



Shoreline Position and Coastal Topographical Change Monitoring at Assateague Island National Seashore *2005–2020 Trend Report*

Natural Resource Data Series NPS/NCBN/NRR—2022/2375



ON THE COVER

Photo of dunes and overwash feature on the oceanside of Assateague Island National Seashore.
Photo taken by Helen Hamilton. September 18, 2000.

Shoreline Position and Coastal Topographical Change Monitoring at Assateague Island National Seashore

2005–2020 Trend Report

Natural Resource Data Series NPS/NCBN/NRR—2022/2375

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Executive Summary

This trend report summarizes the results of shoreline position and coastal topography surveys conducted semi-annually from the spring of 2005 through the fall of 2020. Shoreline position was collected in the Assateague Island National Seashore (ASIS), the Assateague State Park, and the Chincoteague National Wildlife Refuge, whereas coastal topography was collected only in the Assateague Island National Seashore and the Assateague State Park. The assembled datasets are processed to provide spatial depictions and statistical analyses of annual changes, 5-year changes, and the extended 15-year changes.

Although there were considerable variations in the alongshore dimensions of change, the largest and most consistent vectors of annual shoreline position and coastal topography changes were produced by storm impacts, such as Hurricane Sandy and the winter storms in 2016, followed by the subsequent recovery. As a result of Hurricane Sandy (October 2012), the entire oceanside shoreline position of Assateague Island was displaced inland, and there was a loss of total cross-section area in the profiles. There was variable recovery post-Hurricane Sandy in both the shoreline position and coastal topography profiles. The winter of 2016 was also particularly stormy and had a higher mean net landward shoreline position displacement than post-Hurricane Sandy. Throughout the survey period, the termini of the island were exceptionally dynamic. The northern 2.5 km of Assateague Island National Seashore had a mean net seaward displacement, whereas the southern portion of the Chincoteague National Wildlife Refuge was the site of major inland displacement along the oceanside and as well as downdrift seaward extension of Toms Cove Hook.

From 2005 through 2020, the only section of the oceanside shoreline position that had a positive trend of mean net displacement was the northernmost portion of Assateague Island, associated with local conditions created by the presence of the ebb tide delta and the Ocean City inlet jetty. All other parts of the ocean shoreline position had a negative trend of change; the highest rate of erosion occurred at the southern portion of Chincoteague National Wildlife Refuge. Contrary to the oceanside shoreline position, a portion of the Toms Cove Hook shoreline had a trend of seaward displacement as the spit extended in the direction of sediment transport. Other trends occurred in the areas where profiles were surveyed. Most of the dune area in ASIS gained in cross-section over time, except for portions of Assateague State Park. The dune elevation tended to gain in ASIS North and lower in ASIS South. Other than the profiles in Assateague State Park, the total cross-section area increased, with the highest rate of cross-section area gain in the northern portion of Assateague Island.

Acknowledgments

Many people participated in the collection of the field surveys and processing of the data sets and contributed to this product. Members of the NPS survey team included Neil Winn and Danna Muise. Neil Winn was essential in ensuring the consistent and accurate collection of this impressive 15-year dataset. Scott Rasmussen and Dennis Skidds provided critical data management for this project. Robin Baranowski contributed valuable editorial skills throughout the production of this document

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Introduction

This 2005–2020 Trend Report incorporates both shoreline position (1D) and coastal topographical profile (2D) change data at Assateague Island National Seashore (ASIS). In addition, this report includes shoreline position data that extend through Chincoteague National Wildlife Refuge to Toms Cove Hook. There are 27 2D topographical profiles surveyed in an area from Ocean City Inlet, Maryland, to the Maryland/Virginia border. This report and the data within it follow the protocols described in the Northeast Coastal and Barrier Network Geomorphological Monitoring Protocol for Part I: Ocean Shoreline Position (Psuty et al, In Review (a)) and Part II: Coastal Topography (Psuty et al, In Review (b)). Surveys were conducted semi-annually in the spring and fall, except for the spring of 2020 when COVID-19 restrictions precluded field work.

As prescribed in standard operating procedures of both monitoring protocols, the goal of the trend report is a summary of the database of shoreline positions and/or coastal topography data accumulated over spans of multiples of five years. It is a compilation of annual analyses that synthesize and characterize the data and describe aspects of the trends revealed by the numerical analyses. These longer-term comparisons of shoreline position and coastal topography changes reveal trends created by variation in sediment availability and in the intensity of formational processes. It is a comprehensive compilation of the geomorphological change data and provide aspects of the trends revealed in the numerical analyses.

Site and Situation

Assateague Island is a barrier island along the eastern coast of Maryland and Virginia (Figure 1). The barrier is approximately 58 km alongshore from Ocean City Inlet to Toms Cove Hook. The primary geomorphological component of the Assateague Island National Seashore is a Holocene age barrier island, 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 1934–1935 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.



Figure 1. Assateague Island and the administrative units present on the barrier island. Inset map has location of the island in the coastal setting.

The National Park Service owns and manages the 35 km Maryland portion of Assateague Island, with the exception a 3 km stretch of land immediately adjacent to State Route 611, a parcel owned by the state of Maryland and managed as Assateague State Park. The southernmost 23 km section of Assateague Island in Virginia is managed by the U.S. Fish and Wildlife Service as the Chincoteague National Wildlife Refuge. The NPS administrative boundary encircles the refuge and therefore has jurisdiction in Virginia from mean high water out to the boundary. The data included in this report correspond to the portrayal of the shoreline position along the entire Maryland portion of Assateague Island from Ocean City Inlet to Toms Cove Hook, and the 2D topographical profiles that are within the length of Assateague Island National Seashore, including the state park.

Natural and Anthropogenic Impacts on Shoreline Position and Coastal Topography

Storms are important drivers of coastal change at the ocean beach. Shoreline position and coastal topography are affected during storm events by the high-energy mobilization and transportation of beach and dune sediment. Generally, the winter season is considered a time of increased storminess characterized by higher energy levels and considerable sediment transport. The summer season is conversely characterized by lower energy levels and more opportunity for sediment retention, although hurricane events may cause displacement within the seasonal cycle. Shoreline position and coastal topography surveys are scheduled at six-month intervals to provide insight into the comparison between the conditions at the ends of the winter and summer seasons (though not to identify the effects of any specific storm). The seasonal signal, however, is often complicated by additional variables affecting ocean shorelines and topography. Structures at inlets and along the shoreline lead to localized sites of accumulation and loss; human activities manipulate sediment availability and pathways; inshore circulation cells create local erosion and sediment sequestering; alongshore transport can include pulses of sediment; etc.

Natural Impacts

To characterize the annual and 5-year sediment balances at a given site, metrics are to be generated of net shoreline and topographical change of the dune/beach profile (Figure 2) after seasonal stormy and non-stormy conditions. Storms are important drivers of the shoreline and topographical change. The NPS Inventory & Monitoring protocols are 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 (Figures 3, 4, & 5 and Table 1).

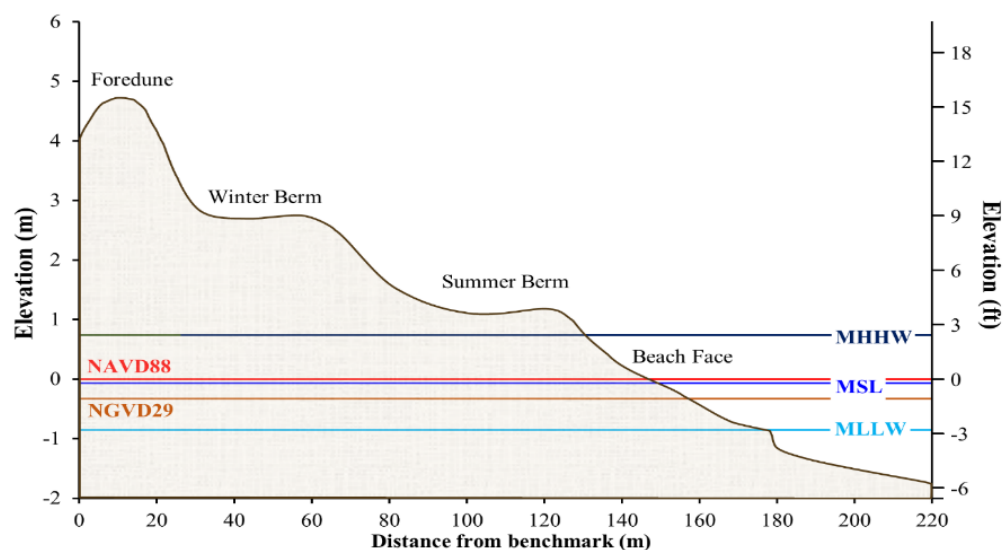


Figure 2. Relationship of 1983–2001 tidal epoch water levels to the North American Vertical Datum of 1988, to the 1929 National Geodetic Vertical Datum, and to a representative beach profile at Sandy Hook. All values are portrayed relative to NAVD88. Other terms are: MLLW = mean lower low water; NGVD29 = National Geodetic Vertical Datum of 1929; MSL = mean sea level; and MHHW = mean higher high water.

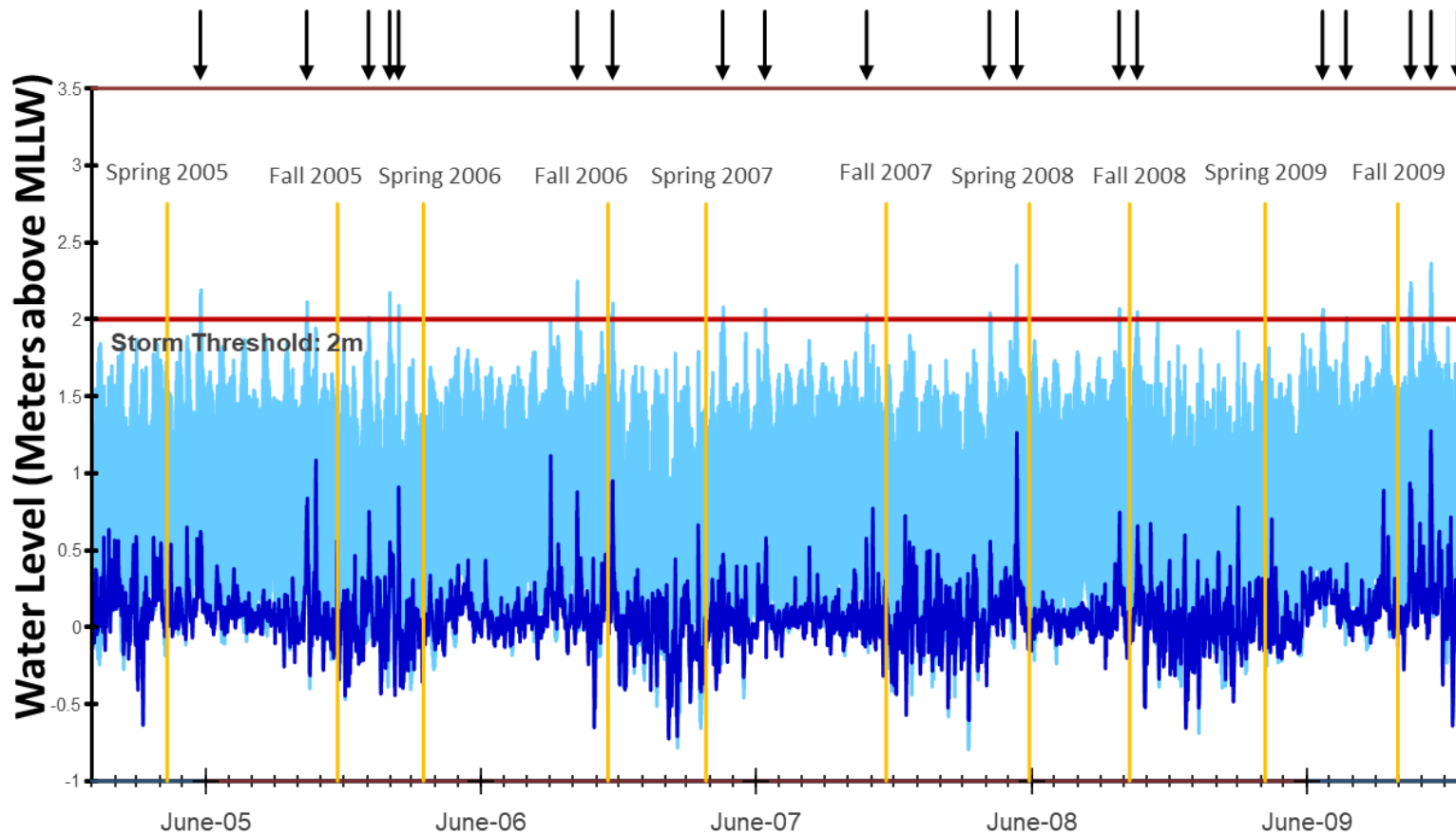


Figure 3. Daily water level variation at Lewes, DE Tide Gauge, with storm water levels surpassing the threshold value of 2 m above Mean Lower Low Water (MLLW). Dates of 19 maximum water levels during storm events are noted by black arrows, Dates of 10 surveys are noted by yellow lines. Dark blue elevations represent surge values (difference of actual water level relative to predicted). Source: NOAA tide gauge (#8557380) Lewes, DE (<http://tidesandcurrents.noaa.gov/>).

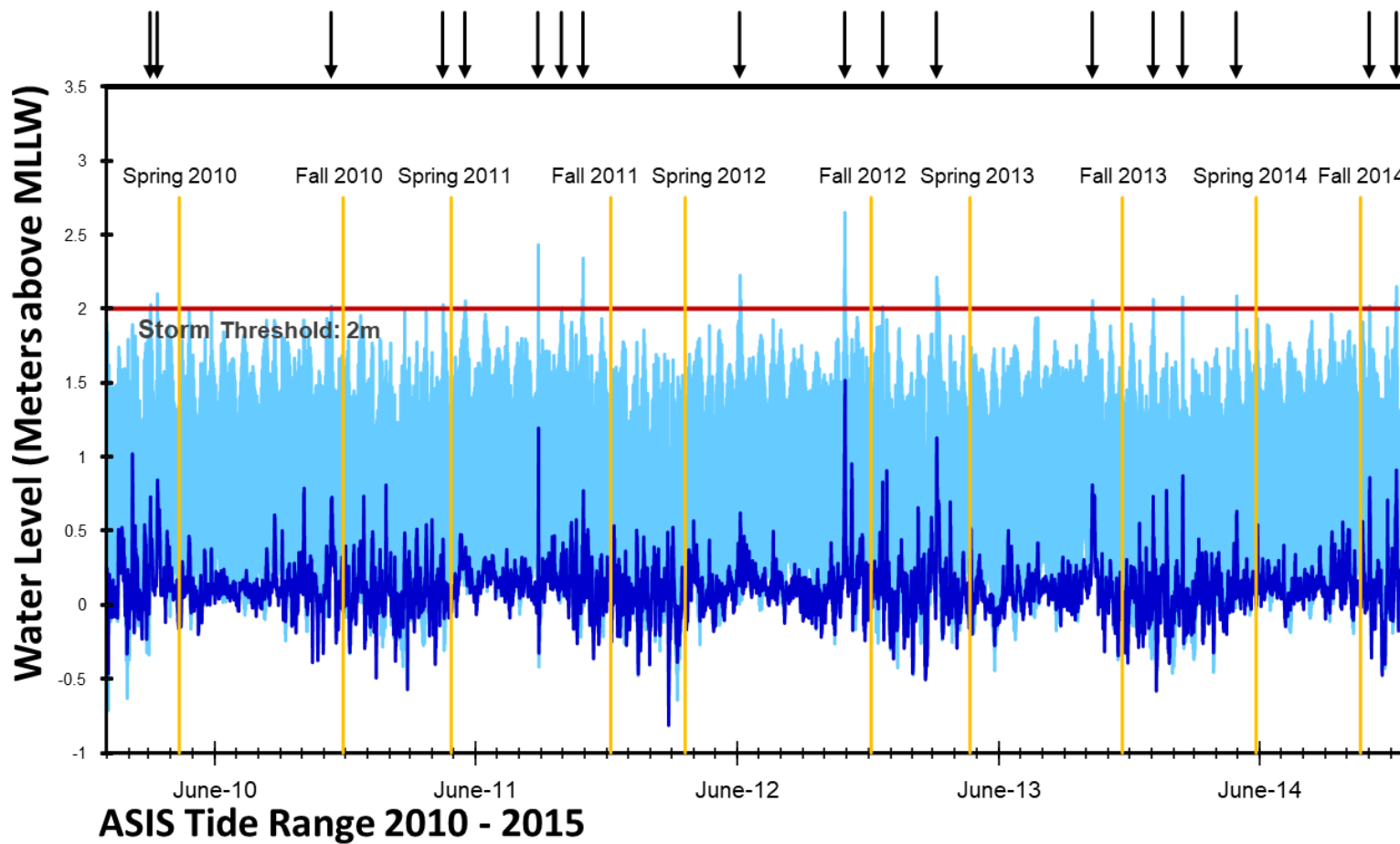


Figure 4. Daily water level variation at Lewes, DE Tide Gauge, with storm water levels surpassing the threshold value of 2 m above Mean Lower Low Water (MLLW). Dates of 17 maximum water levels during storm events are noted by black arrows, Dates of 10 surveys are noted by yellow lines. Dark blue elevations represent surge values (difference of actual water level relative to predicted). Source: NOAA tide gauge (#8557380) Lewes, DE (<http://tidesandcurrents.noaa.gov/>).

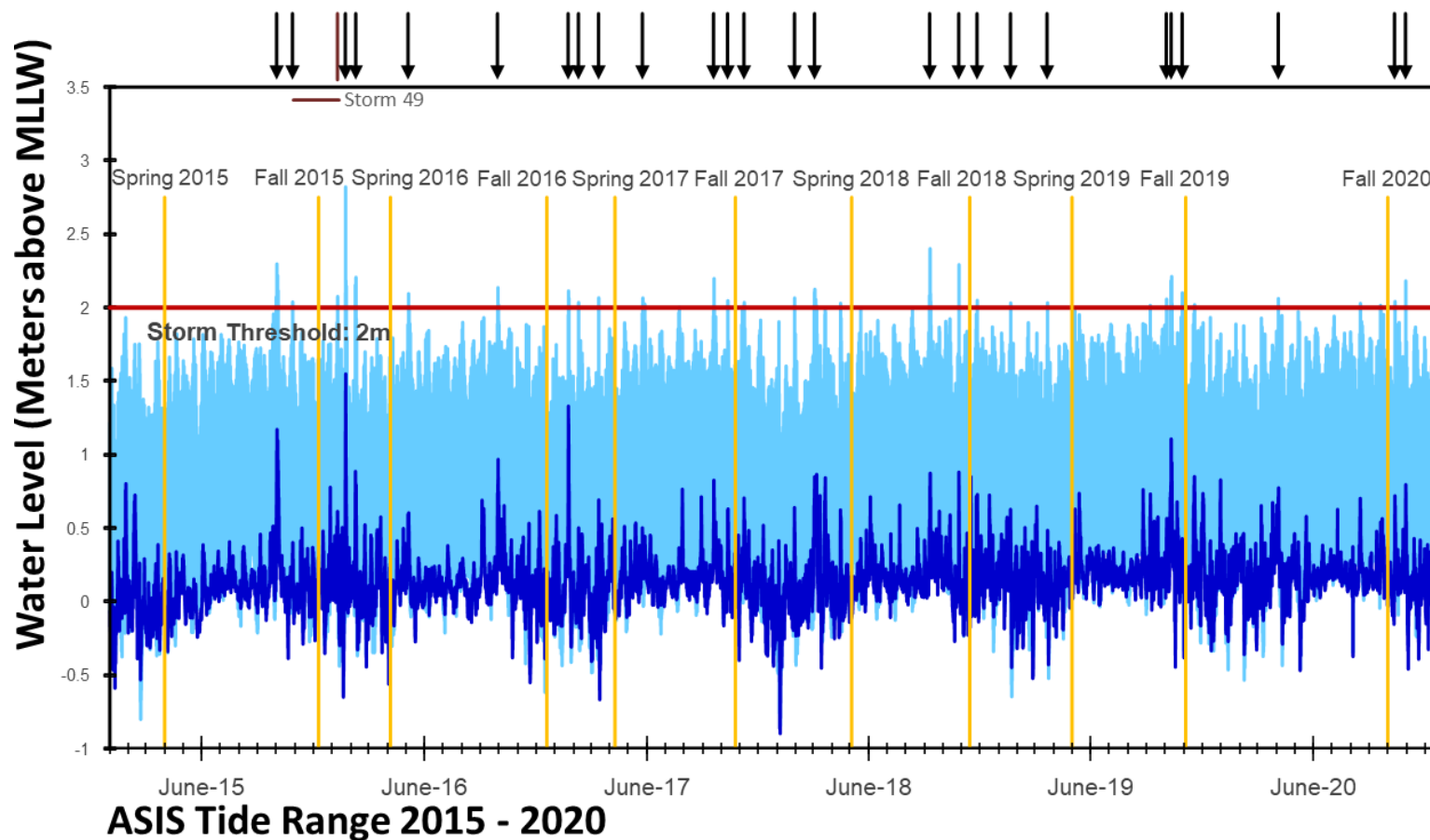


Figure 5. Daily water level variation at Lewes, DE Tide Gauge, with storm water levels surpassing the threshold value of 2 m above Mean Lower Low Water (MLLW). Dates of 26 maximum water levels during storm events are noted by black arrows, Dates of 11 surveys are noted by yellow lines. Dark blue elevations represent surge values (difference of actual water level relative to predicted). Source: NOAA tide gauge (#8557380) Lewes, DE (<http://tidesandcurrents.noaa.gov/>).

Table 1. Dates and characteristics of storms from 2005–2020, derived from the Lewes, Delaware tide gauge (#8557380).

Storm	Number of tides higher than + 2m MLLW (Storm threshold)	Maximum Tide*		
		Tide height (m)	Date	Measured surge (m)
May 24–May 25, 2005	2	2.190	05/25/05	0.519
October 12–October 13, 2005	2	2.111	10/13/05	0.609
January 3, 2006	1	2.011	1/3/2006	0.451
January 31, 2006	1	2.172	1/31/2006	0.553
February 12, 2006	1	2.09	2/12/2006	0.723
October 6–October 7, 2006	2	2.248	10/7/2006	0.575
November 22–November 23, 2006	2	2.103	11/23/2006	0.614
April 18, 2007	1	2.078	4/18/2007	0.350
June 13, 2007	1	2.064	6/13/2007	0.391
October 26, 2007	1	2.025	10/26/2007	0.294
April 6–April 7, 2008	2	2.039	4/6/2008	0.402
May 12, 2008	2	2.351	5/12/2008	0.980
September 25, 2008	1	2.069	9/25/2008	0.571
October 19, 2008	1	2.048	10/19/2008	0.447
June 21–June 22, 2009	2	2.064	6/22/2009	0.338
July 23, 2009	1	2.009	7/23/2009	0.314
October 15–October 18, 2009	6	2.237	10/17/2009	0.649
November 12–November 14, 2009	5	2.362	11/13/2009	0.927
December 19, 2009	1	2.173	12/19/2009	0.786
March 3, 2010	2	2.027	3/3/2010	0.509
March 13, 2010	1	2.100	3/13/2010	0.799
November 11, 2010	1	2.016	11/11/2010	0.624
April 16, 2011	1	2.026	4/16/2011	0.413
May 17, 2011	1	2.052	5/17/2011	0.327
August 27, 2011	1	2.431	8/27/2011	0.839
September 29, 2011	2	2.003	9/29/2011	0.259
October 28–October 29, 2011	2	2.341	10/29/2011	0.605
June 4–June 5, 2012	2	2.225	6/4/2012	0.466
October 28–October 29, 2012	4	2.649	10/29/2012	1.169
December 21, 2012	1	2.013	12/21/2012	0.829
March 6–March 9, 2013	5	2.212	3/6/2013	1.127
October 9–October 10, 2013	2	2.054	10/10/2013	0.508

* Water levels are referenced to Mean Lower Low Water (MLLW) Source: NOAA tide gauge (#8557380) Lewes, Delaware.

Table 1 (continued). Dates and characteristics of storms from 2005–2020, derived from the Lewes, Delaware tide gauge (#8557380).

Storm	Number of tides higher than + 2m MLLW (Storm threshold)	Maximum Tide*		
		Tide height (m)	Date	Measured surge (m)
January 3, 2014	1	2.063	1/3/2014	0.397
February 13, 2014	2	2.077	2/13/2014	0.737
April 29, 2014	5	2.086	4/29/2014	0.493
November 1, 2014	1	2.017	11/1/2014	0.606
December 8–December 9, 2014	2	2.149	12/9/2014	0.704
October 1–October 5, 2015	7	2.297	10/2/2015	0.682
October 28, 2015	1	2.039	10/28/2015	0.293
January 10, 2016	1	2.076	1/10/2016	0.555
January 23–January 24, 2016	3	2.821	1/23/2016	1.324
February 8–February 9, 2016	2	2.206	2/9/2016	0.631
March 5–March 6, 2016	2	2.095	5/5/2016	0.422
September 29–September 30, 2016	3	2.136	9/29/2016	0.693
January 23–January 24, 2017	2	2.114	1/23/2017	1.162
February 8–February 9, 2017	2	2.035	2/9/2017	0.502
March 14, 2017	1	2.067	3/14/2017	0.692
May 25, 2017	1	2.066	5/25/2017	0.322
September 19–September 20, 2017	3	2.198	9/19/2017	0.632
October 12, 2017	1	2.048	10/12/2017	0.547
November 8, 2017	1	2.035	11/8/2017	0.417
January 30, 2018	1	2.066	1/30/2018	0.448
March 3–March 7, 2018	7	2.125	3/4/2018	0.665
September 8–September 9, 2018	2	2.401	9/9/2018	0.716
October 27, 2018	1	2.292	10/27/2018	0.703
November 26, 2018	1	2.05	11/26/2018	0.436
January 20, 2019	1	2.032	1/20/2019	0.417
March 21, 2019	1	2.033	3/21/2019	0.485
October 3, 2019	1	2.058	10/3/2019	0.504
October 9–October 12, 2019	5	2.212	10/11/2019	0.837
October 29, 2019	1	2.101	10/29/2019	0.400
April 4, 2020	1	2.062	4/4/2020	0.64
October 12, 2020	1	2.042	10/12/2020	0.595
October 30, 2020	1	2.182	10/30/2020	0.796

* Water levels are referenced to Mean Lower Low Water (MLLW) Source: NOAA tide gauge (#8557380) Lewes, Delaware.

A storm threshold of 2 m above mean lower low water (MLLW) is derived from the 2D beach profiles that represent an elevation on the berm surface that is above the beach face at the dune toe. 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. However, when it is exceeded, the upper beach and foredune are eroded and, in severe cases, overwash may occur. The representation of storminess during the survey period is indicated by daily max and min water level and occurrences of exceedance of the threshold. A portrayal of daily water levels, (Figures 3, 4, & 5), are illustrated with a solid vertical blue line that represents the maxima and minima 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 water level data describe the seasonality of frequent storm events; storms occur more frequently during the winter and spring than in the summer (Figures 3, 4 & 5 and Table 1). The patterns of water levels indicate a greater frequency of storms in fall and winter versus less stormy late spring and summer (Figures 3, 4 & 5 and Table 1). The maximum water elevation of 2.821 m was reached during a storm in January 23, 2016. The greatest duration of high water occurred during a storm on October 1–October 5, 2015 and March 3–March 7, 2018, each lasting for 7 high tides.

Anthropogenic Impacts

During the period of data collection for this Trend Report, Assateague Island received beach nourishment in the form of sediment dredged from the Ocean City Inlet approximately twice a year (Schupp 2007, USACE 2020) (Table 2). These sediments were placed in the nearshore to restore the sediment pathway cut off by the jetty stabilizing the Ocean City Inlet and its associated flood tide and ebb tide deltas. The sediment was dumped in two locations that were within a nearshore zone that extended from approximately 2.5 km south of the Ocean City Inlet jetty to Assateague State Park. There was also an ongoing USACE project within Ocean City, Maryland placing sediment on the beach several times over the survey period (Callahan 2021).

Table 2. Beach nourishment and inlet dredging projects at or updrift of Assateague Island National Seashore (ASIS) beaches, 2005–2020.

Location	Sediment Placed or Dredged		Time Period
	Cubic Yards	Cubic Meters	
Northern ASIS, nearshore	25,108	19,196	2005
Northern ASIS, nearshore	79,498	60,781	2006
Northern ASIS, nearshore	34,978	26,743	2006
Ocean City Maryland	931,710	712,343	2006
Northern ASIS, nearshore	86,322	65,998	2007
Northern ASIS, nearshore	59,481	45,476	2007
Northern ASIS, nearshore	40,793	31,188	2008

Table 2 (continued). Beach nourishment and inlet dredging projects at or updrift of Assateague Island National Seashore (ASIS) beaches, 2005–2020.

Location	Sediment Placed or Dredged		Time Period
	Cubic Yards	Cubic Meters	
Northern ASIS, nearshore	74,647	57,072	2009
Northern ASIS, nearshore	37,610	28,755	2009
Northern ASIS, nearshore	74,647	57,072	2010
Northern ASIS, nearshore	37,610	28,755	2010
Ocean City Maryland	909,069	695,033	2010
Northern ASIS, nearshore	74,647	57,072	2011
Northern ASIS, nearshore	37,610	28,755	2011
Northern ASIS, nearshore	74,647	57,072	2012
Northern ASIS, nearshore	37,610	28,755	2012
Northern ASIS, nearshore	74,647	57,072	2013
Northern ASIS, nearshore	37,610	28,755	2013
Ocean City Maryland	884,155	675,985	2013
Northern ASIS, nearshore	37,610	28,755	2014
Northern ASIS, nearshore	37,610	28,755	2015
Ocean City Maryland	906,218	692,853	2017
Northern ASIS, nearshore	35,545	27,176	2018
Northern ASIS, nearshore	62,425	47,727	2019
Northern ASIS, nearshore	21,370	16,339	2020

Shoreline Position Surveys (1D), Spring 2005–Fall 2020

Timing of Shoreline Position Surveys

Seasonal surveys of the neap-tide, high-tide swash-line are included in this report (Table 3). Due to COVID-19 restrictions, the Spring 2020 survey could not be conducted.

Table 3. Date of shoreline survey and recorded elevation of previous neap-tide high-tide. Source: NOAA Lewes, Delaware tide gauge (#8557380). (<https://tidesandcurrents.noaa.gov/>)

Season	Date of Survey	Previous High Tide	
		Height*(m)	Time
Spring 2005	4/11/2005	1.388	10:14 AM
Fall 2005	11/23/2005	1.083	1:45 PM
Spring 2006	3/17/2006	1.304	9:56 AM
Fall 2006	11/17/2006	1.313	5:57 AM
Spring 2007	3/27/2007	1.149	3:45 AM
Fall 2007	11/21/2007	1.499	5:07 AM
Spring 2008	5/29/2008	1.205	3:34 PM
Fall 2008	10/9/2008	1.202	4:06 PM
Spring 2009	4/7/2009	1.423	6:45 AM
Fall 2009	9/30/2009	1.137	5:33 AM
Spring 2010	4/13/2010	1.286	7:43 AM
Fall 2010	11/28/2010	1.344	1:31 PM
Spring 2011	4/28/2011	1.214	5:08 AM
Fall 2011	12/7/2011	1.406	6:08 AM
Spring 2012	3/20/2012	1.344	7:08 AM
Fall 2012	12/5/2012	1.267	12:49 PM
Spring 2013	4/22/2013	1.358	5:27 AM
Fall 2013	11/21/2013	1.404	10:36 AM
Spring 2014	5/27/2014	1.233	7:25 AM
Fall 2014	10/20/2014	1.388	5:52 AM
Spring 2015	4/1/2015	1.316	6:41 AM
Fall 2015	12/10/2015	1.604	7:36 AM
Spring 2016	4/6/2016	1.605	7:26 AM
Fall 2016	12/19/2016	1.215	12:41 PM
Spring 2017	4/10/2017	1.293	8:04 AM
Fall 2017	10/25/2017	1.589	11:59 AM
Spring 2018	5/4/2018	1.085	11:27 AM
Fall 2018	11/14/2018	1.086	1:09 PM

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

Table 3 (continued). Date of shoreline survey and recorded elevation of previous neap-tide high-tide. Source: NOAA Lewes, Delaware tide gauge (#8557380). (<https://tidesandcurrents.noaa.gov/>)

Season	Date of Survey	Previous High Tide	
		Height*(m)	Time
Spring 2019	5/1/2019	1.333	6:06 AM
Fall 2019	11/4/2019	1.483	2:18 PM
Spring 2020	No Survey	No Survey	No Survey
Fall 2020	10/1/2020	1.322	12:34 PM

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

The dataset was split into two sections to best describe the changes occurring on Assateague Island. The first dataset included the shoreline facing the Atlantic Ocean starting at the Ocean City Inlet and continuing to the southern portion of the island in Chincoteague National Wildlife Refuge (NWR). The second dataset focused on the Toms Cove Hook shoreline. This dataset was further divided into two sections. The NE/SW Hook section contained the portion of the shoreline that was extending to the southwest as the spit accreted. The NW/SE Hook section of the shoreline was composed of the remainder of the Toms Cove Hook shoreline including the westernmost spit. This was done to more accurately display and discuss the changes on this dynamic portion of the island.

Spring surveys were used as the basis for annual comparison to capture the full stormy and non-stormy conditions throughout the year. The Spring-Spring survey comparisons are more likely to provide the annual displacements because the Spring survey can be delayed in the event of a late winter storm, whereas the Fall survey results may be compromised by an early winter storm that occurs before the Fall survey can be accomplished. Because the Spring 2020 survey could not be collected due to COVID-19 restrictions, the Fall 2020 survey was used to complete the annual comparison.

Spring 2005–Spring 2010 Surveys

Annual Shoreline Change Surveys, 2005–2010

Assateague Island Ocean Shoreline

Annual shoreline changes between successive spring surveys record erosion and accretion events along the oceanside of Assateague Island (Figures 6 & 7). The Spring 2005–Spring 2006 shoreline survey displays consistent seaward shoreline displacement, a mean net seaward shift of +13.21 m (Table 4). The largest seaward displacements occurred on the northern and southern termini of the island, +64.72 m and +60.50 m, respectively. Small pockets of landward movement occurred near the Toms Cove Visitor Center, on the order of –21.86 m. The entire shoreline migrated landward during the Spring 2006–Spring 2007 survey, a mean net displacement of –17.75 m. Larger inland displacements focused around the southern portion of Chincoteague, –53.22 m. During the Spring 2007–Spring 2008 survey, moderate seaward gains were made on the northern and southern termini, a maximum of +46.06 m, with a mean net gain of +8.06 m. A gap in the Spring 2008 shoreline survey data occurred on the northern portion of Chincoteague NWR due to endangered shorebird activity. That data gap caused small breaks in the Spring 2007–Spring 2008 and Spring 2008–Spring

2009 survey comparisons. Large seaward and landward shifts were recorded on the southernmost portion of Chincoteague during the Spring 2008–Spring 2009 survey, +68.05 m and –36.82 m, respectively. Landward migration occurred along the majority of the island’s oceanside shoreline during the Spring 2009–Spring 2010 survey, a mean net of –10.31 m. A small area of seaward movement happened near the southern portion of Chincoteague, +119.39 m. The greatest landward displacement took place on the southern portion of Chincoteague during this period, –84.21 m.

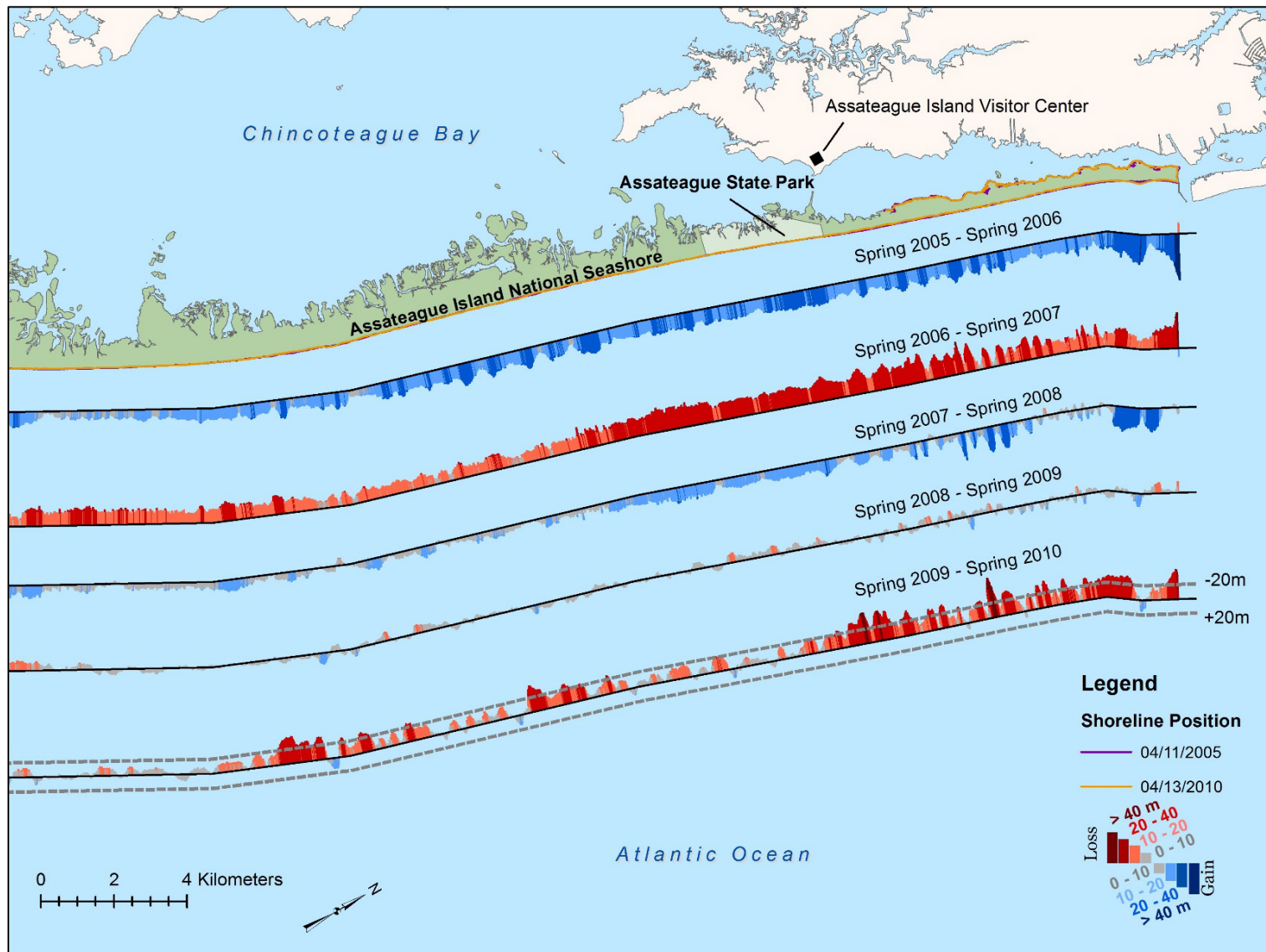


Figure 6. Annual shoreline position changes along the northern half of Assateague Island, Spring 2005–Spring 2010 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

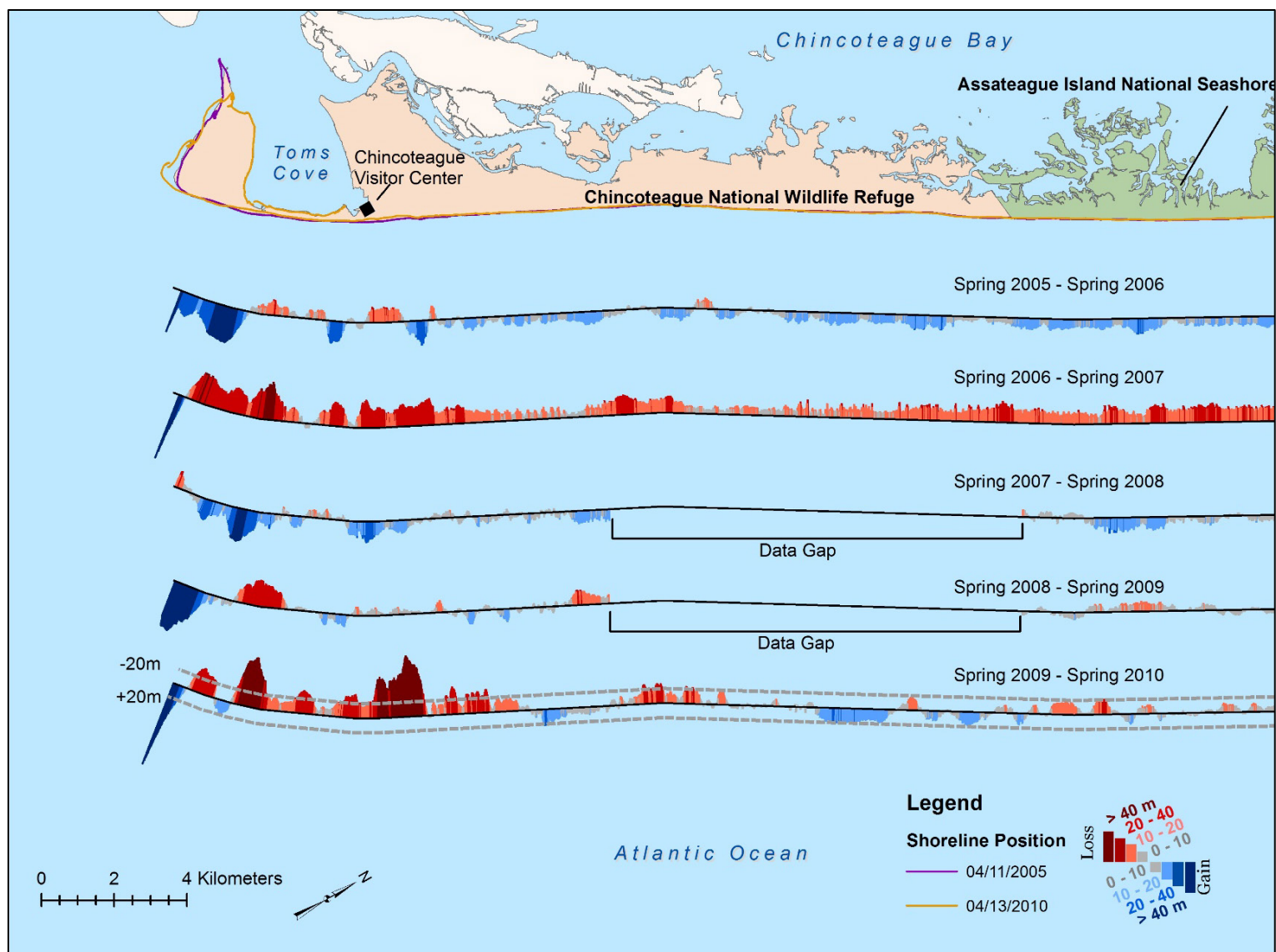


Figure 7. Annual shoreline position changes along the southern half of Assateague Island, Spring 2005–Spring 2010 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

Table 4. Metrics of ocean shoreline change associated with the ocean shoreline position on Assateague Island, Spring 2005–Spring 2010 surveys.

Metric	Survey Period					
	Spring 2005– Spring 2006	Spring 2006– Spring 2007	Spring 2007– Spring 2008	Spring 2008– Spring 2009	Spring 2009– Spring 2010	Spring 2005– Spring 2010
Mean (m)	+13.12	–17.75	+8.06	–0.62	–10.31	–8.14
StDev (m)	±10.17	±8.36	±8.64	±10.23	±16.06	±22.96
Min (m)	–21.86	–53.22	–24.15	–36.82	–84.21	–111.49
Max (m)	+64.72	+93.05	+46.06	+68.05	+119.39	+187.36

Toms Cove Hook Shoreline

Seaward gains were made over much of Toms Cove Hook during the Spring 2005–Spring 2006 survey, a mean net gain of +29.05 m. However, during this same period the westernmost tip shifted landward, –225.41 m (Figure 8, Table 5). During the Spring 2006–Spring 2007 survey, the western tip of the Hook shortened in length, –191.25 m, and the southern terminus of the Hook broadened and expanded southward, +136.89 m, leading to a low mean net gain of +2.86 m. Seaward growth on the southern terminus, a mean net seaward displacement of +16.80 m, was recorded during the Spring 2007–Spring 2008 survey. The NE/SW section of Toms Cove Hook had seaward growth during the Spring 2008–Spring 2009 survey, a mean net shift of +16.56 m. A seaward expansion of the NE/SW section was recorded during the Spring 2009–Spring 2010 survey, a maximum gain of +213.13 m, whereas the western tip continued to shift landward, –137.68 m.

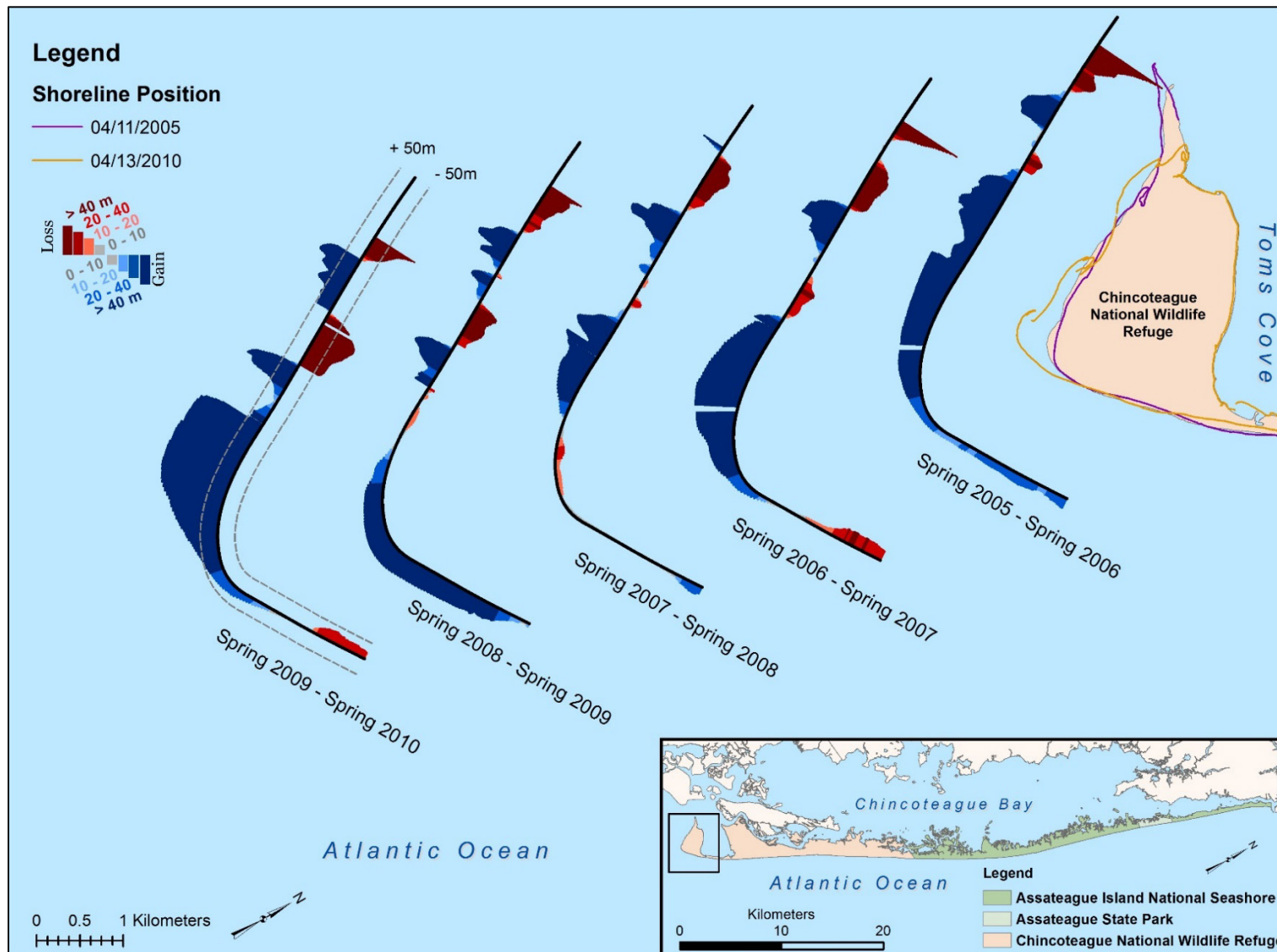


Figure 8. Annual shoreline position changes along the Toms Cove Hook shoreline, Spring 2005–Spring 2010 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

Table 5. Metrics of shoreline position change associated with the Toms Cove Hook on Chincoteague National Wildlife Refuge, Spring 2005–Spring 2010 surveys.

Metric	Survey Period					
	Spring 2005– Spring 2006	Spring 2006– Spring 2007	Spring 2007– Spring 2008	Spring 2008– Spring 2009	Spring 2009– Spring 2010	Spring 2005– Spring 2010
Mean (m)	+29.05	+2.86	+16.80	+16.56	+23.76	+114.01
StDev (m)	±57.58	±58.06	±48.01	±49.45	±84.98	±157.73
Min (m)	–225.41	–191.25	–68.25	–109.70	–137.68	–323.33
Max (m)	+116.57	+136.89	+142.00	+111.26	+213.13	+466.81

5-Year Shoreline Change Survey, 2005–2010

During this survey period, the oceanside shoreline position of Assateague Island had a mean net landward displacement of –8.14 m (Figures 9 & 10). The largest inland shift was in the southern portion of Chincoteague, –111.49 m (Table 4). The largest seaward movement occurred near the Ocean City Inlet and also on the southern portion of Chincoteague, a gain of +64.84 and +187.36 m respectively (Figures 9 & 10).

A general seaward displacement of shoreline position of Toms Cove Hook (Figure 11) was recorded, a mean net shift of +114.01 m (Table 5). However, the Hook’s displacement consisted of very large gain at the southern terminus, a maximum of +466.81 m, and a very large loss at the westernmost point where the tip shifted landward, a loss of –323.33 m. (Table 5).

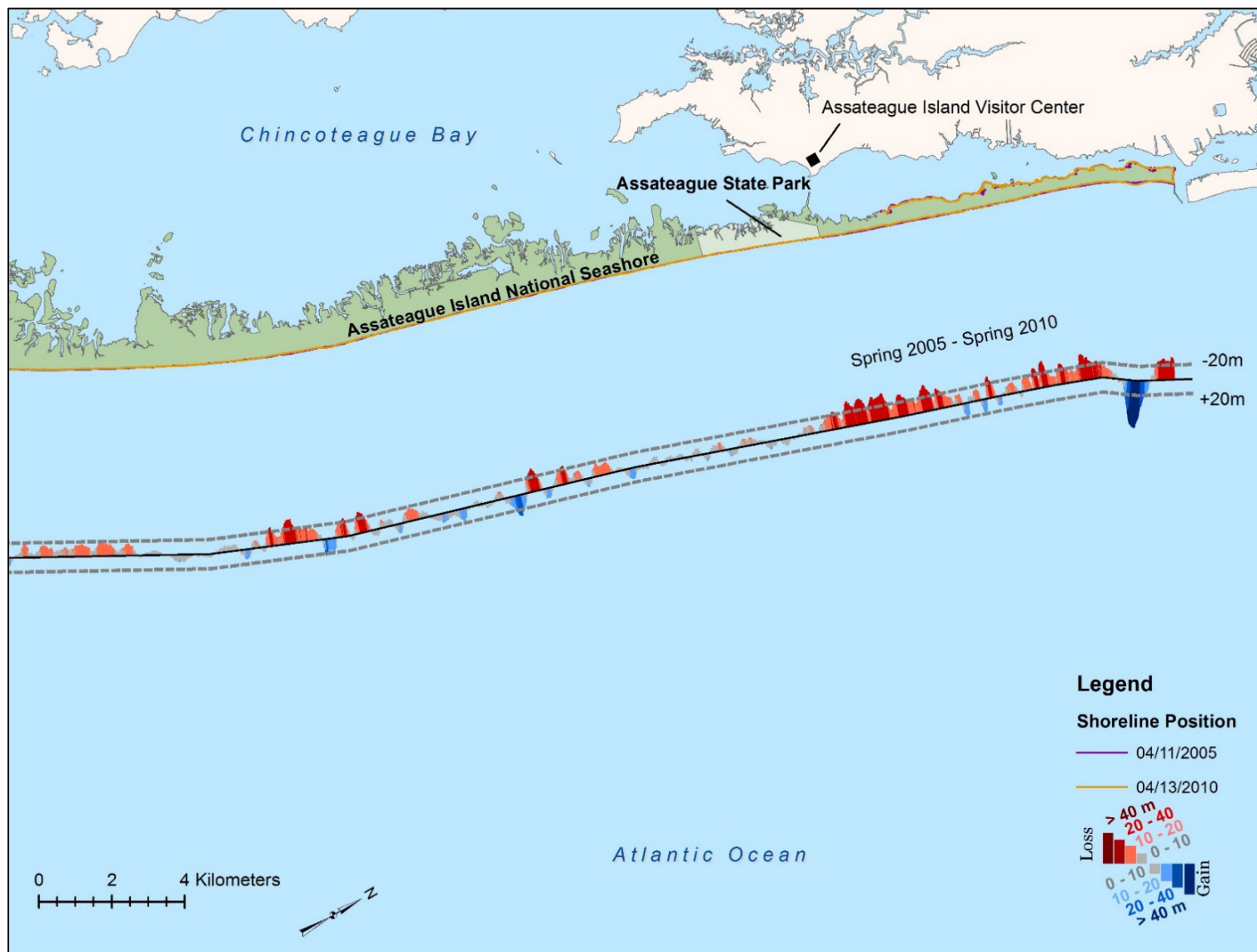


Figure 9. 5-year shoreline position changes along the northern half of Assateague Island, Spring 2005–Spring 2010 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

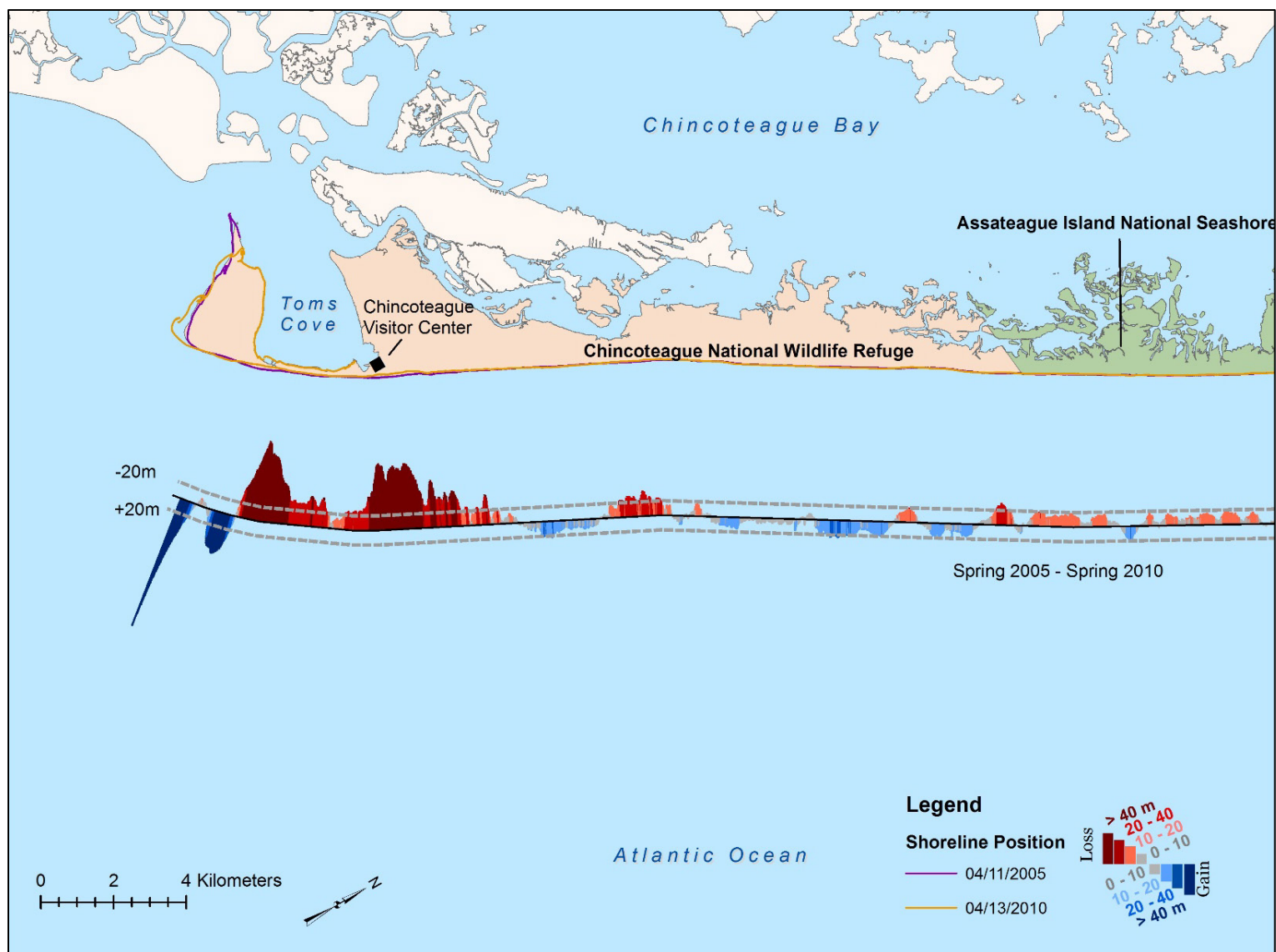


Figure 10. 5-year shoreline position changes along the southern half of Assateague Island, Spring 2005–Spring 2010 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

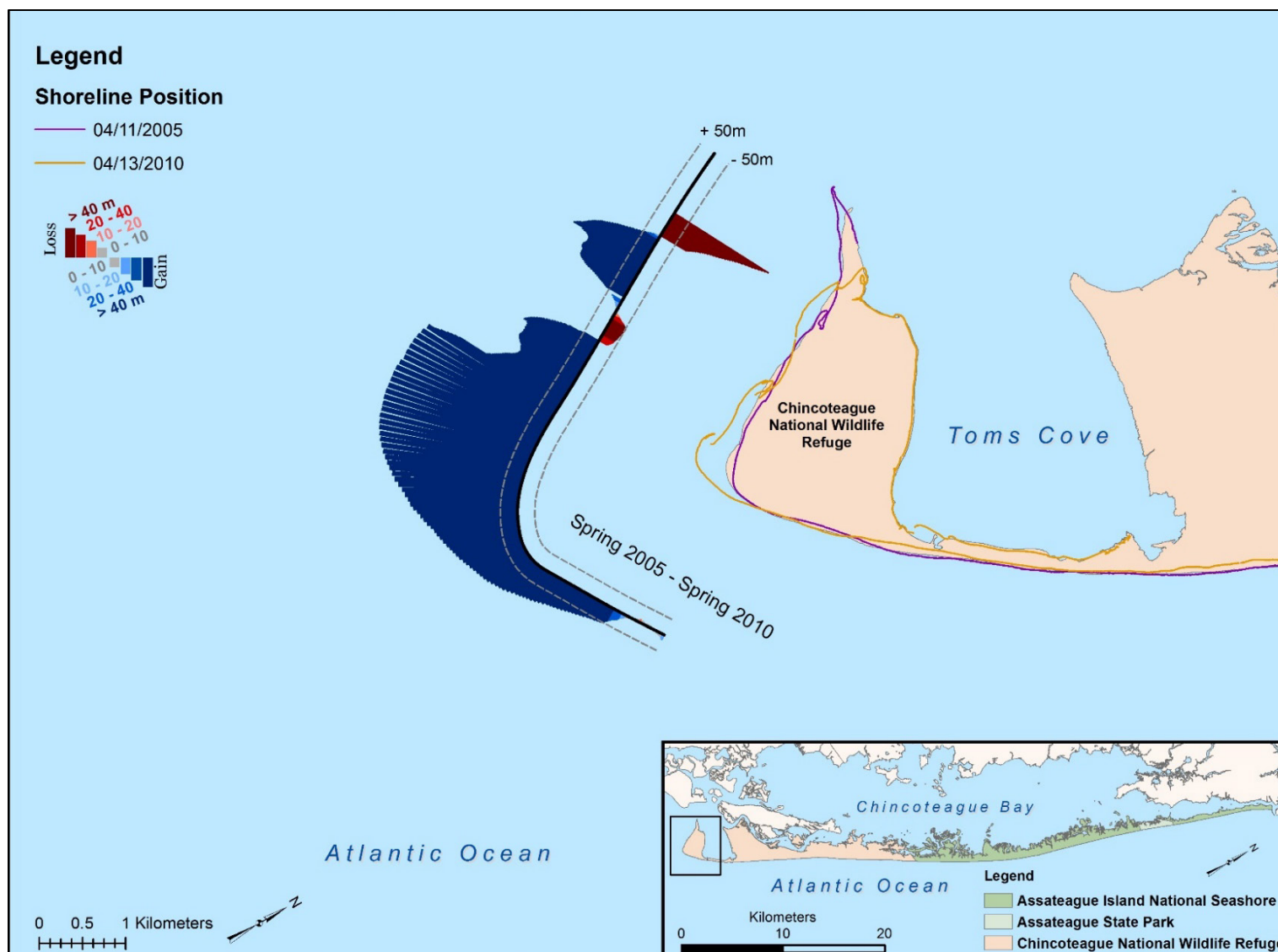


Figure 11. 5-year shoreline position changes along the Toms Cove Hook shoreline, Spring 2005–Spring 2010 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

Spring 2010–Spring 2015 Surveys

Annual Shoreline Change Surveys, 2010–2015

Assateague Island Ocean Shoreline

Annual shoreline position changes between successive spring surveys show erosion and accretion events along the oceanside of Assateague Island (Figures 12 & 13). A seaward displacement occurred from the northern boundary of Assateague State Park to the Ocean City Inlet during the Spring 2010–Spring 2011 survey, with maximum gains of +40.53 m (Table 6). During this same survey period, a landward movement happened from the Chincoteague Visitor Center continuing to the south. The largest loss was –50.92 m. Seaward displacement continued during the Spring 2011–Spring 2012 survey with an overall mean net displacement of +5.11 m. The largest seaward change occurred near the Ocean City Inlet, a maximum seaward movement of +39.18 m. The Spring 2012–Spring 2013 survey changes had a mean net landward displacement of –11.82 m, however an area of acute seaward movement happened near the Ocean City Inlet, reaching a maximum of +44.04 m. It should be noted that the events of Hurricane Sandy took place between October 28th and 29th of 2012 with a storm surge of 1.169 m over the course of 4 tides (Table 1). During the Spring 2013–Spring 2014 survey, seaward gains were made along the entire island, gradually increasing from north to south for a mean net gain of +7.19 m. The largest seaward movement occurred on the southern portion of Chincoteague NWR, a maximum gain of +53.91 m. Seaward movement was more prevalent in the northern half of Assateague Island during the Spring 2014–Spring 2015 survey, with recorded gains of +30.27 m, whereas landward movement was more dominant on the southern half, with a recorded loss of –49.35 m. This led to a low mean gain of +1.71 m for the annual period.

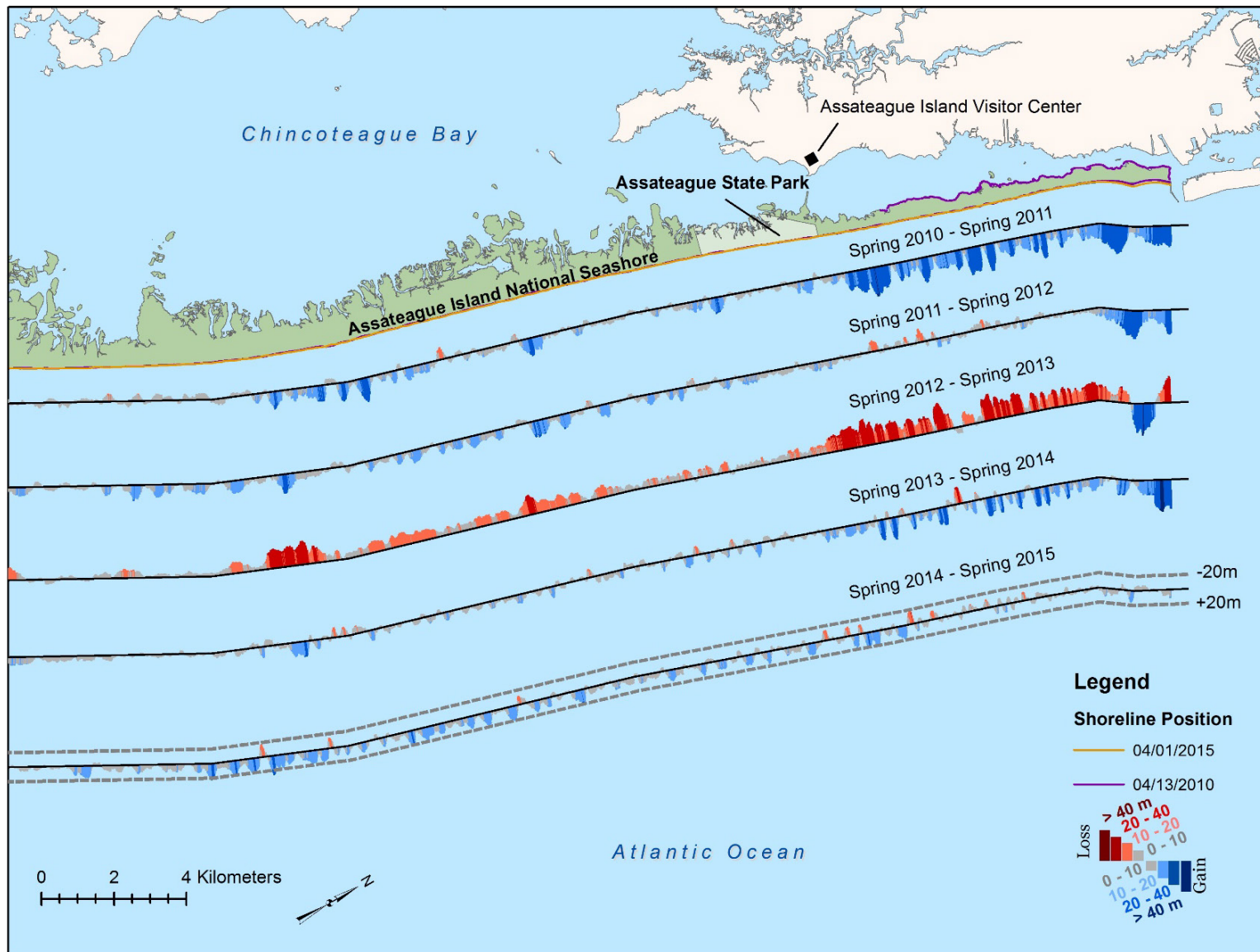


Figure 12. Annual shoreline position changes along the northern half of Assateague Island, Spring 2010–Spring 2015 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

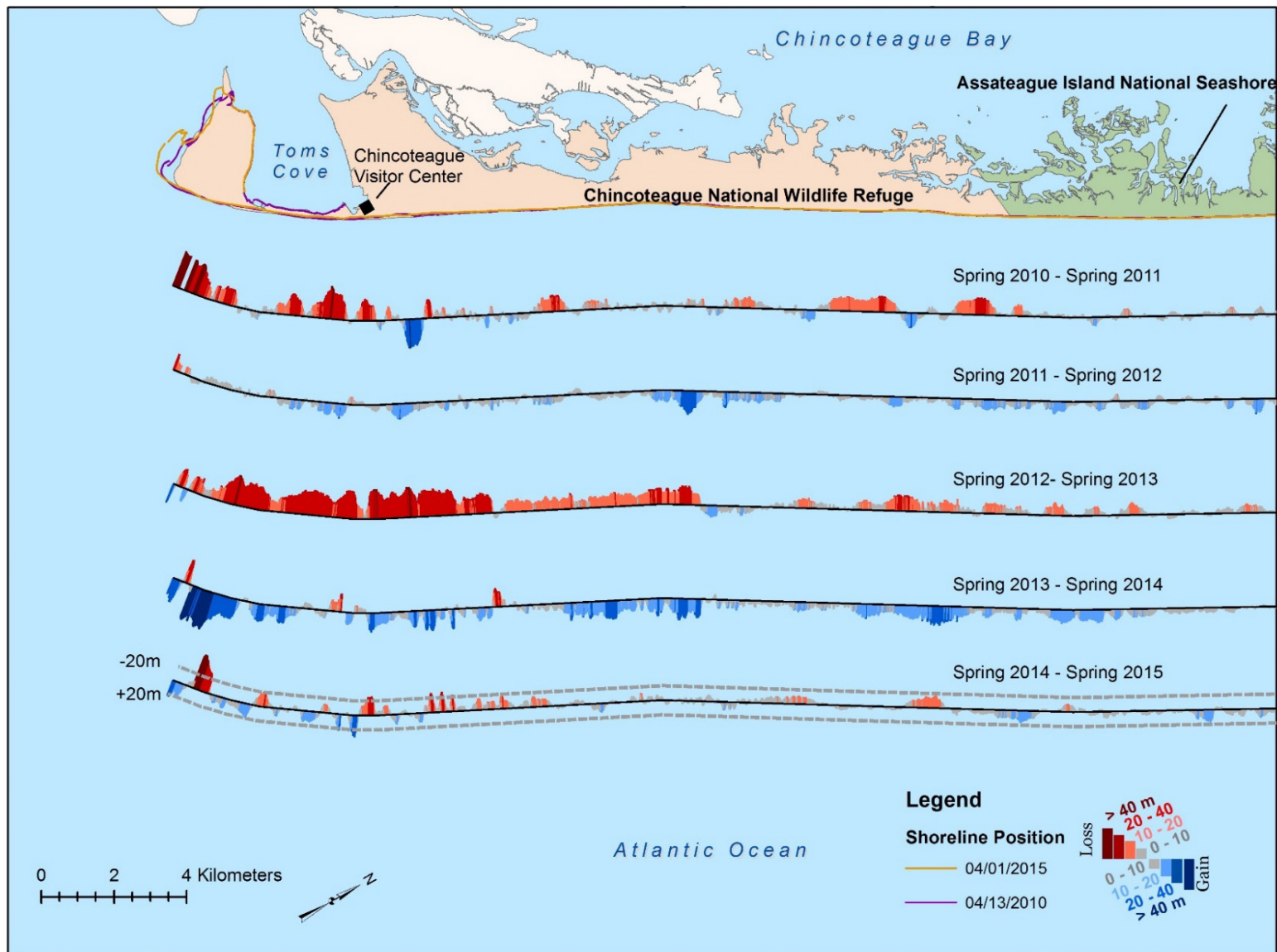


Figure 13. Annual shoreline position changes along the southern half of Assateague Island, Spring 2010–Spring 2015 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

Table 6. Metrics of shoreline change associated with the ocean shoreline position on Assateague Island, Spring 2010–Spring 2015 surveys.

Metric	Survey Period					
	Spring 2010– Spring 2011	Spring 2011– Spring 2012	Spring 2012– Spring 2013	Spring 2013– Spring 2014	Spring 2014– Spring 2015	Spring 2010– Spring 2015
Mean (m)	+1.70	+5.11	–11.82	+7.19	+1.71	+3.69
StDev (m)	±13.41	±7.09	±11.07	±9.91	±8.62	±.69
Min (m)	–50.92	–23.63	–42.67	–33.73	–49.35	–65.82
Max (m)	+40.53	+39.18	+44.04	+53.91	+30.27	+82.47

Toms Cove Hook Shoreline

The annual shoreline position changes on Toms Cove Hook show a trend of seaward movement to the southwest. The Spring 2010–Spring 2011 survey had gains and losses alternate along the Toms Cove Hook shoreline (Figure 14). Landward movement occurred on the NE/SW shoreline, followed by large seaward gains on the southern terminus, up to +233.01 m (Table 7). Overall, the mean net seaward movement was +14.65 m. Seaward gains along the southern terminus and western tip were recorded during the Spring 2011–Spring 2012 survey, a mean net shift of +15.05 m. During the Spring 2012–Spring 2013 survey, the southern terminus and westernmost portions of the shoreline continued to shift seaward, a maximum of +306.34 m. A seaward extension continued towards the southwest during the Spring 2011–Spring 2012 survey, a mean net displacement of +28.88 m, and a maximum change of +355.94 m occurring along the southern terminus. The least change, a mean net seaward movement of +9.53 m, was recorded during the Spring 2014–Spring 2015 survey.

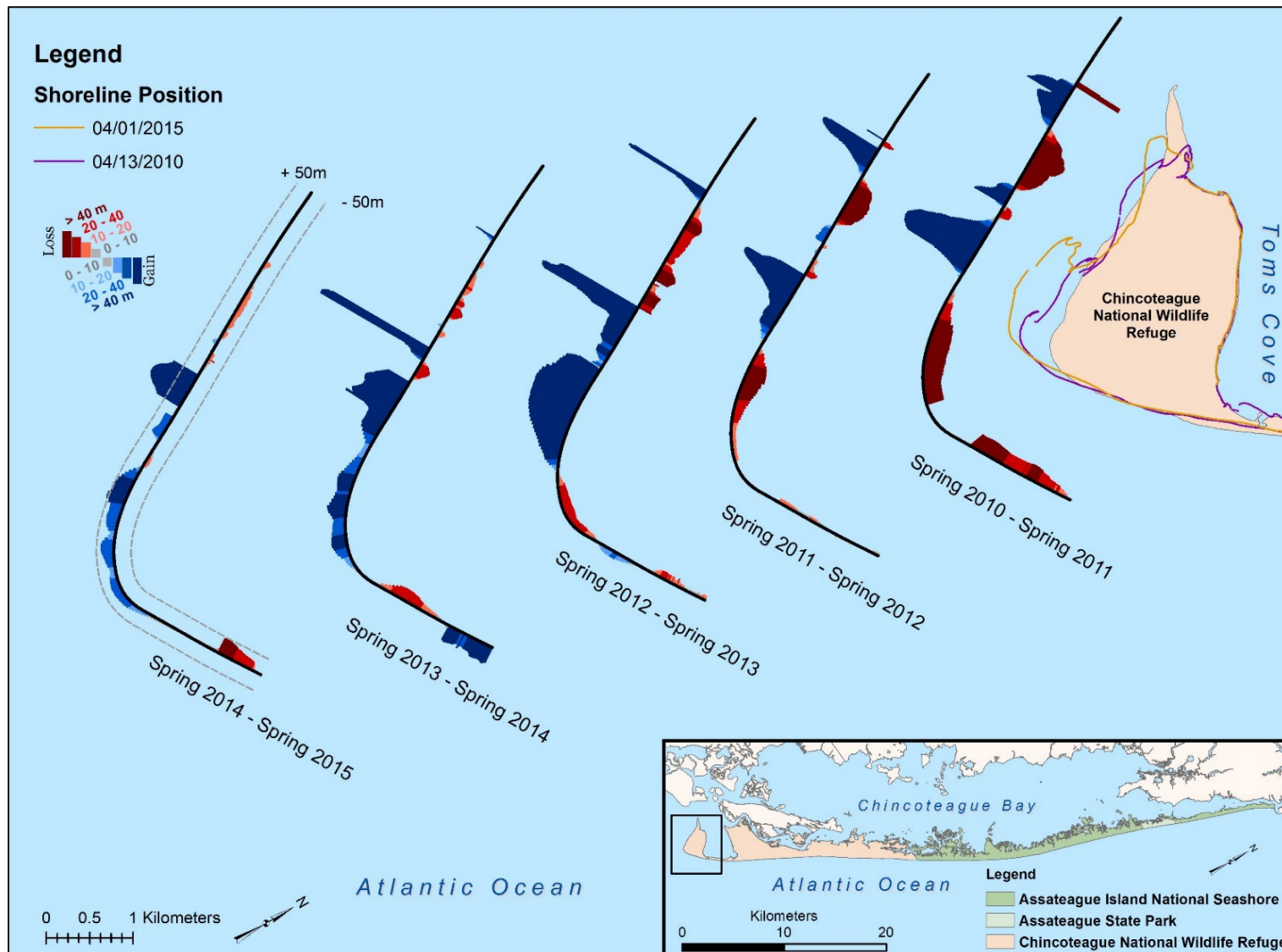


Figure 14. Annual shoreline position changes along the Toms Cove Hook shoreline, Spring 2010–Spring 2015 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

Table 7. Metrics of shoreline position change associated with the Toms Cove Hook shoreline in Chincoteague National Wildlife Refuge, Spring 2010–Spring 2015 surveys.

Metric	Survey Period					
	Spring 2010– Spring 2011	Spring 2011– Spring 2012	Spring 2012– Spring 2013	Spring 2013– Spring 2014	Spring 2014– Spring 2015	Spring 2010– Spring 2015
Mean (m)	+14.65	+15.05	+20.36	+28.88	+9.53	+85.33
StDev (m)	±83.34	±60.58	±76.84	±65.46	±39.57	±208.56
Min (m)	–146.82	–66.85	–57.49	–37.76	–49.83	–210.93
Max (m)	+233.01	+188.92	+306.34	+355.94	+125.36	+497.34

5-Year Shoreline Change Survey, 2010–2015

Net shoreline position change on the Assateague Island oceanside between 2010 and 2015 trended seaward over a majority of the island (Figures 15 & 16), resulting in a mean net of +3.69 m (Table 6). Large seaward gains were on the northern portion of Assateague Island near the Ocean City Inlet, a maximum +82.47 m. The southern end of Assateague Island, within the Chincoteague NWR, had the greatest landward movement, -65.82 m.

Shoreline position changes on Toms Cove Hook between 2010 and 2015 displayed an alternating pattern of movement (Figure 17). The NE/SW portion of the shoreline position had landward movement, -73.93 m (Table 7). A large seaward displacement developed along the southern terminus of the shoreline, a maximum gain of +497.34 m. During this period, the southern terminus was the site of the formation of a secondary spit feature that expanded to the south and west. The westernmost tip of Toms Cove Hook shifted seaward to the southwest, +364.78 m. Overall, Toms Cove Hook had a mean net seaward displacement of +85.33 m.

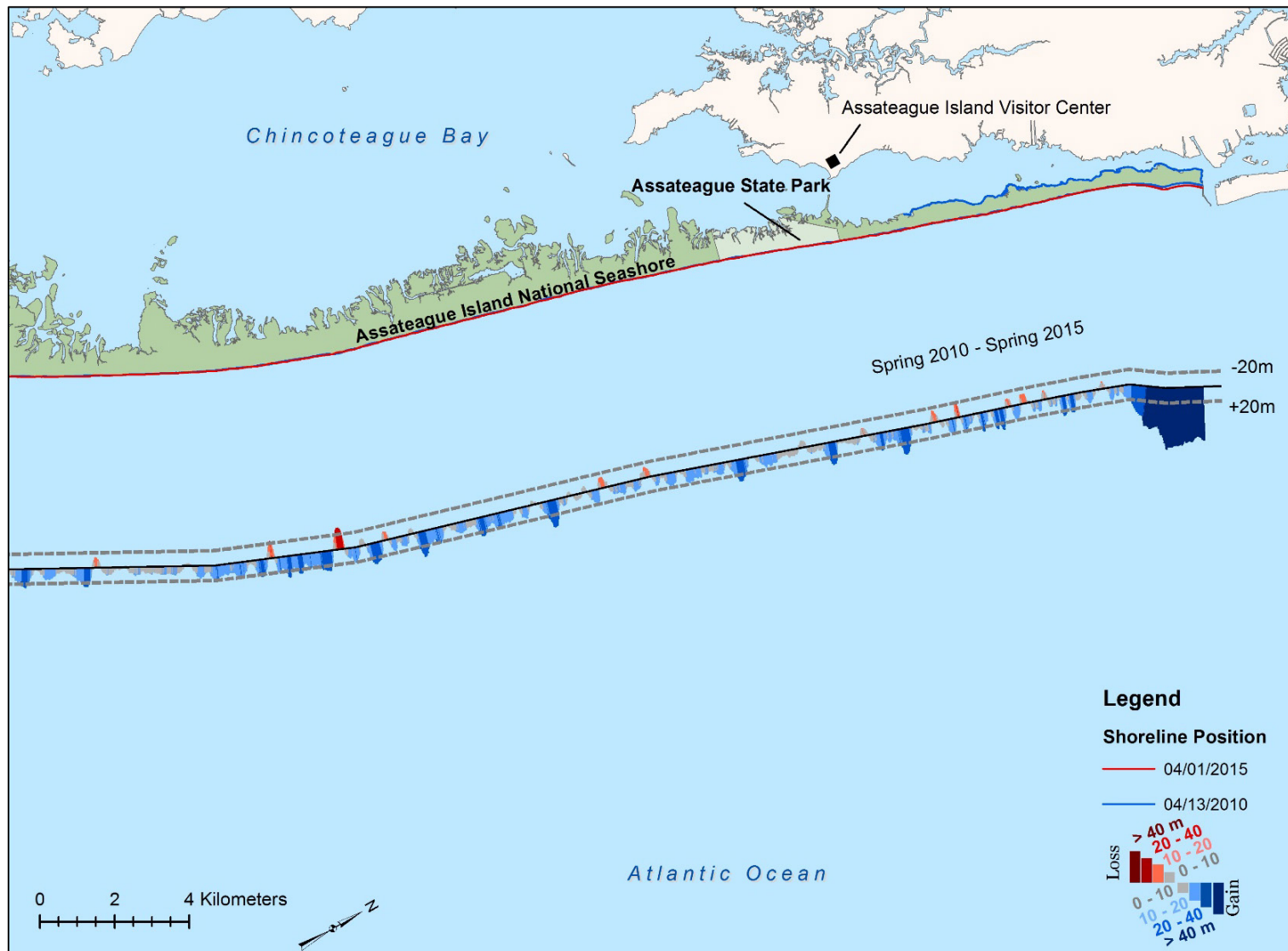


Figure 15. 5-year shoreline position changes along the northern half of Assateague Island, Spring 2010–Spring 2015 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

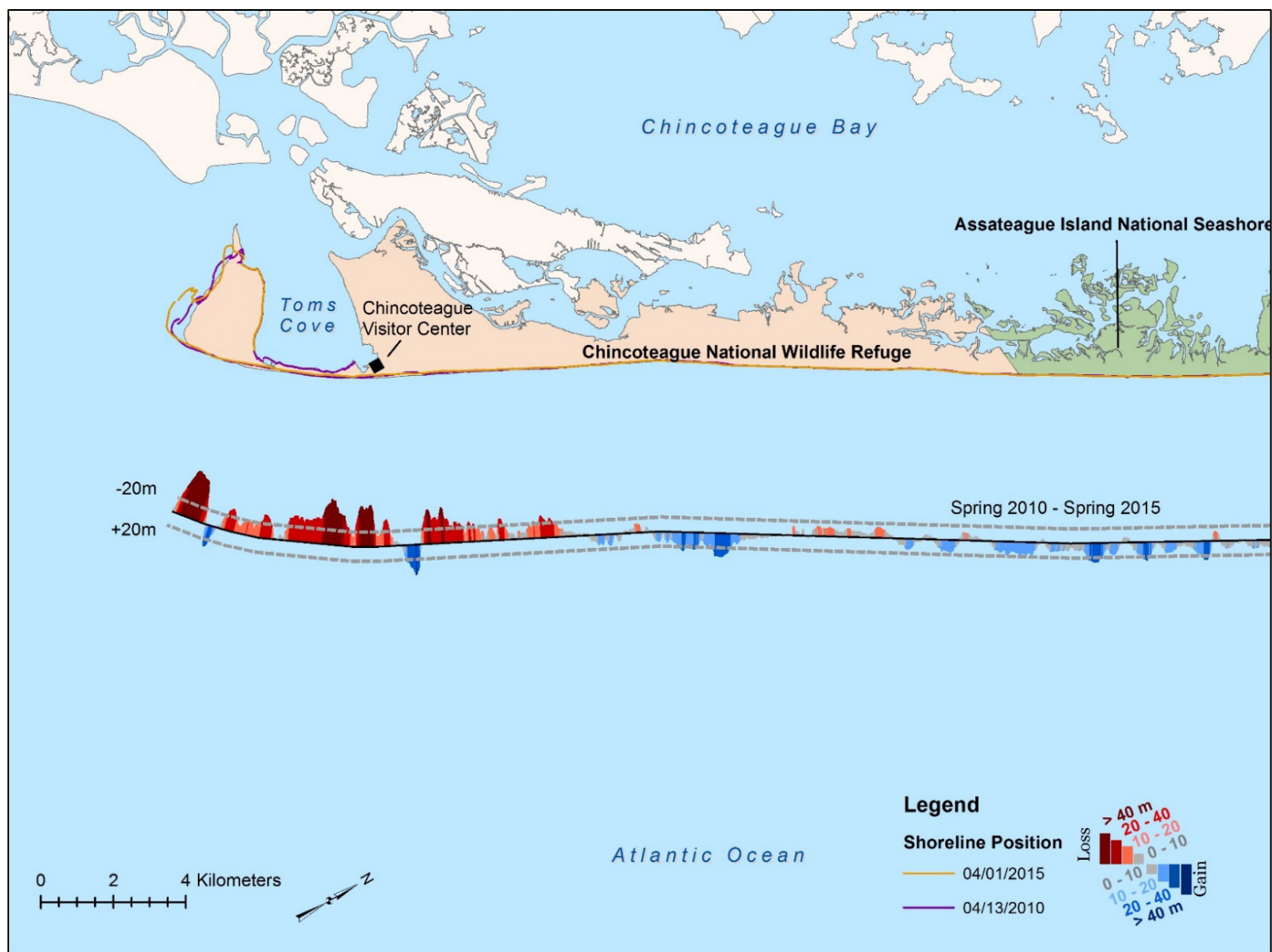


Figure 16. 5-year shoreline position changes along the southern half of Assateague Island, Spring 2010–Spring 2015 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

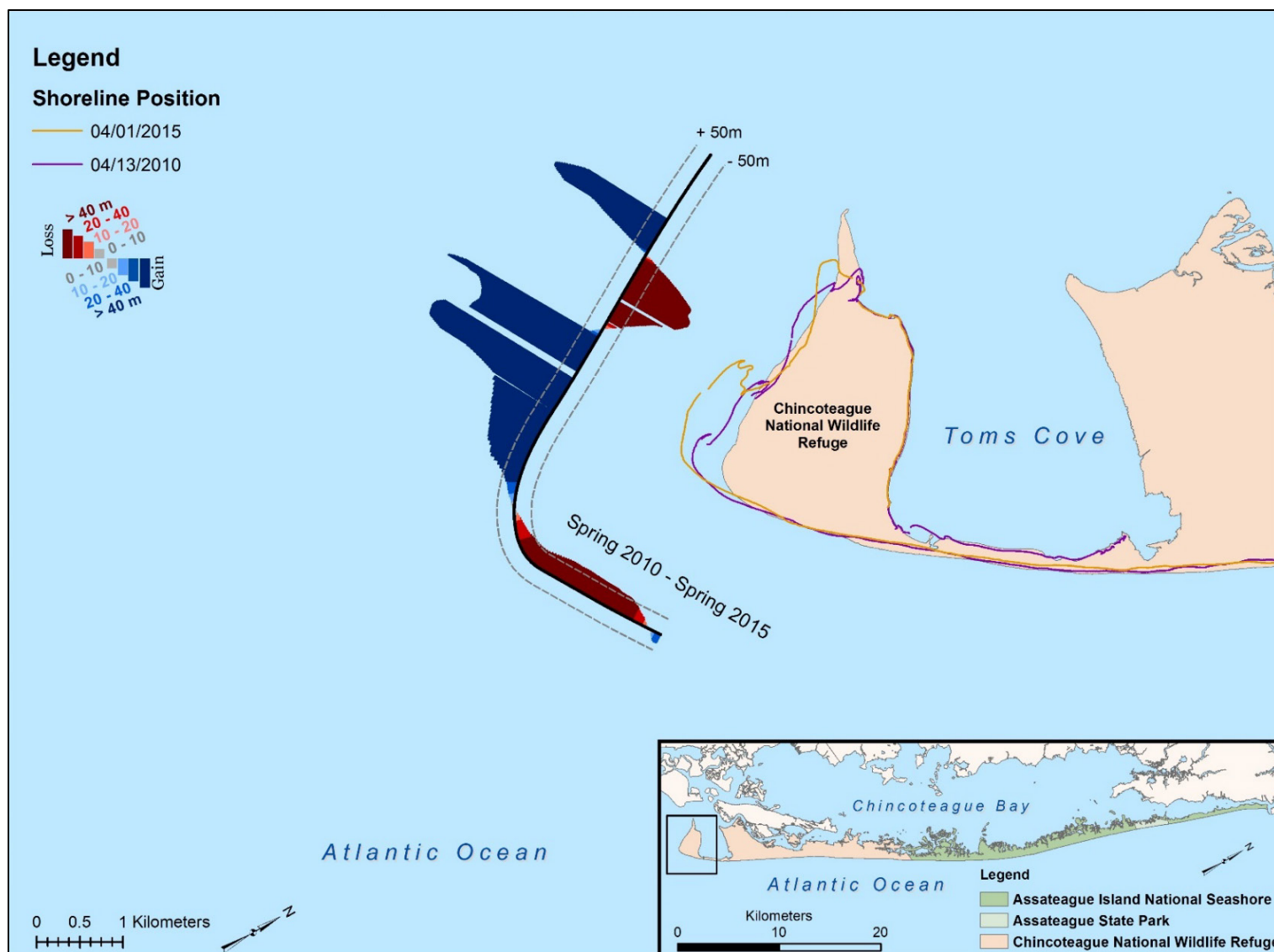


Figure 17. 5-year shoreline position changes along the Toms Cove Hook shoreline, Spring 2010–Spring 2015 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

Spring 2015–Fall 2020 Surveys

Annual Shoreline Change Surveys, 2015–2020

Assateague Island Ocean Shoreline

Large landward displacement occurred during the Spring 2015–Spring 2016 survey, resulting in a mean net loss of -27.86 m (Figures 18 & 19). The largest areas of loss during this period occurred north of Assateague State Park and south of the Chincoteague Visitor Center, -73.85 m and -91.18 m respectively. Along the island, seaward gains were made during the Spring 2016–Spring 2017 survey. A mean net gain of $+18.35$ m was recorded (Table 8), with the largest gains, $+62.07$ m, occurring on the northern half of the island. During the Spring 2017–Spring 2018 survey, the smallest seaward shifts were recorded in the central portion of the island, $+25.49$ m, whereas the northern and southern termini had losses up to -39.61 m. This combination of gains and losses led to a small mean net change of -0.42 m (Table 8). Seaward shoreline displacement occurred during the Spring 2018–Spring 2019 survey with the largest shift, maximum $+52.28$ m, near the Ocean City Inlet, and mean net shift seaward $+6.82$ m. Due to restrictions in surveying caused by COVID-19, shoreline position data could not be collected in spring 2020. Instead, the Fall 2019 survey was compared to the Fall 2020 survey in this report. Moderate landward movement occurred during the Fall 2019–Fall 2020 survey, with the largest landward shift of -29.99 m (Table 8) taking place near the Chincoteague Visitor Center. Overall, the mean net shift was landward, -4.34 m.

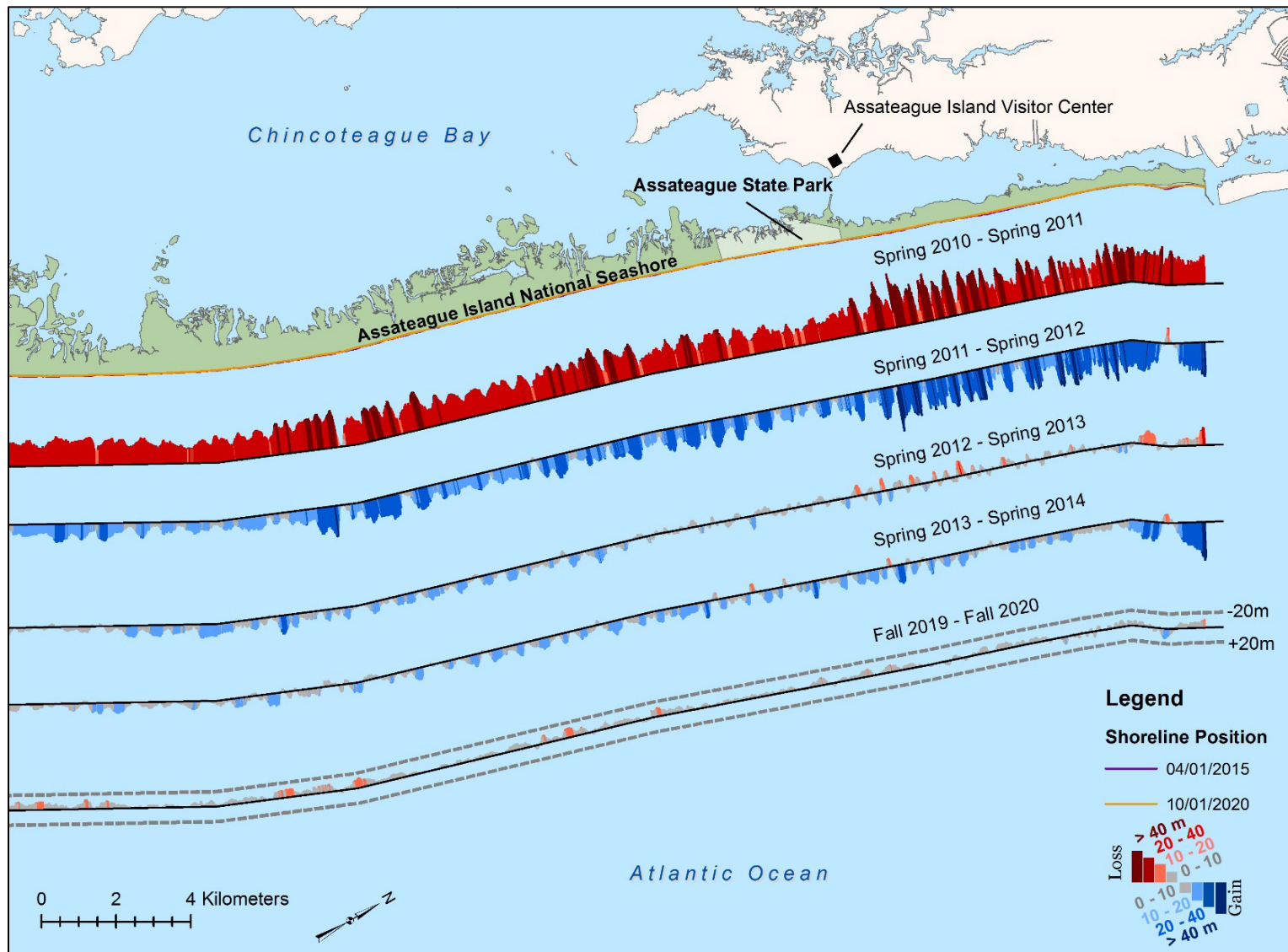


Figure 18. Annual shoreline position changes along the northern half of Assateague Island, Spring 2010–Spring 2015 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

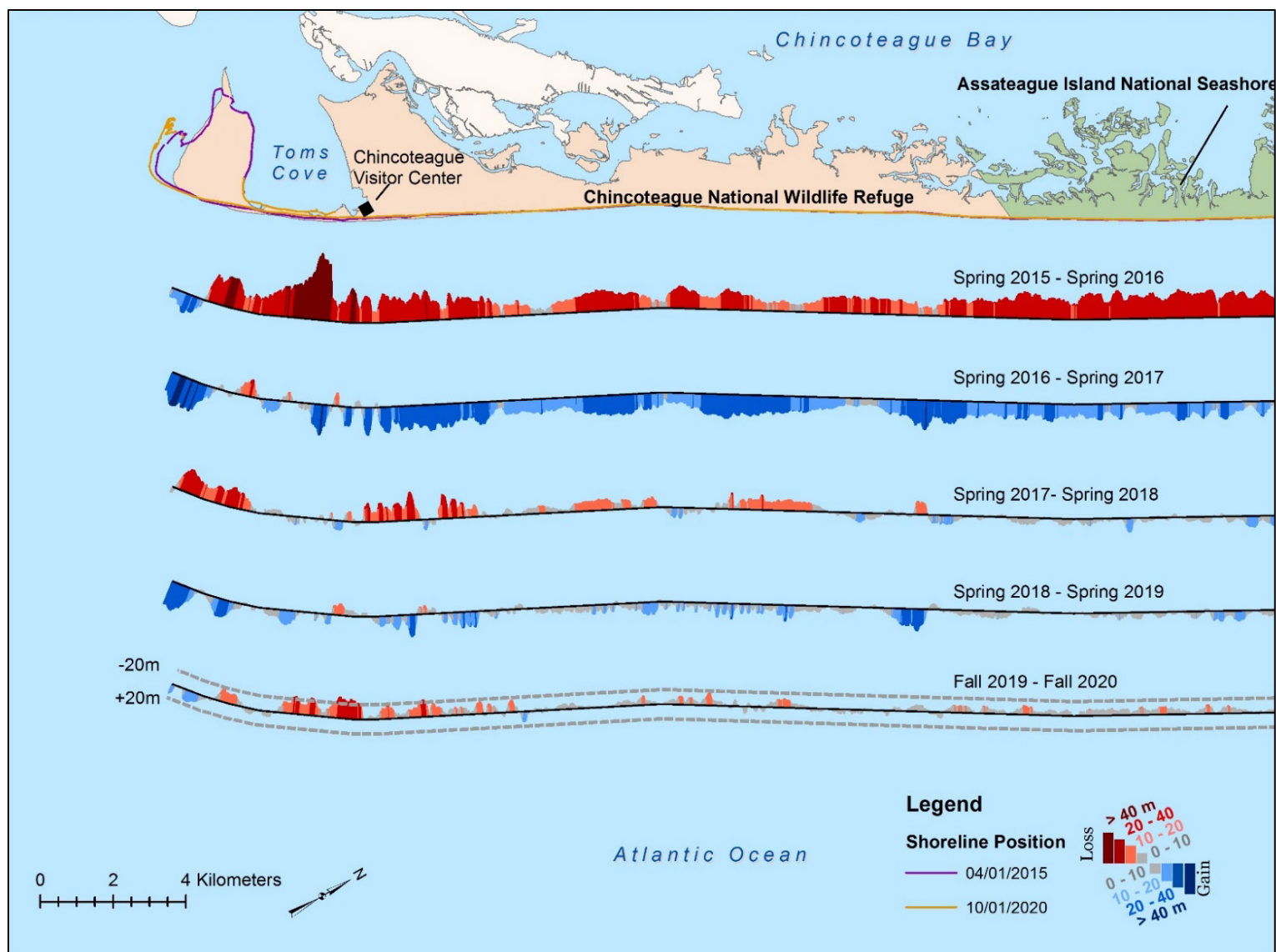


Figure 19. Annual shoreline position changes along the southern half of Assateague Island, Spring 2010–Spring 2015 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

Table 8. Metrics of shoreline change associated with the ocean shoreline of Assateague Island, Spring 2015–Fall 2020 surveys.

Metric	Survey Period					
	Spring 2015– Spring 2016	Spring 2016– Spring 2017	Spring 2017– Spring 2018	Spring 2018– Spring 2019	Fall 2019– Fall 2020	Spring 2015– Fall 2020
Mean (m)	–27.86	+18.35	–0.42	+6.82	–4.34	–11.01
StDev (m)	±12.53	±10.58	±9.74	±7.83	±5.65	±16.74
Min (m)	–91.18	–24.22	–39.61	–16.77	–29.99	–77.91
Max (m)	+27.35	+62.07	+25.49	+52.28	+15.90	+75.49

Toms Cove Hook Shoreline

An issue present over this dataset is the formation of a secondary spit on the southern terminus. As this spit formed, it extended linearly to the south and west leading to an inability to calculate shoreline comparisons, particularly in the mean and maximum gains value (Figure 20). A data gap in the Spring 2016 survey of the NW/SE shoreline affected ability to conduct the full Spring 2015–Spring 2016 and Spring 2016–Spring 2017 survey comparisons. In those areas that had comparable surveys, the Spring 2015–Spring 2016 survey had a seaward shift along a majority of shoreline (Figure 20), with a maximum +414.2 m on the southern terminus spit and a mean net of +22.56 m (Table 9). Large amounts of seaward displacement on the southern terminus spit, a maximum of +608.67 m and a mean net of +72.81 m was recorded during the Spring 2016–Spring 2017 survey. During the Spring 2017–Spring 2018 survey, landward shifts were recorded. On the NW/SE section of shoreline, up to –86.65 m, whereas the southern terminus spit had gains up to +165.40 m. Overall, the mean net displacement of surveyed portions of the Hook was +8.67 m. The Spring 2018–Spring 2019 survey had seaward shifts along the NE/SW and southern terminus section of shoreline, maximum of +149.24, whereas the NW/SE section shifted landward –90.76 m. Due to restrictions in surveying caused by COVID-19, shoreline position data could not be collected in spring. Instead, the Fall 2019 survey was compared to the Fall 2020 survey for this report. The Fall 2019–Fall 2020 survey showed a seaward displacement on the NE/SW and southern terminus of shoreline, a mean net growth of +19.06 m (Table 9). A gap in data in the Fall 2019 and the Fall 2020 shoreline position surveys prevented a comparison of the western portion of Toms Cove Hook.

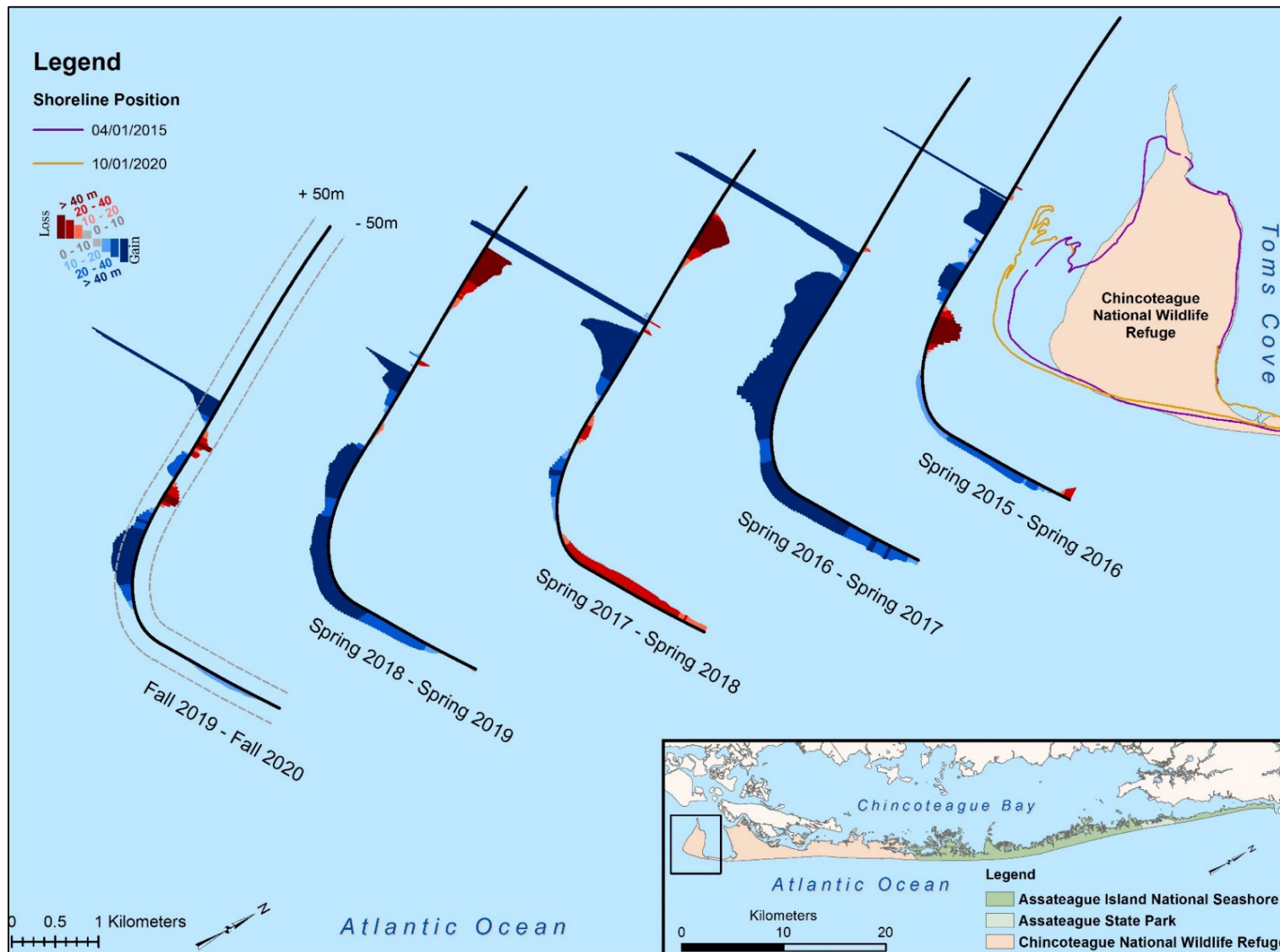


Figure 20. Annual shoreline position changes along the Toms Cove Hook shoreline, Spring 2010–Spring 2015 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

Table 9. Metrics of shoreline position change associated with the Toms Cove Hook shoreline in Chincoteague National Wildlife Refuge, Spring 2015–Fall 2020 surveys.

Metric	Survey Period					
	Spring 2015– Spring 2016*	Spring 2016– Spring 2017*	Spring 2017– Spring 2018	Spring 2018– Spring 2019	Fall 2019– Fall 2020*	Spring 2015– Fall 2020*
Mean (m)	+22.56	+72.81	+8.67	+6.69	+19.06	+198.33
StDev (m)	±46.52	±91.83	±85.59	±37.87	±51.03	±227.59
Min (m)	–84.02	–22.09	–86.65	–90.76	–50.94	–32.77
Max (m)	+414.20	+608.67	+587.19	+149.24	+430.55	+935.52

5-Year Shoreline Change Survey, 2015–2020

Shoreline position data could not be collected during spring 2020 due to COVID-19 restrictions. Instead, the Spring 2015 survey is compared to the Fall 2020 survey. A landward displacement characterized the majority of the island with the largest losses, –77.91 m, occurring near the Chincoteague Visitor Center. For the period, Assateague Island had a net mean loss of –11.01 m (Figures 21 & 22, Table 8).

The absence of shoreline position data from the western tip in fall 2020 prevented comparison of this area. Large amounts of seaward gain occurred during the Spring 2015–Fall 2020 survey as the southern terminus spit shifted to the south and west, +935.52 m (Figure 23, Table 9). An overall net mean seaward displacement of +198.33 m occurred during this period, however because there was no shoreline position data of the eroding western tip, the mean net result for the Hook was skewed and biased toward larger gains.

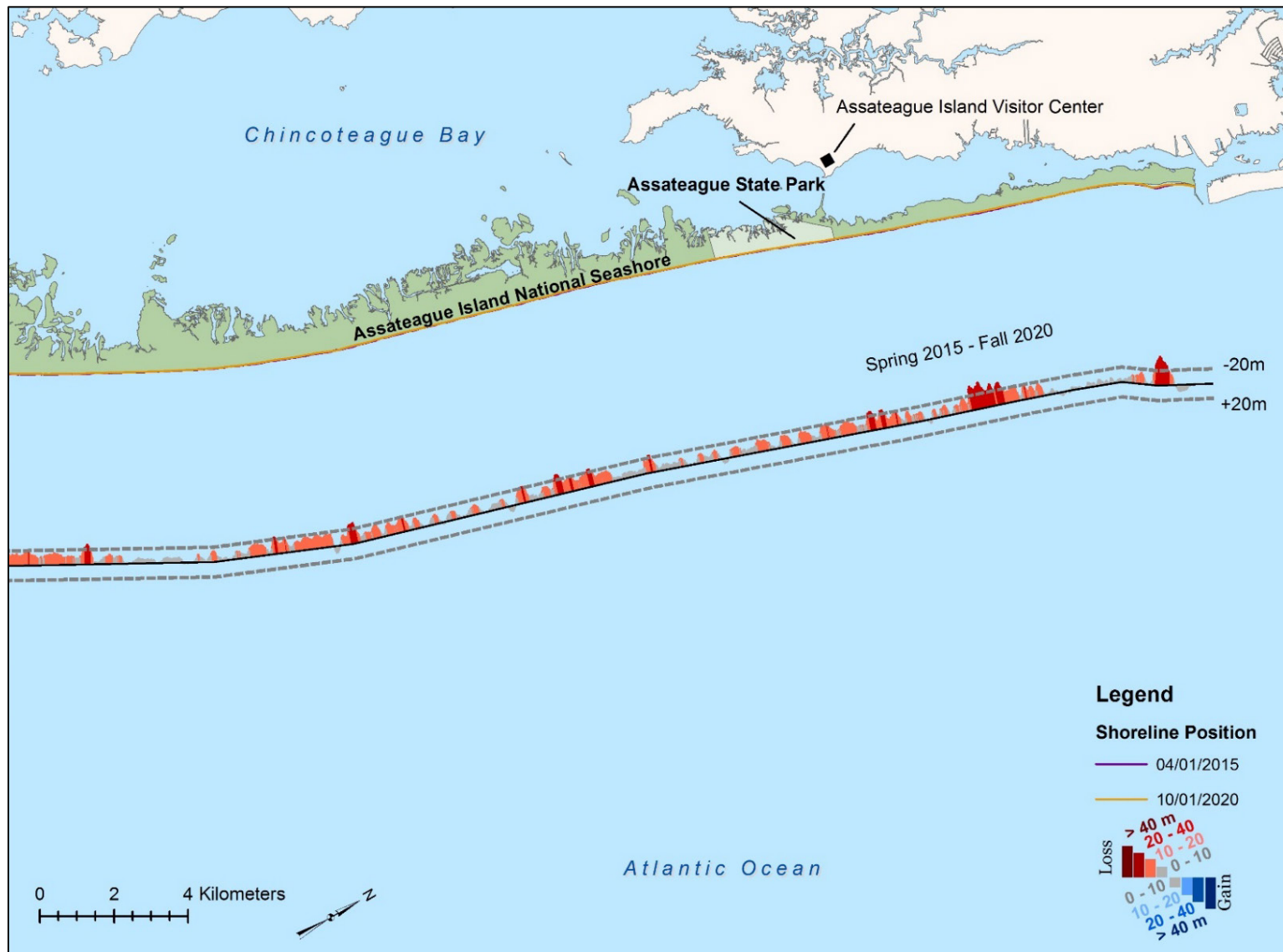


Figure 21. 5-year shoreline position changes along the northern half of Assateague Island, Spring 2015–Fall 2020 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

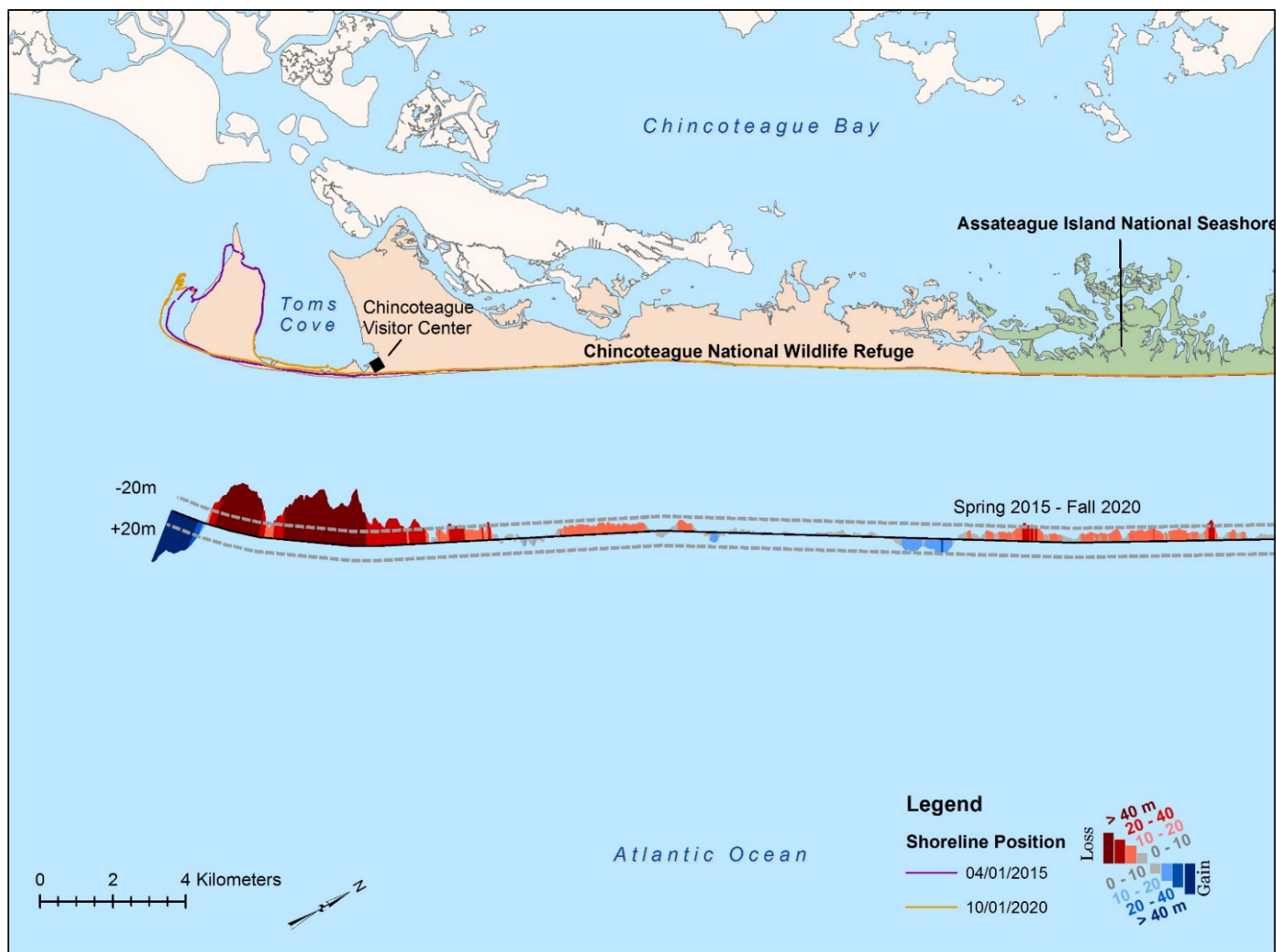


Figure 22. 5-year shoreline position changes along the southern half of Assateague Island, Spring 2015–Fall 2020 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

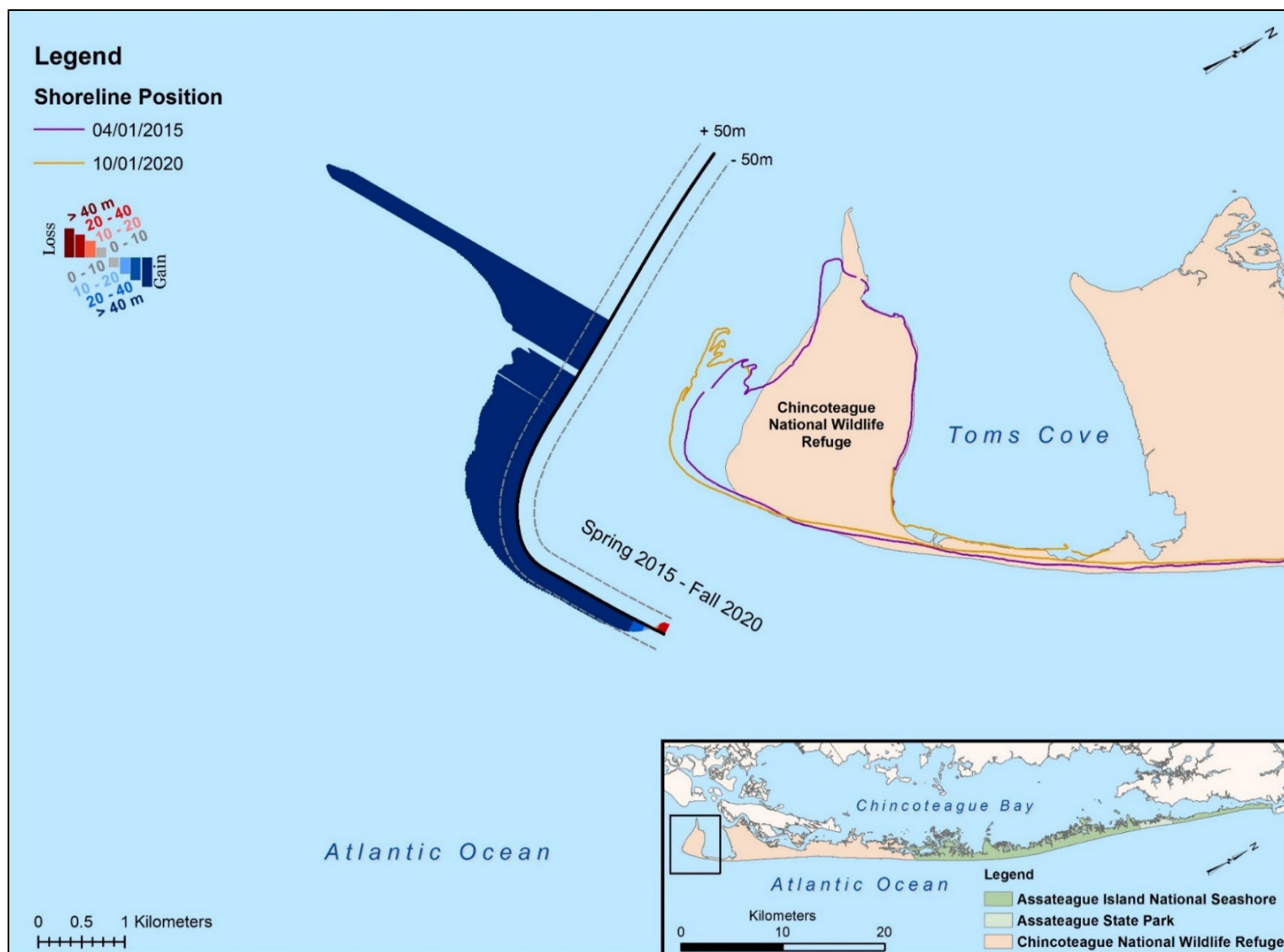


Figure 23. 5-year shoreline position changes along the Toms Cove Hook shoreline, Spring 2015–Fall 2020 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

1D Trends of Change

The dimensions of net changes during each of the 5-year periods and net changes over the longer term 2005–2020 period offer insights into the spatial variations along Assateague Island and Toms Cove Hook (Figures 24, 25, & 26). They demonstrate the temporal and spatial variation that can occur on an island that has different exposures to incident waves and currents, to the impacts of variations in storminess over the period, and to the differential magnitudes of sediment budgets. Importantly, the 15-year trend is largely negative, with the greatest negative values in the southern margin of the island before evidence of sediment accumulation and shoreline accretion along much of Toms Hook Cove.

Another view of the annual and longer term trends is gained by a graphing of the annual changes in segments of the island from the initial Spring 2005–Fall 2020 survey and plotting a trend line. To aid in the description of trends of changes along the island, the shoreline was divided into several different sections depending on the morphology and jurisdiction (Figure 27). The Assateague Island oceanside shoreline was broken into six different sections: ASIS Inlet Delta, ASIS North, State Park, ASIS South, Chincoteague North, and Chincoteague South. ASIS Inlet Delta consisted of the part of the shoreline 2.5 km to the south of the Ocean City Inlet where there is wave refraction around the jetty bordering the Ocean City Inlet and wave breaking on the ebb tide delta. ASIS North is the shoreline to the south of the area affected by the ebb tide delta conditions and extending to the northern border of Assateague State Park. The shoreline within Assateague State Park was in its own category, and ASIS South contained shoreline from the southern margin of Assateague State Park to the Virginia Border, coincident with the boundary separating the National Seashore and the National Fish and Wildlife Refuge. Chincoteague North consisted of 13 km of shoreline to the south of the Maryland/Virginia border, a portion of the coast where the beach was backed by a variety of substantial dune features. The remainder of the oceanside shoreline either had a single minor dune feature or lacked a natural dune and was categorized as Chincoteague South. The Toms Cove Hook shoreline was divided into two sections. The NE/SW Hook section contained the portion of the shoreline that was extending to the southwest as the spit accreted. The NW/SE Hook section of the shoreline was composed of the remainder of the Toms Cove Hook shoreline.

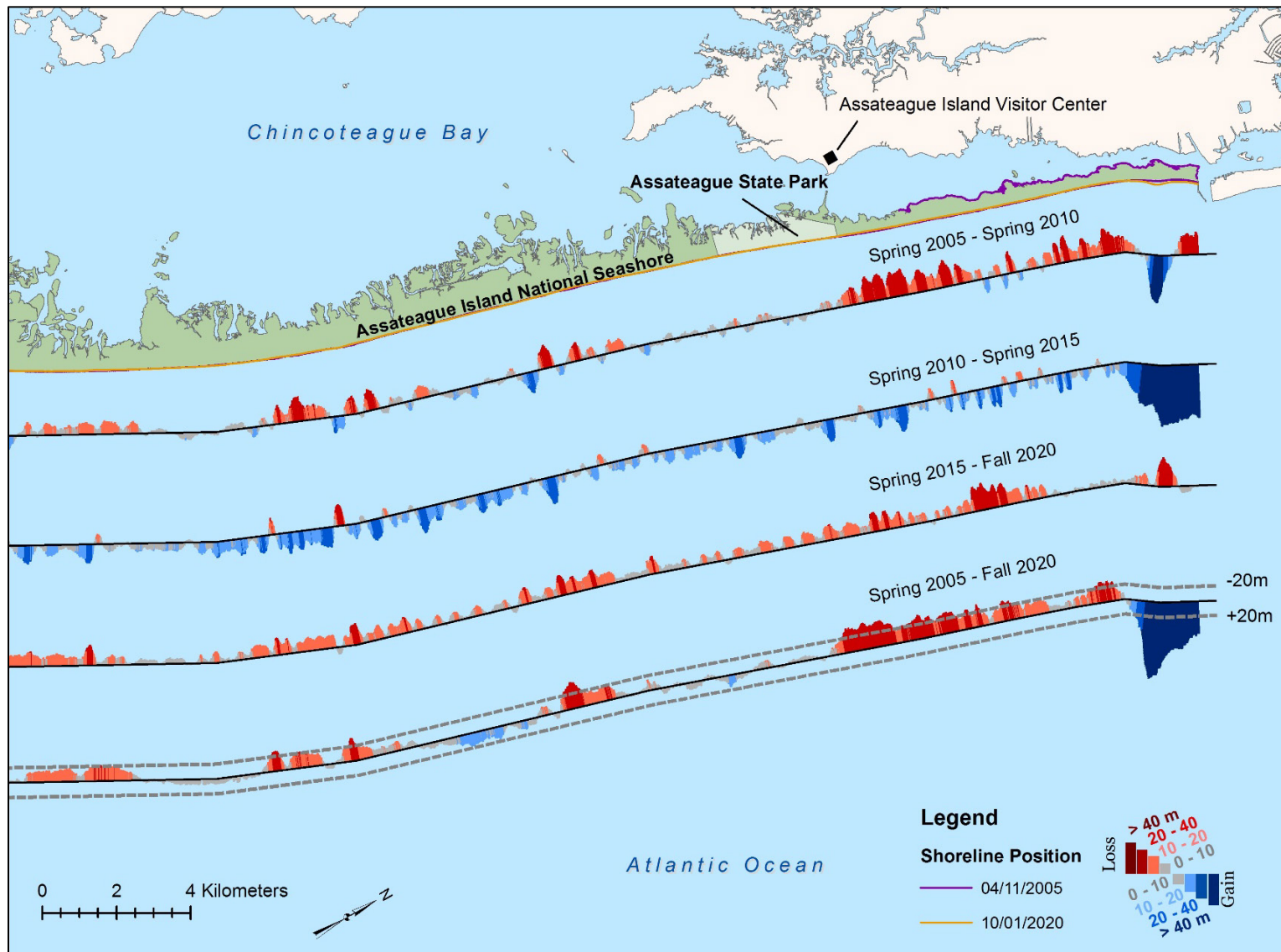


Figure 24. 15-year shoreline position change comparisons along the northern half of Assateague Island, Spring 2005–Fall 2020 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

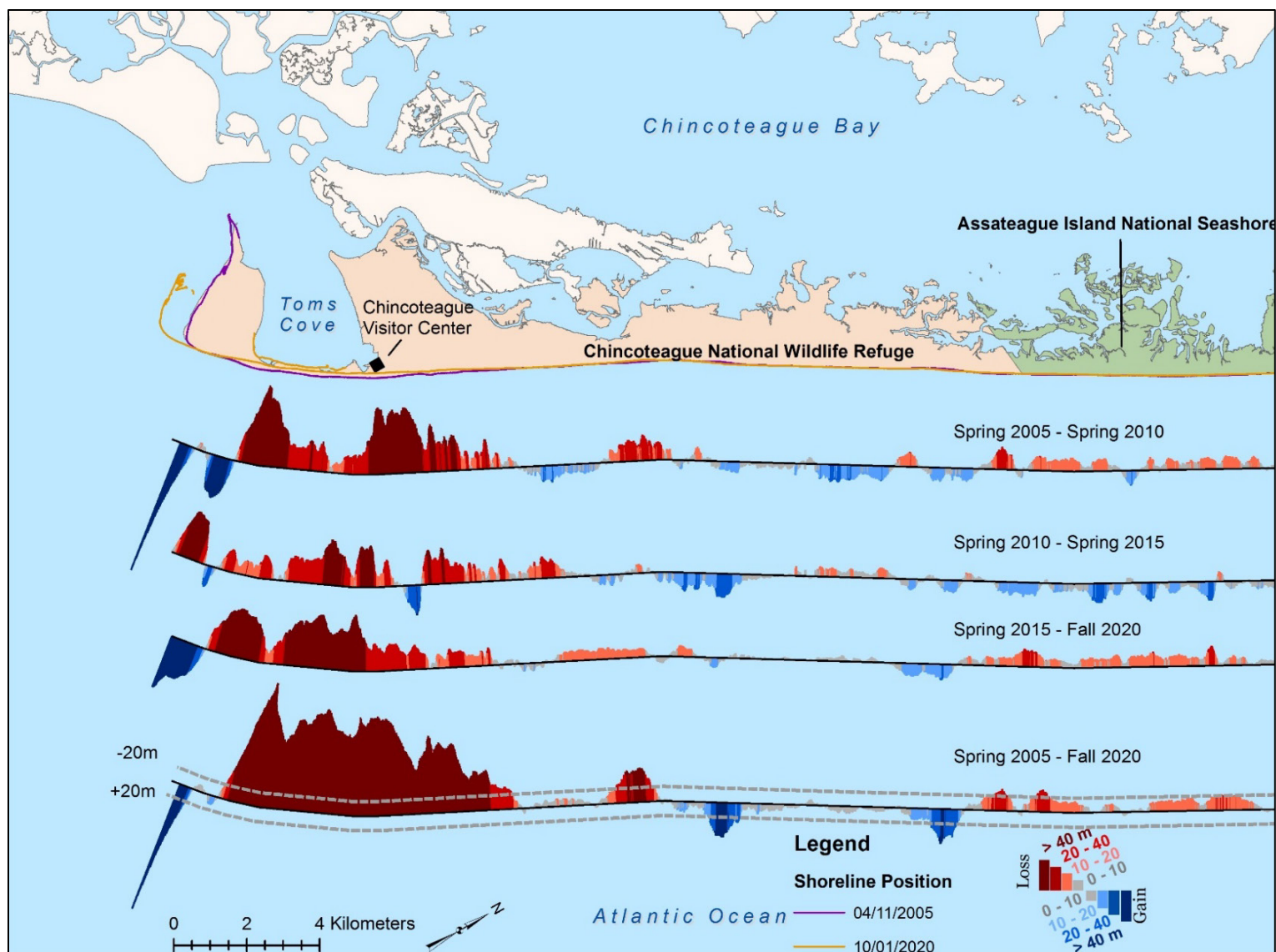


Figure 25. 15-year shoreline position change comparisons along the southern half of Assateague Island, Spring 2005–Fall 2020 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

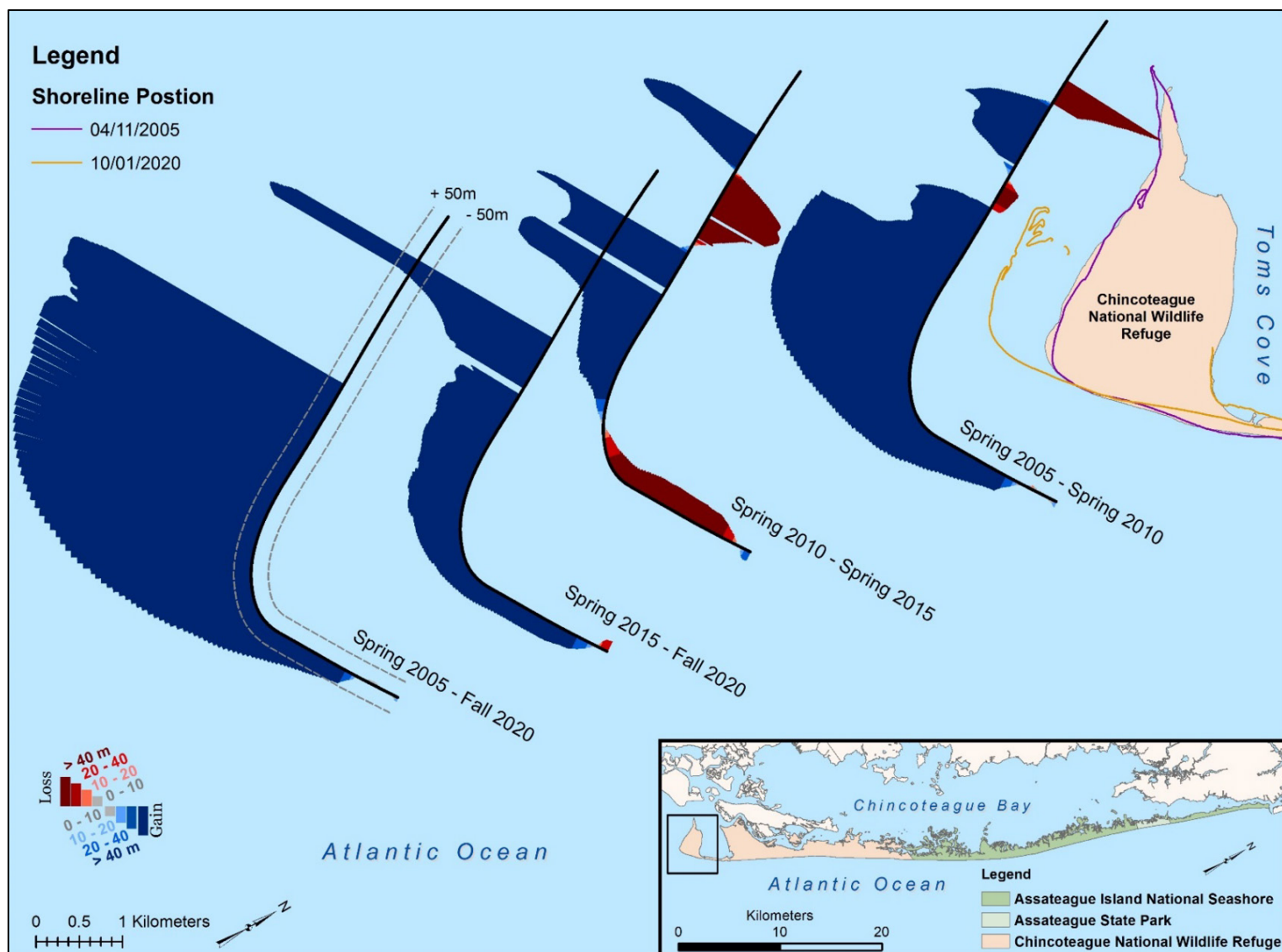


Figure 26. 15-year shoreline position change comparisons along Toms Cove Hook, Spring 2005–Fall 2020 surveys. Dashed grey lines are visual representation of the magnitude of the vectors.

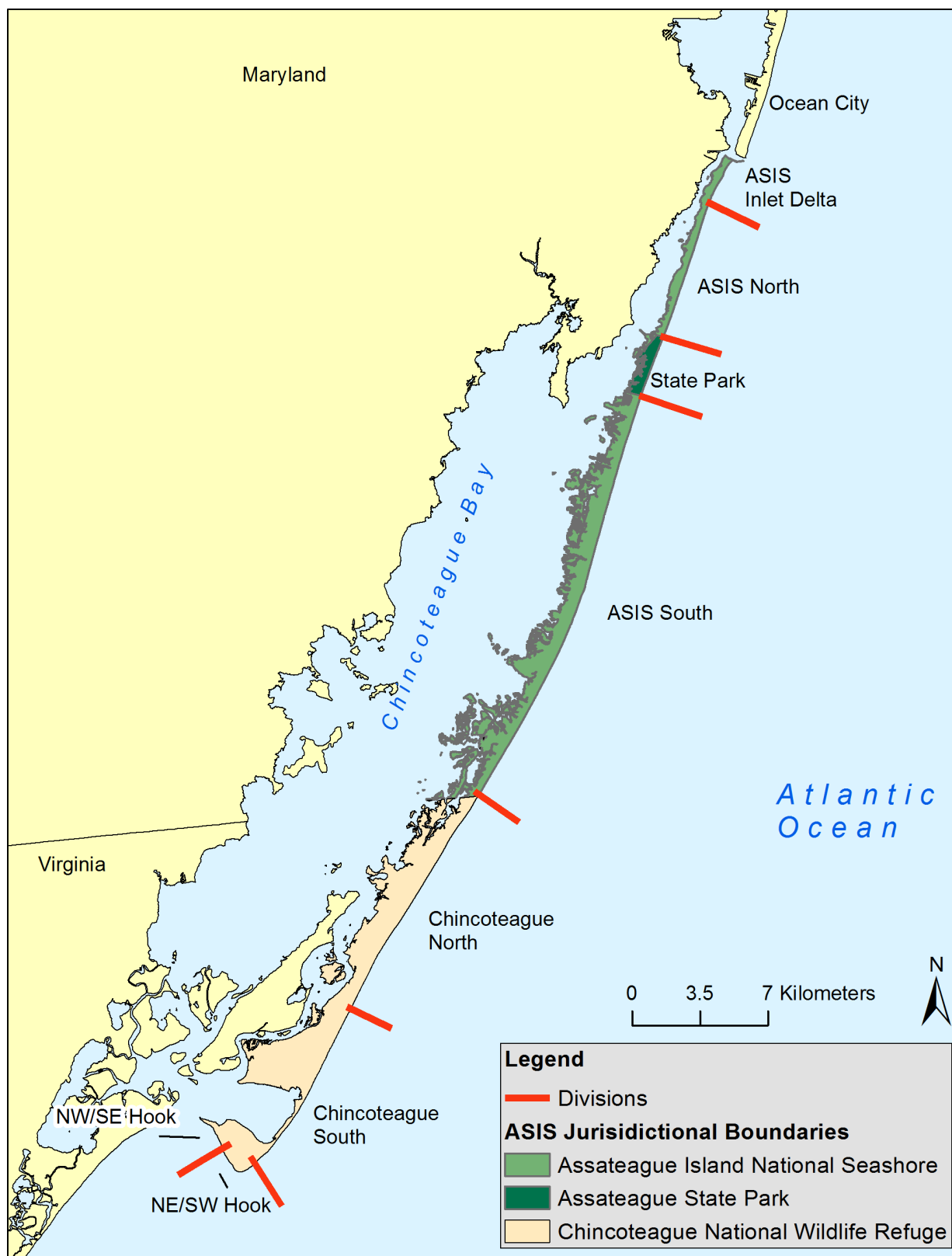


Figure 27. Location of shoreline sections based on the morphology and jurisdiction along Assateague Island.

The mean net shoreline displacement starting with the Spring 2005 survey was calculated for each successive annual temporal span for the entire ASIS oceanside and subsections as well as Toms Cove Hook and it's subsections (Figures 28 & 29).

Assateague Island Ocean Shoreline

This analysis indicates that the mean net shoreline position along the entire oceanside of Assateague Island was displaced landward at a rate of -1.11 m/yr (Figure 28). The termini of the island had the greatest variation in displacement rates. ASIS Inlet Delta had a net seaward displacement rate of $+2.29$ m/yr, largely due to sediment input from the ebb tide delta in this area. The southern margin of the island, Chincoteague South, had a landward net displacement rate of -5.44 m/yr. The sections in the middle of the island had lower net rates of change, all landward displacement. ASIS North had the highest mean net displacement rate of the middle sections, -2.01 m/yr, despite the placement of dredged sediment there. The State Park, ASIS South, and Chincoteague North all had small mean net landward displacement rates, -0.64 m/yr, -0.87 m/yr, and -0.72 m/yr, respectively.

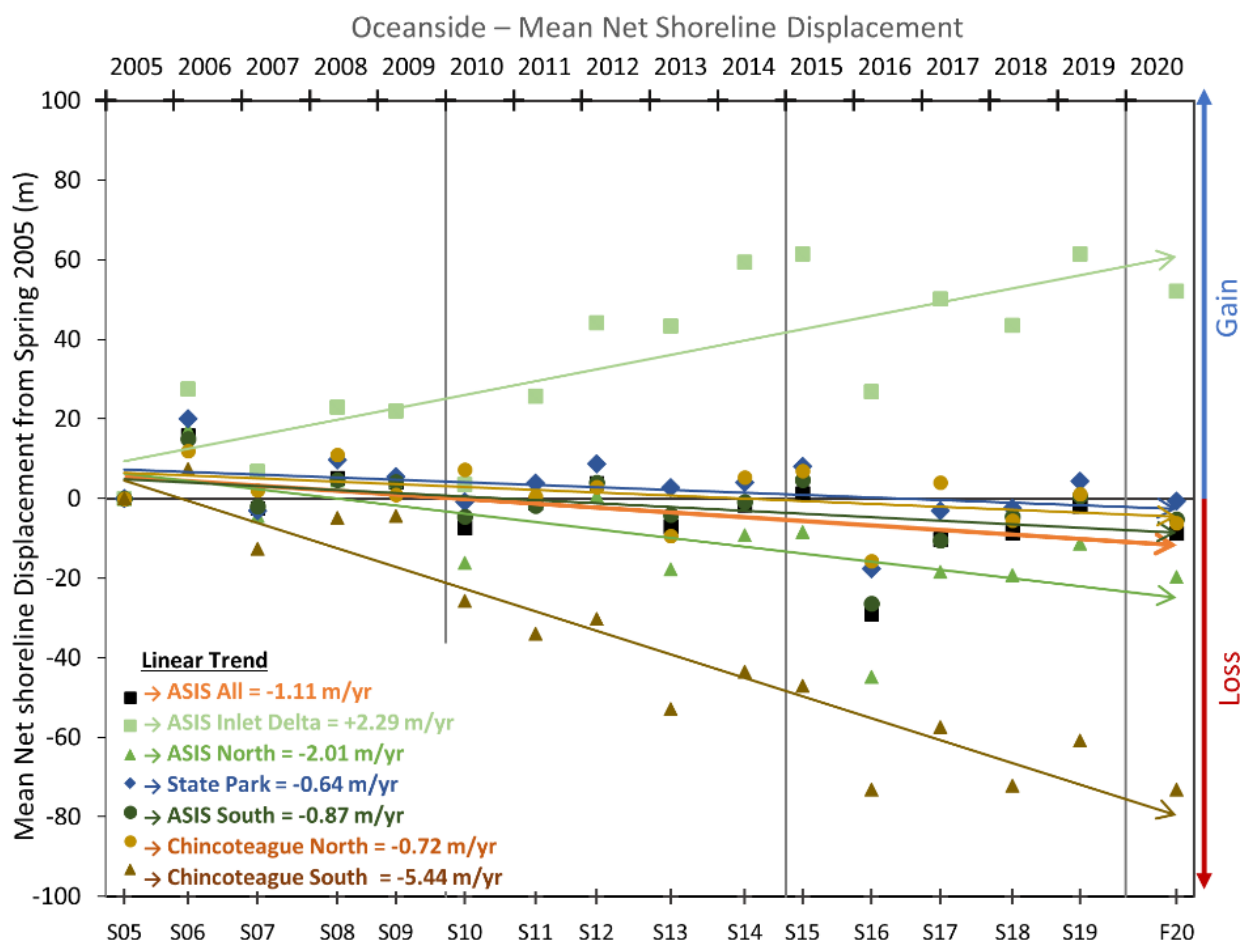


Figure 28. Trend of mean net seasonal shoreline displacement at ASIS Oceanside, Spring 2005–Fall 2020. Seasonal survey dates are represented on the lower x-axis, and the annual timeline on the upper x-axis.

Toms Cove Hook Shoreline

This analysis indicates that the mean net shoreline position along Toms Cove Hook was displaced seaward at the rate of +21.08 m/yr (Figure 29). The shoreline was divided into two sections. The NE/SW Hook portion of the shoreline contained the continual extension of the spit at the southwestern portion of Toms Cove Hook. This portion had a mean net seaward displacement rate of +31.46 m/yr. Around the curve from the ocean to the bay, the NW/SE Hook portion of the shoreline had been displaced landward over time, a net rate of -7.23 m/yr. As the spit extended to the southwest, less sediment was transported to the NW/SE Hook shoreline. The Fall 2020 shoreline survey did not reach the farthest extent of the NW/SE Hook shoreline and was not included in the analysis.

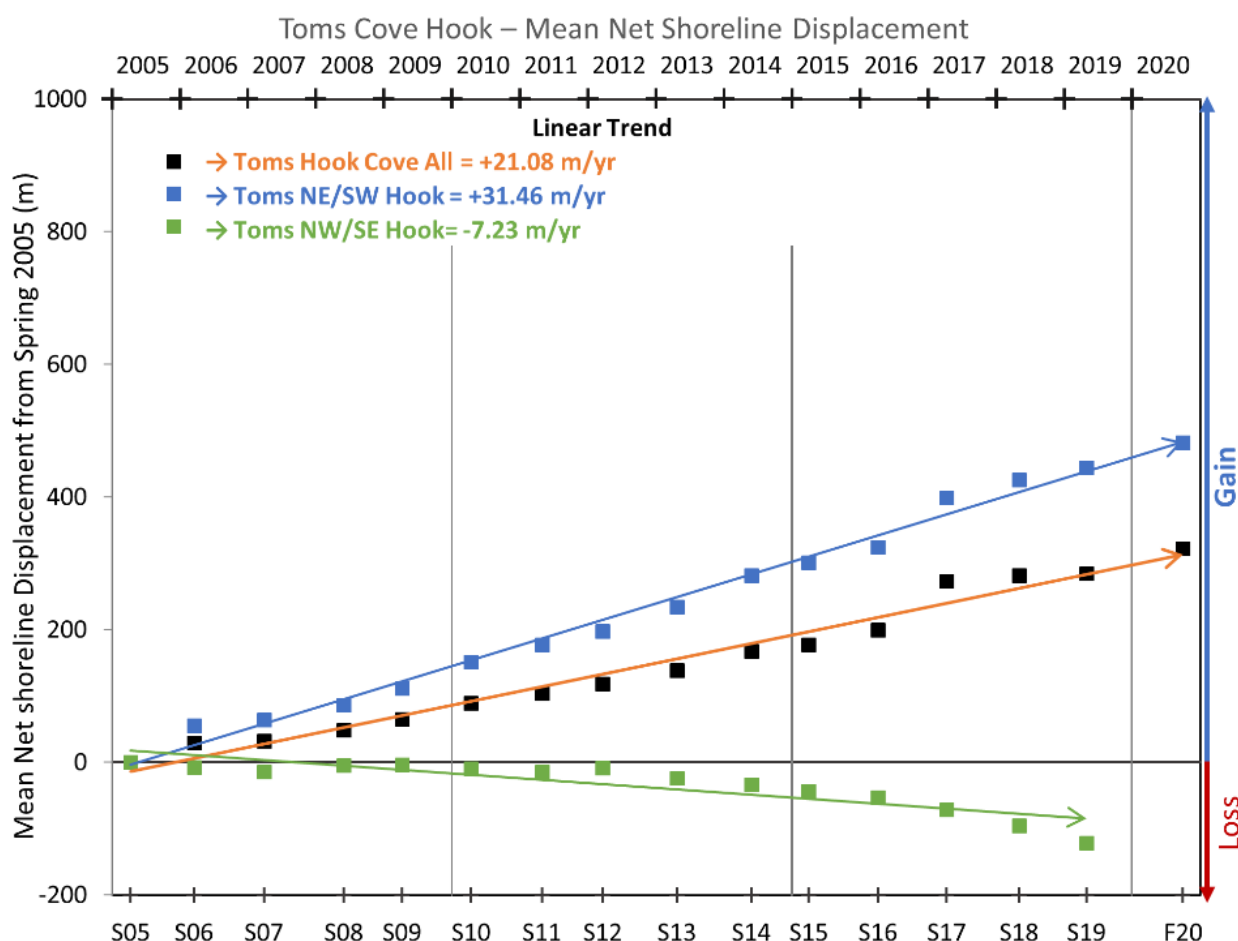


Figure 29. Trend of mean net seasonal shoreline displacement at Toms Cove Hook, Spring 2005–Fall 2020. Seasonal survey dates are represented on the lower x-axis, and the annual timeline on the upper x-axis.

Net Trend Lines, 2005–2020

The plots of the annual means of the island segments illustrate the consistency of the magnitude and direction of the displacements along the oceanside study area. Whereas the area adjacent to Ocean City Inlet that was the recipient of sediment dredged from the inlet gained consistently, and the area

in the southern portion of the island was eroding greatly, the remainder of the island had a low but consistent rate of inland displacement during this time period. The shoreline at Toms Hook Cove was not so consistent because of breaches and disrupted shoreline lengths that made net comparisons difficult. The direction of displacement is evident, but net means were not comparable because of gaps in the surveys.

Coastal Profile Surveys (2D)

Defining Profile Features and Datums

The dune/beach profiles are surveyed and recorded relative to a fixed datum, the North American Vertical Datum of 1988 (NAVD88). At the present time, NAVD88 and mean sea level are at similar elevations (7.3 cm offset at Lewes tide gauge) and the dune/beach topography has a similar relationship to these two elevations (Figure 2). Referencing a constant elevation and position with a fixed monument permits the precise monitoring of spatial and elevation evolution as the profile responds to changes in sediment supply, seasonal storminess, and increased water level due to sea level rise.

Several metrics are tracked on each profile: distance to NAVD88 intercept, distance to foredune crest, foredune crest elevation, and cross-section area. Distance to NAVD88 is defined as the distance from the benchmark point to the intersection with 0 m NAVD88 along the beach face. Cross-section area metrics are divided into two feature categories: dune and beach. The dune-beach elevation threshold divides the two feature areas. The base of the dune is determined to be 2.3 m relative to NAVD88, an elevation derived through an analysis of the topographic profiles of the site. Cross-section area change occurring above this dune-beach threshold is considered change in the dune feature, whereas elevation and area changes below the threshold and above 0 m NAVD88 are considered changes in the beach feature. The foredune crest is the seawardmost highest point in elevation within the foredune feature, by definition it must be higher than the dune threshold of 2.3 m and be at the inland margin of the active beach. Assateague Island also has a number of hummocks defined as isolated mounds of sediment caused by either the dissection of an active foredune or the accumulation of windblown sand on the leeward side of debris or vegetation and separated from the active beach. These hummocks are not identified as dune crests on the profiles.

Timing of Coastal Topography Surveys

Coastal topography profiles were collected within ASIS semi-annually; timing and tide of survey dates were also recorded. The surveys were conducted during spring tide conditions to expose as much of the beach profile as possible and to facilitate the collection of the profile to at least the NAVD88 datum position (near mean sea level). On the basis of the protocol, the surveys occur at the end of the winter stormy period and at the end of the summer calm period, recording the seasonal variation of the dune/beach geomorphological system. For the purposes of this report, Spring–Spring surveys are used to display an annual comparison (Table 10). Due to the COVID-19 pandemic in 2020, data collection could not be completed in spring 2020. Instead, the fall 2020 dataset was used.

Table 10. Date of coastal topography survey and elevation of spring low tide at Assateague Island National Seashore, 2005–2020 surveys.

Season	Date of survey	Height above MLLW (m)	Time
Spring 2005	04/15/2005	0.833	8:24 AM
Spring 2006	04/15/2006	0.119	4:12 PM
Spring 2007	04/15/2007	0.096	1:30 PM
Spring 2008	04/15/2008	0.224	12:06 PM
Spring 2009	04/15/2009	0.649	7:18 AM
Spring 2010	05/15/2010	−0.013	4:00 PM
Spring 2011	04/15/2011	0.045	12:42 PM
Spring 2012	04/15/2012	0.059	11:00 AM
Spring 2013	05/15/2013	0.155	6:36 AM
Spring 2014	05/15/2014	−0.001	3:24 PM
Spring 2015	04/15/2015	−0.124	12:12 PM
Spring 2016	04/15/2016	0.251	10:30 AM
Spring 2017	04/15/2017	0.205	5:48 PM
Spring 2018	05/15/2018	−0.04	2:54 PM
Spring 2019	04/16/2019	−0.216	12:42 PM
Fall 2020	10/15/2020	0.106	1:54 PM

Uncertainty: Profile Distance, Elevation, and Cross-section Area

A calculation for profile uncertainty was developed for the revision of the Geomorphological Monitoring Protocol: Part II—Coastal Topography (Psuty et al., In Review (b)). Point collection is subject to the collecting instrument’s horizontal uncertainty of ± 0.02 m; this uncertainty in turn impacts all linear distance metrics (distance to NAVD88/ distance to foredune crest). A vertical uncertainty of ± 0.04 m is also incurred by point collection, and this uncertainty affects all vertical distance metrics (profile elevation). This vertical uncertainty then translates to a cross-section area uncertainty of ± 0.04 m² for every meter a profile extends (to NAVD88), applying to dune cross-section area (profile extent that exceeds dune threshold), beach cross-section area (extent below dune threshold), and total cross-section area. A comparison of two metrics will have an uncertainty equivalent to the square root of the sum of squares of each survey’s individual error. These sources of uncertainty are incorporated into all tables.

Coastal Topography Metrics of Change

The Assateague Island barrier island extends north-south 58 km from Ocean City Inlet, Maryland, at its northern margin to Chincoteague Inlet, Virginia, at its southern point (Figure 30). The coastal topography profiles cover only the Maryland portion of the National Seashore, extending 2.5 km to the north of the border with Chincoteague National Wildlife Refuge, the boundary between the two national holdings is near the Maryland and Virginia border. Assateague State Park lies within ASIS,

with an alongshore extent of 3.26 km, profiles NPS5.5, NPS 5.75 and GPS 6.0 are within its boundary. North of Assateague State Park, the island is very narrow, 330 m from the ocean to the bay. South of Assateague State park, island width increases to as much as 890 m. Although ASIS is in a protected status at present, human manipulation of the landscape has previously altered many aspects of the natural topography, resulting in a combination of original and anthropogenically-modified landforms. Details about the geomorphology of ASIS and its evolution can be found in the technical report “Development of a geomorphological Map of Assateague Island National Seashore: Principal Characteristics and Components” (Psuty et al. 2016).

Twenty-seven transects have been established along the ocean shoreline of ASIS (Figure 30). Each transect is tied to a stable benchmark or “monument” that is associated with some pre-existing item, such as a concrete pad, tied to a newly-installed PVC pipe filled with and embedded in concrete, or is a virtual benchmark stored in a shapefile on the controller.

The 27 profiles within ASIS are in four areas: 1) ASIS Inlet Delta consisting of four profiles (NPS0.5–NPS 1.5), extending 2.5 km to the south of the Ocean City Inlet where the ebb tide delta and wave refraction around the jetty affect local sediment transport; 2) ASIS North incorporating nine profiles that are to the north of Assateague State Park (NPS GPS2.0–GPS 5.0); 3) Four profiles within Assateague State Park (NPS 5.5–GPS 7.0); and 4) ASIS South incorporating ten profiles south of Assateague State Park to the MD and VA state line (GPS 8.0–GPS 17.0).

Most profiles have data going back to spring 2005. However, collection at some profiles did not start until 2008 (NPS0.5, NPS 1.25, NPS 2.75, NPS 5.75) and NPS 1.5 was not collected in spring 2011. Gaps in data collection are noted on the profiles and data tables.

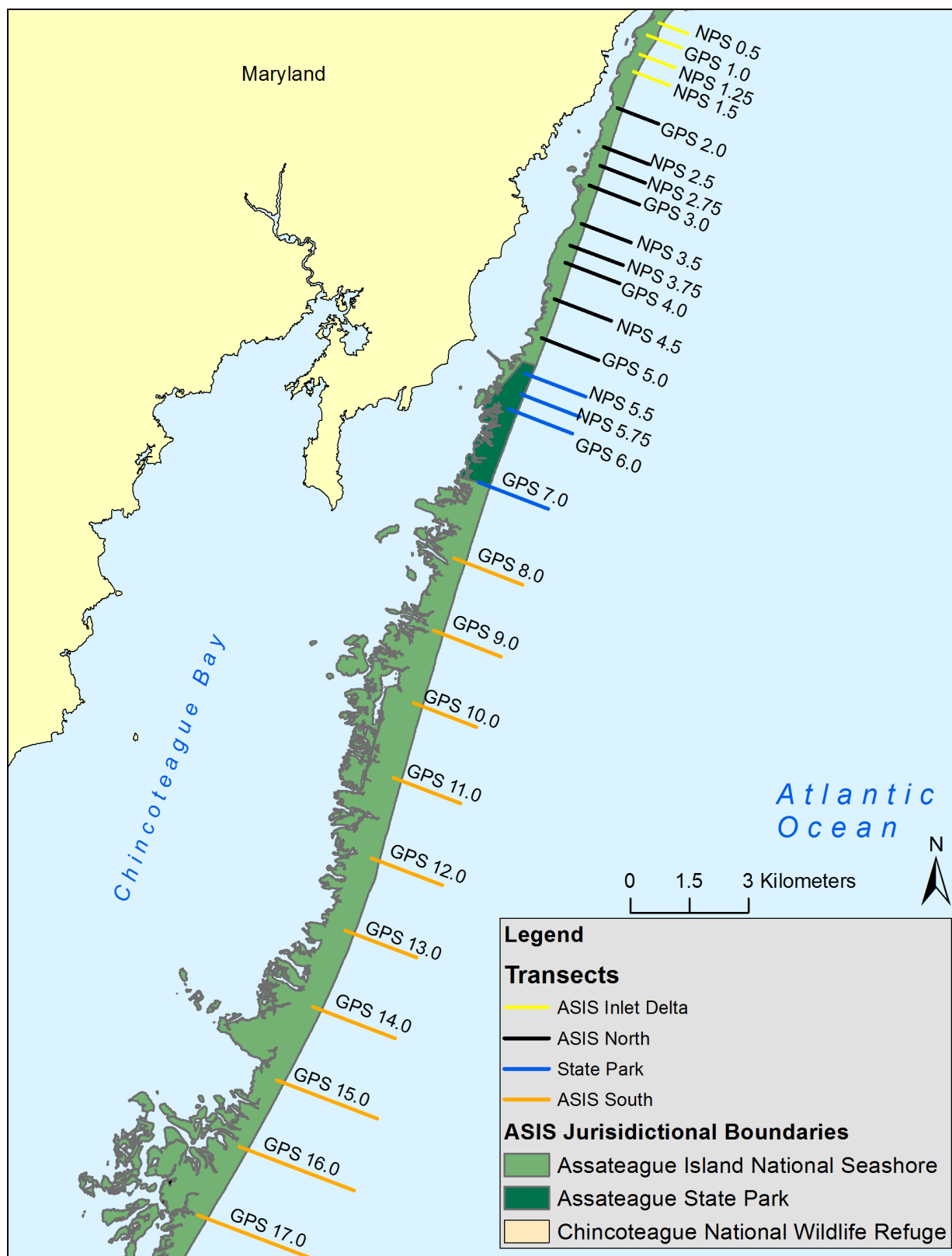


Figure 30. Sites of coastal topography profiles along Assateague Island National Seashore.

Coastal Topography Change Surveys, 2005–2010

During the Spring 2005–Spring 2010 surveys, the NAVD88 intercept was displaced seaward in ASIS North, and landward in Assateague State Park and ASIS South (Figure 31–Figure 46). The largest landward displacements were in the area from NPS 1.25 to NPS 5.5 just to the north Assateague State Park (Figure 32–Figure 35). The NAVD88 intercept was displaced -43 m landward on NPS 3.75 (Figure 35). The dune crest position was also largely displaced landward, with the largest displacement occurring on GPS 11 where the dune crest was displaced -64 meters inland (Figure 41). The dune crest also lowered in elevation during this 5 year period, especially in ASIS South. There was a small height gain in ASIS North. From 2005–2010 there was variable change in cross-section area throughout the profiles. There were small gains in ASIS North in both the dune and beach, loss in Assateague State Park, and gain along the southern portion.

Coastal Topography Change Surveys, 2010–2015

The Spring 2010–Spring 2015 surveys were dominated by changes due to Hurricane Sandy (October 2012), captured by the Spring 2013 survey (Figure 31–Figure 46). During the Spring 2012–Spring 2013 survey, the NAVD88 intercept was largely displaced landward. The largest displacement was on profile GPS 3.0 where the NAVD88 intercept shifted -42 m inland (Figure 34). Post-storm, there was seaward displacement of the NAVD88 intercept, leading to a net seaward displacement over the five-year period. The dune feature was slower to recover. There was a large landward displacement of the dune crest, especially in ASIS South during the Spring 2012–Spring 2013 survey. GPS 12.0 had an inland displacement of -34 m (Figure 41). There was some seaward displacement post-storm, however the net displacement for this five-year period was landward. The overall height of the dune feature increased during this time, with the exception of GPS 14.0 (Figure 42). Almost all profiles had losses of cross-section area during the Spring 2012–Spring 2013 survey due to Hurricane Sandy. There was an overall gain of cross-section area in ASIS North, loss in Assateague State Park, and some gain in ASIS South during the 2010–2015 survey.

Coastal Topography Change Surveys, 2015–2020

During the Spring 2015–Fall 2020 surveys, the NAVD88 intercept was displaced almost entirely landward throughout the park. NPS 3.5 had the largest landward displacement of -31 m (Figure 35). The dune crest displacement was variable during this time. At the northern margin the dune crest shifted seaward, it shifted landward closer to Assateague State Park. The dune crest was relatively stable in the southern portion, with some seaward displacement. This time period also had a gain in height of the dune crest, especially in the north. Almost all profiles during this time period gained cross-section area in the beach and dune. NPS 1.25 had the largest gain in cross-section area, +98 m² (Figure 32).

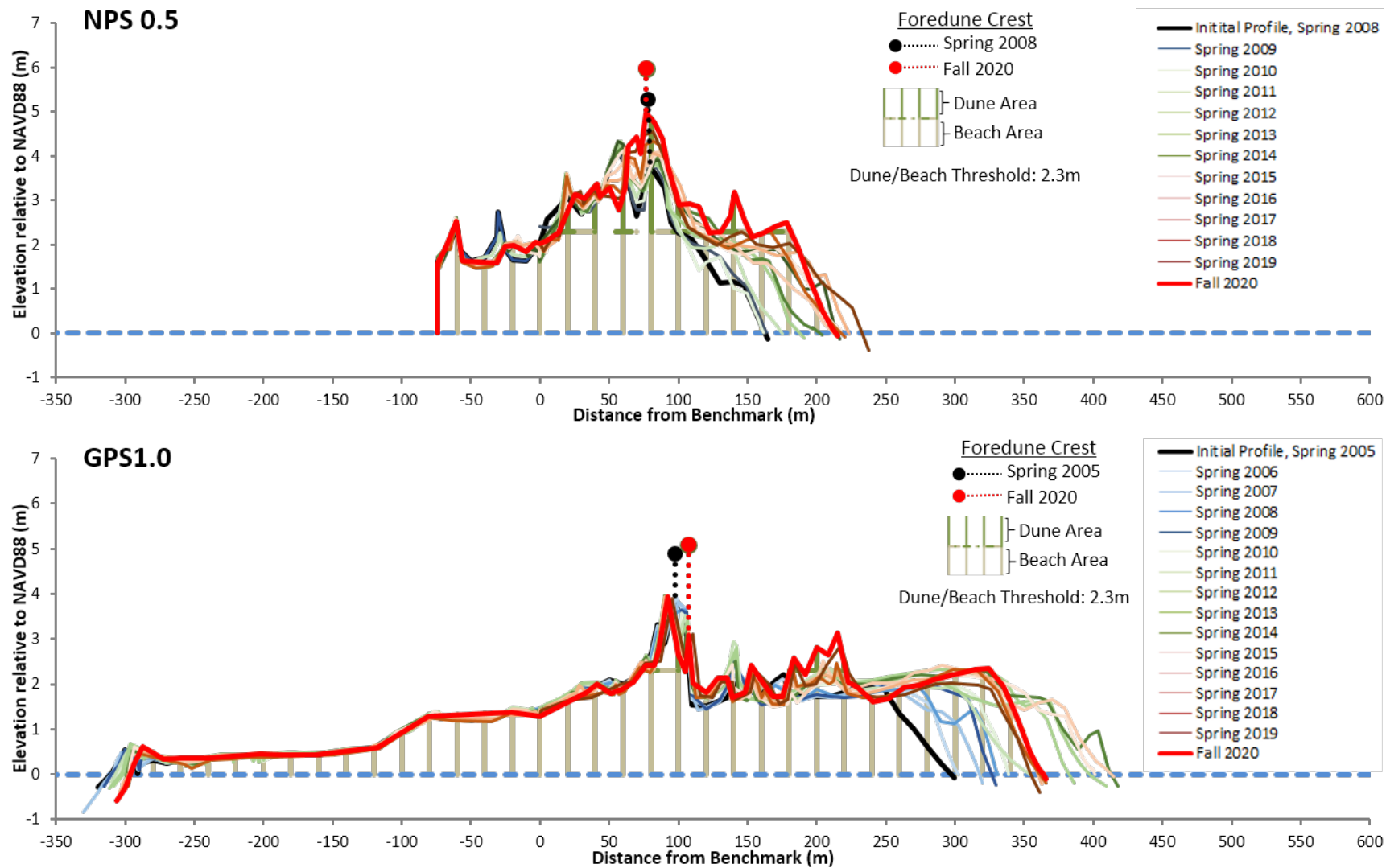


Figure 31. Coastal topography of Profiles NPS 0.5 and GPS 1.0 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dotted line, color coded respectively.

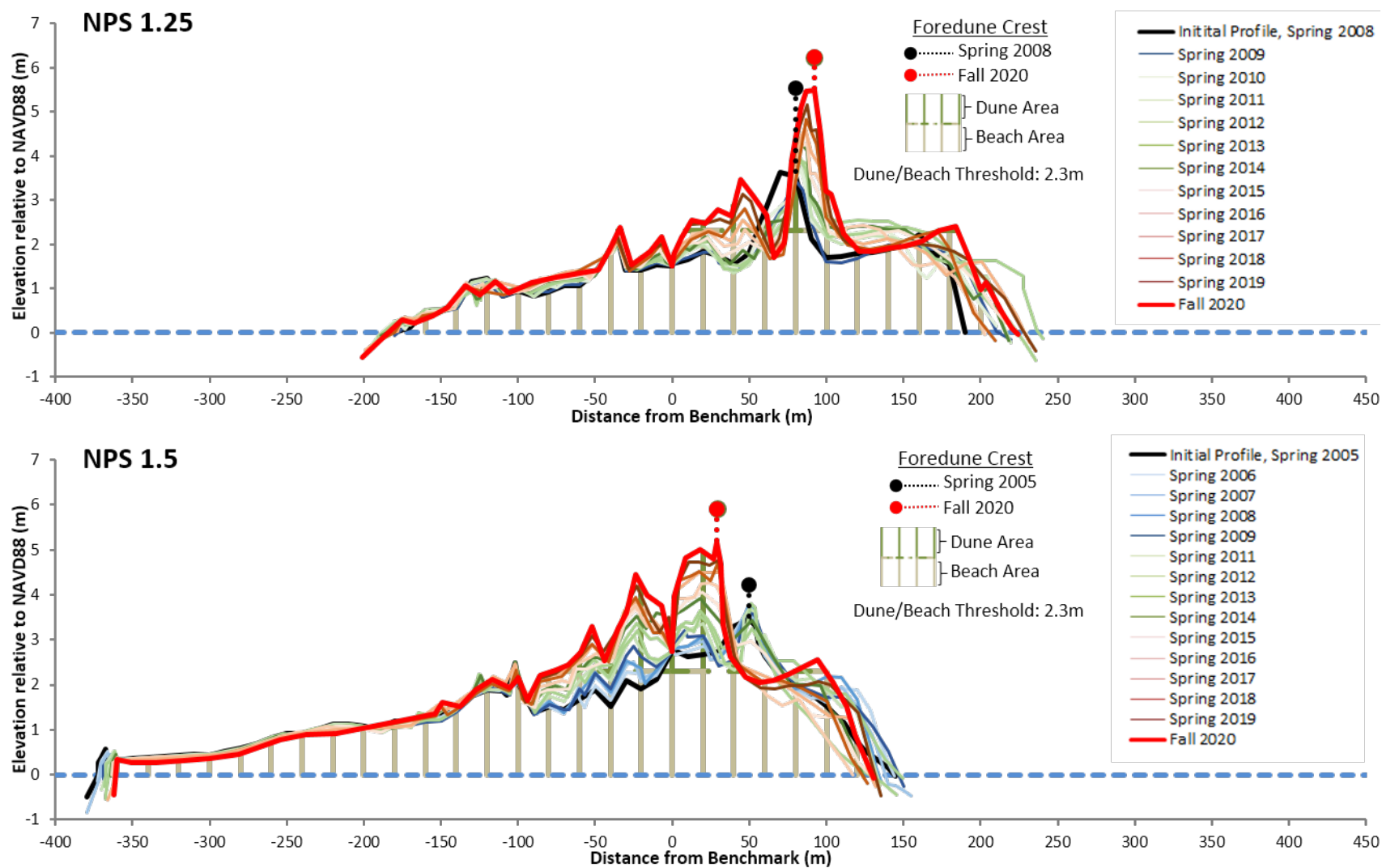


Figure 32. Coastal topography of Profiles NPS 1.25 and NPS 1.5 along the oceanside of Assateague Island National Seashore. Fore-dune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively.

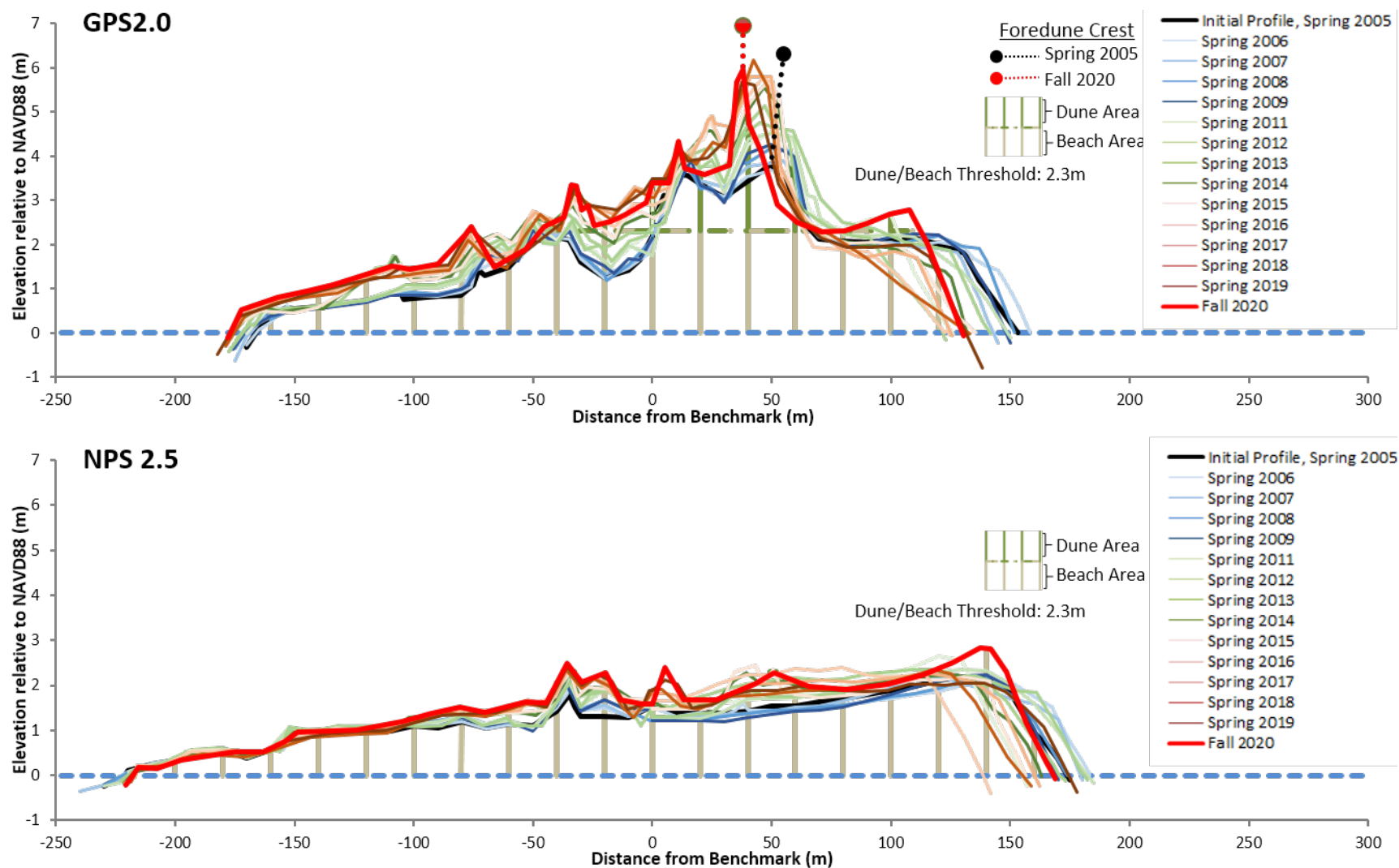


Figure 33. Coastal topography of Profiles GPS 2.0 and NPS 2.5 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively. No foredune crest present in NPS 2.5.

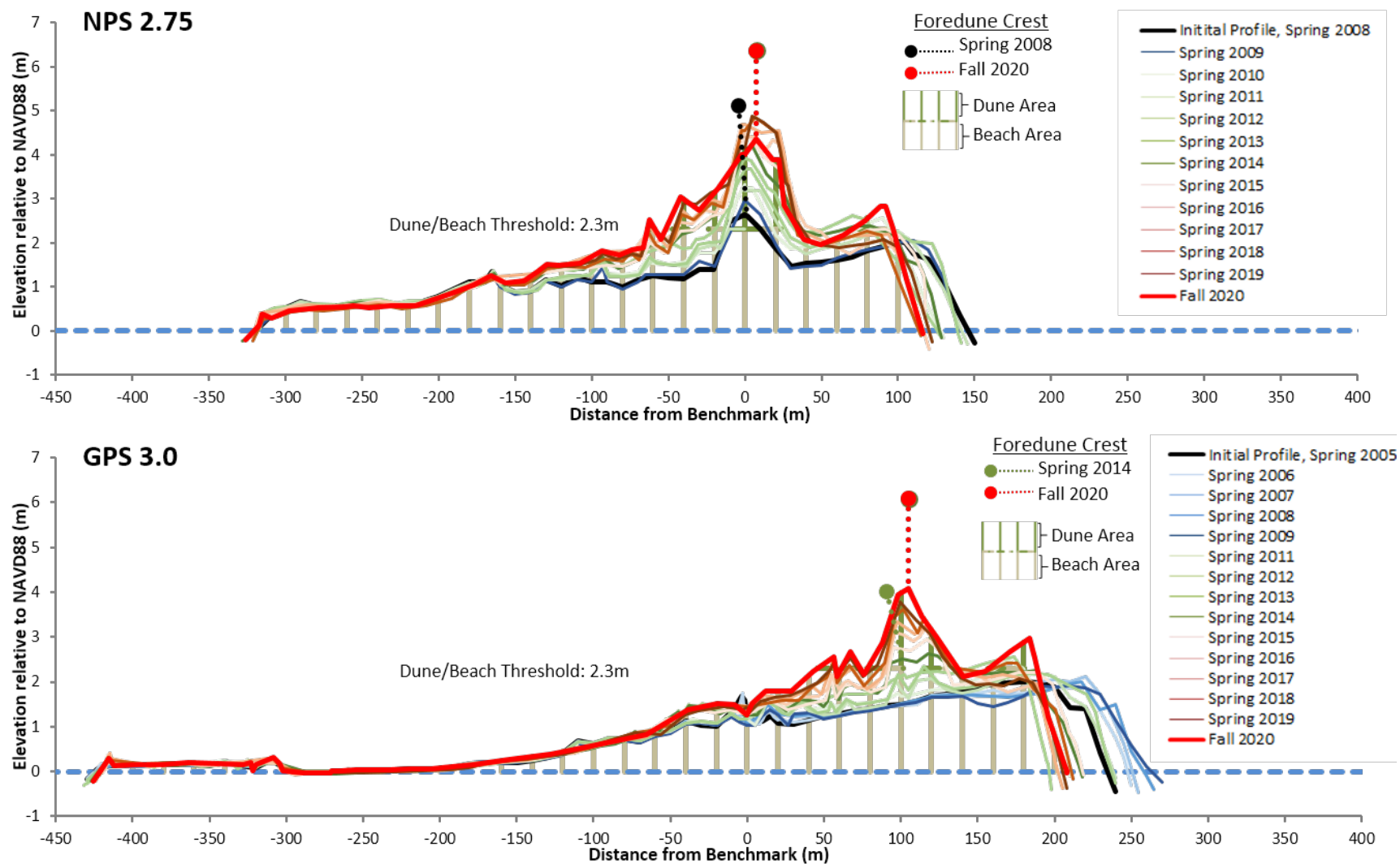


Figure 34. Coastal topography of Profiles NPS 2.75 and GPS 3.0 along the oceanside of Assateague Island National Seashore. Fore-dune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively. No fore-dune crest present until Spring 2014 on GPS 3.0.

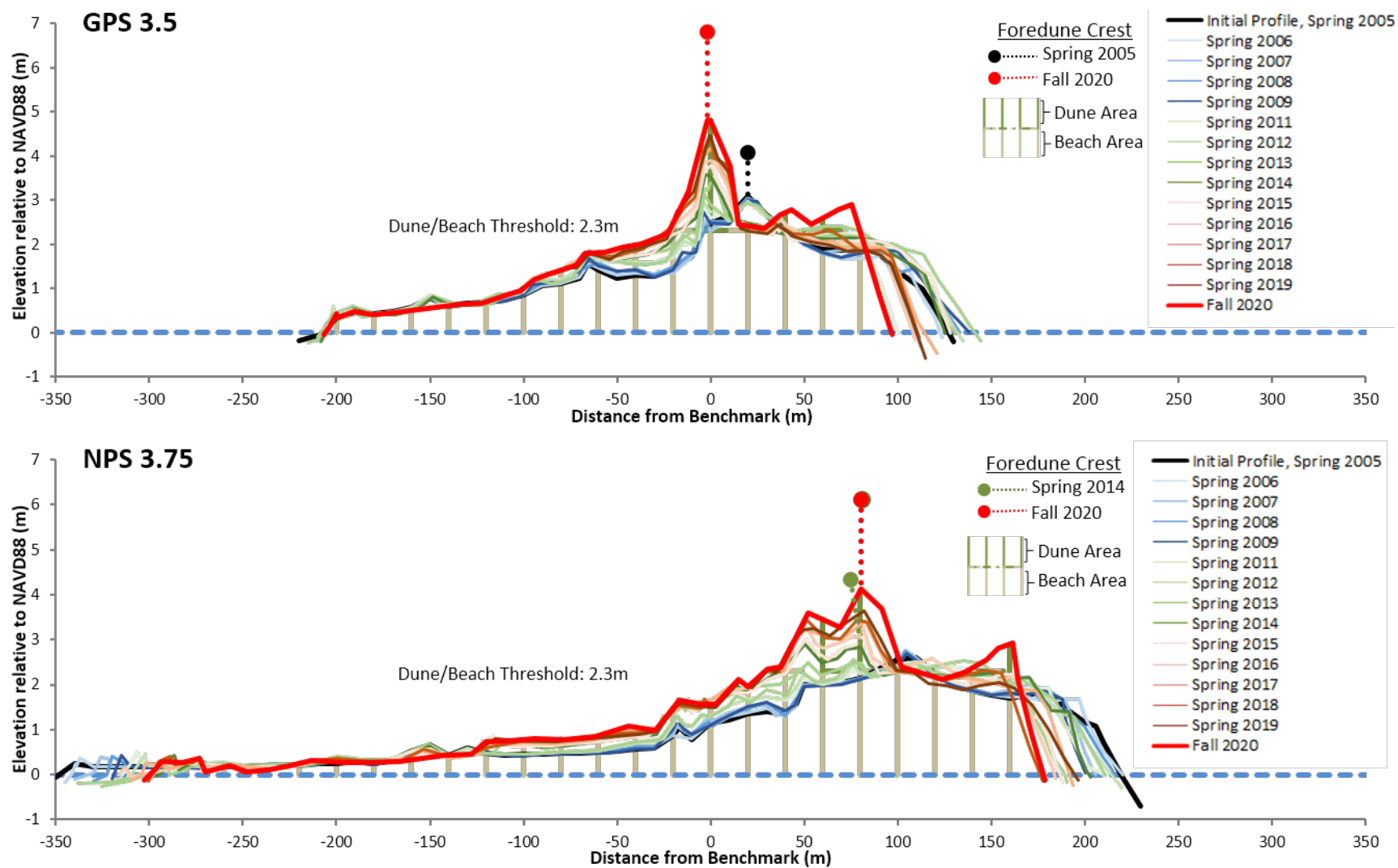


Figure 35. Coastal topography of Profiles GPS 3.5 and NPS 3.75 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively. No foredune crest present until Spring 2014 on GPS 3.75.

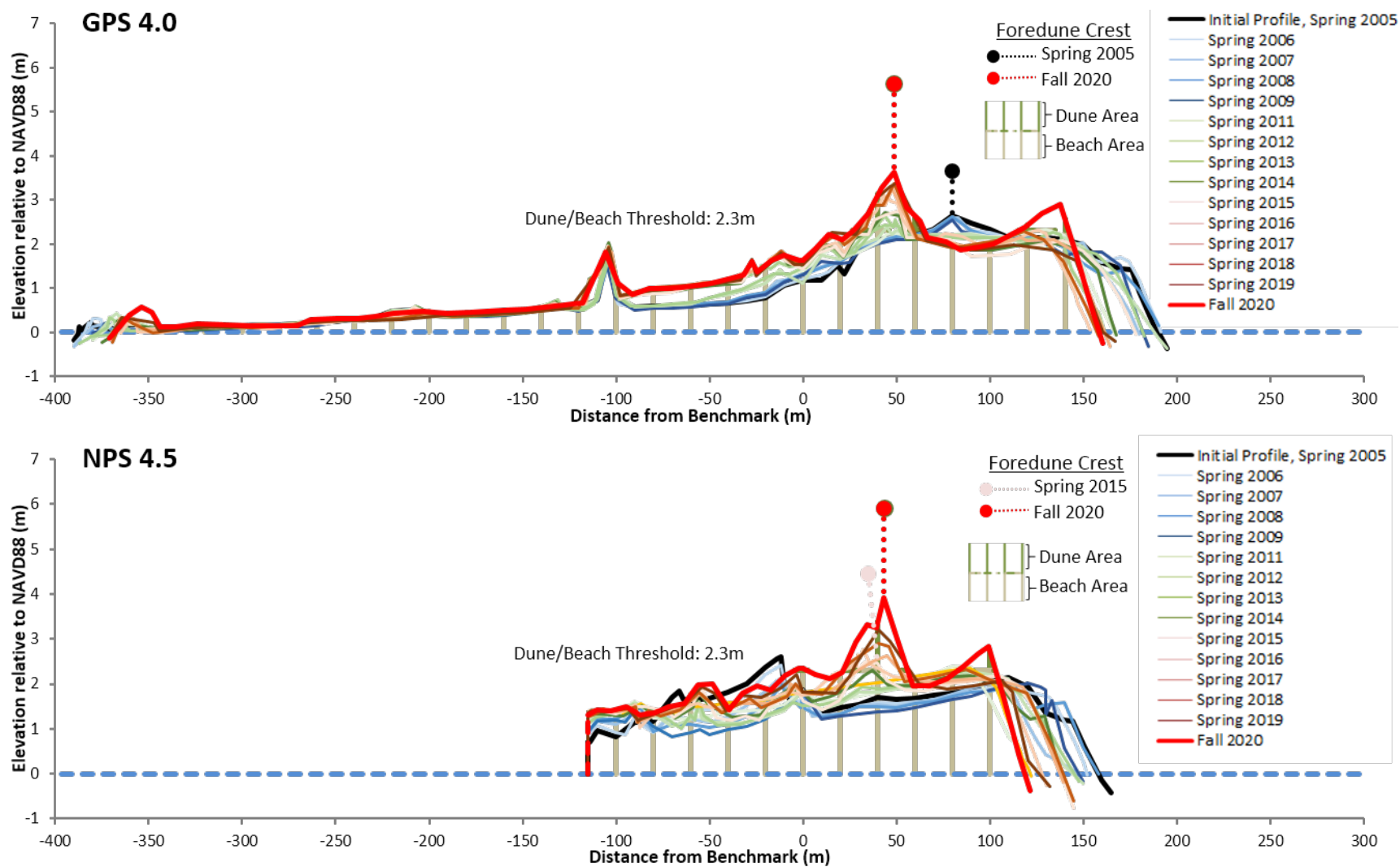


Figure 36. Coastal topography of Profiles GPS 4.0 and NPS 4.5 along the oceanside Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively. No foredune crest present until Spring 2015 on NPS 4.5.

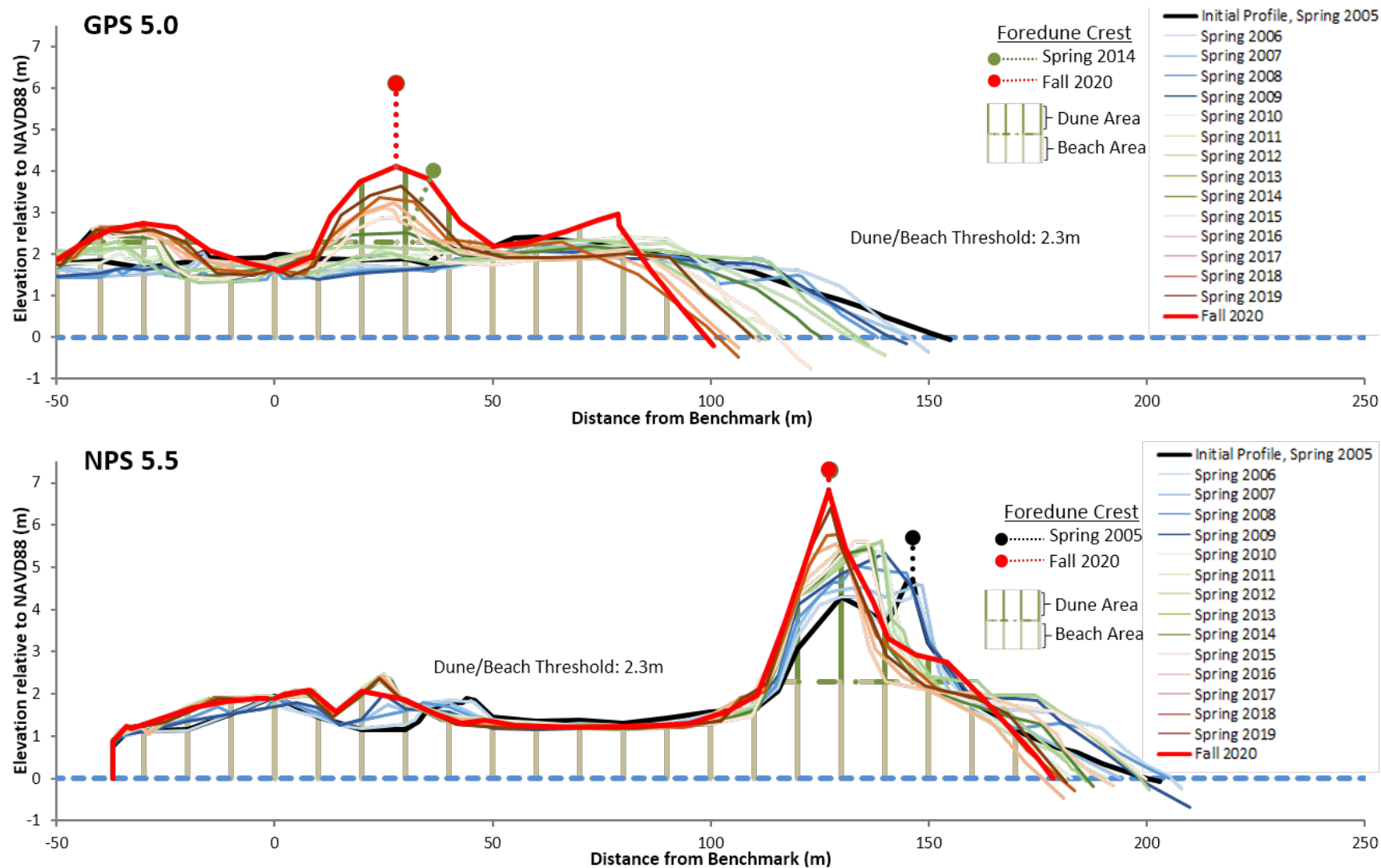


Figure 37. Coastal topography of Profiles GPS 5.0 and NPS 5.5 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively. No foredune crest present until Spring 2014 on GPS 5.0.

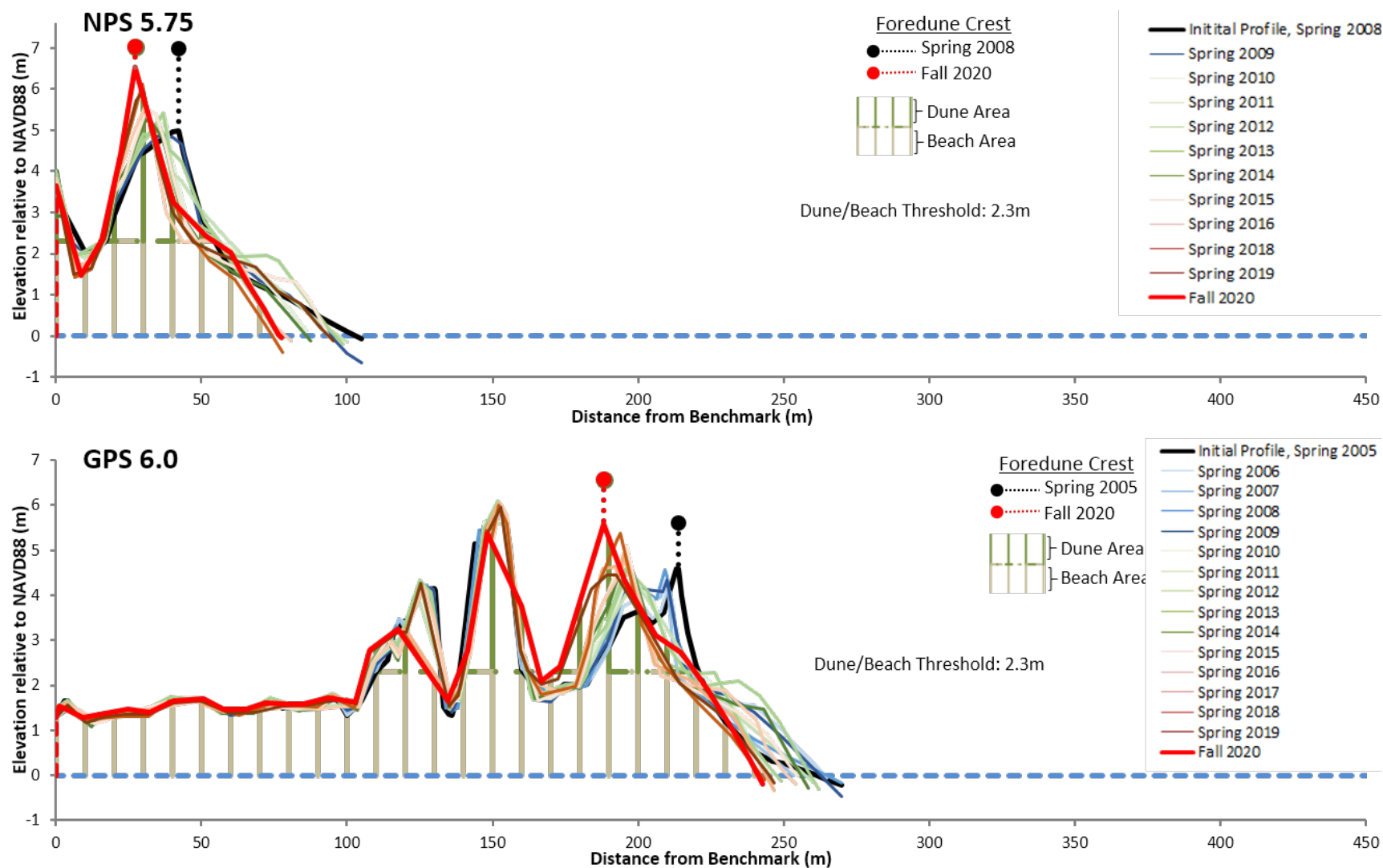


Figure 38. Coastal topography of Profiles NPS 5.75 and GPS 6.0 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively.

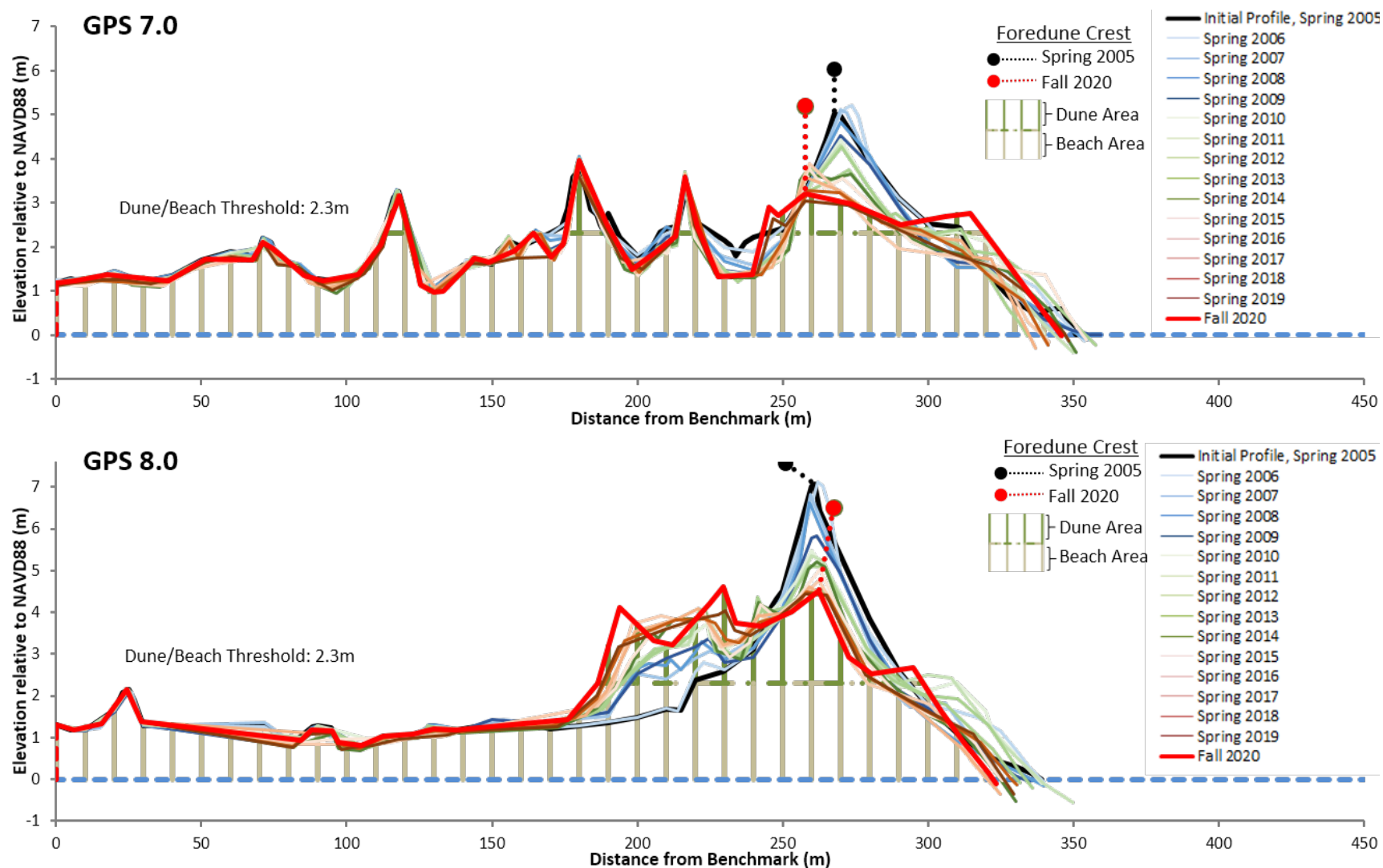


Figure 39. Coastal topography of Profiles GPS 7.0 and GPS 8.0 along the oceanside of Assateague Island National Seashore. Fore-dune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively.

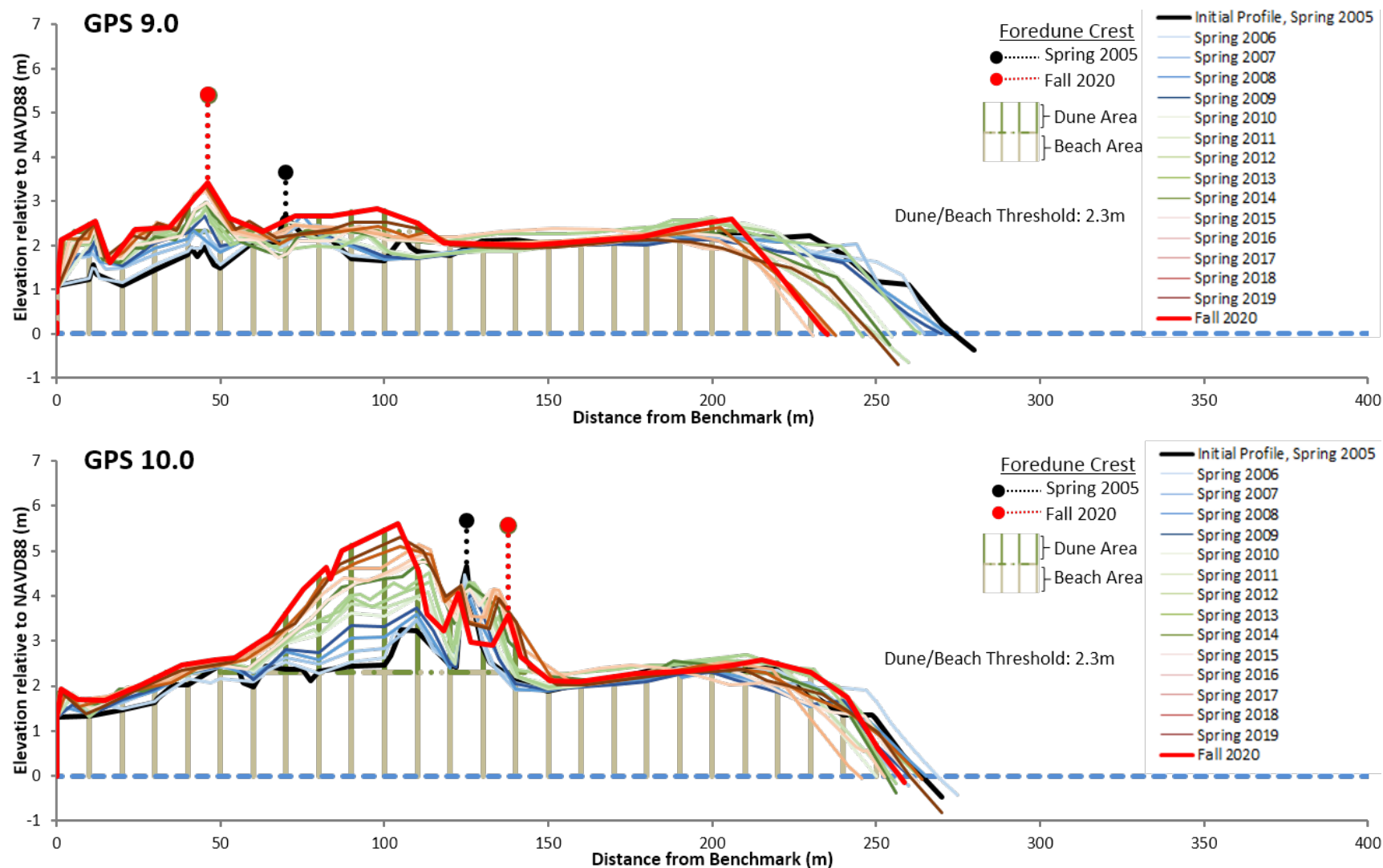


Figure 40. Coastal topography of Profiles GPS 9.0 and GPS 10.0 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively.

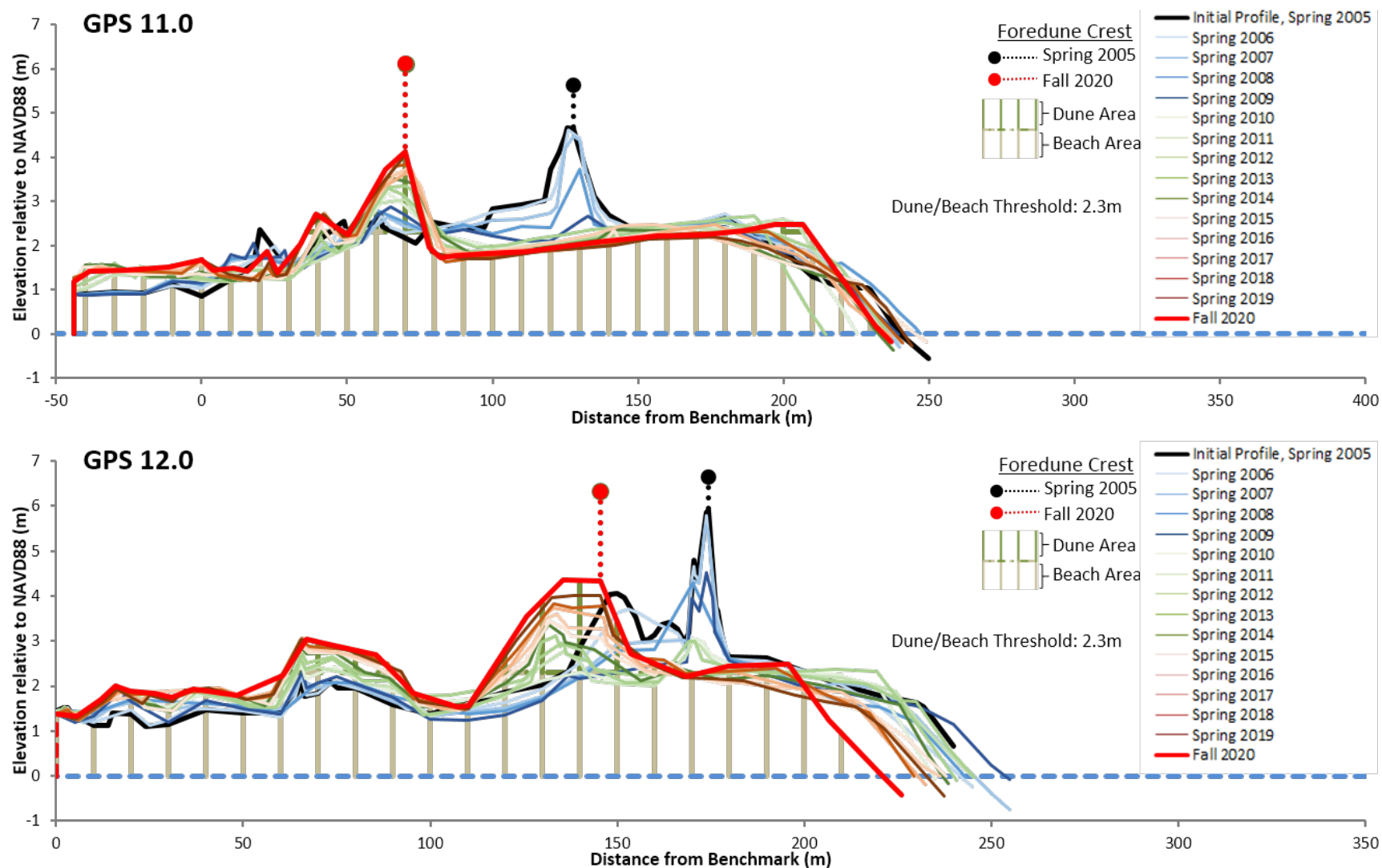


Figure 41. Coastal topography of Profiles GPS 11.0 and GPS 12.0 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively.

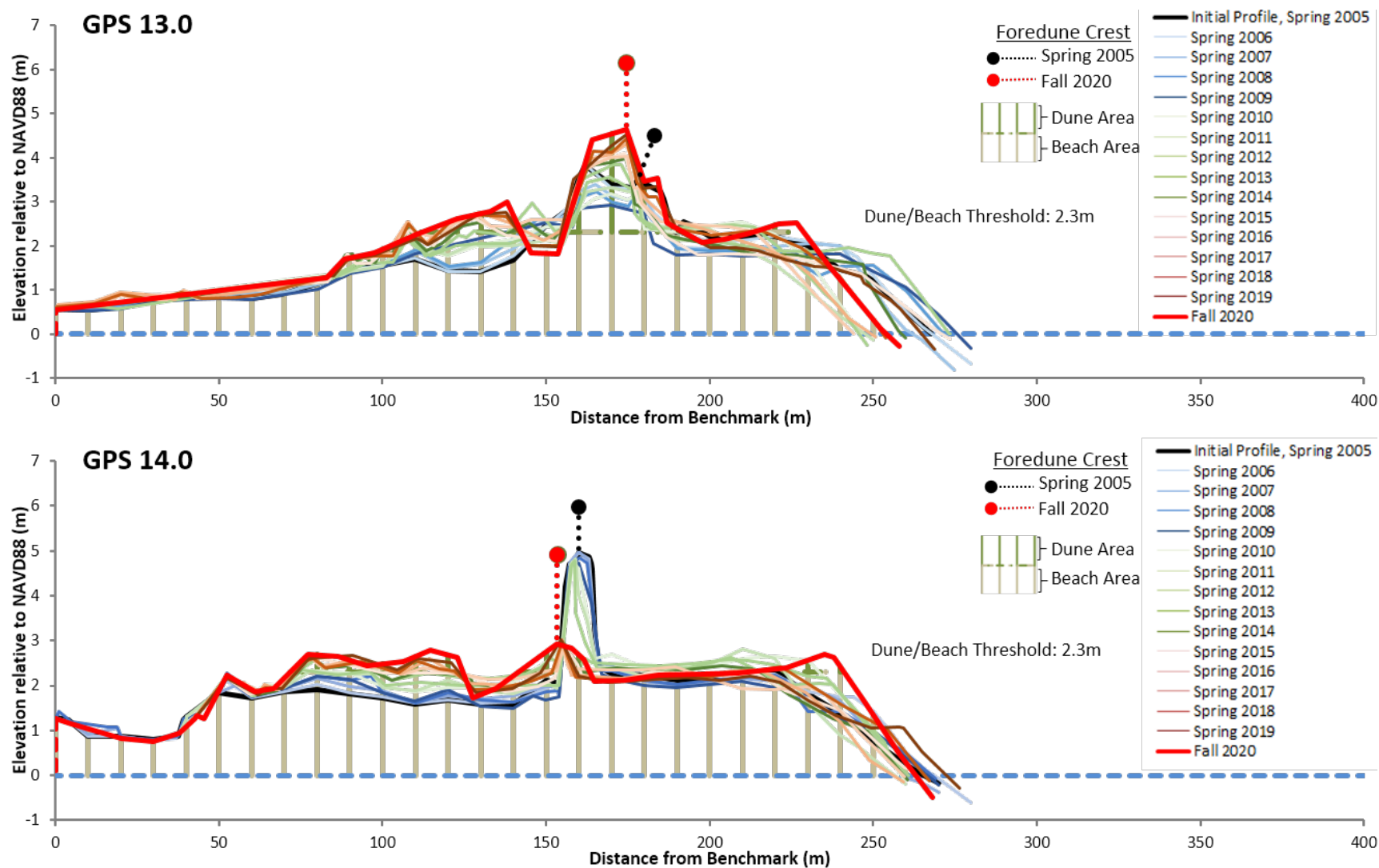


Figure 42. Coastal topography of Profiles GPS 13.0 and GPS 14.0 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively.

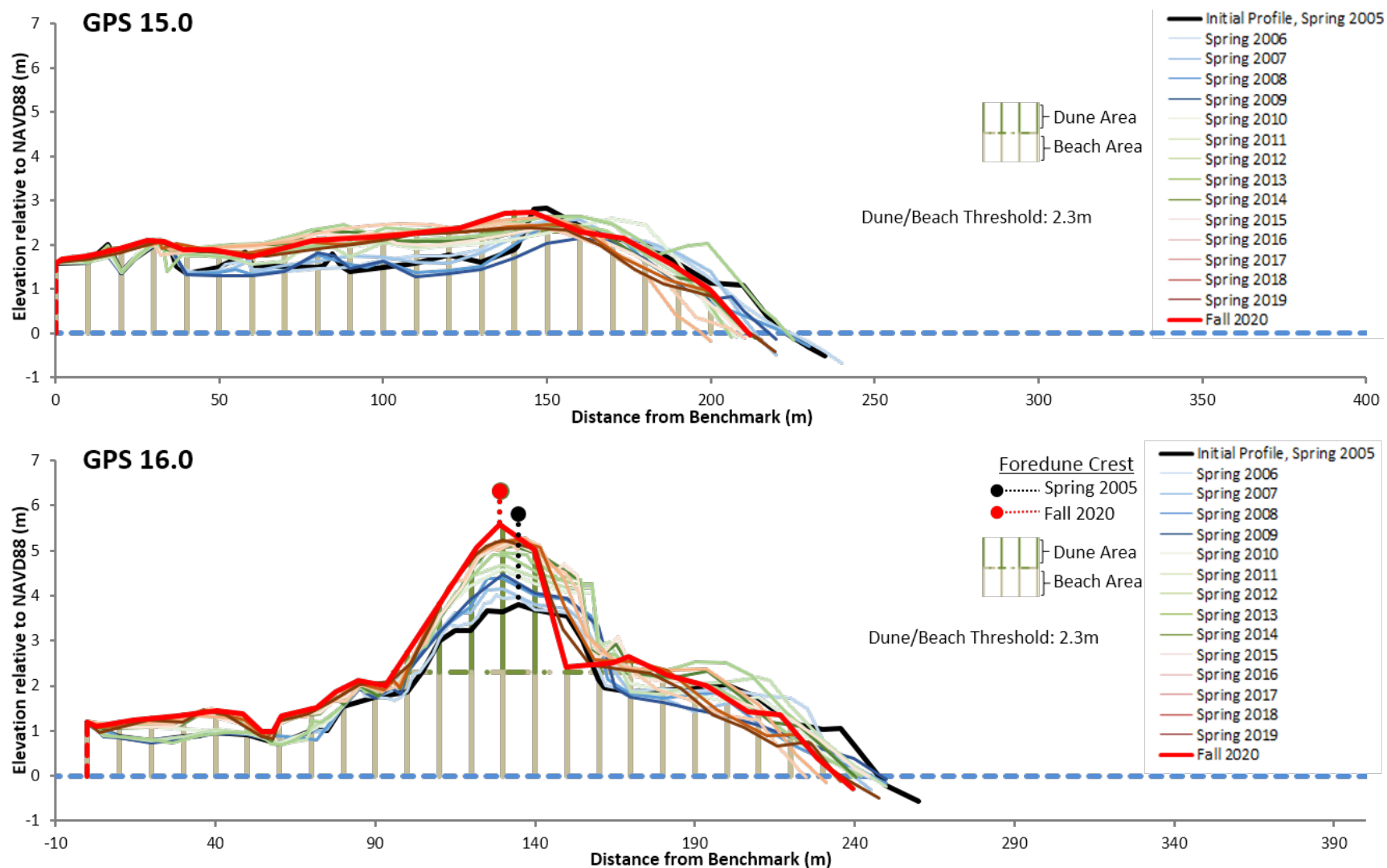


Figure 43. Coastal topography of Profiles GPS 15.0 and GPS 16.0 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively. No foredune crest present on GPS 15.0.

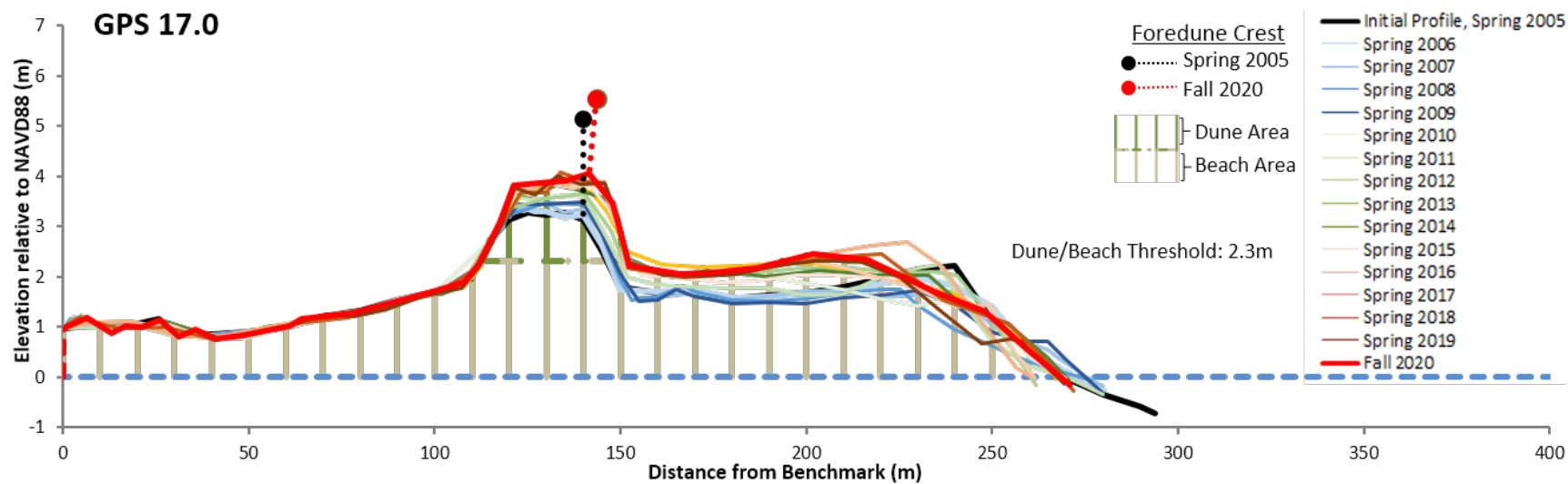


Figure 44. Coastal topography of Profile GPS 17.0 along the oceanside of Assateague Island National Seashore. Foredune crest location at initial and most recent survey represented by a dot and dashed line, color coded respectively.

15-year Coastal Topography Change

From the initial surveys to the Fall 2020 survey, the NAVD88 intercept was displaced inland on every profile except the three northernmost (NPS 0.5, GPS 1.0 and NPS 1.25) (Figure 31, Figure 32, and Table 11). GPS 1.0 had a net seaward displacement of +52 m, and GPS 4.0 had a net landward displacement of -90 m (Figure 36). The seaward displacement of the northernmost profiles is likely due to the presence of the ebb tide delta and local positive sediment budget. The dune crest over this 15-year period was largely displaced landward. The dune crest on GPS 11.0 was displaced -57 m landward from Spring 2005 to Fall 2020 (Figure 41). GPS 1.25 was the only profile to have significant net seaward displacement of the dune crest, +16 m (Figure 32). The dune crest elevation increased in ASIS North and in Assateague State Park during this period. Profiles GPS 2.0 and NPS 5.5 gained about +2 m in elevation over the 15 years (Figure 33). In ASIS South, the dune crest elevation mostly lowered through time. The dune on GPS 14.0 was eliminated in Hurricane Sandy, resulting in a loss of -2 m of elevation (Figure 42). GPS 14.0 had minimal recovery of height since Hurricane Sandy. The dune crest on GPS 8.0, however, has been consistently lowering through time, an overall loss of -2.6 m in height (Figure 39). From Spring 2005 to Fall 2020, there was a large gain in cross-section area in ASIS North, but that graded into cross-section area loss in Assateague State Park profiles (Figure 46). In ASIS North, GPS 1.0 gained +193 m², mostly in the beach area, only 2% of the gain was in the dune area. GPS 11.0 gained +147 m²; most of this gain (84%) was in the dune area.

Table 11. Net change metrics of distance to NAVD88, distance to foredune crest, elevation of foredune crest and cross-section area at Assateague Island National Seashore, Spring 2005–Fall 2020 surveys.

ID	Δ Distance (m)		Δ Elevation (m)	Δ Cross-section Area (m ²)		
	NAVD88	Dune Crest	Dune Crest	Total	Dune	Beach
NPS 0.5 ^a	51.14 ± 0.03	-3.19 ± 0.03 ^b	1.21 ± 0.06	181.21 ± 14.90	46.41 ± 7.15	134.80 ± 7.81
GPS 1.0	52.21 ± 0.03	-4.25 ± 0.03 ^b	-0.78 ± 0.06 ^b	193.07 ± 35.88	3.61 ± 3.90	189.46 ± 32.29
NPS 1.25 ^a	37.70 ± 0.03	16.83 ± 0.03	1.93 ± 0.06	176.38 ± 21.99	64.42 ± 4.36	111.96 ± 18.12
NPS 1.5	-25.67 ± 0.03 ^b	-32.44 ± 0.03 ^b	1.70 ± 0.06	160.68 ± 28.15	115.20 ± 6.79	45.48 ± 21.58
GPS 2.0	-12.05 ± 0.03 ^b	-1.11 ± 0.03 ^b	2.14 ± 0.06	124.84 ± 17.71	54.50 ± 6.75	70.34 ± 11.77
NPS 2.5	-9.72 ± 0.03 ^b	–	–	101.57 ± 22.11	0.45 ± 42.59	101.12 ± 31.43
NPS 2.75 ^a	-29.04 ± 0.03 ^b	7.45 ± 0.03	1.76 ± 0.06	176.20 ± 25.51	92.40 ± 4.83	83.80 ± 21.81
GPS 3.0	-29.71 ± 0.03 ^b	–	–	168.77 ± 36.46	66.93 ± 4.13	101.84 ± 33.74
NPS 3.5	-31.97 ± 0.03 ^b	-23.08 ± 0.03 ^b	1.71 ± 0.06	72.69 ± 18.04	52.65 ± 3.68	20.05 ± 14.59
NPS 3.75	-90.31 ± 0.03 ^b	–	–	113.16 ± 29.65	74.46 ± 4.45	38.69 ± 26.07
GPS 4.0	-51.07 ± 0.03 ^b	-51.08 ± 0.03 ^b	0.99 ± 0.06	65.24 ± 31.25	26.19 ± 2.93	39.05 ± 28.51
NPS 4.5	-39.44 ± 0.03 ^b	–	–	39.62 ± 14.37	31.44 ± 2.24	8.18 ± 12.69
GPS 5.0	-54.17 ± 0.03 ^b	–	–	33.84 ± 14.11	48.47 ± 2.75	-14.62 ± 12.05 ^b
NPS 5.5	-21.39 ± 0.03 ^b	-19.10 ± 0.03 ^b	2.11 ± 0.06	34.59 ± 12.80	25.45 ± 2.46	9.15 ± 10.37
NPS 5.75 ^a	-25.90 ± 0.03 ^b	-14.86 ± 0.03 ^b	1.53 ± 0.06	-18.59 ± 5.14 ^b	1.43 ± 2.40	-20.02 ± 2.75
GPS 6.0	-20.02 ± 0.03 ^b	-25.38 ± 0.03 ^b	0.98 ± 0.06	17.48 ± 14.23	8.78 ± 4.40	8.70 ± 9.82

^a Collection did not begin until spring 2008. Comparison shown is from spring 2008 through fall 2020

^b Indicate losses or distances inland (also shaded in gray).

Table 11 (continued). Net change metrics of distance to NAVD88, distance to foredune crest, elevation of foredune crest and cross-section area at Assateague Island National Seashore, Spring 2005–Fall 2020 surveys.

ID	Δ Distance (m)		Δ Elevation (m)	Δ Cross-section Area (m ²)		
	NAVD88	Dune Crest	Dune Crest	Total	Dune	Beach
GPS 7.0	-5.16 ± 0.03^b	-10.23 ± 0.03^b	-1.82 ± 0.06^b	-45.59 ± 19.71^b	-32.16 ± 6.25^b	-13.43 ± 13.48^b
GPS 8.0	-16.47 ± 0.03^b	1.62 ± 0.03	-2.58 ± 0.06^b	29.99 ± 18.71	5.91 ± 5.37	24.08 ± 13.53
GPS 9.0	-38.74 ± 0.03^b	-23.81 ± 0.03^b	0.76 ± 0.06	35.02 ± 14.42	35.33 ± 4.60	-0.31 ± 11.73^b
GPS 10.0	-6.94 ± 0.03^b	12.79 ± 0.03	-1.09 ± 0.06^b	147.30 ± 14.74	124.22 ± 8.12	23.08 ± 6.81
GPS 11.0	-5.61 ± 0.03^b	-57.67 ± 0.03^b	-0.52 ± 0.06^b	-17.33 ± 15.91^b	-25.53 ± 5.79^b	8.19 ± 10.79
GPS 12.0	-24.99 ± 0.03^b	-29.05 ± 0.03^b	-1.57 ± 0.06^b	14.42 ± 13.23	11.20 ± 4.86	3.22 ± 8.66
GPS 13.0	-13.52 ± 0.03^b	-3.54 ± 0.03^b	1.16 ± 0.06	49.38 ± 14.77	24.01 ± 3.87	25.37 ± 11.08
GPS 14.0	-2.33 ± 0.03^b	-6.54 ± 0.03^b	-2.05 ± 0.06^b	67.13 ± 14.94	4.50 ± 4.27	62.64 ± 11.50
GPS 15.0	-11.27 ± 0.03^b	–	–	50.23 ± 12.29	3.98 ± 2.04	46.25 ± 10.42
GPS 16.0	-12.78 ± 0.03^b	-5.96 ± 0.03^b	1.78 ± 0.06	85.33 ± 13.64	53.28 ± 4.00	32.04 ± 9.80
GPS 17.0	-1.28 ± 0.03^b	1.54 ± 0.03	0.91 ± 0.06	53.99 ± 15.22	27.02 ± 2.89	26.97 ± 12.48

^a Collection did not begin until spring 2008. Comparison shown is from spring 2008 through fall 2020

^b Indicate losses or distances inland (also shaded in gray).

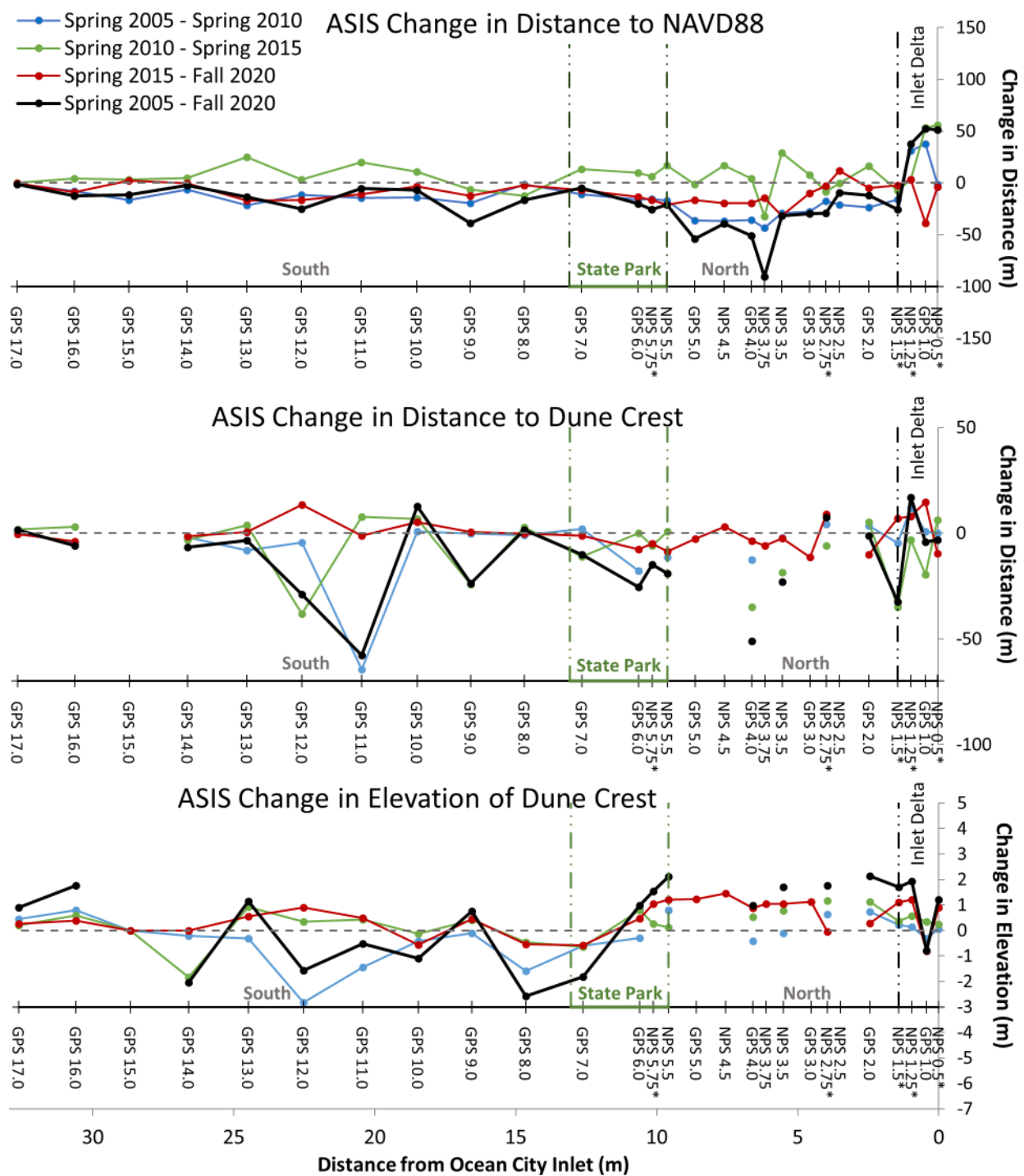


Figure 45. Alongshore change in distance to NAVD88, dune crest, and change in elevation of dune crest within Assateague Island National Seashore (ASIS), Spring 2005–Fall 2020 surveys. Alongshore dimensions divided by dune/beach profile sites along ASIS Inlet Delta, ASIS North, State Park, and ASIS South.

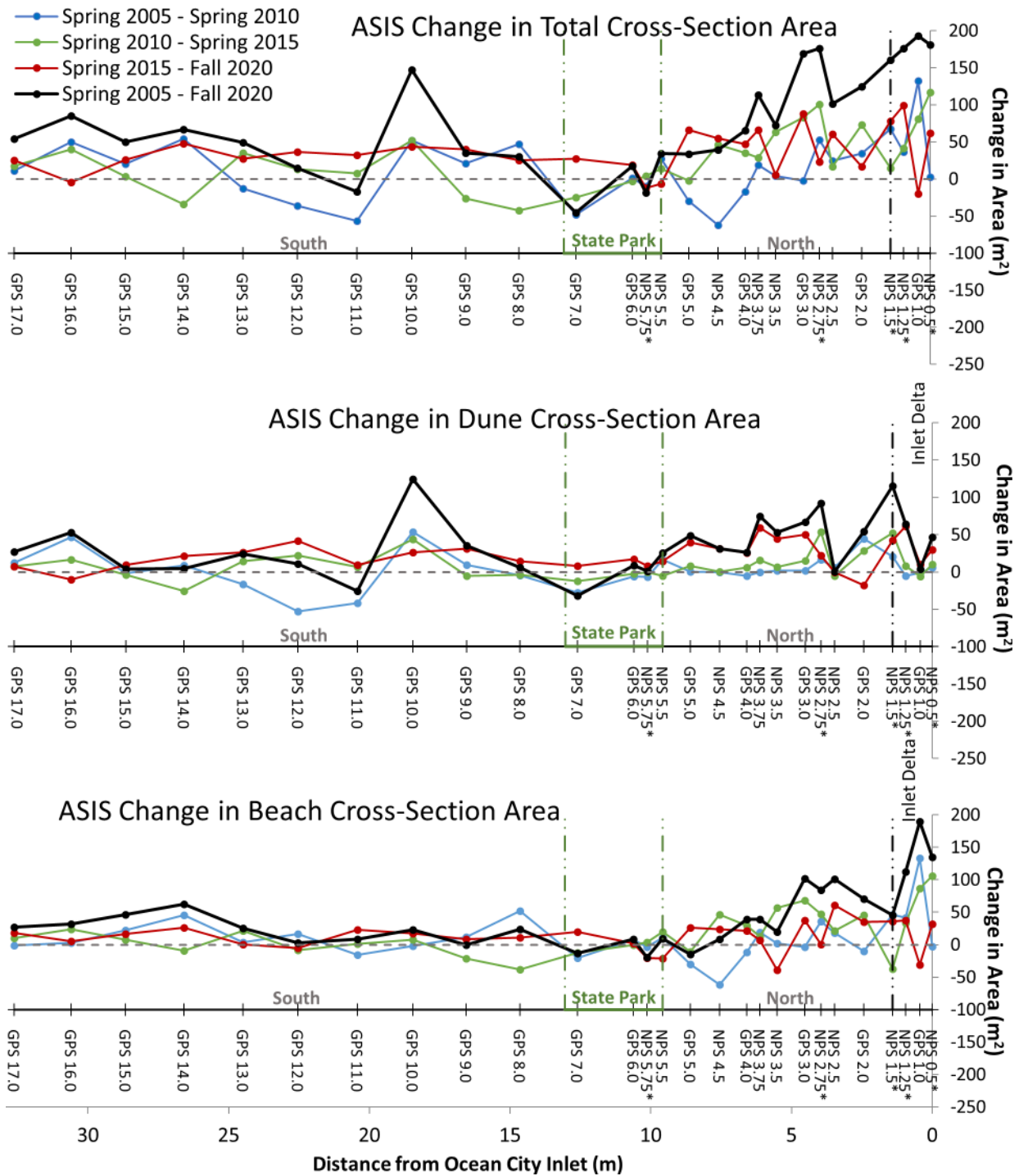


Figure 46. Alongshore dimensions of selected topographical metrics within Assateague Island National Seashore (ASIS), Spring 2005–Fall 2020 surveys. Alongshore dimensions divided dune/beach profile sites along the along ASIS Inlet Delta, ASIS North, State Park, and ASIS South.

2D Trends of Change

The net displacement of the 2D metrics, starting with the Spring 2005 survey, was calculated for each successive annual period. Net displacement is an additive statistical value that can display general trends of displacement and recovery. It is calculated by adding the mean value of annual change to the previous year's displacement. Profiles are grouped by location as described previously.

The NAVD88 intersect was displaced consistently landward in ASIS North, Assateague State Park, and ASIS South (Figure 47). Assateague State Park had the greatest net landward rate of displacement in the 15-year period, -1.24 m/yr. ASIS South was displaced landward at a slower mean net rate, -0.9 m/yr, and ASIS North was displaced at a mean net rate of -1.08 m/yr. The ASIS Inlet Delta profiles had a mean net seaward displacement of $+2.63$ m/yr.

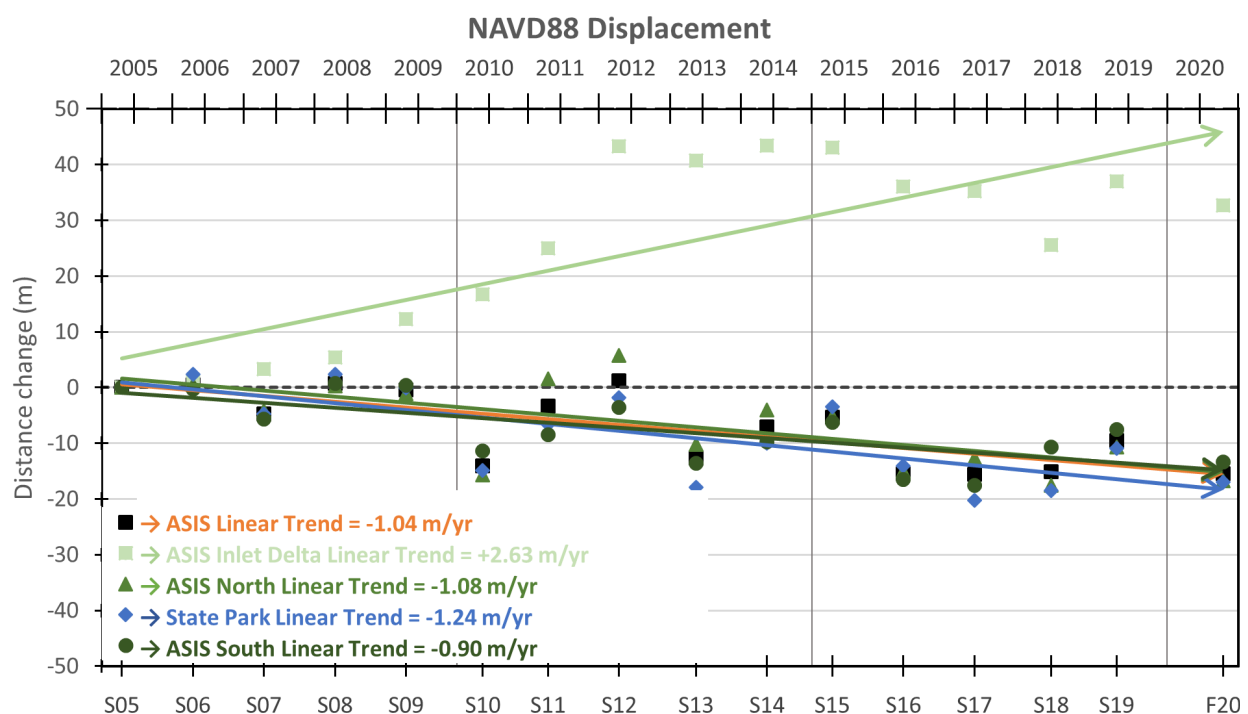


Figure 47. Trend of mean annual NAVD88 intercept displacement at Assateague Island National Seashore (ASIS) Inlet Delta (NPS 0.5–NPS 1.5), ASIS North (GPS 2.0–GPS 5.0), State Park (NPS 5.5–GPS 7.0), and ASIS South (GPS 8.0–GPS 17.0) during Spring 2005–Fall 2020 surveys. Spring survey dates are represented on the lower x-axis, and the annual timeline on the upper x-axis.

The dune crest location and elevation generally had trends opposite to each other. The dune crest was displaced landward in every section except ASIS North but gained elevation in every section except ASIS South (Figure 48). The net displacement rate in ASIS North of the dune crest location was $+0.48$ m/yr. Assateague State Park had the greatest net landward displacement rate of the dune crest, -1.11 m/yr. ASIS Inlet Delta, ASIS North, and the Assateague State Park profiles all had a trend of net elevation gain, $+0.05$ m/yr, $+0.10$ m/yr, and $+0.03$ m/yr, respectively. The ASIS South section was the only one without a positive trend in dune crest elevation. There was a small trend of net elevation loss, -0.02 m/yr, in this section.

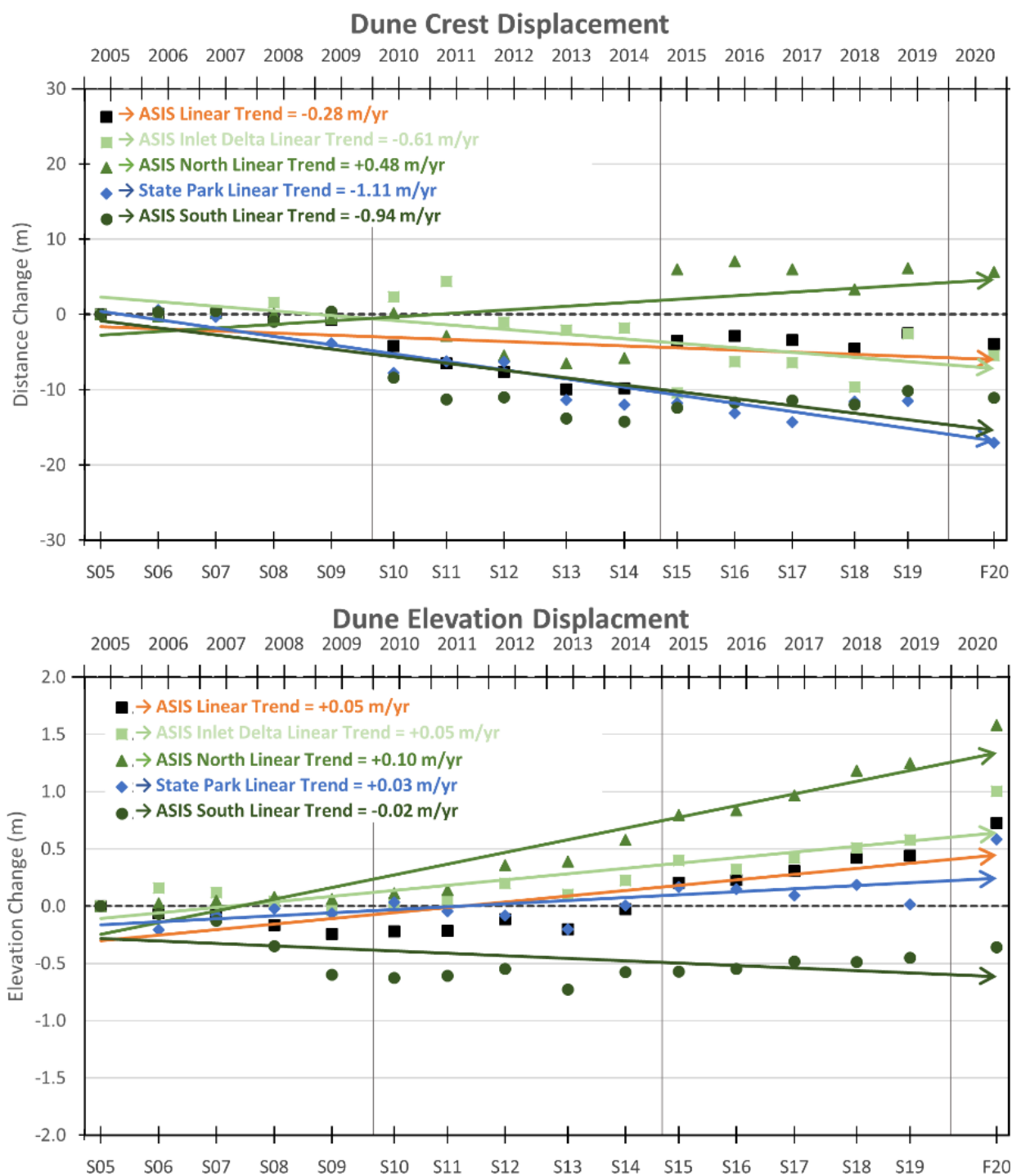


Figure 48. Trend of mean annual Dune Crest location and elevation displacement at Assateague Island National Seashore (ASIS) Inlet Delta (NPS 0.5–NPS 1.5), ASIS North (GPS 2.0–GPS 5.0), State Park (NPS 5.5–GPS 7.0), and ASIS South (GPS 8.0–GPS 17.0) during Spring 2005–Fall 2020 surveys. Spring survey dates are represented on the lower x-axis, and the annual timeline on the upper x-axis.

All of the sections except Assateague State Park had a net trend of cross-section area gain in both the beach and the dune (Figure 49). The ASIS Inlet Delta profiles had the highest net rate of gain in the beach area, $+6.40 \text{ m}^2/\text{yr}$, and in the total cross-section area, $+9.41 \text{ m}^2/\text{yr}$. ASIS North and ASIS Inlet Delta had similar rates of net gain in the dune area $+3.22 \text{ m}^2/\text{yr}$ and $+3.01 \text{ m}^2/\text{yr}$ respectively. The State Park profiles were the only group that had a trend of net loss in cross-section area in the 15 years. The dune area of the State Park profiles had a higher rate of net loss, $-1.16 \text{ m}^2/\text{yr}$, than the beach area, $+0.98 \text{ m}^2/\text{yr}$.

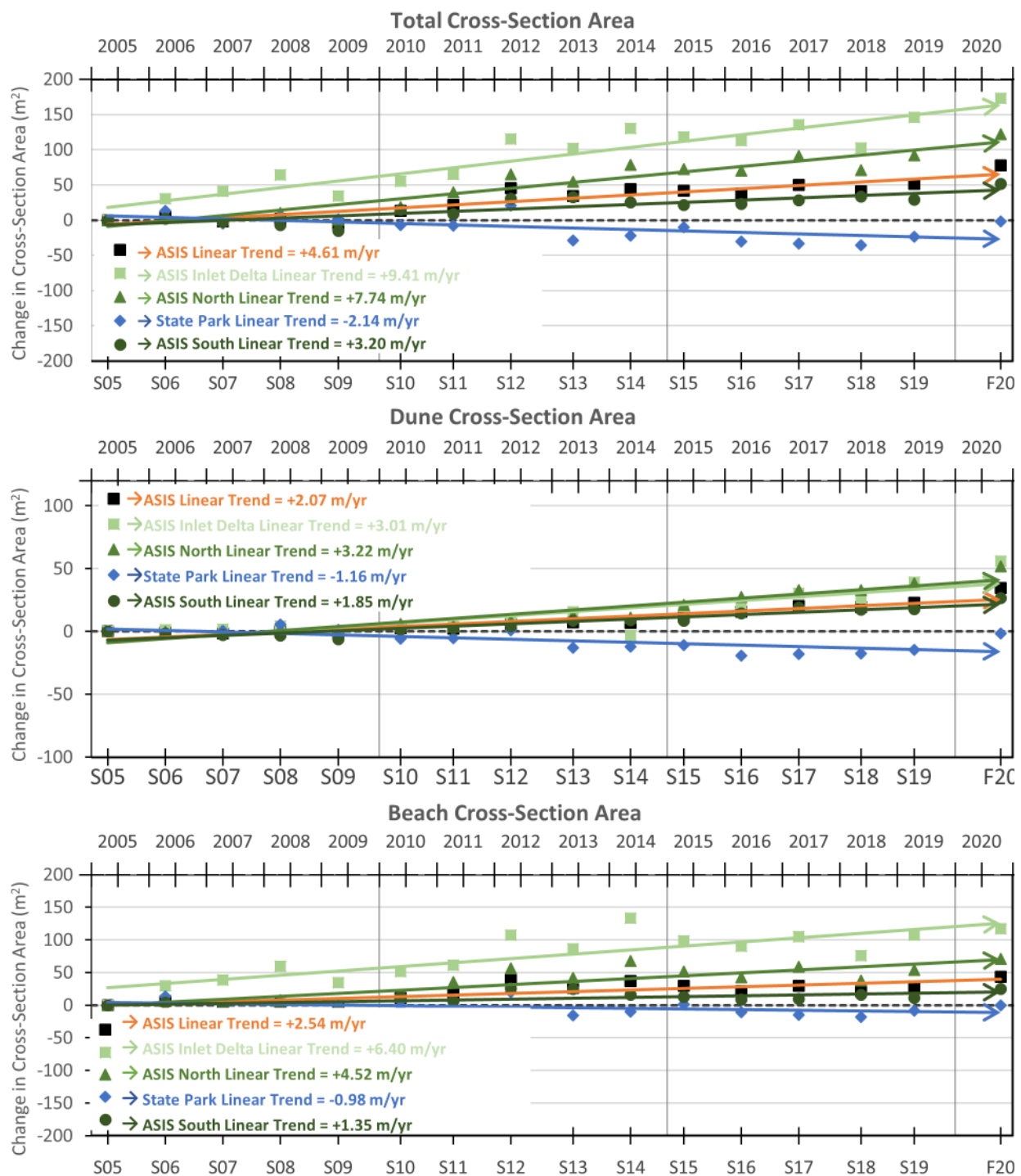


Figure 49. Trend of mean annual total, dune and beach cross-section area change at Assateague Island National Seashore (ASIS) Inlet Delta (NPS 0.5–NPS 1.5), ASIS North (GPS 2.0–GPS 5.0), State Park (NPS 5.5–GPS 7.0), and ASIS South (GPS 8.0–GPS 17.0) during Spring 2005–Fall 2020 surveys. Spring survey dates are represented on the lower x-axis, and the annual timeline on the upper x-axis.

Description of Trends

Analysis of the ASIS ocean shoreline data, Toms Cove Hook shoreline data, and topographical change data from profiles within the National Seashore and Assateague State Park provides a preview for future patterns and trends of change. The main variables that influenced the trends of shoreline change and coastal topography within ASIS during the 15-year survey period were natural impacts (storminess), anthropogenic modifications (disposal of sediment dredged from the inlet, Assateague State Park stabilization of inland margin of dune feature), and morphology (ebb tide delta connection downdrift of jetty, established dune system in the north, less established in the south).

Hurricane Sandy, October 2012, caused landward displacement of the entire oceanside shoreline and affected all profiles within ASIS. There was variable recovery post-Hurricane Sandy in both the shoreline position and coastal topography profiles. The shoreline in ASIS North showed some post-storm recovery, the shoreline within Chincoteague South never fully recovered. The winter of 2016 was also particularly stormy and had a higher mean landward shoreline displacement than post-Hurricane Sandy for the oceanside shoreline. Toms Cove Hook was less effected by storm events. During this time period there was loss of cross section area in the beach on almost all of the profiles.

During the Spring 2005–Fall 2020 surveys, the only section of the oceanside shoreline that had a positive rate of mean net displacement was the northernmost portion of Assateague Island where the ebb tide delta and presence of the jetty affected local sediment transport. The unique characteristics of this section around the jetty and ebb tide delta led to a localized positive sediment budget. All other parts of the ocean shoreline had negative rates of shoreline displacement. The highest rate of erosion was the southern portion of Chincoteague National Wildlife Refuge. This portion of the island does not have an established dune system and is frequently the site of washover and occasional breaching during storm events. The accreting shoreline of Toms Cove Hook had a high rate of seaward displacement as the spit grew in the direction of sediment transport. As the spit extended to the southwest, less sediment was transported to the shoreline to the northwest, causing erosion.

The dune area throughout Assateague Island National Seashore gained in cross-sectional area over time, with the exception of Assateague State Park. The dune crest in Assateague State Park was displaced landward at the highest rate as well. The northern part of Assateague Island had the highest rate of cross-section area gain in both the beach and the dune. Variation in sediment budget caused by structures and anthropogenic manipulations of sediment supply, impacts of storm events, and shoreline exposure were major drivers of shoreline position and topographical change during the 2005–2020 period.

Information for Management

The southern portion of Chincoteague had the highest rate of landward displacement of the shoreline position during this survey period, incorporating the area near the existing visitor center and parking lot. The rates of shoreline position displacement at the location of the current parking facility will continue to cause damage and interfere with visitor use of the area. A relocation of the parking facility to a site with a lower rate of landward shoreline position displacement and with an existing dune feature offers an opportunity to enhance visitor use and reduce maintenance activity.

The dunes fronting Assateague State Park had the highest rate of landward displacement. Whereas the current practice in Assateague State Park is to slow the migration of the dune's position through fencing, due to negative sediment budget and sea level rise this may become less feasible through time. The dunes seaward of the ASIS parking areas in ASIS South also had a net landward displacement.

As is true for many coastal areas, the positive and negative changes are being driven by the availability of sediment. Whether the result of unscheduled natural impacts or planned anthropogenic manipulations, the shoreline position and coastal topography are responding to the local sediment supply and sediment budget. Some changes are just part of the natural trajectory of the environmental drivers. Other changes are in response to human actions and can be predicted with the knowledge gained through this monitoring. Importantly, armed with knowledge of the past responses to the variety of manipulations, management can anticipate and adjust to the potential impacts at determined locations within the public lands.

Changes to the Protocol

There are no documented changes to the protocol used in the data collection cited in this report.

Problems/Concerns

The gaps in shoreline position data during certain surveys analyzed in this report reduce the comparability of shoreline position data from season to season and year to year. Statistics calculated with incomplete data sets are either flagged or portions of the shoreline represented in every survey must be extracted from the full data sets for analysis. Despite these efforts, gaps in shoreline position data result in a skewed analysis that must be taken into consideration when viewing some of the results of this report. There were also data gaps in the coastal topography profiles due to issues with equipment or issues accessing the survey areas. Profiles missing a Spring survey use either Fall survey data to complete an annual comparison. Points that fall outside of a 1m buffer are not considered in the creation of the profiles and cross section areas. Due to the COVID-19 pandemic, the Spring 2020 survey could not be collected for 1D or 2D. The Fall 2020 survey was used instead to identify the temporal variation compared the Spring 2019 survey.

Data Archives

The lines that represent the shoreline position change for each of the surveyed periods are stored as features 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 (Thieler et al. 2017). Coastal topography data is stored as the raw data files and processed .csv files with northing, easting and elevation data. These data are available from the [NPS Integrated Resource Management Applications \(IRMA\) Portal](#).

- [Ocean Shoreline Position data](#)
- [Coastal Topography data](#)

Questions may be directed to the Northeast Coastal and Barrier Network Data Manager.

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