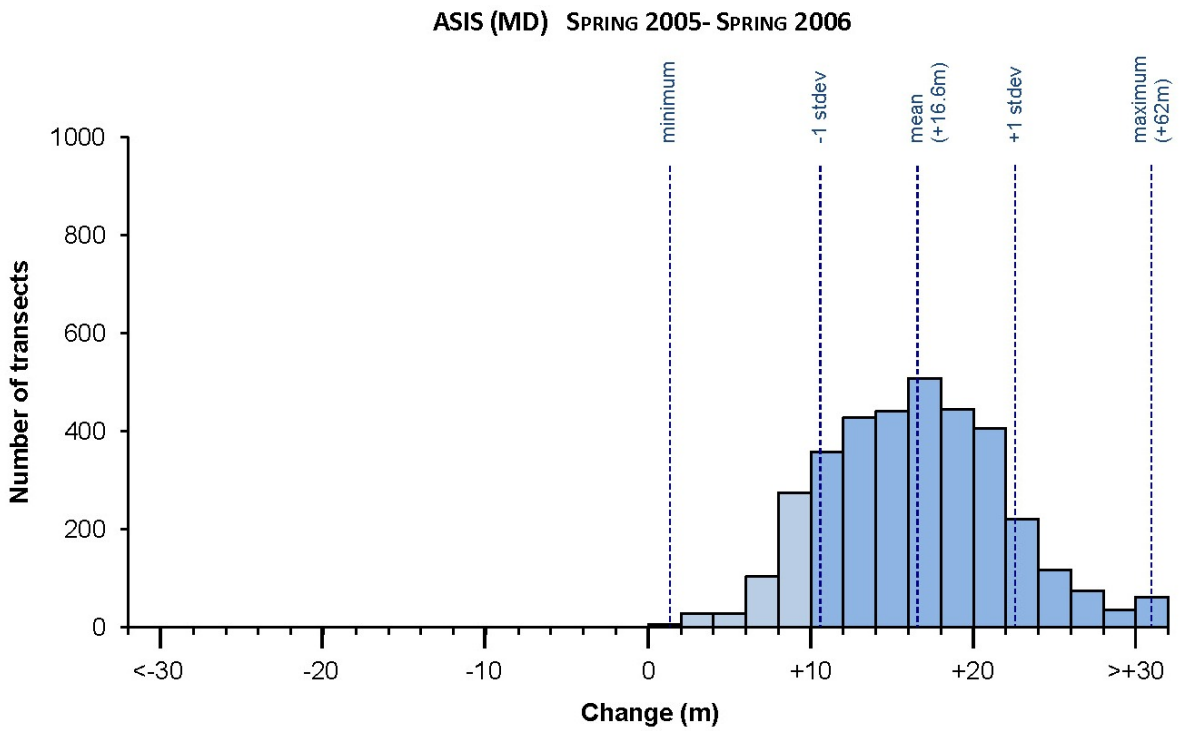

Figure 58. Distribution of annual shoreline change values for the Maryland portion of Assateague Island, Spring 2005 – Spring 2006.

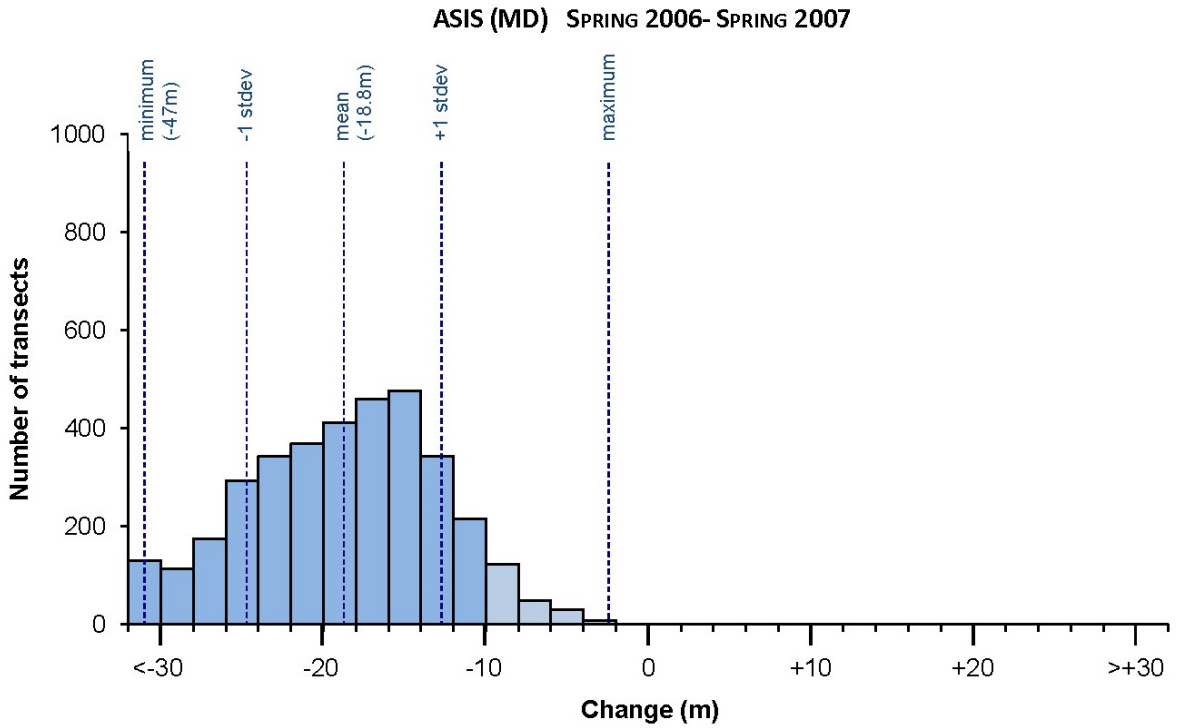

Figure 59. Distribution of annual shoreline change values for the Maryland portion of Assateague Island, Spring 2006 – Spring 2007.

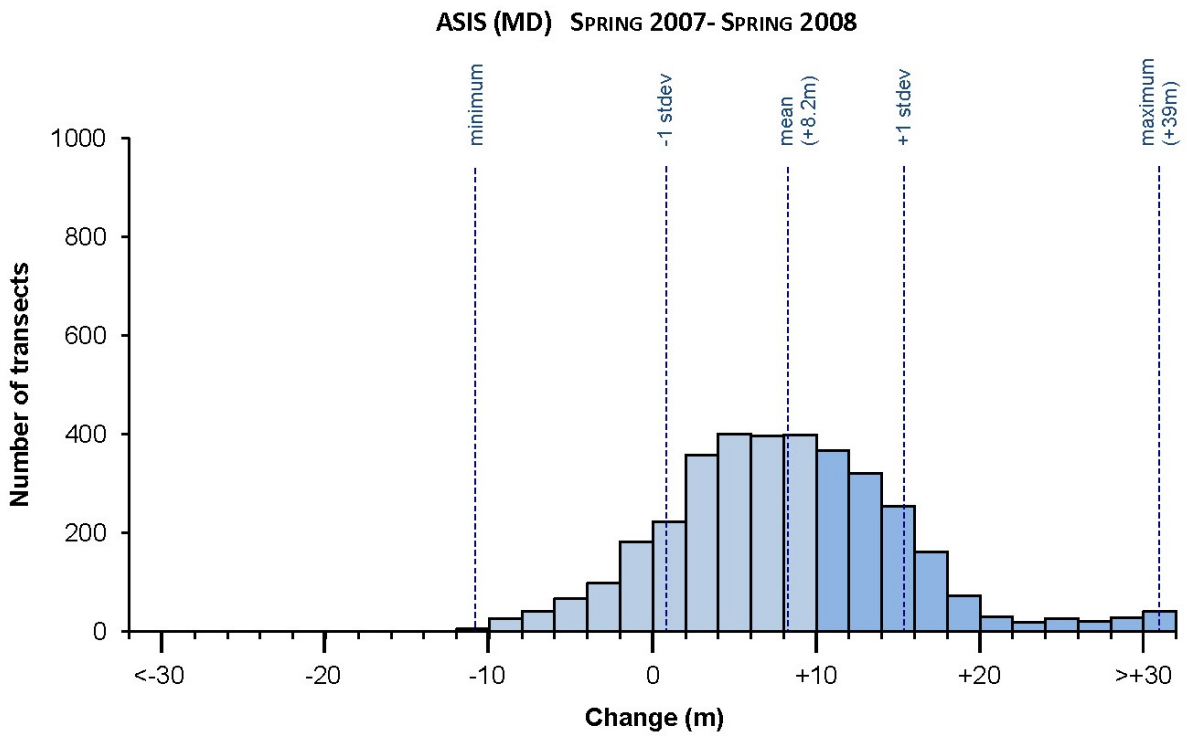

Figure 60. Distribution of annual shoreline change values for the Maryland portion of Assateague Island, Spring 2007 – Spring 2008.

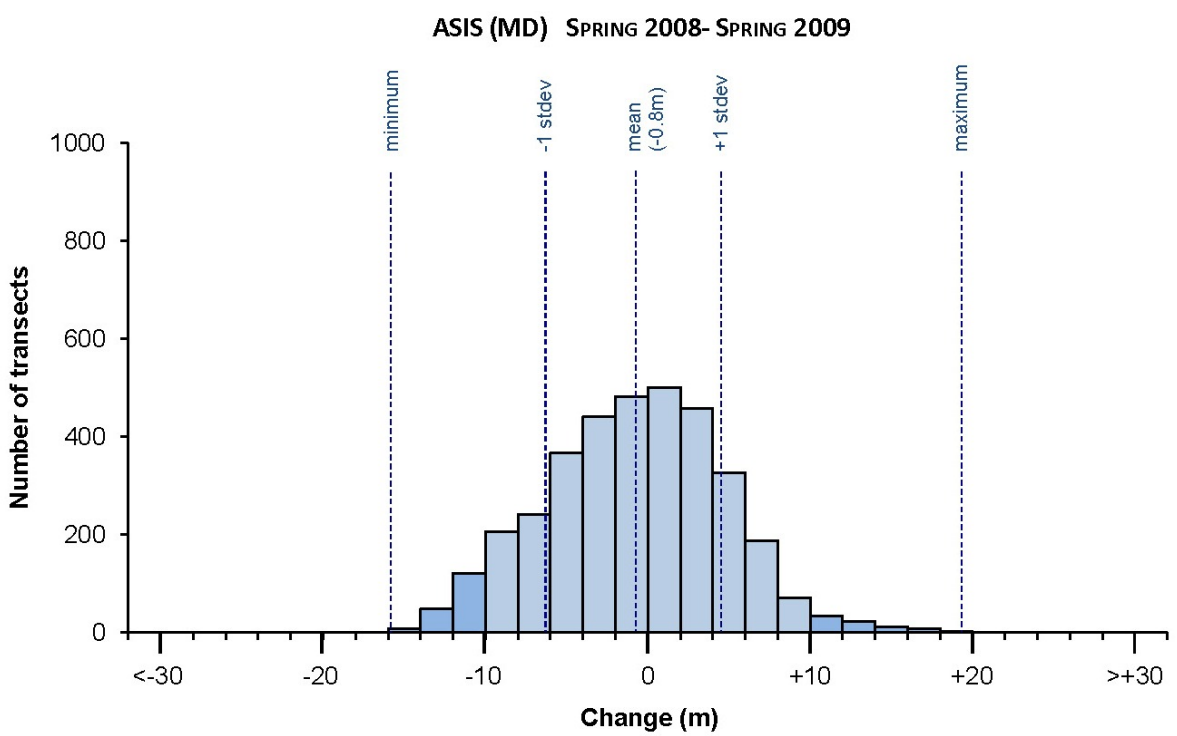

Figure 61. Distribution of annual shoreline change values for the Maryland portion of Assateague Island, Spring 2008 – Spring 2009.

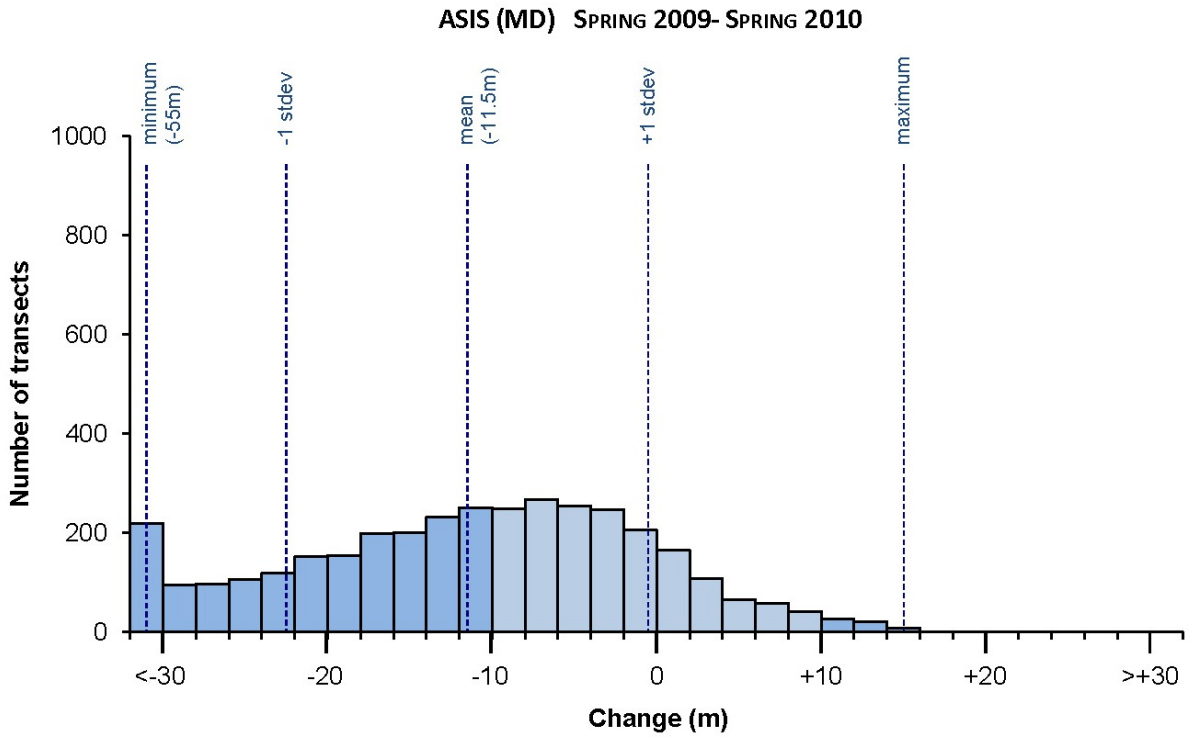

Figure 62. Distribution of annual shoreline change values for the Maryland portion of Assateague Island, Spring 2009 – Spring 2010.

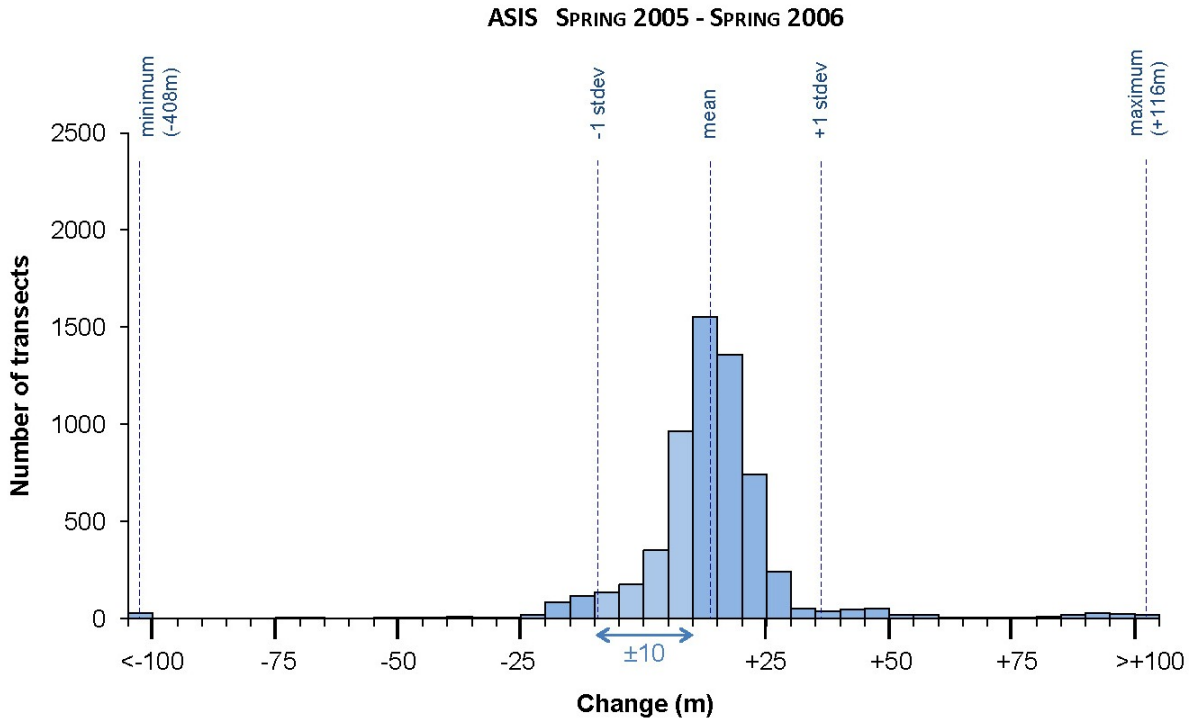

Figure 63. Distribution of annual shoreline change values for Assateague Island, Spring 2005 – Spring 2006.

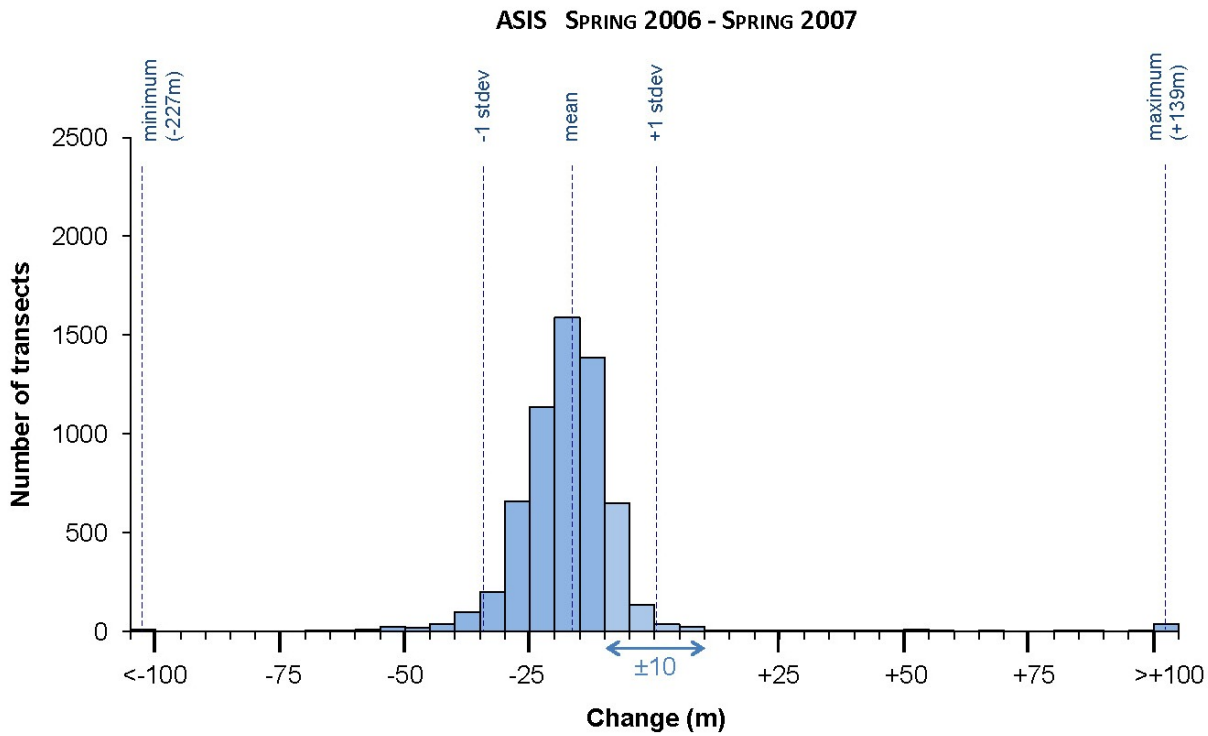

Figure 64. Distribution of annual shoreline change values for Assateague Island, Spring 2006 – Spring 2007.

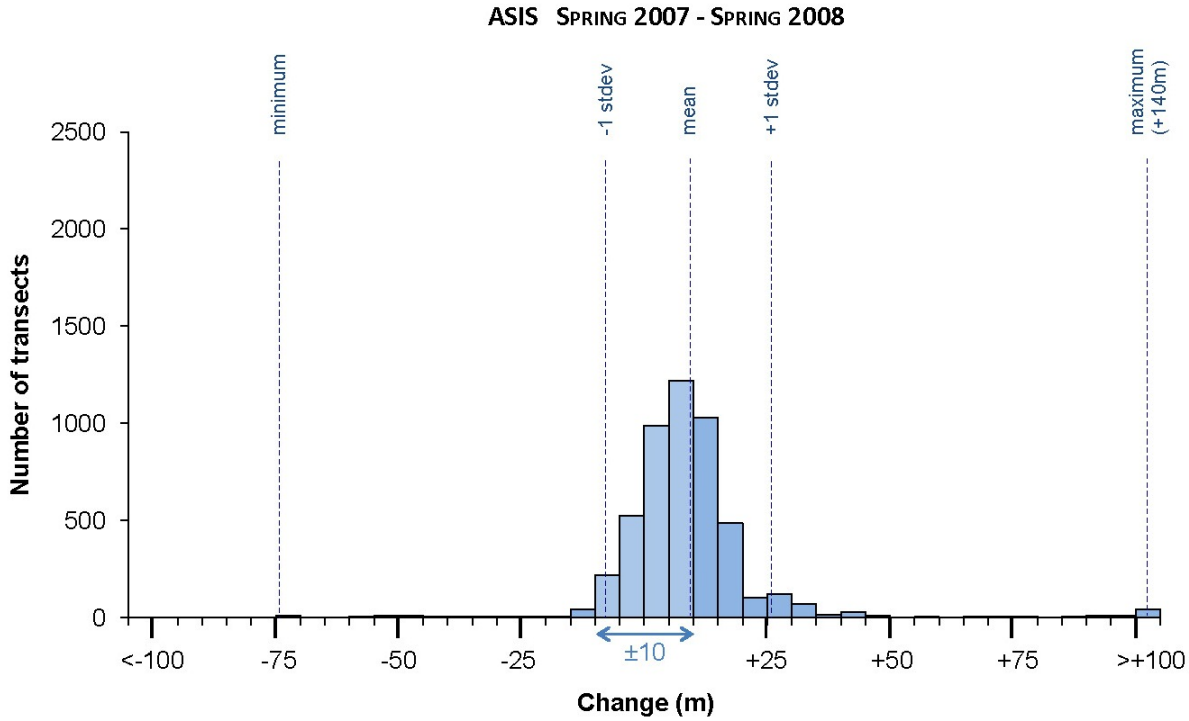

Figure 65. Distribution of annual shoreline change values for Assateague Island, Spring 2007 – Spring 2008.

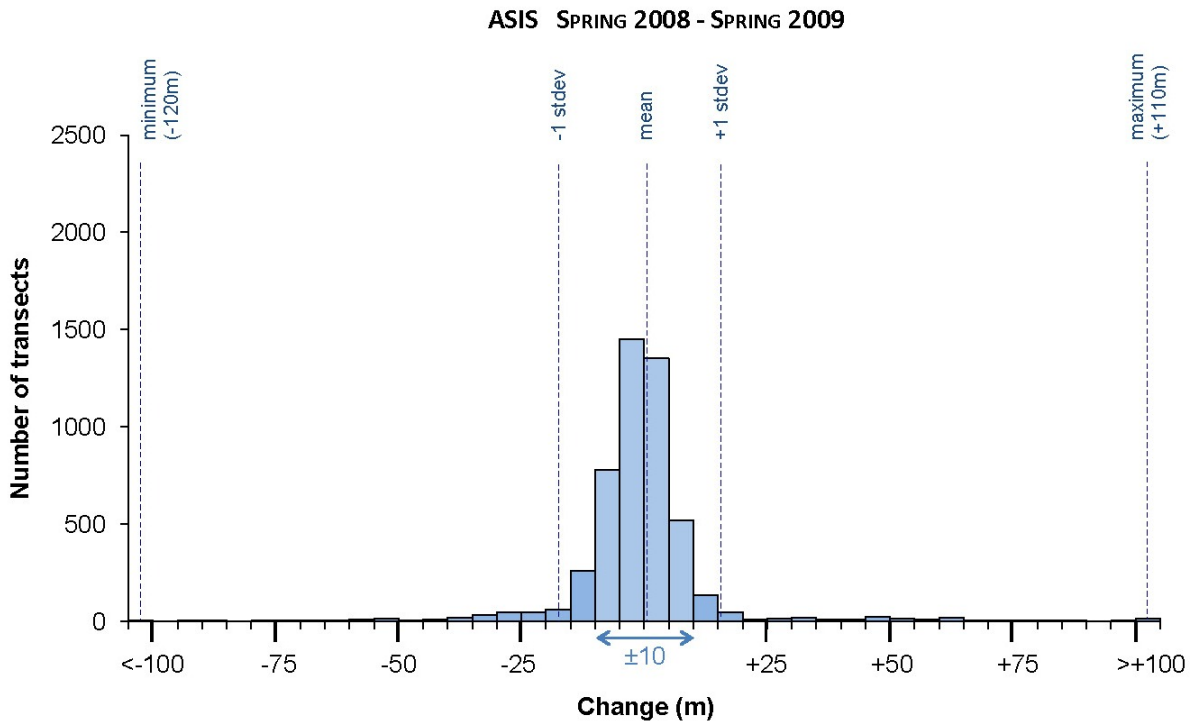

Figure 66. Distribution of annual shoreline change values for Assateague Island, Spring 2008 – Spring 2009.

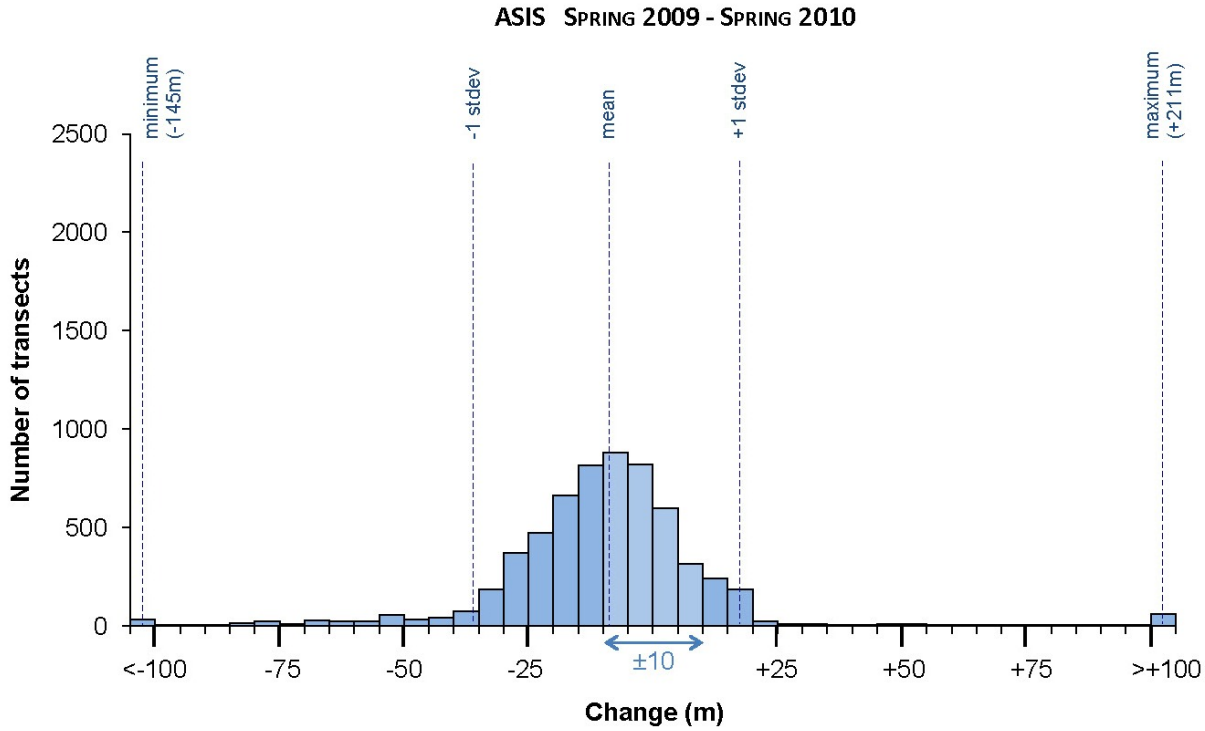

Figure 67. Distribution of annual shoreline change values for Assateague Island, Spring 2009 – Spring 2010.

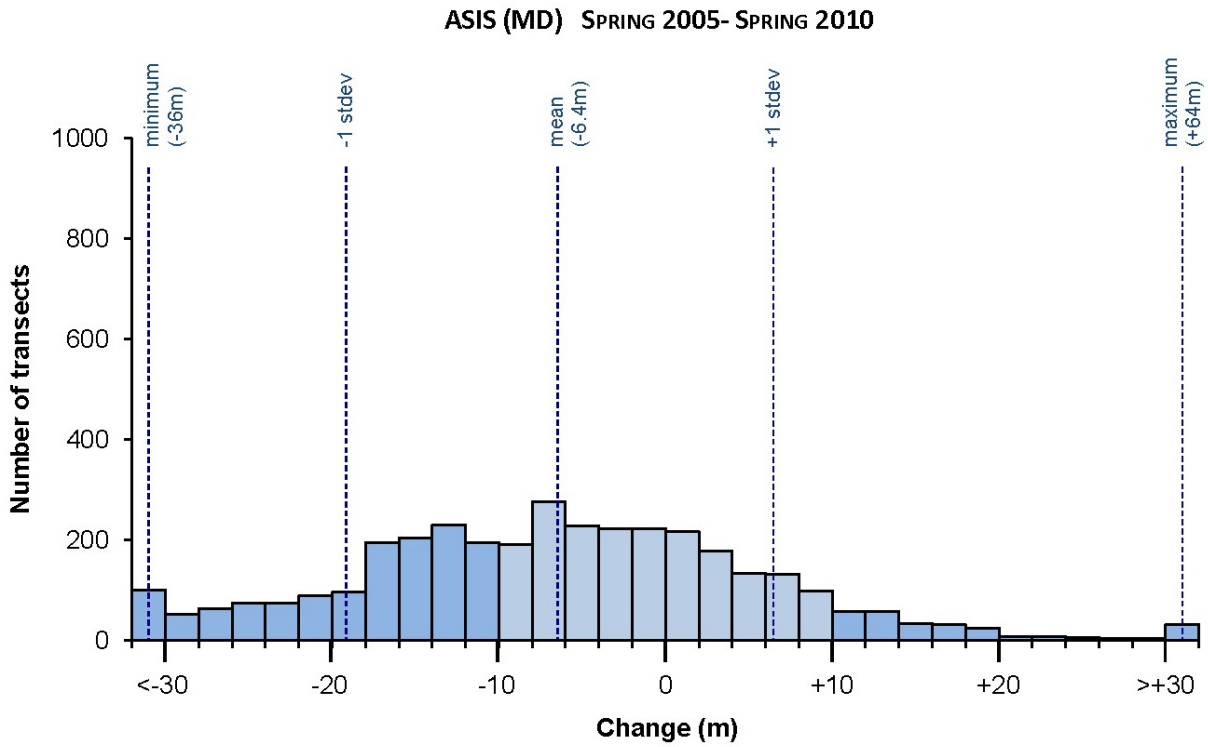

Figure 68. Distribution of change values between Spring 2005 and Spring 2010 for the Maryland portion of Assateague Island.

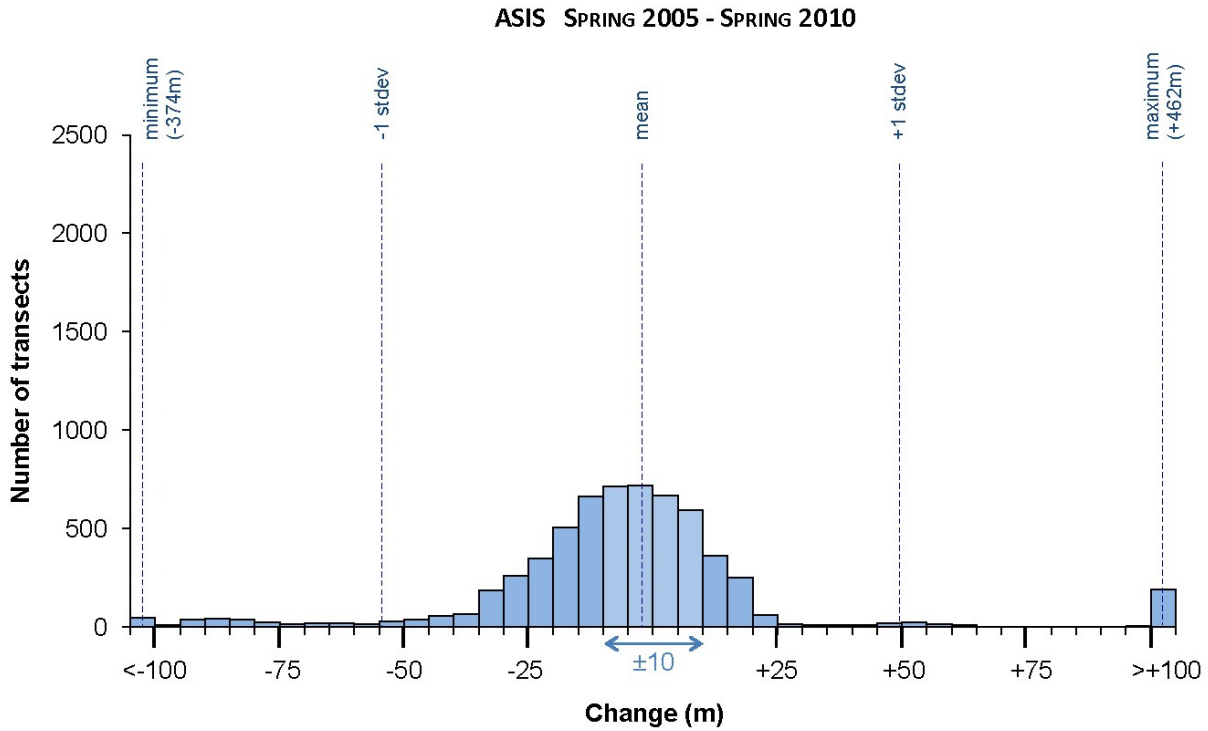

Figure 69. Distribution of change values between Spring 2005 and Spring 2010 for Assateague Island.

Descriptive Statistics

An analysis of the measures of comparisons of shoreline position recounts the large variations that characterize short-term modifications of ocean beaches (Tables 4 and 5). Different levels of storm effects product spatial and temporal contrasts that are nearly impossible to discern on the very limited scale represented by these data. Even the 5-year 'trend' is strongly affected by the conditions at the beginning and end of the surveys. However, it is a start and there is now a measure to compare subsequent displacements in both the time and space continuum.

Table 4. Descriptive statistics of seasonal, annual, and 5-year shoreline change data distribution for the Maryland portion of Assateague Island, Spring 2005-Spring 2010. Values in meters.

	Mean	1 St Dev	Max Accretion	Max Erosion
Seasonal Changes				
Spring 2005 – Fall 2005	3.02	5.88	28.44	-16.26
Fall 2005 –Spring 2006	13.58	5.48	51.87	-8.80
Spring 2006 – Fall 2006	-17.32	4.83	-	-60.52
Fall 2006 – Spring 2007	-1.48	5.48	19.61	-23.65
Spring 2007 – Fall 2007	-4.36	5.74	23.85	-20.28
Fall 2007 – Spring 2008	12.51	6.78	34.95	-8.80
Spring 2008 – Fall 2008	0.79	4.57	15.08	-24.33
Fall 2008 – Spring 2009	-1.58	5.85	20.36	-18.00
Spring 2009 – Fall 2009	-3.45	5.58	22.26	-22.85
Fall 2009 – Spring 2010	-8.07	10.84	19.54	-47.53
Annual Changes				
Spring 2005 – Spring 2006	16.59	5.99	62.00	-
Spring 2006 – Spring 2007	-18.81	6.04	-	-47.43
Spring 2007 – Spring 2008	8.15	7.27	38.91	-10.88
Spring 2008 – Spring 2009	-0.80	5.44	19.20	-15.91
Spring 2009 – Spring 2010	-11.52	11.09	14.95	-54.52
End Points				
Spring 2005 – Spring 2010	-6.38	12.73	63.70	-36.43

Table 5. Descriptive statistics of seasonal, annual , and 5-year shoreline change data distribution for Assateague Island, Spring 2005-Spring 2010. Values in meters.

	Mean	1 St Dev	Max Accretion	Max Erosion
Seasonal Changes				
Spring 2005 – Fall 2005	3.75	20.34	106.45	-318.44
Fall 2005 –Spring 2006	9.41	9.88	51.87	-117.43
Spring 2006 – Fall 2006	-18.24	14.01	93.05	-209.12
Fall 2006 – Spring 2007	1.40	9.71	90.31	-35.14
Spring 2007 – Fall 2007	-4.97	11.89	147.13	-62.02
Fall 2007 – Spring 2008	13.43	13.68	135.68	-56.84
Spring 2008 – Fall 2008	0.13	9.43	76.21	-47.69
Fall 2008 – Spring 2009	-0.67	11.21	73.11	-82.87
Spring 2009 – Fall 2009	-2.23	11.50	94.50	-96.41
Fall 2009 – Spring 2010	-6.76	22.58	180.69	-89.61
Annual Changes				
Spring 2005 – Spring 2006	13.47	22.73	116.39	-408.56
Spring 2006 – Spring 2007	-16.78	17.37	138.84	-227.39
Spring 2007 – Spring 2008	9.11	16.93	140.05	-74.93
Spring 2008 – Spring 2009	-0.54	16.43	109.76	-120.21
Spring 2009 – Spring 2010	-8.88	26.29	211.69	-144.86
End Points				
Spring 2005 – Spring 2010	-2.26	51.94	462.06	-374.20

Presentation and Description of Trend Analysis

The span of five years is really too short to describe a 'trend' to shoreline change. But, it is an opportunity to evaluate the scale of variation of displacement that exists along the island. Accompanied by a nearly constant bypassing of sediment downdrift of Ocean City Inlet, there is a similarity of shoreline response in both the Maryland section and the entire Assateague Island, with the latter summation calculation affected by the large variation at Ton's Cove Hook. The problems with the Spring 2006 survey is well-displayed in the trend graphs (Figs. 70 and 71). That survey does show up as an aberration and probably should be ignored in a final analysis. Nonetheless, the linear trend describes a negative shoreline displacement (shoreline retreat), very similar to that given by the end-point and Spring05-Spring10 trend analysis. Three measures of the trend are depicted in Figures 70 and 71: 1) a trend based on a linear regression calculation of the 10 points of change between successive surveys (-1.48 m/yr and -0.95 m/yr); 2) a trend line connecting the rate of change in the first two surveys and the last two surveys (end point trend) -2.53 m/yr and -2.40 m/yr); and 3) a trend line between the first survey and the last survey during this period (-1.27 m/yr and -0.45 m/yr).

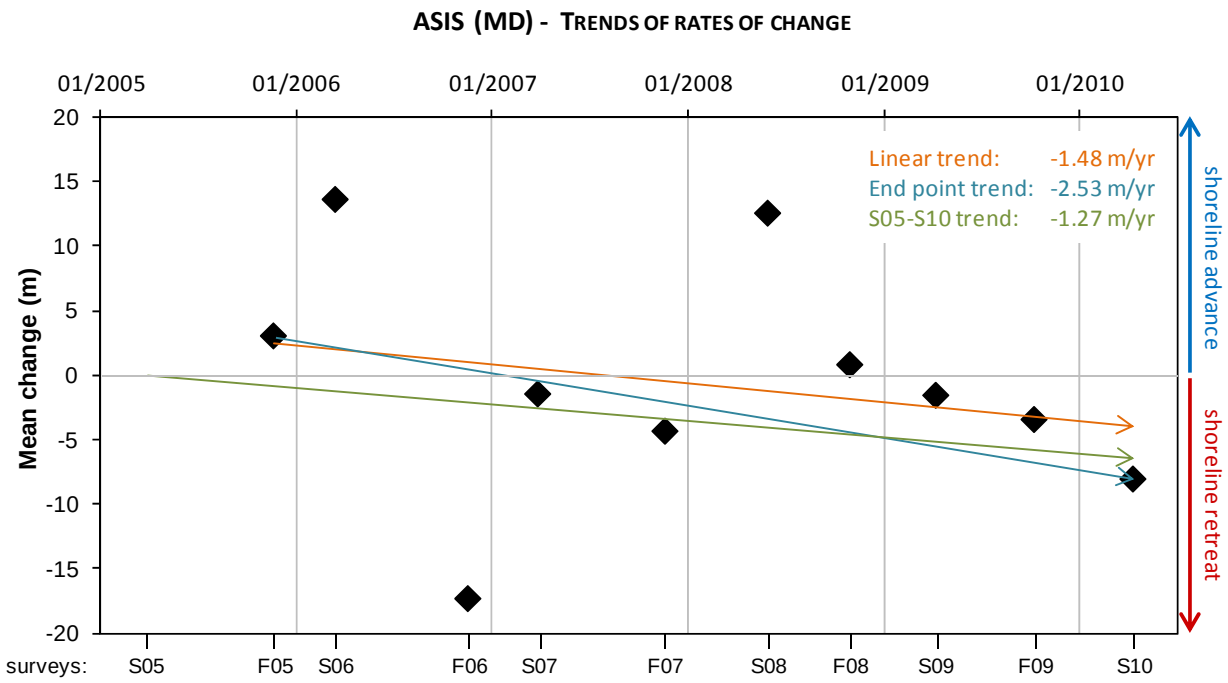

Figure 70. End-point trend, linear regression trend, and Spring05-Spring10 trend derived from the annual shoreline change data distribution for the Maryland portion of Assateague Island, Spring 2005-Spring 2010.

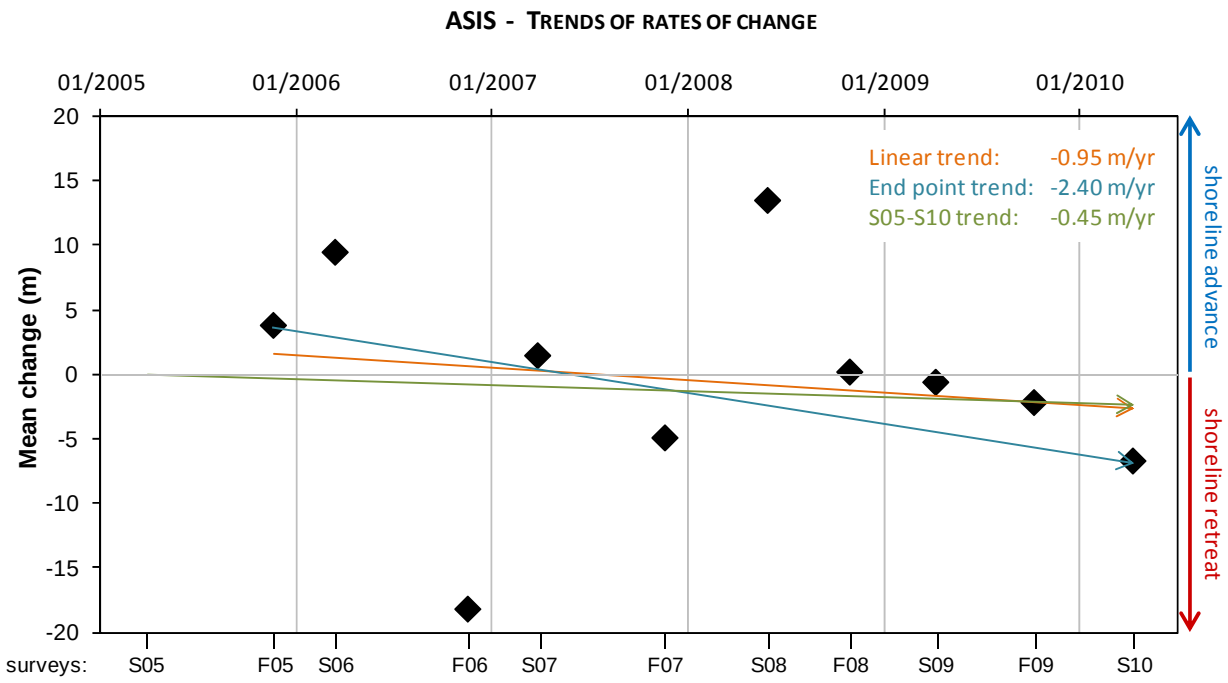

Figure 71. End-point trend, linear regression trend, and Spring05-Spring10 trend derived from the annual shoreline change data distribution for Assateague Island, Spring 2005-Spring 2010.

Interpretation of Trends

Despite the relatively-short period of measurement and the inherent temporal variation, there are some interpretations that are possible with the caution of applying the uncertainty value of +/- 6 m. More than half of the Maryland section of Assateague has a 5-year dimension of change that is greater than the measure of uncertainty. The area adjacent to the Ocean City Inlet is generally eroding, except for the location of an offshore transfer of sediment from the ebb-tide delta that is causing a very local seaward displacement. Downdrift of the attachment is a consistent inland displacement that is not offset by the periodic placement of dredged sediment. Beyond the erosion zone, there is some oscillatory variation that may be related to circulation cells. The amount of displacement throughout the central portion of the barrier island is within or close to the uncertainty values and could be within the error range. However, the displacements at the southern terminus of the barrier island are far greater than the uncertainty and thus do depict the great amounts of deposition and erosion that is characteristic of the distal end of a barrier island. The last survey year was very energetic and was marked by both a high frequency and high magnitude of storm events. The shoreline response was consistent with the stormy conditions that mobilized and transported considerable sediment to the south (downdrift). There are several facets to the Assateague Island shoreline, segments that have a similar orientation. The downdrift ends of the facets tend to have a local erosional/depositional. The facets are extending downdrift and thus the characteristics describing the facets are slowly shifting downdrift as well. Overall, the central tendency of the Assateague Island shoreline is a slow inland displacement, within the margin of error in this short time period, with sites at the termini of the island that are beyond the margin of error.

Conclusions and Information for Management

There are several points to be made regarding management from this short-term data record. The first point is that the area at the northern portion of the Park (downdrift from the attachment zone) is being eroded and displaced inland. There is a persistent signature of displacement greater than the measure of uncertainty that raises concern about the viability of this portion of the barrier island. Most of the Park shoreline displays an irregularity that is probably related to the presence of circulation cells and to the shifting of coastal facets. In most areas, there is sufficient mass and sufficient width to absorb local erosional episodes. The few exceptions are the area seaward of Tom's Cove and downdrift of Ocean City Inlet.

Problems / Concerns

The Spring 2006 survey either did not adhere to the protocol or there was a very unusual situation that was not covered in the protocol. There was no field data form to refer to and thus there was not opportunity to adjust the results. The data are used as recorded, but acknowledged as problematic.

Data Availability

The lines that represent the shoreline position for each of the surveyed periods are stored as shapefiles in a Geodatabase along with the Transects and Baseline used in the shoreline change analysis, and the spreadsheet with the results from the DSAS analysis. This information and data are available from the Data Manager for the National Park Service, Northeast Coastal and Barrier Network, Inventory and Monitoring Program.

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NPS 622/111651, November 2011

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