



Post-Dorian Shoreline Change at Cape Hatteras National Seashore

2019 Report

Natural Resource Report NPS/SECN/NRR—2020/2205



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ON THE COVER

Photo taken during the post Hurricane Dorian data collection on Ocracoke Island, North Carolina. The photo is looking south and was taken on the overwash area, just north of the breach located on the northern end of Ocracoke Island, North Carolina (Photo taken September 16, 2019 by Lisa Cowart Baron).

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Summary and Key Findings

In 2018 and 2019 the Southeast Coast Network (SECN), with assistance from park staff, collected long-term shoreline monitoring data at Cape Hatteras National Seashore as part of the National Park Service (NPS) Vital Signs Monitoring Program. Monitoring was conducted following methods developed by the NPS Northeast Coastal and Barrier Network and consisted of mapping the high-tide swash line using a Global Positioning System unit in the spring of each year (Psuty et al. 2010). Shoreline change was calculated using the Digital Shoreline Analysis System (DSAS) developed by the United States Geological Survey (USGS; Himmelstoss et al. 2018). Following the same field methods used for monitoring long-term shoreline change, geospatial data were collected as part of the Hurricane Dorian (or Dorian) Incident Response from September 12–16, 2019. This report summarizes the post-Dorian data and the previous two shoreline data collection efforts (spring 2019 and fall 2018).

Key findings from this effort:

- Pre-and post-storm surveys of approximately 122.04 kilometers (75.83 miles) of shoreline indicate a geomorphologically dynamic beach/barrier island system response to a major storm system. Many areas of both accretion and erosion were noted in both the seasonal and annual shoreline change analyses performed. The mean seasonal shoreline change distance was positive (denoting accretion) for the seasonal analysis of Bodie and Hatteras Islands. When the data from all three islands area averaged, the mean annual shoreline change distance was negative (denoting erosion). The mean seasonal shoreline change distance on Ocracoke Island was also negative. In comparing the shoreline change on the three islands of Cape Hatteras NS, Ocracoke Island exhibited the most erosion on average.
- Overall, there appears to be a short-term trend in shoreline erosion during the 2018 to 2019 time period; however, the net impact to shoreline position from Dorian was minimal along the ocean facing beaches. There was a large amount of shoreline change in areas near inlets.
- Of the park facilities analyzed for potential impacts of future storms, seven buildings were identified within 25 meters (82 feet) of the post-Dorian shoreline and twenty-three buildings within 100 meters (328 feet).

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Introduction

The problem of land loss and gain and landscape alteration at the marine edge is fundamental to the many issues facing coastal park resource stewards. Shoreline change is a prime geo-indicator of coastal environmental resource threats within parks. Change in shoreline position drives the alteration and replacement of established natural habitats, and shoreline retreat may destroy cultural resources, facilities, and other infrastructure where they exist. Geomorphologic change is a basic concern because it also influences change in other natural resource areas of interest within the NPS program—estuarine and subsurface water quality, focal species and habitats of concern, and recreational visitor use. Spatial variability is inherent in shoreline change. Early identification of changes in past trends, along with an understanding of normal variability, is key to recognizing ecological problems in coastal parks. For managers, an understanding of the spatial and temporal patterns of geomorphologic change is important for optimal management of any coastal park because (1) the interface of marine and land systems is very dynamic and is driven by multiple forcing mechanisms, (2) it results in alterations to resource patterns and dynamics at habitat and ecosystem levels, and (3) it will eventually result in the loss of static resources (e.g., facility buildings).

To effectively monitor the diverse and dynamic coastal resources, the Southeast Coast Network has implemented a monitoring approach which consists of mapping the high-tide swash line along the oceanfront beaches using Geospatial Positioning System (GPS) equipment. The collected data is post processed to attain higher accuracy and analyzed using the Digital Shoreline Analysis System (DSAS) created by the USGS (Himmelstoss et al. 2018). This approach is modeled after the National Park Service Northeast Coastal Barrier Network Geomorphological Protocol: Part 1 (Psuty et al. 2010). The post-Dorian shoreline survey was requested by the park as part of the Hurricane Dorian Incident data collection and is not part of ongoing vital sign monitoring of this resource by the Southeast Coast Network. However, the post-Dorian shoreline data was collected using the same methods as the SECN long-term monitoring protocol (Baron 2018a), except for the timing of the data collection window.

As part of the Cape Hatteras National Seashore Hurricane Dorian Incident response, post-hurricane shoreline data collection was performed September 12–16, 2019.

This report provides a comparison of the post-Dorian shoreline monitoring data collected as part of the incident, and the spring 2019 and fall 2018 data collections prior to the hurricane. The spring 2019 and fall 2018 data is compared with the post-Dorian data collected to determine the seasonal and annual shoreline change. Therefore, two shoreline change analyses are performed: (1) Annual Shoreline Analysis—fall 2018 to post-Dorian (fall 2019) and (2) Seasonal Shoreline Analysis—spring 2019 to post-Dorian (fall 2019). The fall 2018 and post-Dorian shoreline data were collected during a similar time of the year; therefore, this analysis identifies areas where the shoreline has changed, but is not influenced by seasonal changes in shoreline position. The spring 2019 to post-Dorian shoreline data were collected during different times of the year and therefore are seasonally influenced. This means that the shoreline change identified in the seasonal shoreline change analysis includes the seasonal fluctuations of the shoreline position. In general, shorelines in the southeast tend to become narrower throughout the winter, as they endure nor'easters, until approximately March and April. Around March and April, the beaches start to build throughout the summer until approximately October and November. Then, the cycle repeats. Thus, seasonal shoreline change anticipates the shoreline to move landward in the winter season and seaward in the summer season (Psuty et al. 2010). The shoreline data and analysis in this report will be useful for park managers in making critical decisions on the protection and preservation of the park's critical resources.

The post-Dorian shoreline change analysis report objectives are:

1. Determine seasonal and annual changes in mean high-water shoreline position (average and standard deviation of change in position at fixed transects, and cumulatively within management islands).
2. Determine the magnitude, direction (landward or seaward), and spatial distribution of rates of observed shoreline change including the identification of areas of highly dynamic shorelines, and areas of accretion versus erosion.
3. Determine park facilities potentially impacted by future hurricanes that flood 25 meters (82 feet) or 100 meters (328 feet) inland of post-Dorian shoreline position.

Study Area

Cape Hatteras National Seashore is a series of barrier islands that make up the northern portion of the Outer Banks of North Carolina. The seashore consists of approximately 119 kilometers (74 miles) of shoreline. The islands are made up of both east- and south-facing beaches, which are very close to the Gulf Stream and Labrador oceanic currents, and encompass many points, spits and inlets, making for an extremely dynamic area.

The seashore is made up of three separate islands; Bodie Island, Hatteras Island and Ocracoke Island. Its northern boundary is bordered by the Village of Nags Head and at its southern boundary ends at Ocracoke Inlet. Two other major inlets (Oregon Inlet and Hatteras Inlet) play a role in the seashore's makeup.

Major local interest lies in the protection of roadways and property on the island, which are under constant threat from storm surges, high winds and sand deposition and erosion. The seashore surrounds nine villages where most of this sensitive property is located, and also where much of the development pressure originates. An artificial dune line, which was put into place by the Civilian Conservation Corps in the late 1930s, has offered protection in the past, but is now in need of continuous maintenance due to erosion from storms and sea-level rise.

Historic sites, such as the Cape Hatteras Lighthouse—already moved in 1999 due to threats from shoreline erosion—and several Coast Guard life-saving stations, are constantly threatened from sea-level rise and the island's dynamic nature. The seashore is comprised of a variety of different habitats such as maritime forest, salt marsh, bog, back dune, and ocean shoreline, which allow for an array of wildlife to inhabit the area. The seashore has been designated as Globally Important Bird Area by the American Bird Conservancy because of the importance of the habitats to avian breeding, migration, and wintering (Cecil et al. 2009). Several threatened and endangered species use the island for nesting and overwintering such as the loggerhead sea turtle and piping plover. Preferred nesting and overwintering areas change as shorelines change over time. Knowledge of the dynamics of the shoreline and impacts from Hurricane Dorian will help with future planning for and protection of wildlife at the seashore.

This report includes data collected from the northern seashore boundary near the village of Nags Head to the southern boundary at Ocracoke Inlet (Figure 1). This area includes Pea Island National Wildlife Refuge, which encompasses 21 kilometers (13 miles) of shoreline starting at the south end of Oregon Inlet and ending at the northern end of Rodanthe village.

Cape Hatteras National Seashore Shoreline Study Area

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Figure 1. Map showing the sections of beach, highlighted in red (study area), where data is collected for the long-term shoreline monitoring project and the post-Dorian data collection. Data is collected along the sandy beaches of Bodie Island, Hatteras Island, and Ocracoke Island.

Hurricane Dorian Impacts

Hurricane Dorian moved northward through the Caribbean as a category 5 hurricane, wreaking havoc on the Bahamas as the strongest hurricane to ever make landfall there. The storm moved northward and weakened, staying just off the southeastern U.S. coast until making landfall as a category 3 storm near Cape Hatteras in eastern North Carolina on

September 6, 2019 (Figure 2). As the hurricane impacted Cape Hatteras National Seashore, the water levels reached peaks ranging from 1.07 to 2.93 meters (3.51 to 7.83 feet; Table 1). The hydrographs of the water levels during Hurricane Dorian are shown in Appendix A.



Figure 2. Map of Hurricane Dorian path (image taken from NWS 2019).

Table 1. List of peak high-water levels, in meters, during Hurricanes Dorian, Florence, Matthew, and Joaquin (USGS 2020). Peak high-water levels are in NAVD88.

Location	Dorian	Florence	Matthew	Joaquin
Oregon Inlet Boat Ramp (sound side)	1.07	0.64	0.81	N/A
Tri-Villages	1.91	2.95	2.34	2.50
Avon	1.78	3.52	2.67	2.71
Buxton	2.39	N/A	2.26	1.74
Hatteras Ferry (sound side)	1.73	0.63	2.15	1.06

The wind and precipitation from Dorian are summarized in Tables 2 and 3 (NWS 2019). The eye of the hurricane passed Cape Lookout (Figure 2) with peak wind gusts of 110 miles-per-hour (mph) reported at Cedar Island Ferry Terminal (Table 2). Rainfall totals within Carteret, Dare and Hyde

counties ranged from 27.63 to 39.10 millimeters (1.09 to 1.54 inches; Table 3). Storm-surge flooding from the hurricane severely impacted Ocracoke with a storm surge of 1.22 to 2.13 meters (4.00 to 7.00 feet; NWS 2019).

Table 2. Table of the highest wind speeds in Carteret, Dare, and Hyde counties during Hurricane Dorian (NWS 2019).

County	Location	Speed (mph)	Time	Date	Provider
Carteret	Cedar Island Ferry Terminal	110	05:18 AM	9/5/2019	NWS
	Fort Macon (WxFlow)	89	04:21 AM	9/6/2019	WXFLOW
	Beaufort	85	02:14 PM	9/5/2019	CWOP
	Cape Lookout	82	06:00 AM	9/6/2019	NDBC
	Cedar Island RAWS	76	05:25 AM	9/6/2019	RAWS
	Beaufort (MRH ASOS)	68	08:15 AM	9/6/2019	ASOS
	Piney Island (KNBT ASOS)	66	04:09 AM	9/6/2019	ASOS
	Newport WFO	65	06:37 AM	9/6/2019	RSOIS
	Newport	53	07:45 AM	9/6/2019	CWOP
	Bogue Field (NJM ASOS)	53	02:55 AM	9/6/2019	AWOS
	Cape Lookout	51	11:00 PM	9/5/2019	NDBC
	Croatan RAWS	50	03:05 AM	9/6/2019	RAWS
	Indian Beach	50	05:46 PM	9/5/2019	CWOP
Dare	Hatteras High (WxFlow)	10	09:33 AM	9/6/2019	WXFLOW
	Oregon Inlet CG (WxFlow)	99	12:20 PM	9/6/2019	WXFLOW
	KHK Resort (WxFlow)	91	12:19 PM	9/6/2019	WXFLOW
	Buxton (WxFlow)	91	09:34 AM	9/6/2019	WXFLOW
	Oregon Inlet (WxFlow)	84	11:37 AM	9/6/2019	WXFLOW
	Avon (WxFlow)	84	08:08 AM	9/6/2019	WXFLOW
	Real Slick (WxFlow)	82	11:55 AM	9/6/2019	WXFLOW
	Nags Head	78	11:20 AM	9/6/2019	CWOP
	Frisco (HSE ASOS)	78	06:39 AM	9/6/2019	ASOS
	Dare Co Gnry Ran (2DP AWOS)	72	11:11 AM	9/6/2019	AWOS
	Dare Bomb Range RAWS	69	11:28 AM	9/6/2019	RAWS
	Buxton (WxFlow)	62	05:49 AM	9/6/2019	WXFLOW
	Manteo (MQI AWOS)	61	10:55 AM	9/6/2019	AWOS
	Kill Devil Hills (FFA AWOS)	54	11:40 AM	9/6/2019	AWOS
Hyde	Fairfield RAWS	60	09:17 AM	9/6/2019	RAWS
	Hyde Count Airport	36	05:00 PM	9/5/2019	ASOS

Table 3. Table of precipitation amounts in Carteret, Dare, and Hyde counties during Hurricane Dorian (NWS 2019).

County	Location	Precipitation (Inches)	Precipitation (Millimeters)	Time	Date	Provider
Carteret	Beaufort 0.6 SSE	6.82	32.22	07:00 AM	9/6/2019	COCORAHS
	Cedar Island RAWS	6.55	31.95	11:25 AM	9/6/2019	RAWS
	Morehead City 0.6 NW	5.70	31.10	07:00 AM	9/6/2019	COCORAHS
	Cedar Island 0.6 SSE	5.46	30.86	07:00 AM	9/6/2019	COCORAHS
	Morehead City 2.4 WNW	5.22	30.62	07:00 AM	9/6/2019	COCORAHS
	1 ESE Morehead City	5.06	30.46	01:25 AM	9/6/2019	AWS
	Newport	4.95	30.35	12:42 PM	9/6/2019	CWOP
	Emerald Isle	4.94	30.34	01:22 AM	9/6/2019	CWOP
	Cedar Point 0.9 WSW	4.82	30.22	05:35 AM	9/6/2019	COCORAHS
	Morehead City 0.1 E	4.37	29.77	08:00 AM	9/6/2019	COCORAHS
	Morehead City 3.0 WNW	4.00	29.40	07:00 AM	9/6/2019	COCORAHS
	Swansboro 3.0 NE	3.98	29.38	09:00 AM	9/6/2019	COCORAHS
	Beaufort (MRH ASOS)	3.91	29.31	03:58 AM	9/6/2019	ASOS
	Ocean 0.5 S	3.87	29.27	08:00 AM	9/6/2019	COCORAHS
	0.2 SW Newport	3.78	29.18	04:23 AM	9/6/2019	CWOP
	Newport 2.5 W	3.71	29.11	08:00 AM	9/6/2019	COCORAHS
	Croatan RAWS	3.66	29.06	12:05 PM	9/6/2019	RAWS
	Emerald Isle 0.2 ENE	3.45	28.85	07:00 AM	9/6/2019	COCORAHS
Dare	Nags Head	7.75	33.15	11:36 AM	9/6/2019	CWOP
	Dare Bomb Range RAWS	4.60	30.00	12:28 PM	9/6/2019	RAWS
	Frisco (HSE ASOS)	4.36	29.76	07:51 AM	9/6/2019	ASOS
	Dare Co Gnry Ran (2DP AWOS)	3.26	28.66	12:42 PM	9/6/2019	AWOS
	Manteo (MQI AWOS)	2.48	27.88	10:55 AM	9/6/2019	AWOS
	Manteo 2.8 NW	2.25	27.65	07:35 AM	9/6/2019	COCORAHS
Hyde	Nccat Campus	13.70	39.10	12:00 PM	9/6/2019	HADS
	Fairfield RAWS	5.88	31.28	12:17 PM	9/6/2019	RAWS
	Ocracoke 0.2 ESE	5.32	30.72	07:00 AM	9/6/2019	COCORAHS
	Fairfield RAWS	5.22	30.62	08:17 AM	9/6/2019	RAWS
	Engelhard 0.8 NW	4.90	30.30	07:00 AM	9/6/2019	COCORAHS
	Fairfield RAWS	2.90	28.30	01:17 AM	9/6/2019	RAWS
	Nccat Campus	2.23	27.63	12:25 AM	9/6/2019	HADS

Methods

Standard Operating Procedures

Although not collected as part of SECN's on-going Vital Signs monitoring efforts, this activity utilized the same equipment and methods to conduct the post-Dorian survey, except the post-Dorian shoreline data was not collected during a neap high-tide window (see SOP 1.3.21 *Survey Timing and GPS Mission Planning for Coastal Shoreline Monitoring—Version 1.0* [Baron 2018b] for additional information on shoreline mapping window and planning).

The park requested the post-Dorian shoreline data collection be performed as soon as possible following the hurricane to capture the post-Dorian impact. Table 4 lists the monitoring protocol standard operating procedures (SOPs) utilized in the long-term and post-Dorian shoreline monitoring data collection, processing, and reporting. These SOPs are critical to maintaining continuity between data sets across many surveys to ensure comparable results. The version numbers in the table apply to all 2018 and 2019 data sets.

Table 4. List of SOPs used for shoreline position data collection, processing, and reporting.

SOP Number	SOP Title	SOP Version
1.3.21	Survey timing and GPS mission planning	1.0
1.3.22	Conducting the GPS shoreline survey	1.0
2.3.10	Post survey GPS data processing	1.0
2.3.11	Coastal shoreline monitoring annual change analysis	1.0
2.3.09	Coastal shoreline monitoring annual reporting	1.0

In all three surveys, the shoreline was mapped along the oceanfront sandy shoreline of Cape Hatteras National Seashore following survey methods developed by the National Park Service Northeast Coast Barrier Network (Psuty et al. 2010). Digital Shoreline Analysis System (DSAS; Himmelstoss et al. 2018) was used to analyze the shoreline change. Annual shoreline change distances were calculated by determining the distance between two shorelines. Shoreline surveys were collected in fall 2018, spring 2019, and fall 2019 (post-Dorian); therefore, the shoreline change that occurred between those three shoreline surveys is calculated in this report.

The uncertainty of the individual shoreline survey is ± 5 meters (16.4 feet; Baron 2018d). This value is derived from the (1) GPS accuracy, (2) differential tide position, (3) meteorological effects—wave dimension and run-up, and (4) interpretation of the line (Psuty et al. 2010). The annual comparisons, deduced using two individual shoreline surveys, will have a combined uncertainty of ± 10 meters (32.8 feet; Psuty et al. 2010). Refer to Psuty et al. 2010 for additional information regarding shoreline survey uncertainty.

Shoreline Data Collection

Shoreline data is collected according to SOP 1.3.22 *Conducting the Shoreline Survey—Version 1.0* (Baron 2018c). The high-tide swash line is mapped using a Trimble® GPS unit. The data collected is differentially corrected using

Pathfinder Office software to obtain higher accuracy data (Baron 2018d). The corrected data is exported as an ESRI shapefile. The ESRI shapefile is then edited, formatted, and uploaded to a personal geodatabase to analyze using DSAS (Baron 2018b).

Shoreline Change Analysis

The three shoreline data collections were analyzed using DSAS to calculate the shoreline change between two time periods: fall 2018 to post-Dorian and spring 2019 to post-Dorian. The shoreline change was performed by analyzing the 2018 and 2019 shoreline data collected. The fall 2018 shoreline was collected October 20–24, 2018, the spring 2019 shoreline data was collected March 28–31, 2019 and the post-Dorian 2019 shoreline was collected September 12–16, 2019. The three shoreline data sets were analyzed by calculating the distance the high-tide lines of two shorelines moved along cross-shore transects, which are spaced approximately 10 meters (32.8 feet) apart. This analysis is termed Net Shoreline Movement in DSAS. For this report the shoreline change was analyzed from fall 2018 to post-Dorian and spring 2019 to post-Dorian.

Erosion areas were determined as areas having negative shoreline change distance less than the uncertainty range of the data (± 10 meters [32.8 feet]). Accretion areas were determined as locations with positive shoreline change distances greater than the uncertainty range (± 10 meters [32.8 feet]).

Water Levels

The fall 2018 and spring 2019 shoreline surveys of the high-tide swash line included in this report were conducted during a neap-tide window, as outlined in the protocol. The post-Dorian shoreline data were not collected during neap tides and were within and during the full moon. The actual tide heights that occurred before the surveys included in this annual report are listed in Table 5. The post-Dorian

shoreline data collection high tides were slightly higher than the spring 2019 and fall 2018 shoreline data collection high tides. The slightly higher high tides that occurred during the post-Dorian shoreline data collection can potentially cause the position of the shoreline to be more landward, this can slightly overestimate erosion and underestimate accretion, depending on the topography of the beach face during data collection.

Table 5. High tide levels for areas within the Cape Hatteras NS shoreline assessment area. High-tide heights are relative to Mean Lower Low Water, Oregon Inlet Marina, NC—Station ID: 8652587 [m—meters].

Season	Area Surveyed	Survey Collection Date	High Tide Height (m)	High Tide Time
Fall 2018	Bodie Island	10/20/2018	0.44	05:54 AM
	PINWR	10/24/2018	0.36	08:24 AM
	North Hatteras Island	10/22/2018	0.38	07:06 AM
	South Hatteras Island	10/22/2018	0.38	07:06 AM
	Ocracoke Island	10/23/2018	0.40	07:42 AM
Spring 2019	Bodie Island	03/28/2019	0.37	02:48 AM
	PINWR	03/29/2019	0.42	03:48 AM
	North Hatteras Island	03/30/2019	0.39	04:48 AM
	South Hatteras Island	03/31/2019	0.41	05:30 AM
	Ocracoke Island	03/31/2019	0.42	05:18 AM
Post-Dorian 2019	Bodie Island	09/12/2019	0.54	07:46 AM
	PINWR	09/13/2019	0.47	08:12 AM
	Tri Villages	09/15/2019	0.55	09:18 AM
	North Hatteras Island	09/14/2019	0.56	08:48 AM
	South Hatteras Island	09/14/2018	0.56	08:48 AM
	Ocracoke Island	09/16/2019	0.49	09:54 AM



Photo of the south end of Bodie Island at Oregon Inlet during the post-Dorian 2019 shoreline data collection. The shoreline is accreting under the old bridge (Photo taken September 12, 2019 By Lisa Cowart Baron).

Facilities Analysis

As part of this report, Cape Hatteras National Seashore requested a facilities analysis to determine park buildings that may be potentially impacted by future storms. To address this question, the park facilities layer was obtained from the park, and GIS analysis was performed to determine

the park facilities that were within 25 meters (82 feet) and 100 meters (328 feet) of the post-Dorian shoreline. For this analysis, a 25-meter and 100-meter buffer was created for the post-Dorian shoreline data collected. The facilities located within the 25-meter and 100-meter buffer were selected and exported.

Results

Shoreline Data

Three shoreline data collection events are discussed in this report: fall 2018, spring 2019, and post-Dorian. Fall 2018 shoreline data collection was performed October 20–24, 2018. Spring 2019 shoreline data collection was performed March 28–31, 2019. Post-Dorian shoreline data collection

was performed September 12–16, 2019. On average, 122.04 kilometers (75.83 miles) of shoreline were mapped during the three shoreline data collection events (Table 6). The GPS data collected had a mean horizontal positional error of 10.92 centimeters (4.30 inches; Table 6).

Table 6. Table of the length and horizontal precision of the shorelines collected during 2018 and 2019 with the mean length and horizontal precision were calculated by averaging the entire shoreline feature [cm—centimeters; km—kilometers].

Data Collection Event	Area	Collection Date	Mean Horizontal Accuracy (cm)	Length (km)
Fall 2018	Bodie Island	10/20/2018	22.50	9.30
	PINWR	10/24/2018	9.96	21.95
	North Hatteras Island	10/22/2018	9.93	37.56
	South Hatteras Island	10/22/2018	6.55	25.28
	Ocracoke Island	10/23/2018	10.00	27.49
Spring 2019	Bodie Island	03/28/2019	10.05	9.40
	PINWR	03/29/2019	10.00	19.93
	North Hatteras Island	03/30/2019	11.57	40.03
	South Hatteras Island	03/31/2019	8.79	24.61
	Ocracoke Island	03/31/2019	13.75	27.59
Post-Dorian	Bodie Island	09/12/2019	9.99	9.30
	PINWR	09/13/2019	10.02	20.45
	Tri Villages of Hatteras Island	09/15/2019	11.02	4.47
	North Hatteras Island	09/14/2019	10.19	35.20
	South Hatteras Island	09/14/2018	10.42	24.68
	Ocracoke Island	09/16/2019	10.06	28.88

Shoreline Change Analysis

Fall 2018 to post-Dorian Shoreline Change

Appendix B contains maps of the fall 2018 to post-Dorian shoreline change distances. The annual shoreline change distance is displayed by the extent of each transect, clipped between two shorelines, and colored according to the shoreline change distance. A negative shoreline change distance denotes erosion, and is shown in warmer colors (red, orange, yellow). Positive shoreline change distance depicts accretion, and is shown in cooler colors (light green, dark green, blue).

The shoreline change distance from fall 2018 to post-Dorian ranged from -920.07 meters to 127.45 meters (-3,018.60 to 418.14 feet; Appendix B). The mean shoreline distance

change from fall 2018 to post-Dorian was -12.84 meters (-42.13 feet) with a standard deviation of 46.70 meters (153.22 ft). When the shoreline change distance data is summarized by island (Table 7), the lowest mean shoreline change distance occurred on Ocracoke Island. This means that, on average, the highest erosion occurred on Ocracoke Island. Not surprisingly, the transect where the greatest amount of erosion was recorded also occurred on Ocracoke Island (Table 7). The mean shoreline change distance on Hatteras and Bodie Islands were both negative, suggesting erosion. However, the mean shoreline change distance on Hatteras and Bodie Islands were more than half of the mean shoreline change distance that was calculated for Ocracoke Island.

Table 7. Fall 2018 to post-Dorian shoreline change distance summary statistics and number of transects for each island. Summary statistics units are in meters. *Includes Pea Island National Wildlife Refuge.

Island	Minimum	Maximum	Mean	Standard Deviation	Number of Transects
Bodie Island	-106.70	49.56	-7.03	21.07	914
Hatteras Island*	-286.06	127.45	-8.78	21.77	8386
Ocracoke Island	-920.07	27.26	-27.82	89.21	2636

Erosion areas are represented as orange and red transects in the maps in Appendix B. Erosion was identified for 45.07% of the transects (5,320 of 11,805) in the analysis (Figure 3). Because the transects are located approximately every 10 meters (32.8 feet) along the shoreline study area, it can be inferred that erosion occurred along a cumulative 53.20 kilometers (33.06 miles) of the study area surveyed.

Most of the erosion areas were located at inlets and at Cape Point. On Bodie Island, the shoreline retreat exceeded 25 meters (82 feet) along five sections of the beach. On Hatteras Island, the shoreline retreat exceeded 25 meters (82 feet) along the two inlets, Cape Point, and multiple small sections within Pea Island National Wildlife Refuge and the Tri-Villages. On Ocracoke Island, the shoreline retreat exceeded 25 meters (82 feet) primarily at or near the inlets.

Accretion is represented as dark green and blue transects in the maps in Appendix B. Accretion was identified for 6.83% of the transects (806 of 11,805) in the analysis (Figure 3). Because the transects are located approximately every 10 meters (32.8 feet) along the baseline, it can be inferred that accretion occurred along a cumulative 8.06 kilometers (5.01 miles) of the study area surveyed.

On Bodie Island, the shoreline advanced greater than or equal to 25 meters (82 feet) at the northern end of the park boundary and near the Oregon Inlet. On Hatteras Island, the shoreline advanced greater than or equal to 25 meters (82 feet) on the northern end of Pea Island National Wildlife Refuge, near Oregon Inlet, and near Cape Point. There are only two small sections where the shoreline advanced greater than or equal to 25 meters (82 feet) on Ocracoke Island, which was on the southwest end of the island, before Ocracoke Inlet.



Photo of beached buoy on Ocracoke Island taken during the post-Dorian 2019 shoreline data collection (Photo taken September 16, 2019 by Lisa Cowart Baron).

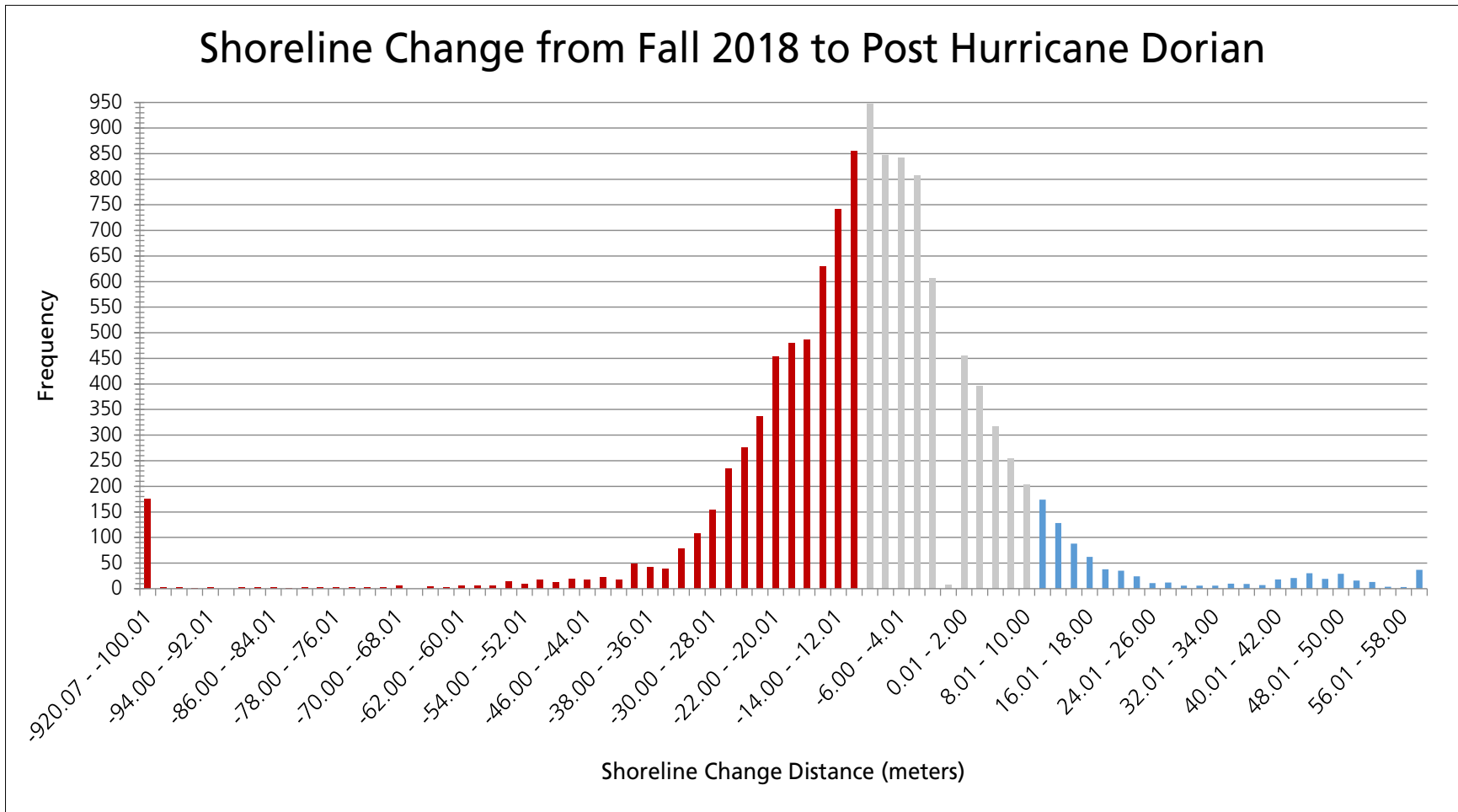


Figure 3. Modified histogram of transect shoreline change distances from fall 2018 to post-Dorian data collection. The shoreline change distance is binned by 2-meter increments, except the bar representing no change (0 meters) and the first and last bins. Erosion areas are shown as red bars, transects within the uncertainty range (± 10 meters [32.8 feet]) are shown as grey, and accretion areas are shown as blue. The first and last bins are larger than 2 meters (6.6 feet) because the bin ranges larger than 58 meters (190 feet) and less than -100 meters (-328 feet) have 1 or 0 transects.

Spring 2019 to post-Dorian Shoreline Change
Appendix C contains maps of the spring 2019 to post-Dorian shoreline change distances. The seasonal shoreline change distance is displayed by the extent of each transect, clipped between two shorelines and colored according to the shoreline change distance. The shoreline change envelope is the greatest extent of the shoreline change that occurred at the transect location. A negative shoreline change distance denotes erosion, shown in warmer colors (red, orange, yellow). Positive shoreline change distance is depicting accretion, and is shown in cooler colors (light green, dark green, blue). The shoreline change distance ranged from

-926.15 meters to 126.74 meters (-3,038.55 to 415.81 feet; Appendix C). The mean shoreline change distance for the area mapped was -1.93 meters (-6.33 feet) with a standard deviation of 47.18 meters. When the shoreline change distance data is summarized by island (Table 8), the lowest mean shoreline change distance occurred on Ocracoke Island. This means that on average, the most erosion occurred on Ocracoke Island. Not surprisingly, Ocracoke Island also had the lowest shoreline change distance (Table 8). The mean shoreline change distance on Hatteras and Bodie island were both positive, suggesting accretion.

Table 8. Spring 2019 to post-Dorian shoreline change distance summary statistics and number of transects for each island. Summary statistics units are in meters. *Includes Pea Island National Wildlife Refuge.

Island	Minimum	Maximum	Mean	Standard Deviation	Number of Transects
Bodie Island	-26.36	71.98	19.81	17.16	914
Hatteras Island*	-323.65	126.74	1.80	21.01	8327
Ocracoke Island	-926.15	22.23	-21.51	89.54	2636

Erosion areas are represented as light orange and red transects in the maps in Appendix C. Erosion was identified for 20.58% of the transects (2,430 of 11,805) in the analysis (Figure 4). Because the transects are located approximately every 10 meters (32.81 feet) along the baseline, it can be inferred that erosion occurred along a cumulative 24.30 kilometers (15.10 miles) of the study area surveyed.

Most of the erosion areas were located at inlets and at Cape Point. On Bodie Island, there was only one transect where shoreline retreat exceeded 25 meters (82 feet), which is located near Oregon Inlet. On Hatteras Island, the shoreline retreated exceeded 25 meters (82 feet) along the two inlets, Cape Point, and some small sections near the Tri-Villages. On Ocracoke Island, shoreline retreat exceeded 25 meters (82 feet) primarily at or near the inlets.

Accretion is represented as dark green and blue transects in the maps in Appendix C. Accretion was identified for 25.54% of the transects (3015 of 11,805) in the analysis (Figure 4). Because the transects are located approximately every 10 meters (32.8 feet) along the baseline, it can be inferred that accretion occurred along a cumulative 30.15 kilometers (18.73 miles) of the study area surveyed.

On Bodie Island, the shoreline advanced greater than or equal to 25 meters (82 feet) at the northern end of the park boundary, near beach access ramp 2, and near the Oregon Inlet. On Hatteras Island, the shoreline advanced greater than or equal to 25 meters (82 feet) on the northern end of and many locations within Pea Island National Wildlife Refuge, and near Cape Point. There were no areas where the shoreline advanced greater than or equal to 25 meters (82 ft) on Ocracoke Island, as the maximum shoreline change distance is 22.23 meters (72.93 ft; Table 8).



Photo taken at Hatteras Inlet on the north end of Ocracoke Island during the post-Dorian 2019 data collection. The high-tide line was in the vegetation; therefore, the crew walked the remaining distance to capture the high-tide line within the eroding vegetation (Photo taken September 16, 2019 By Lisa Cowart Baron).

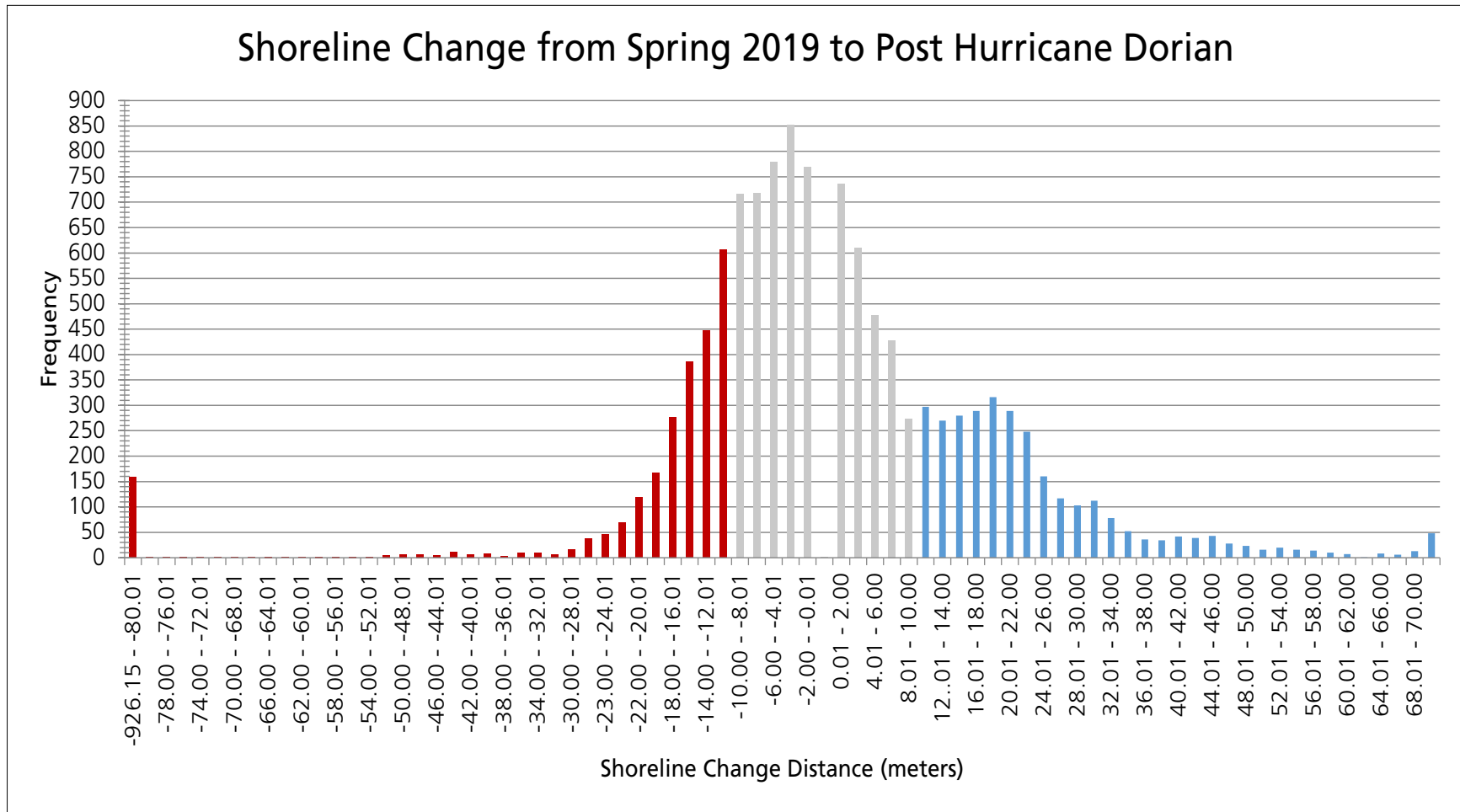


Figure 4. Modified histogram of transect shoreline change distances from spring 2019 to post-Dorian data collection. The shoreline change distance is binned by 2-meter increments, except the bar representing no change (0 meters) and the first and last bins. Erosion areas are shown as red bars, transects within the uncertainty range (± 10 meters [32.8 feet]) are shown as grey, and accretion areas are shown as blue. The first and last bins are larger than 2 meters (6.6 feet) because the bin ranges larger than 70 meters (230 feet) and less than -80 meters (-262.4 feet) have 1 or 0 transects.

Facilities Analysis

The proximity of the post-Dorian shoreline data collected was analyzed with the facilities data at Cape Hatteras NS. There were two analyses run: (1) buildings within 25 meters (82 feet) of the post-Dorian shoreline, and (2) facilities within 100 meters (328 feet) of the post-Dorian shoreline (Tables 9 and 10). As shown in Table 9, there are seven

buildings within 25 meters (82 feet) of the post-Dorian shoreline. Of those seven, six buildings are on Hatteras Island and one building is on Ocracoke Island. There are twenty-three buildings within 100 meters (328 feet) of the post-Dorian shoreline data collected (Table 10), which includes six buildings on Bodie Island, fifteen buildings on Hatteras Island, and two buildings on Ocracoke Island.

Table 9. NPS facility buildings within 25 meters of the post-Dorian shoreline data collected.

Island	District	Facility ID	Building Name	Latitude	Longitude
Hatteras Island	–	93951	BI BD Hatteras Island (Rodanthe) Pier House	35.58496077	-75.4614605
Hatteras Island	–	93925	HI BD Avon Pier House	35.34728237	-75.5013464
Hatteras Island	Hatteras	93941	HI BD Cape Hatteras (Frisco) Pier House	35.22558485	-75.6361742
Ocracoke Island	Ocracoke	–	Ocracoke Day Use Area Lifeguard Tower	35.10674087	-75.9525434
Hatteras Island	Hatteras	–	Old CAHA Lite Site Lifeguard Stand	35.25298251	-75.5218426
Hatteras Island	Hatteras	28660	HI HS CAHA Original Lighthouse Ruins	35.25492196	-75.5207008
Hatteras Island	Hatteras	–	Buxton-Schooner Coast Guard Bldg	35.25808552	-75.5199836

Table 10. NPS facility buildings within 100 meters of the post-Dorian shoreline data collected.

Island	District	Facility ID	Building Name	Latitude	Longitude
Bodie Island	Bodie	28888	BI Maintenance Shop	35.84578846	-75.56400933
Bodie Island	Bodie	28887	BI Maint Carpenter Shop	35.8455291	-75.56383398
Bodie Island	Bodie	28898	BI QT Q117	35.84476977	-75.56315896
Bodie Island	Bodie	28900	BI QT Q118	35.84454972	-75.56291702
Bodie Island	Bodie	28901	BI QT Q119	35.84403636	-75.56313332
Bodie Island	Bodie	28917	BI BD Coquina Sandcastle	35.83388508	-75.55872486
Hatteras Island	–	28955	BI BD Pea Island Comfort Station	35.71590466	-75.49329075
Hatteras Island	–	93951	BI BD Hatteras Island (Rodanthe) Pier House	35.58496077	-75.46146051
Hatteras Island	–	93925	HI BD Avon Pier House	35.34728237	-75.50134638
Hatteras Island	Hatteras	28839	HI BD Frisco Comfort Station	35.22466248	-75.6434519
Hatteras Island	Hatteras	93941	HI BD Cape Hatteras (Frisco) Pier House	35.22558485	-75.63617421
Ocracoke Island	Ocracoke	–	Ocracoke Island North Area (Ferry Landing) Comfort Station	35.18970072	-75.77906759
Ocracoke Island	Ocracoke	–	Ocracoke Day Use Area Lifeguard Tower	35.10674087	-75.95254336
Hatteras Island	Hatteras	–	Old CAHA Lite Site Lifeguard Stand	35.25298251	-75.52184263
Hatteras Island	Hatteras	28660	HI HS CAHA Original Lighthouse Ruins	35.25492196	-75.52070079
Hatteras Island	Hatteras	–	Buxton - Schooner Coast Guard Bldg	35.25852031	-75.52075314
Hatteras Island	Hatteras	–	Buxton - Schooner Coast Guard Bldg	35.25752445	-75.52079533
Hatteras Island	Hatteras	–	Buxton - Schooner Coast Guard Bldg	35.25843783	-75.52025289
Hatteras Island	Hatteras	–	Buxton - Schooner Coast Guard Bldg	35.25808552	-75.51998358
Hatteras Island	–	–	Pea Island Visitor Center	35.71666572	-75.49371334
Hatteras Island	–	–	Pea Island Maintenance	35.68387883	-75.48248867
Hatteras Island	–	–	Pea Island Maintenance	35.68391097	-75.48217773
Hatteras Island	–	–	Pea Island Maintenance	35.68359201	-75.48246845

Conclusion

Approximately 122.04 kilometers (75.83 miles) of shoreline data collected in fall 2018, spring 2019 and post-Dorian indicate a geomorphologically dynamic beach/barrier island system and response to a major storm system. Many areas of both accretion and erosion were noted in the seasonal and annual shoreline change analyses performed. On average, the seasonal shoreline change on Hatteras and Bodie Island was positive, denoting accretion. The seasonal shoreline advance during the summer is representative of the general seasonal shoreline change of Atlantic beaches, as they tend to build throughout the summer. Conversely, the overall annual shoreline change of Hatteras and Bodie Islands was erosional. Ocracoke Island not only exhibited erosion when the annual shoreline change was analyzed, but also when the seasonal shoreline change was determined. In comparing the shoreline change on the three islands of Cape Hatteras NS, Ocracoke Island exhibited the most erosion on average. The majority of the erosion was located near inlet areas.

When the fall 2018 to fall 2019 (post-Dorian) cumulative shoreline change distance from this study (-12.84 meters

[-42.13 feet]) is compared to the annual shoreline change distance from spring 2018 to spring 2019 (-1.46 meters [-4.79feet]; Baron 2020), the fall 2019 to post-Dorian shoreline change is more negative, denoting higher erosion. However, even though they are both annual analyses, these data are from different seasons. The influence of comparing annual analyses from different seasons of this park is still being determined. Therefore, the conclusion of higher mean erosion due to Hurricane Dorian is uncertain. Long-term trends in the SECN shoreline change monitoring effort will help put this post-storm survey event into a broader temporal context.

Of the park facilities analyzed for potential impacts of future storms, seven buildings were identified within 25 meters (82 feet) of the post-Dorian shoreline and twenty-three buildings within 100 meters (328 feet) of the post-Dorian shoreline data collected. The potential impact of these facilities will be determined by the intensity of future storms and by the topography of the landscape between these facilities and the approaching storm surge.



Photo of the damage sustained by Ocracoke Village residents. Due to the high water levels during the storm, most of the contents within the Village homes were damaged. The streets were lined with trash to be taken away. (Photo taken on September 17, 2019 by Kelsey Mack).

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Appendix A. Hurricane Dorian Hydrographs

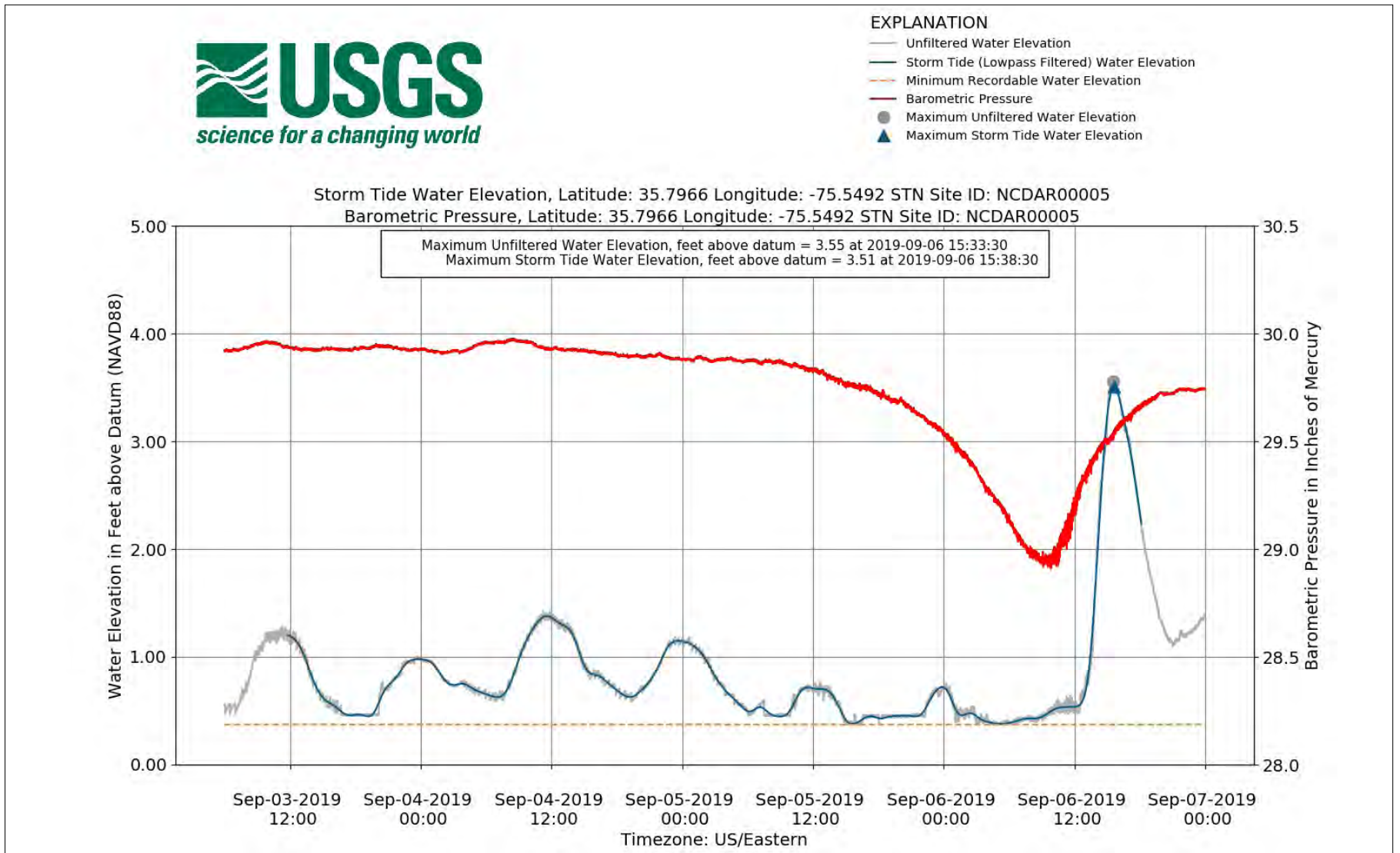


Figure A-1. Hydrograph of the water level during Hurricane Dorian at Oregon Inlet Boat Ramp. Information is from USGS Short-Term Network Monitoring (<https://stn.wim.usgs.gov/STNPublicInfo/#/SensorPage?Site=6940&Sensor=10010> last accessed June 03, 2020)



EXPLANATION

- Unfiltered Water Elevation
- Storm Tide (Lowpass Filtered) Water Elevation
- Minimum Recordable Water Elevation
- Barometric Pressure
- Maximum Unfiltered Water Elevation
- ▲ Maximum Storm Tide Water Elevation

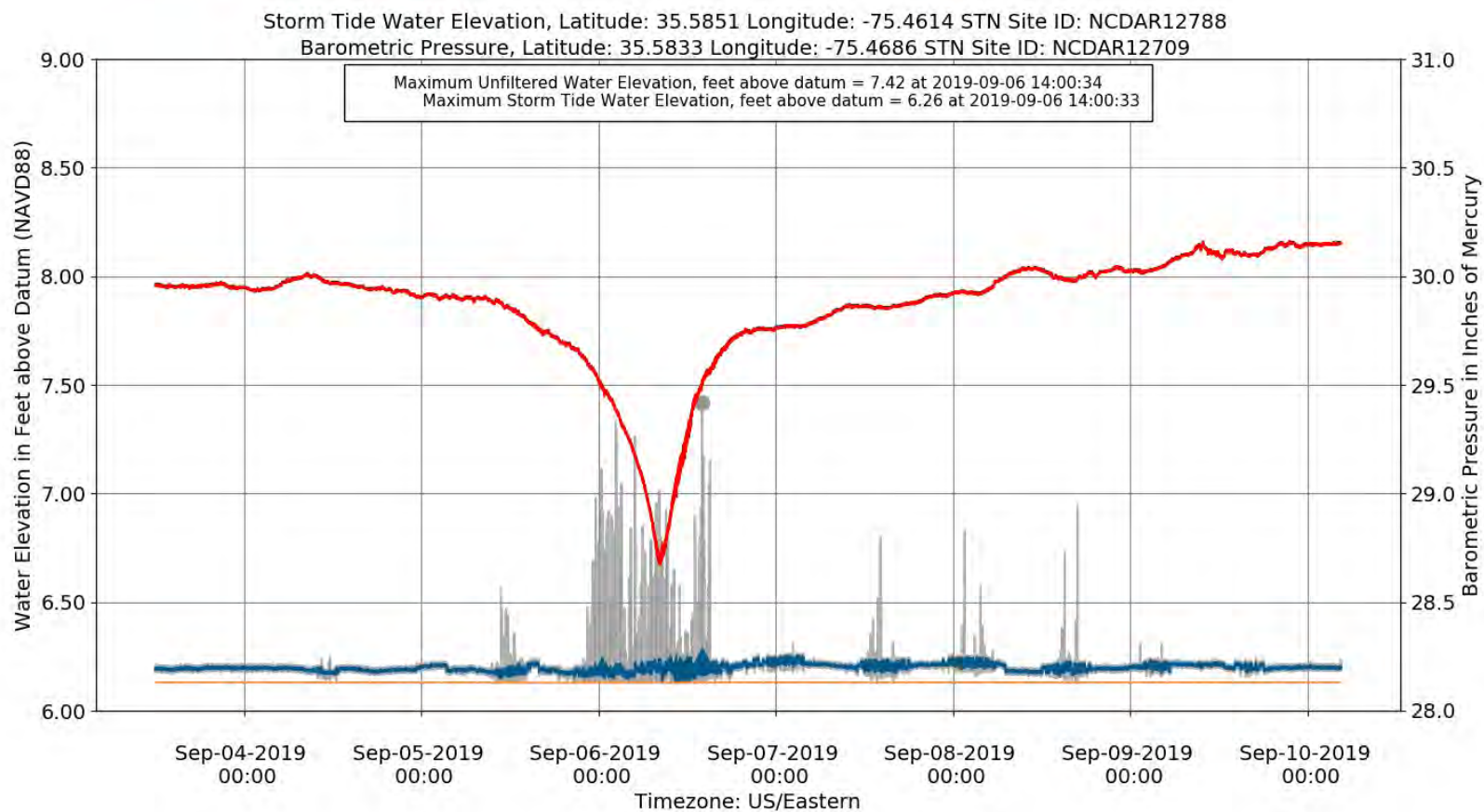


Figure A-2. Hydrograph of the water level during Hurricane Dorian between Rodanthe and Waves in the Tri Villages. Information is from USGS Short-Term Network Monitoring (<https://stn.wim.usgs.gov/STNPublicInfo/#/SensorPage?Site=12709&Sensor=10095> last accessed on June 05, 2020)

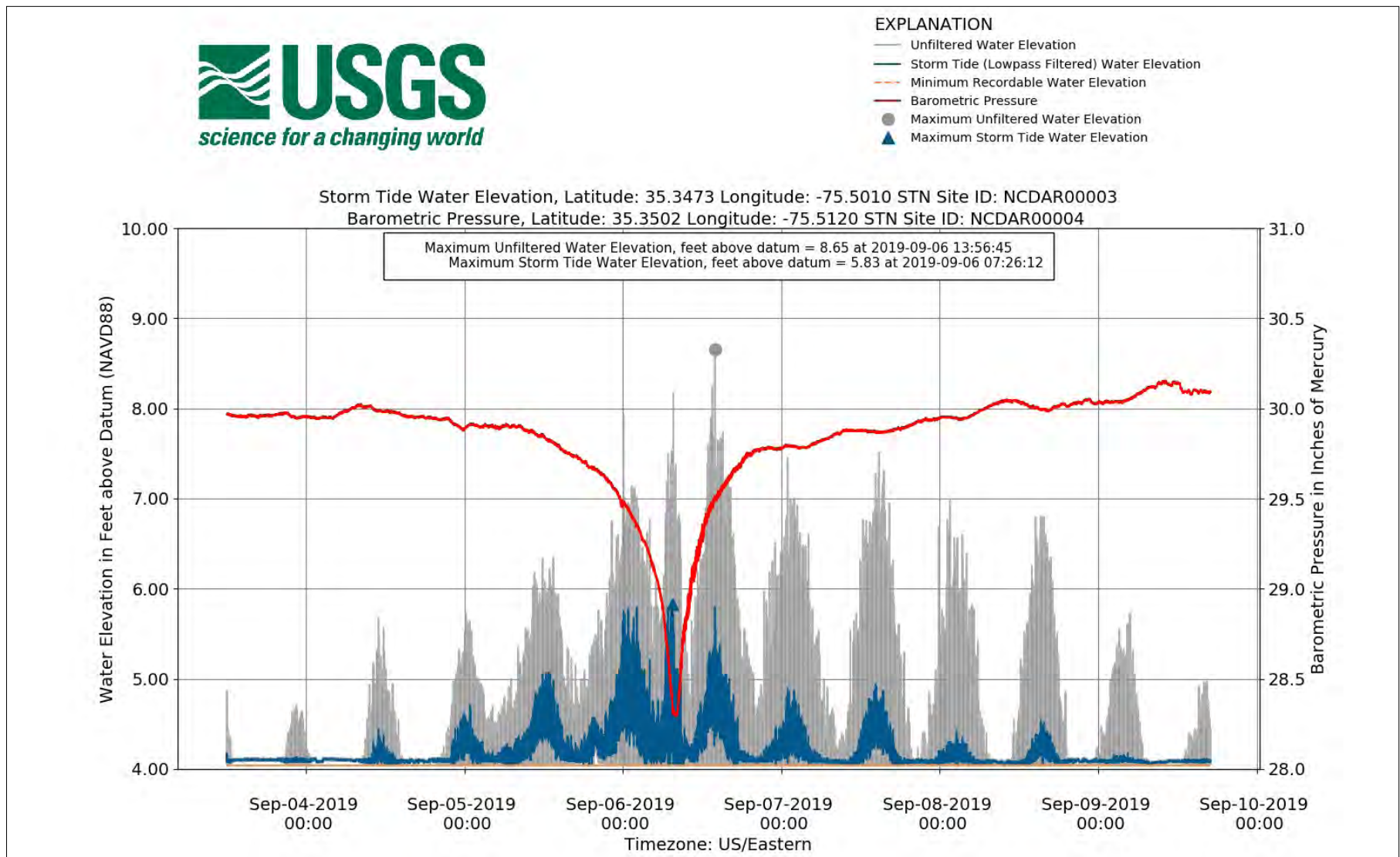


Figure A-3. Hydrograph of the water level during Hurricane Dorian at Avon. Information is from USGS Short-Term Network Monitoring (<https://stn.wim.usgs.gov/STNPublicInfo/#/SensorPage?Site=6911&Sensor=10054> last accessed June 05, 2020).

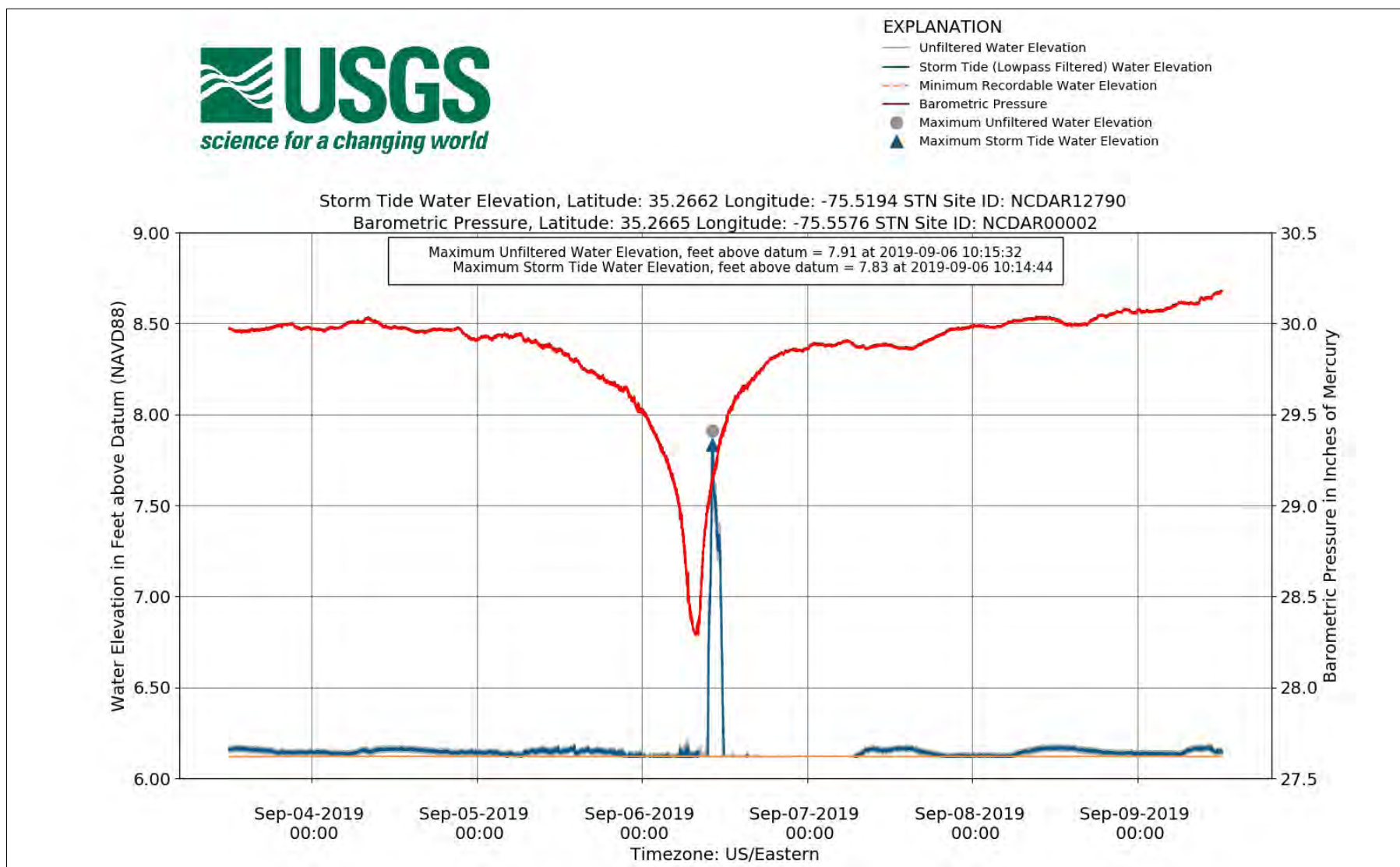


Figure A-4. Hydrograph of the water level during Hurricane Dorian at Buxton, north of the point. Information is from USGS Short-Term Network Monitoring (<https://stn.wim.usgs.gov/STNPublicInfo/#/SensorPage?Site=12790&Sensor=10039> last accessed June 05, 2020).



EXPLANATION

- Unfiltered Water Elevation
- Storm Tide (Lowpass Filtered) Water Elevation
- Minimum Recordable Water Elevation
- Barometric Pressure
- Maximum Unfiltered Water Elevation
- ▲ Maximum Storm Tide Water Elevation

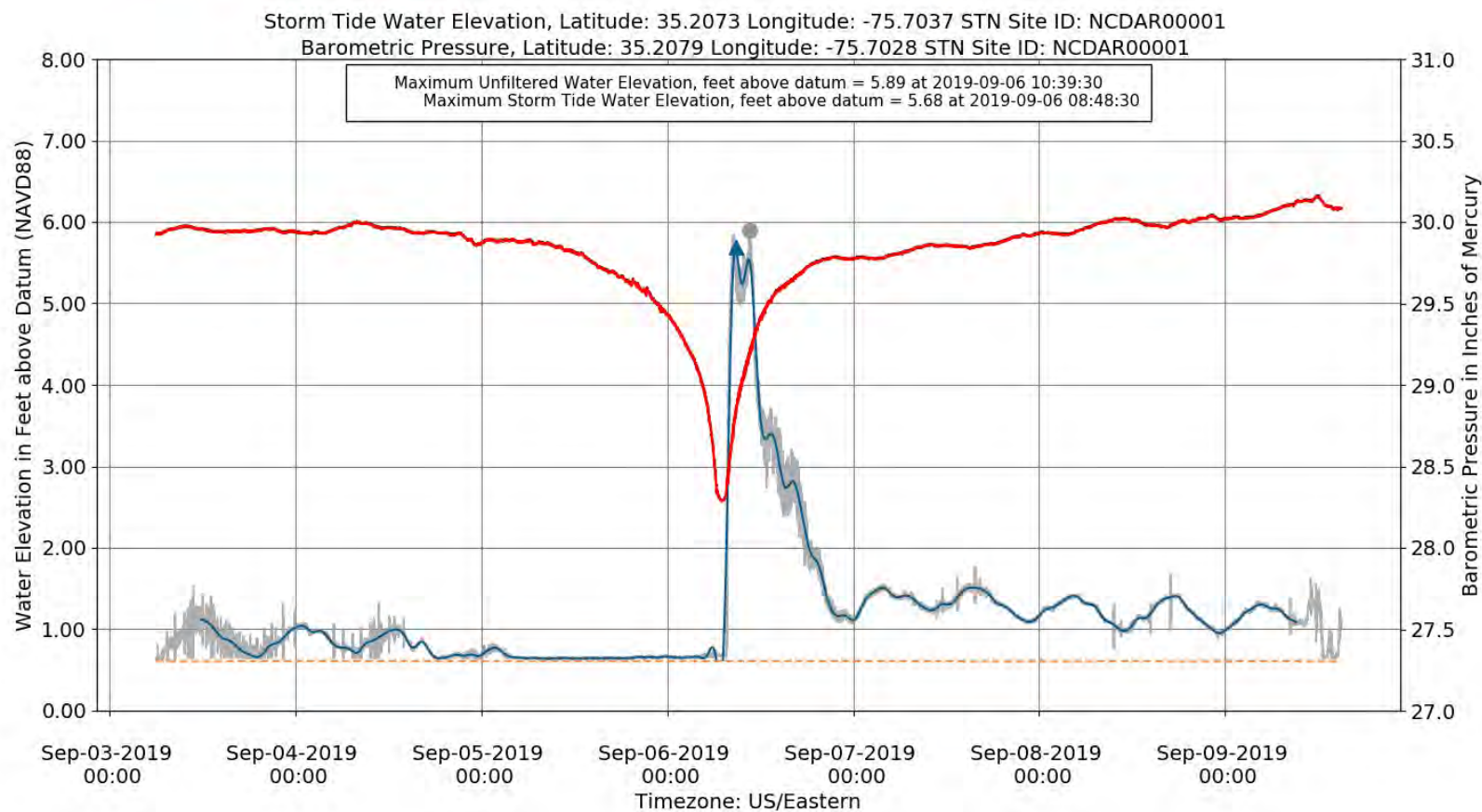


Figure A-5. Hydrograph of the water level during Hurricane Dorian at Hatteras. Information is from USGS Short-Term Network Monitoring (<https://stn.wim.usgs.gov/STNPublicInfo/#/SensorPage?Site=6896&Sensor=10026> last accessed June 05, 2020).

Appendix B. Fall 2018 to post-Dorian Shoreline Change Distance Maps

The following maps show the shoreline surveys collected and the fall 2018 to post-Dorian shoreline change at Cape Hatteras National Seashore. These maps show the post-Dorian (solid black line), fall 2018 (hatched line), and spring 2019 (dotted line) shoreline data collected for Bodie Island, Hatteras Island, and Ocracoke Island. Additionally, these maps show the net shoreline movement (NSM) in meters from fall 2018 to post-Dorian shoreline data collection. The red, orange, and yellow transects denote erosion and the light green, dark green, and blue transects denote accretion. The background image of these maps is from the 2012 National Agriculture Imagery Program (NAIP). The inset map in the middle of the figure contains a red box that displays the location of the two map views, on the left and right side of the figure, within the park area.

Bodie Island

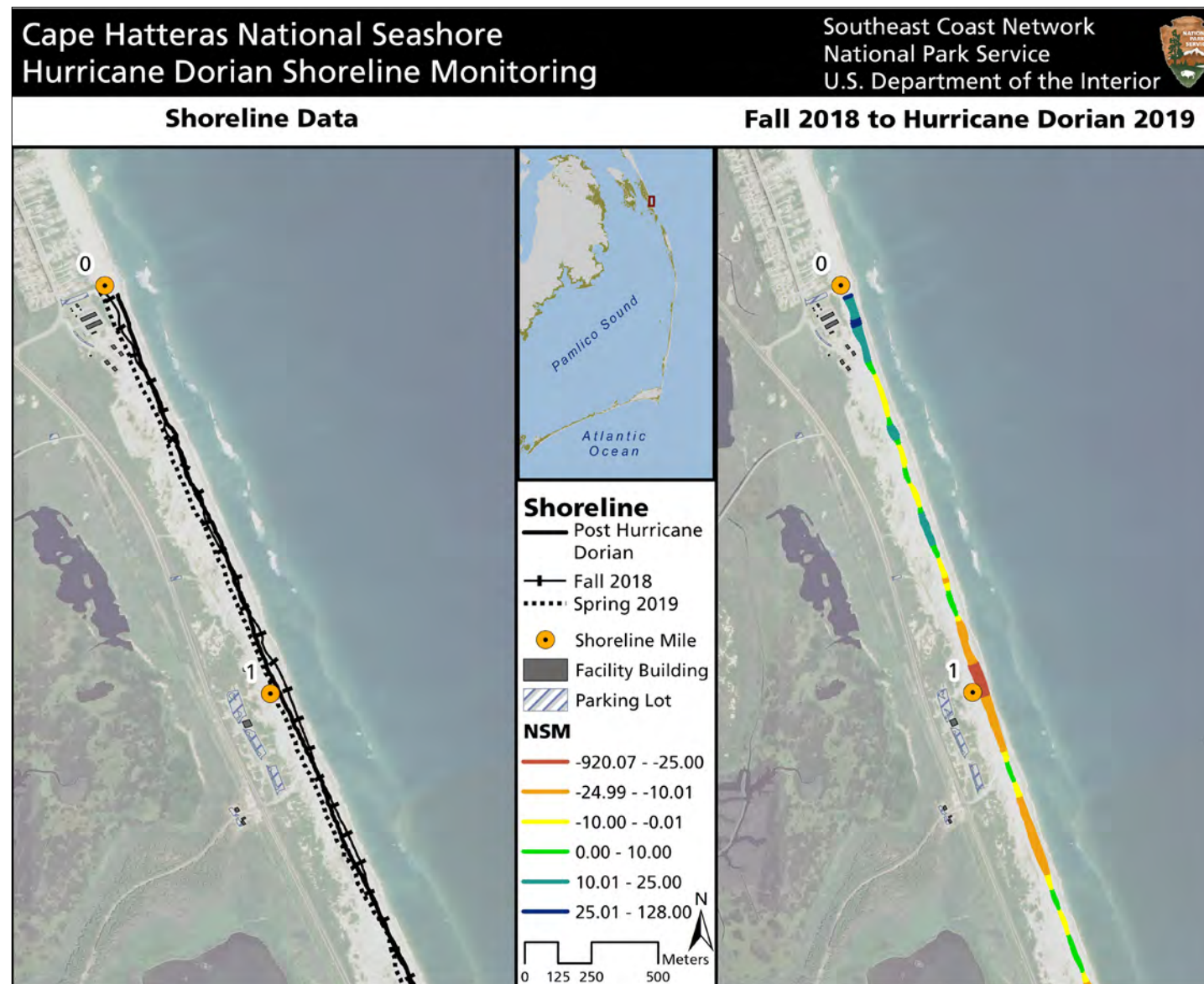


Figure B-1. Shoreline change in the vicinity of mile markers 0 and 1.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

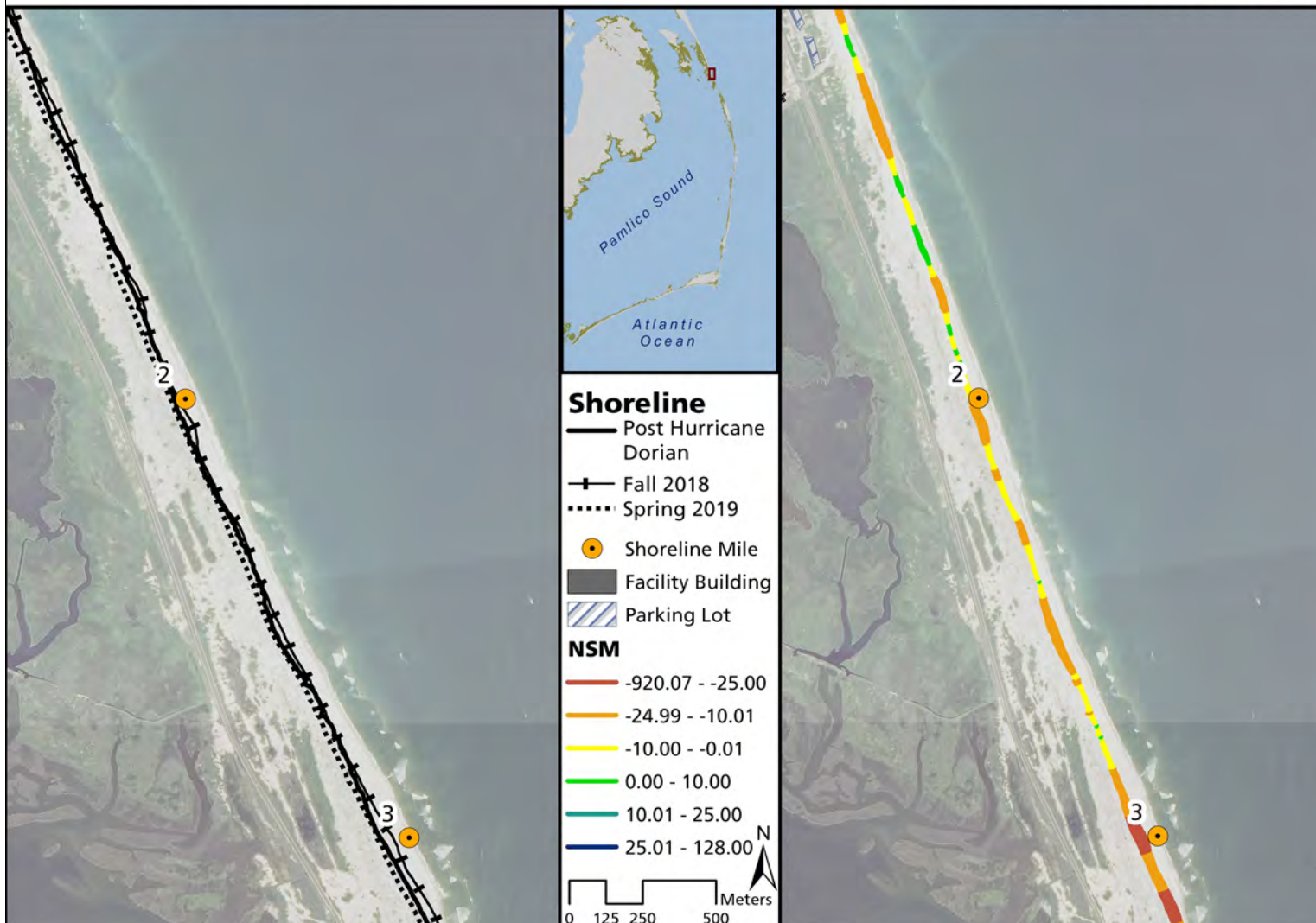


Figure B-2. Shoreline change in the vicinity of mile markers 2 and 3.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

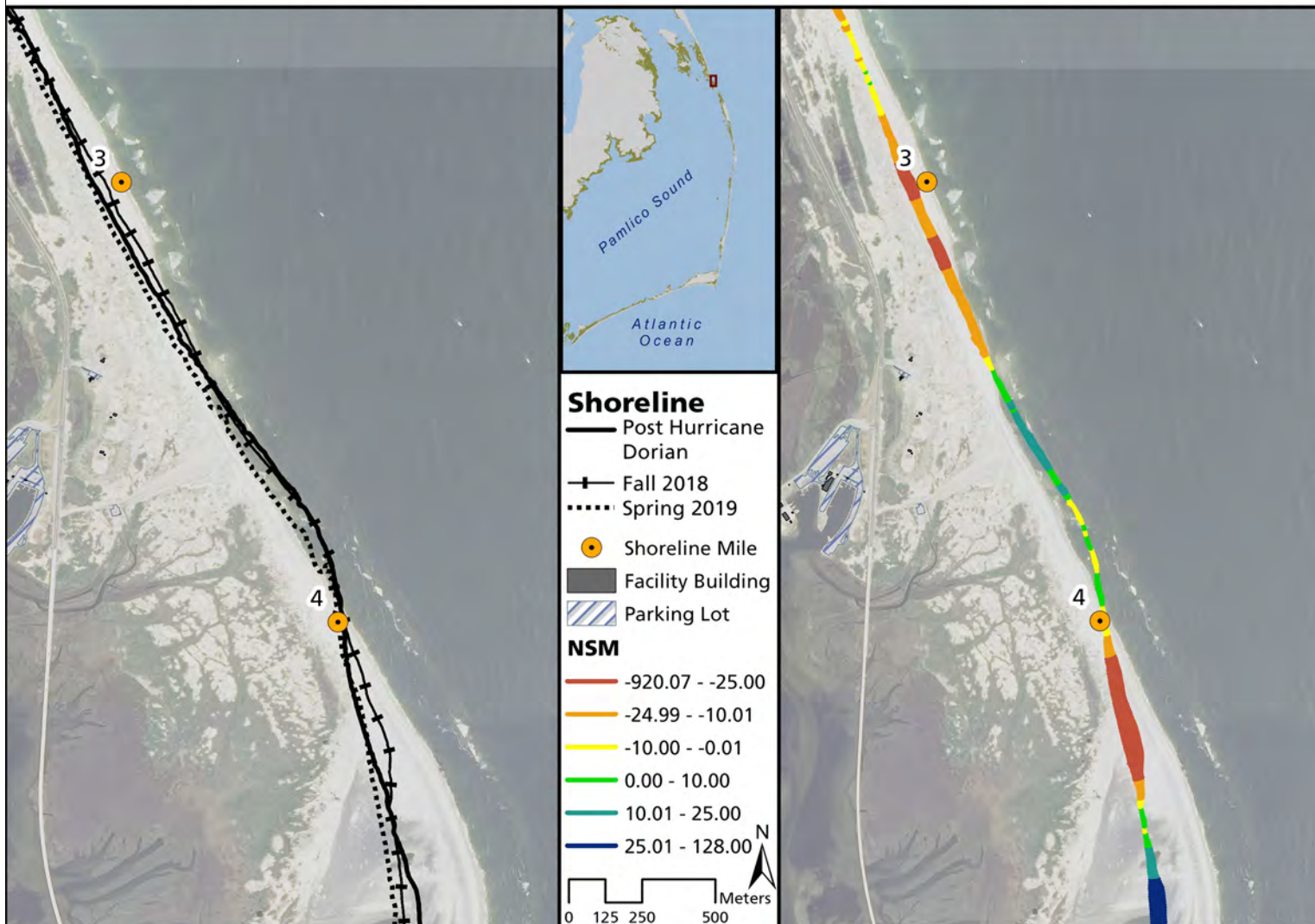


Figure B-3. Shoreline change in the vicinity of mile markers 3 and 4.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

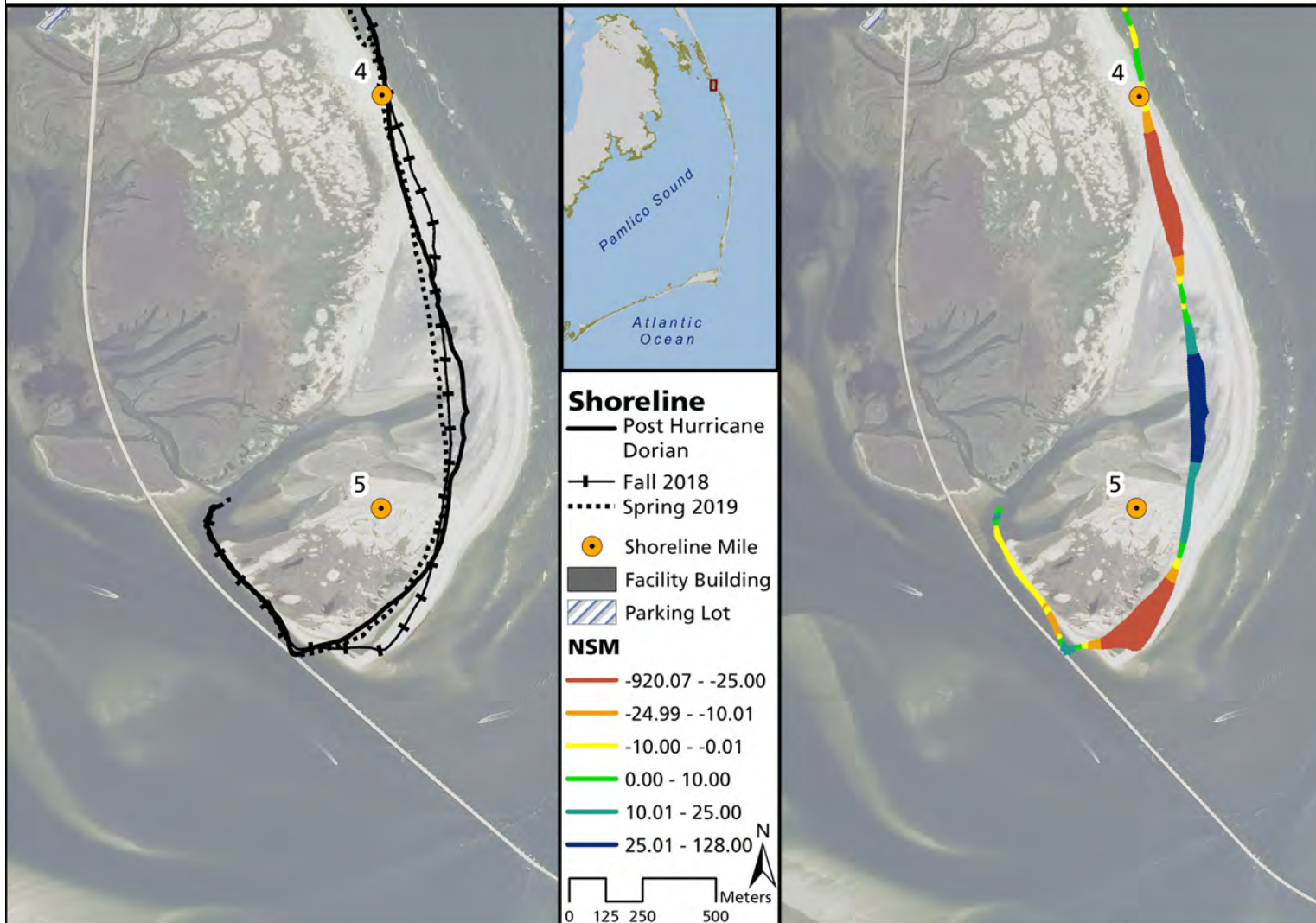


Figure B-4. Shoreline change in the vicinity of mile markers 4 and 5.

Hatteras Island

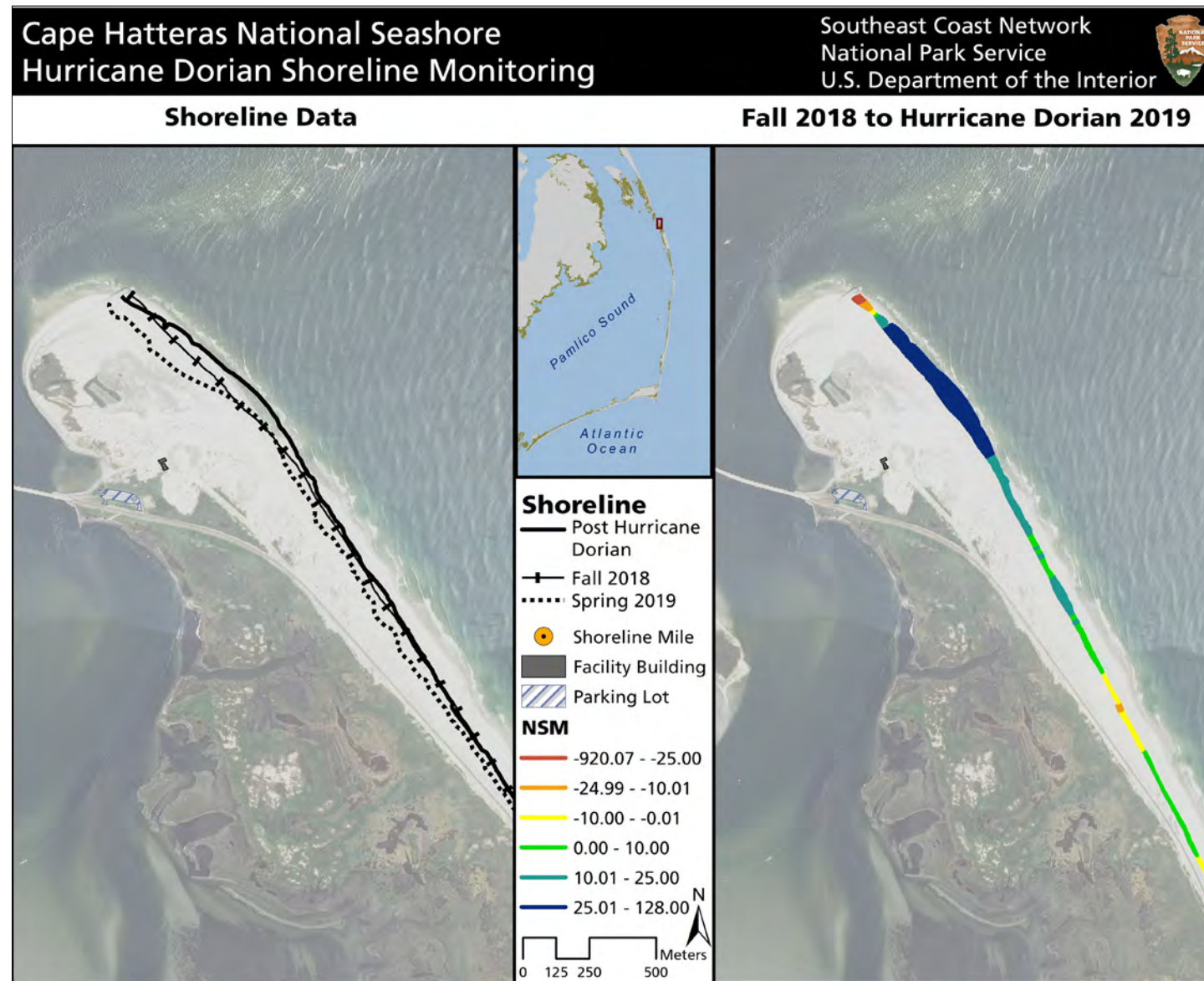


Figure B-5. Shoreline change in the vicinity of the north end of Hatteras Island, section 1.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

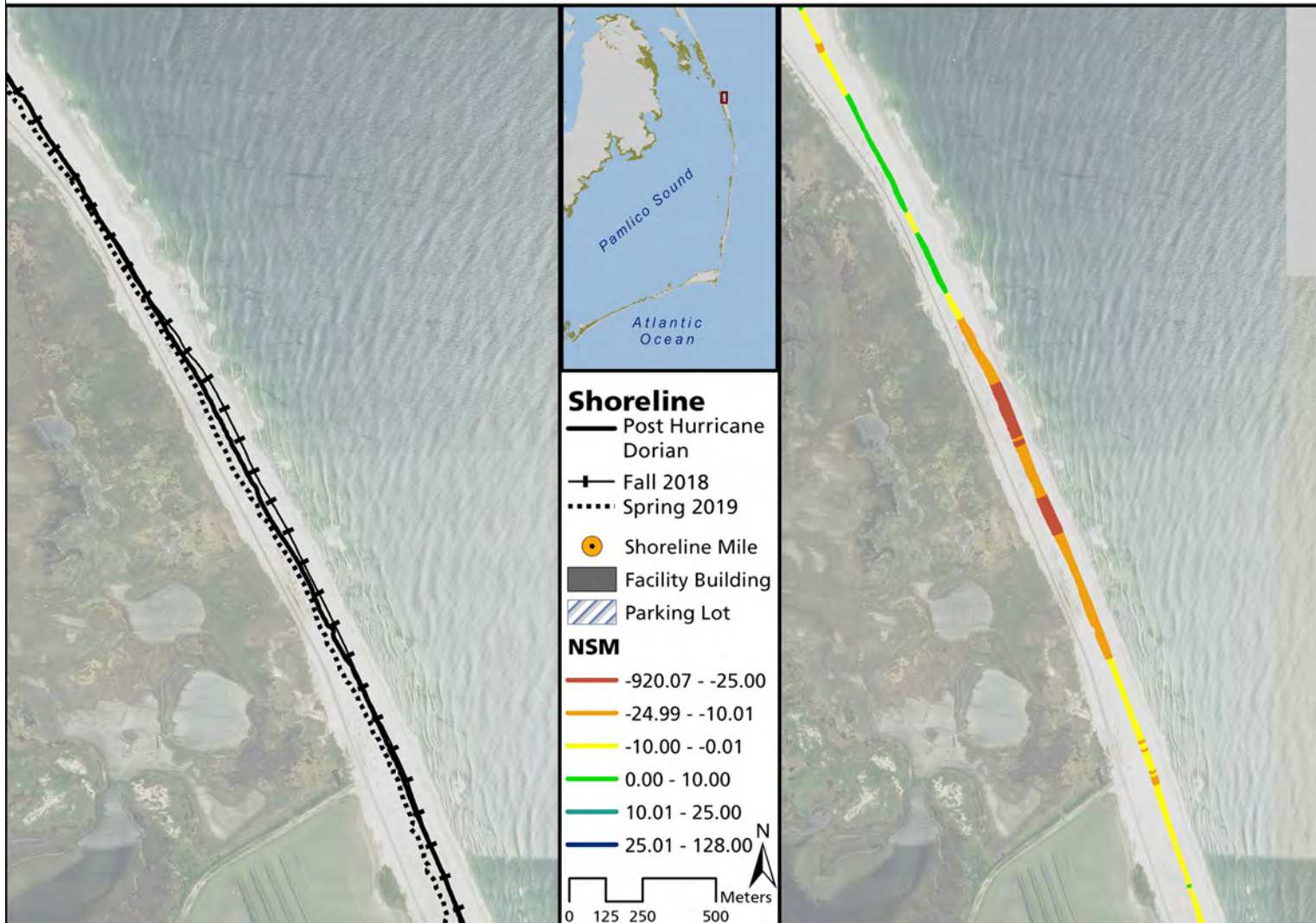


Figure B-6. Shoreline change in the vicinity of the north end of Hatteras Island, section 2.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

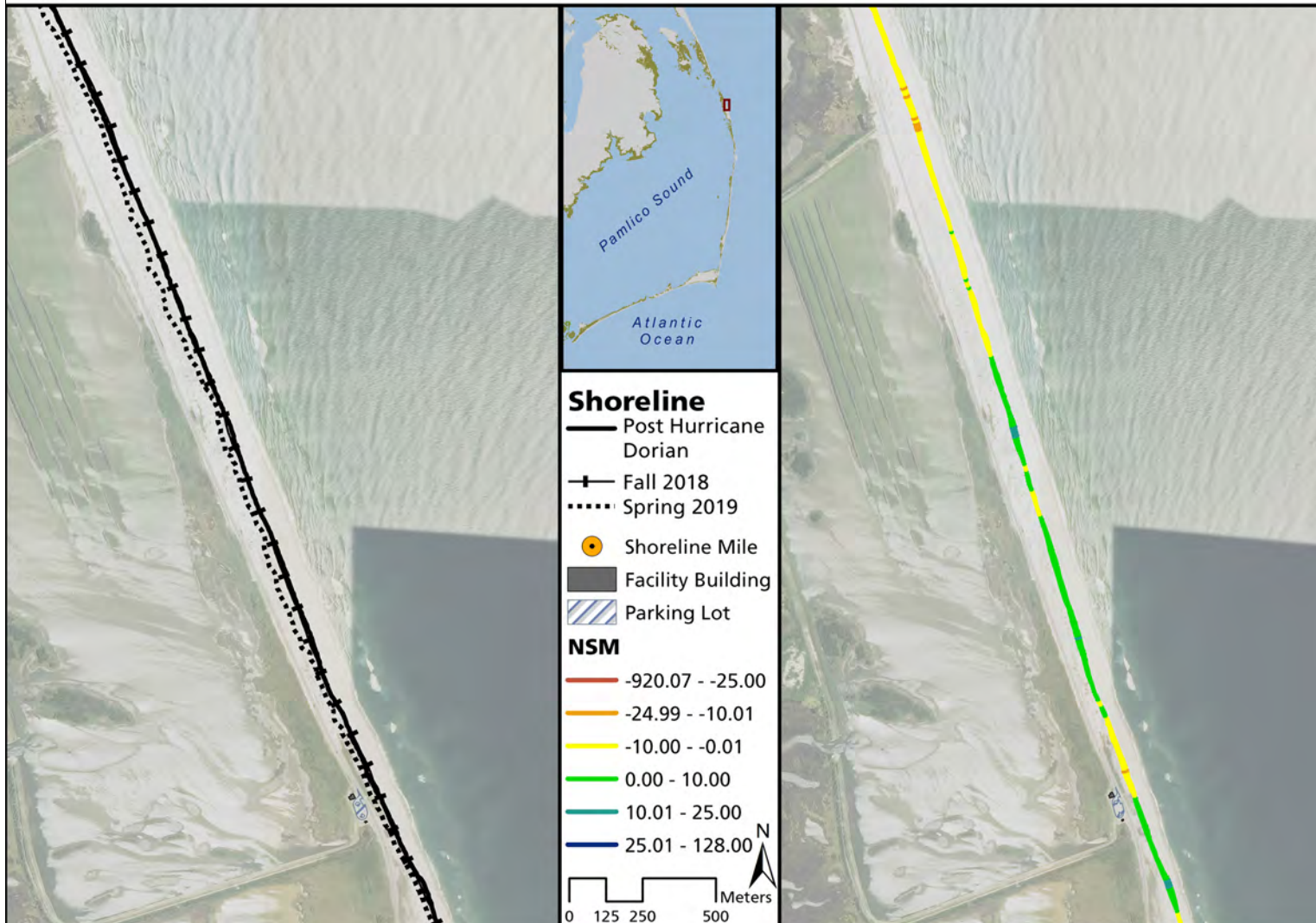


Figure B-7. Shoreline change in the vicinity of the north end of Hatteras Island, section 3.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

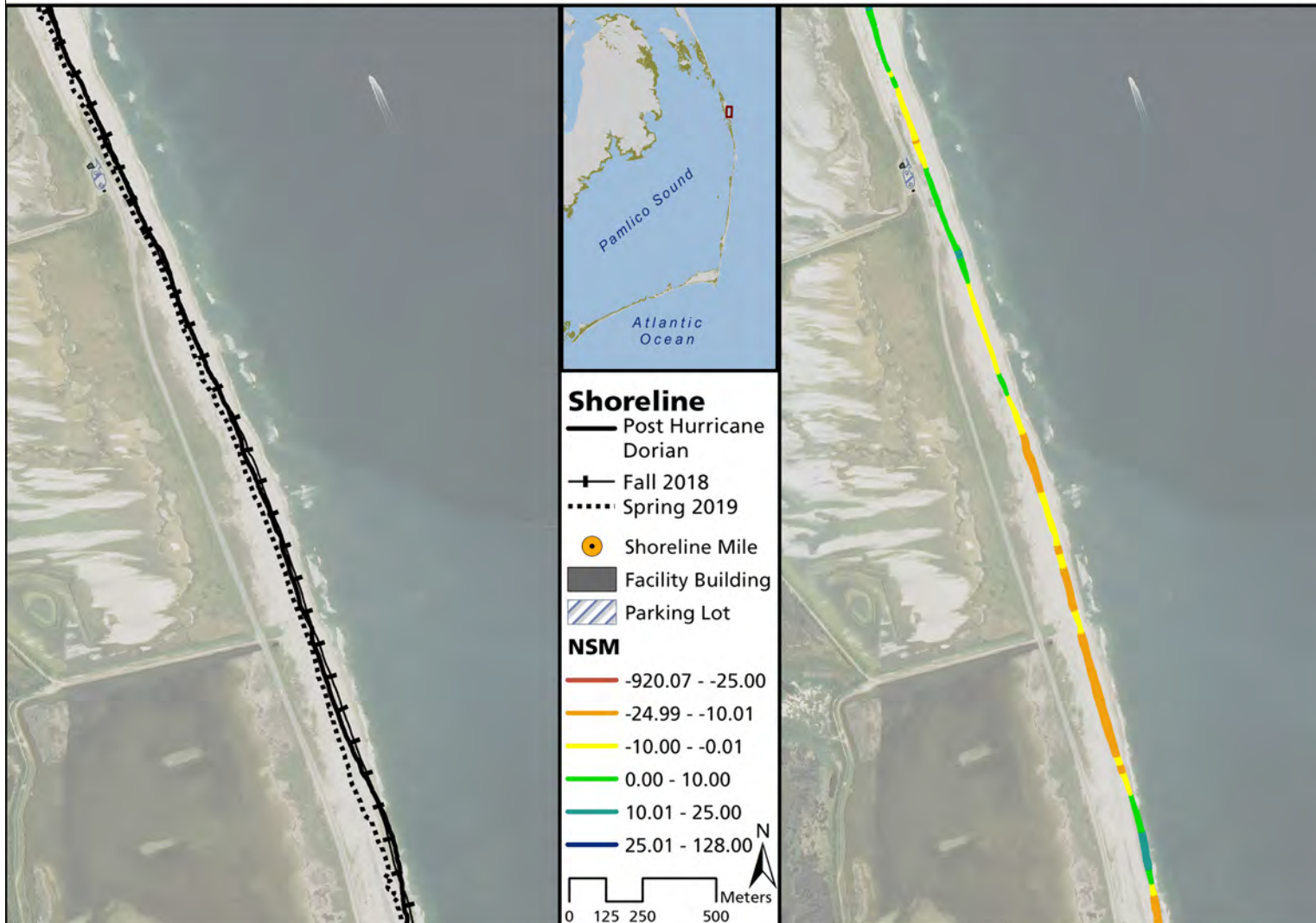


Figure B-8. Shoreline change in the vicinity of the north end of Hatteras Island, section 4.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

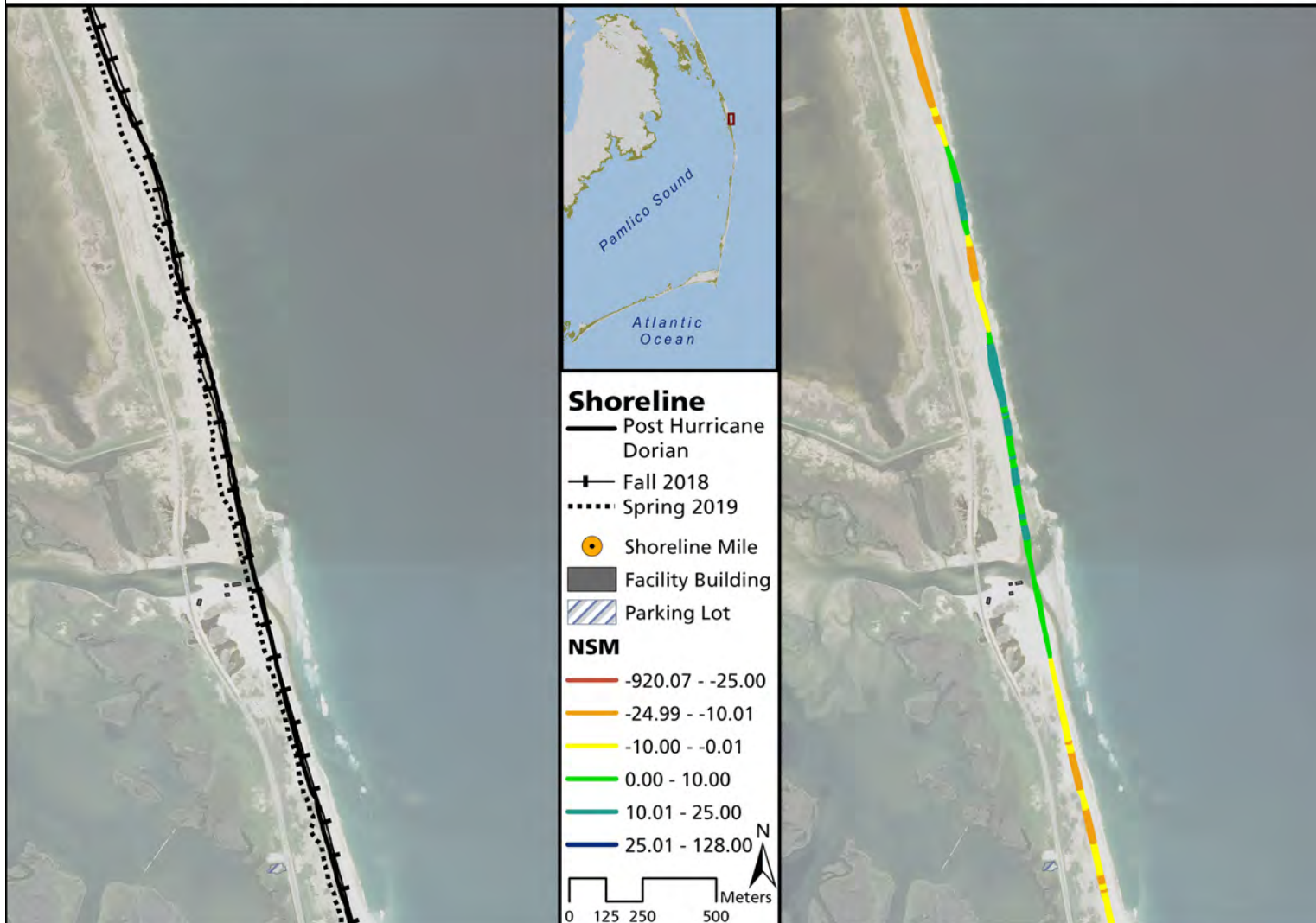


Figure B-9. Shoreline change in the vicinity of the north end of Hatteras Island, section 5.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

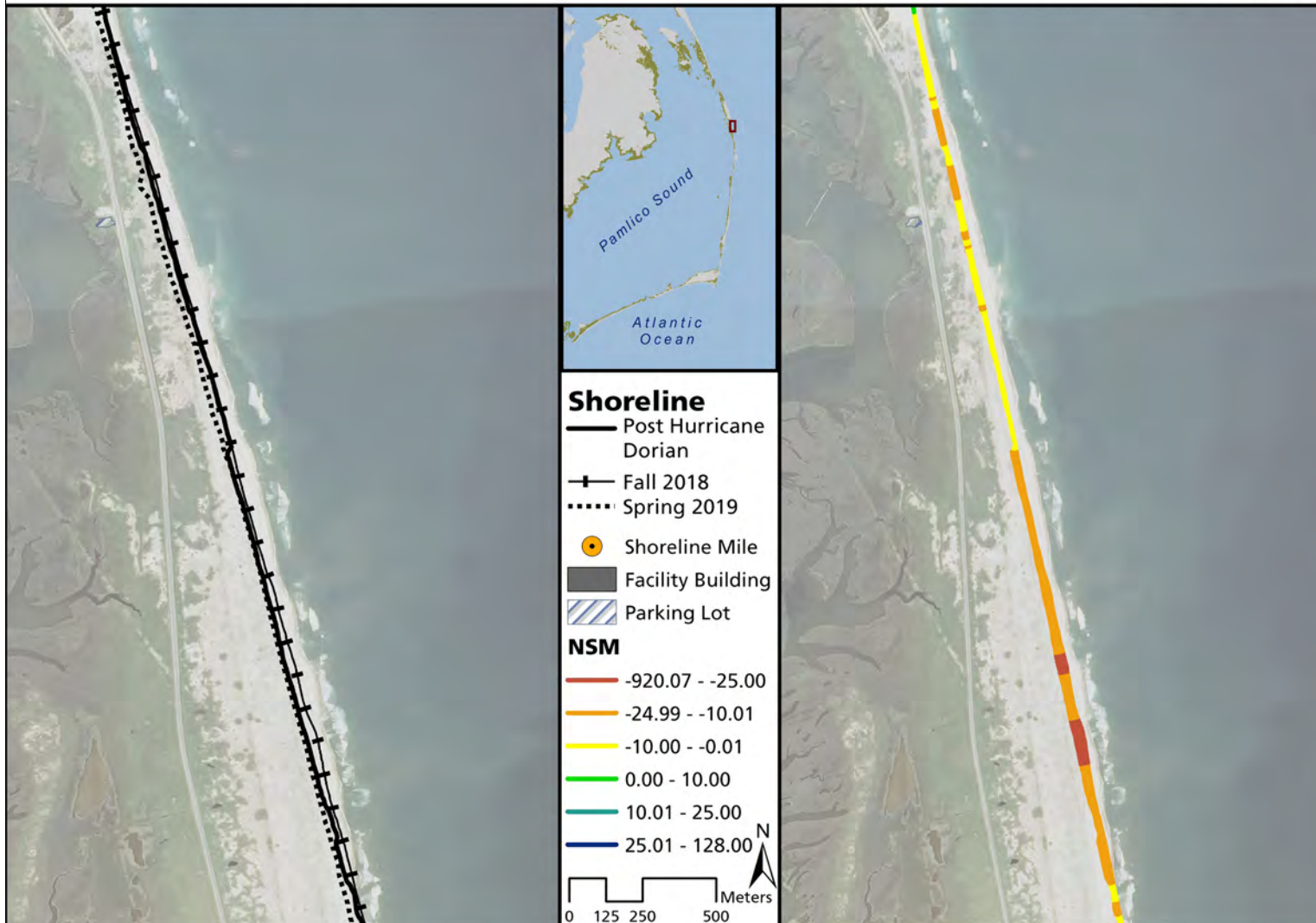


Figure B-10. Shoreline change in the vicinity of the north end of Hatteras Island, section 6.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

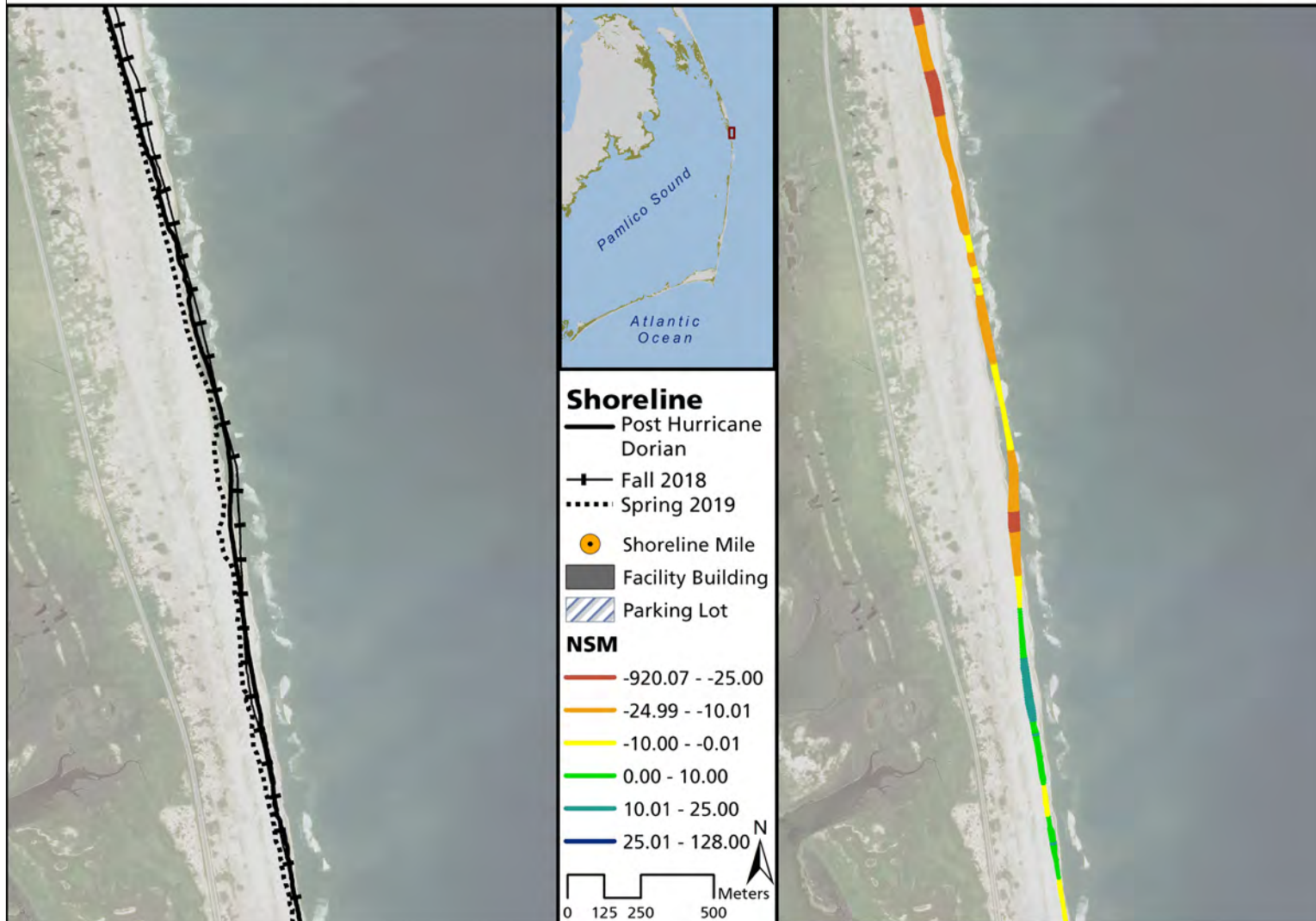


Figure B-11. Shoreline change in the vicinity of the north end of Hatteras Island, section 7.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

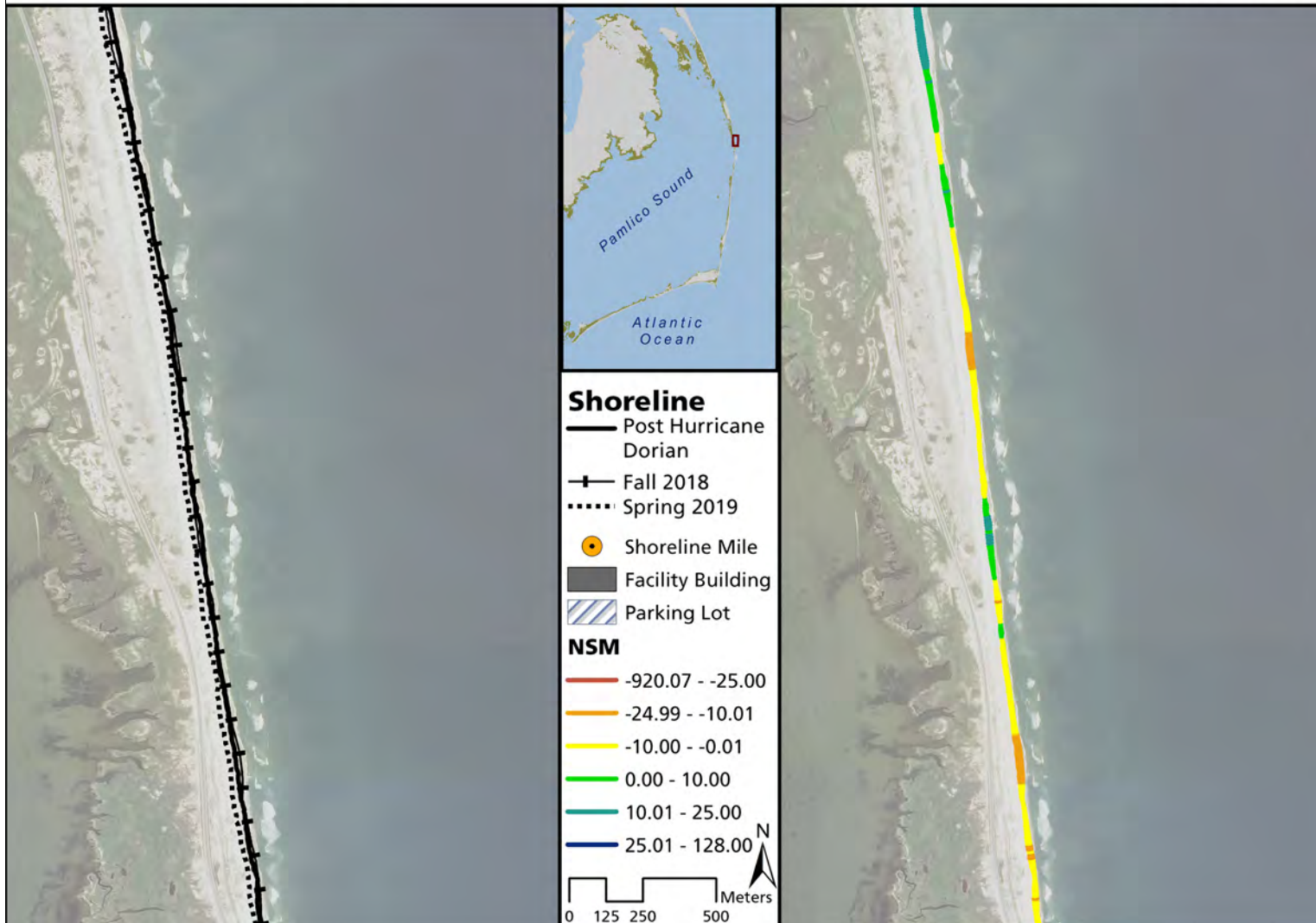


Figure B-12. Shoreline change in the vicinity of the north end of Hatteras Island, section 8.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

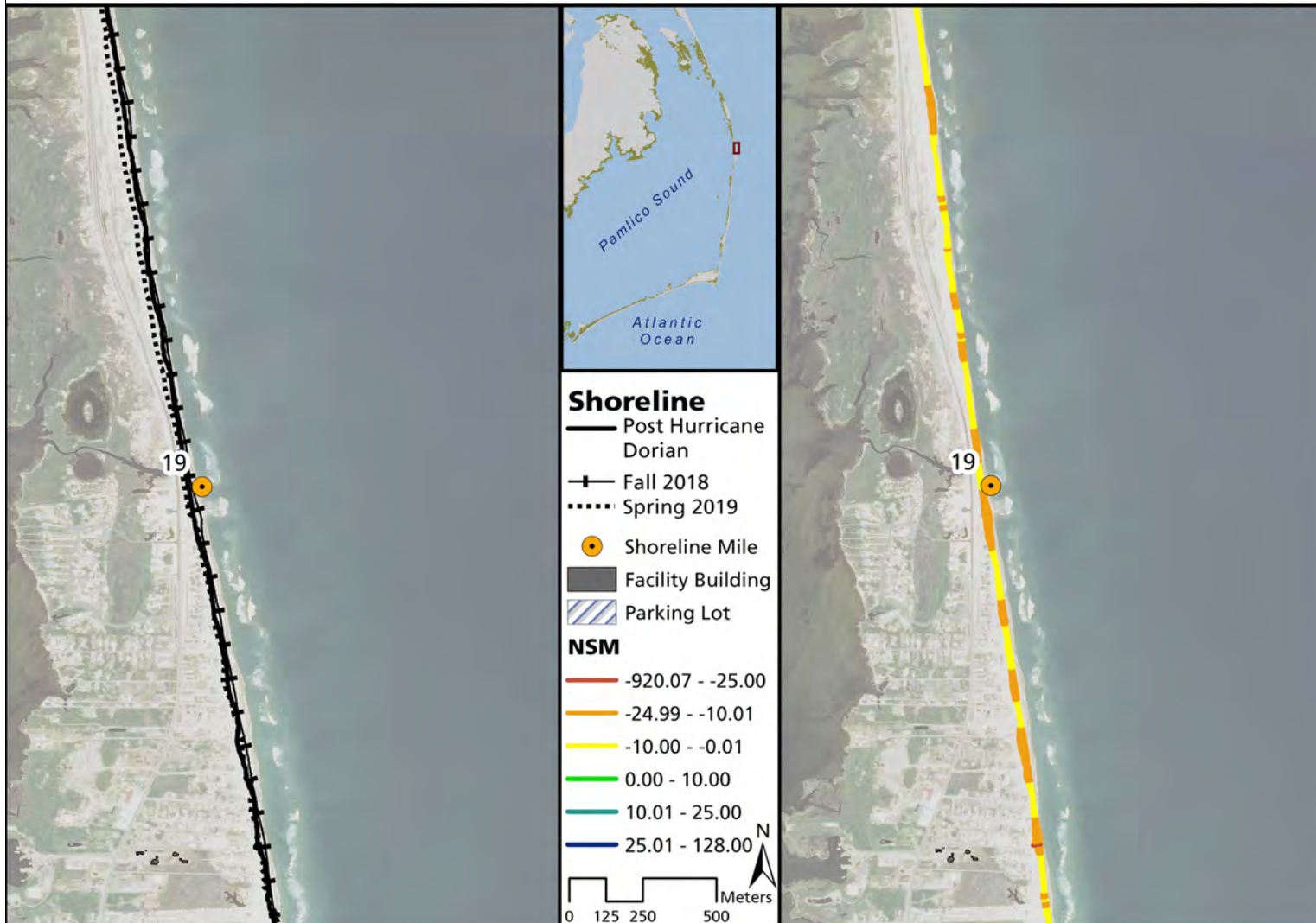


Figure B-13. Shoreline change in the vicinity of mile marker 19.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

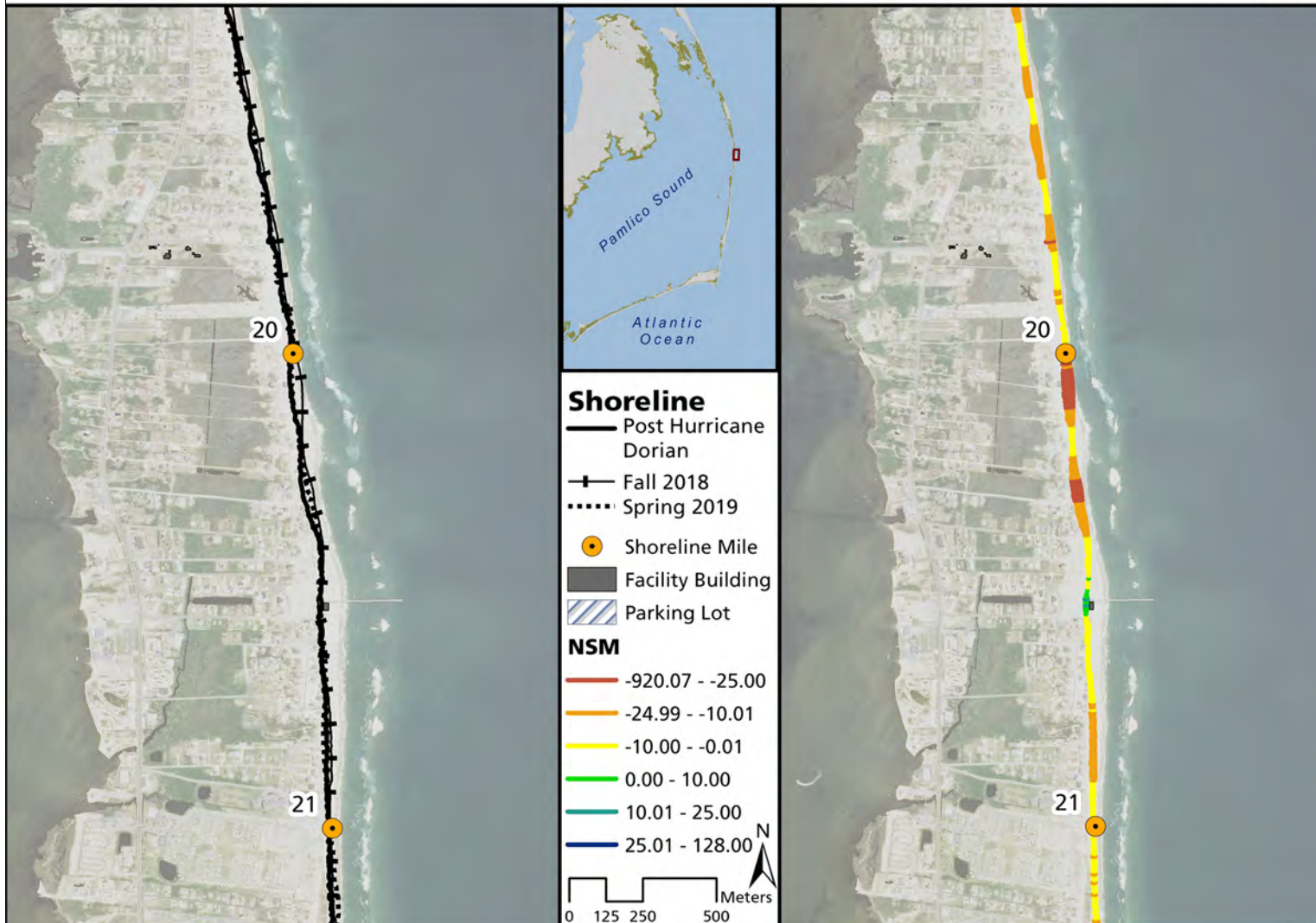


Figure B-14. Shoreline change in the vicinity of mile markers 20 and 21.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

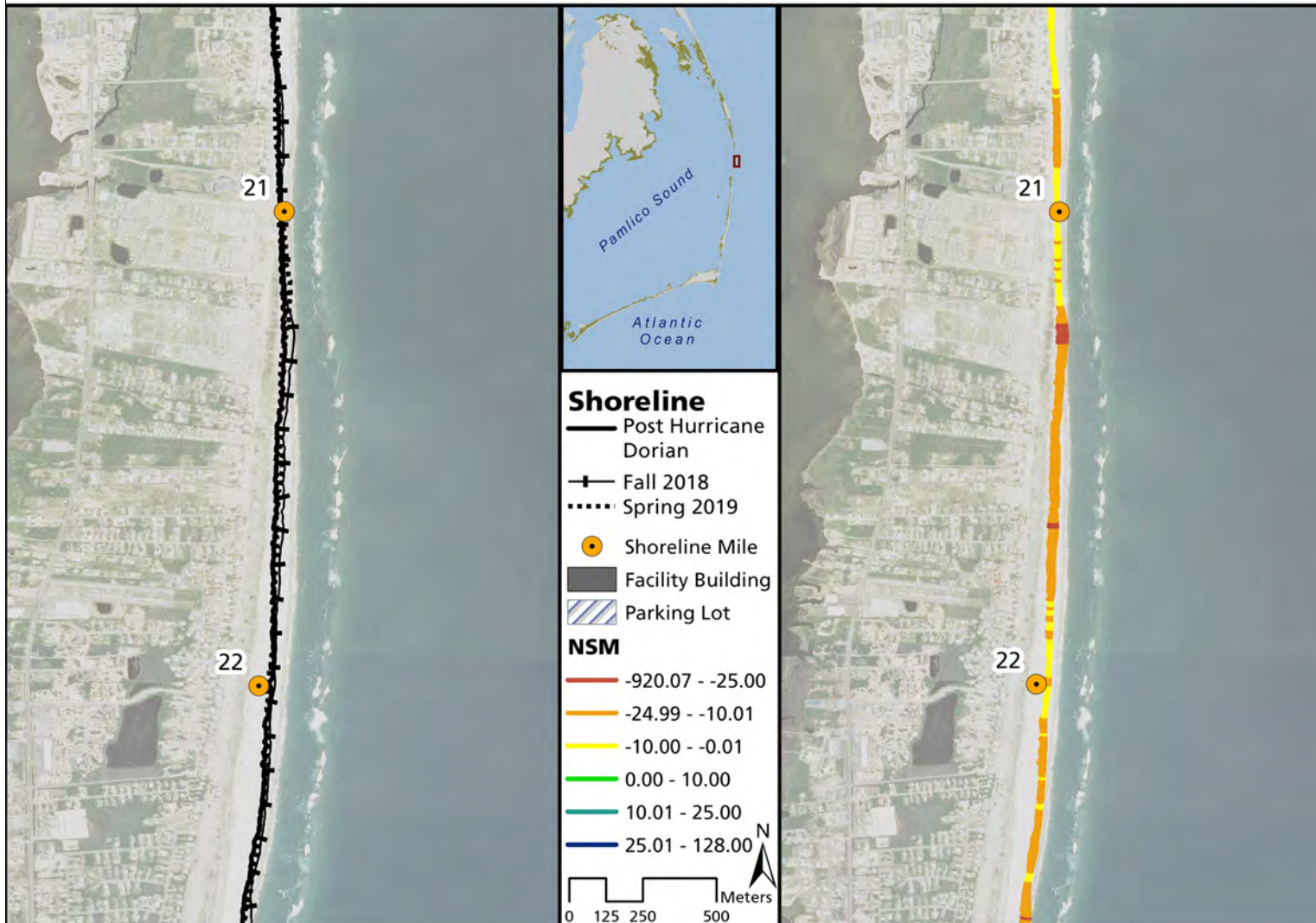


Figure B-15. Shoreline change in the vicinity of mile markers 21 and 22.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

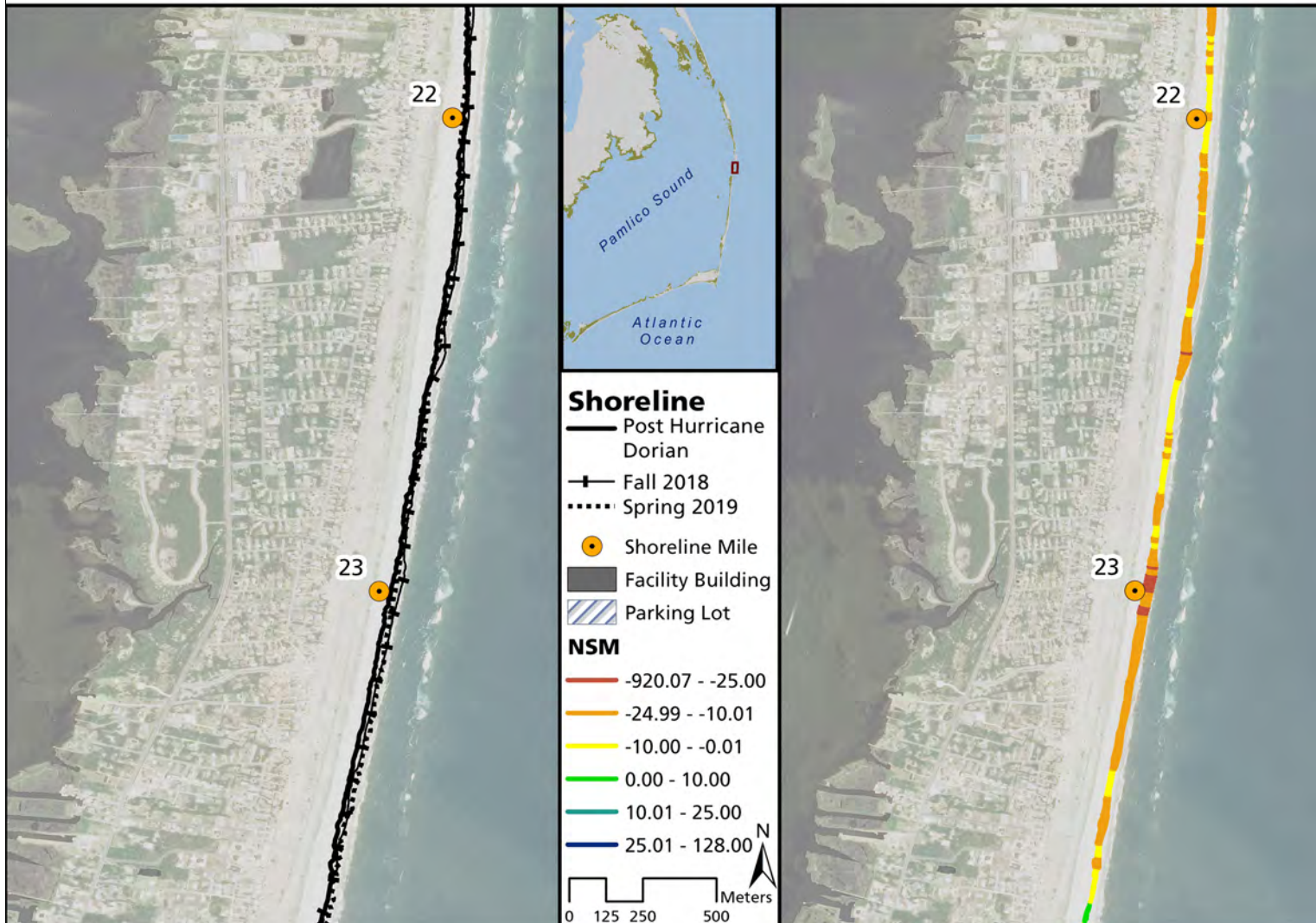


Figure B-16. Shoreline change in the vicinity of mile markers 22 and 23.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

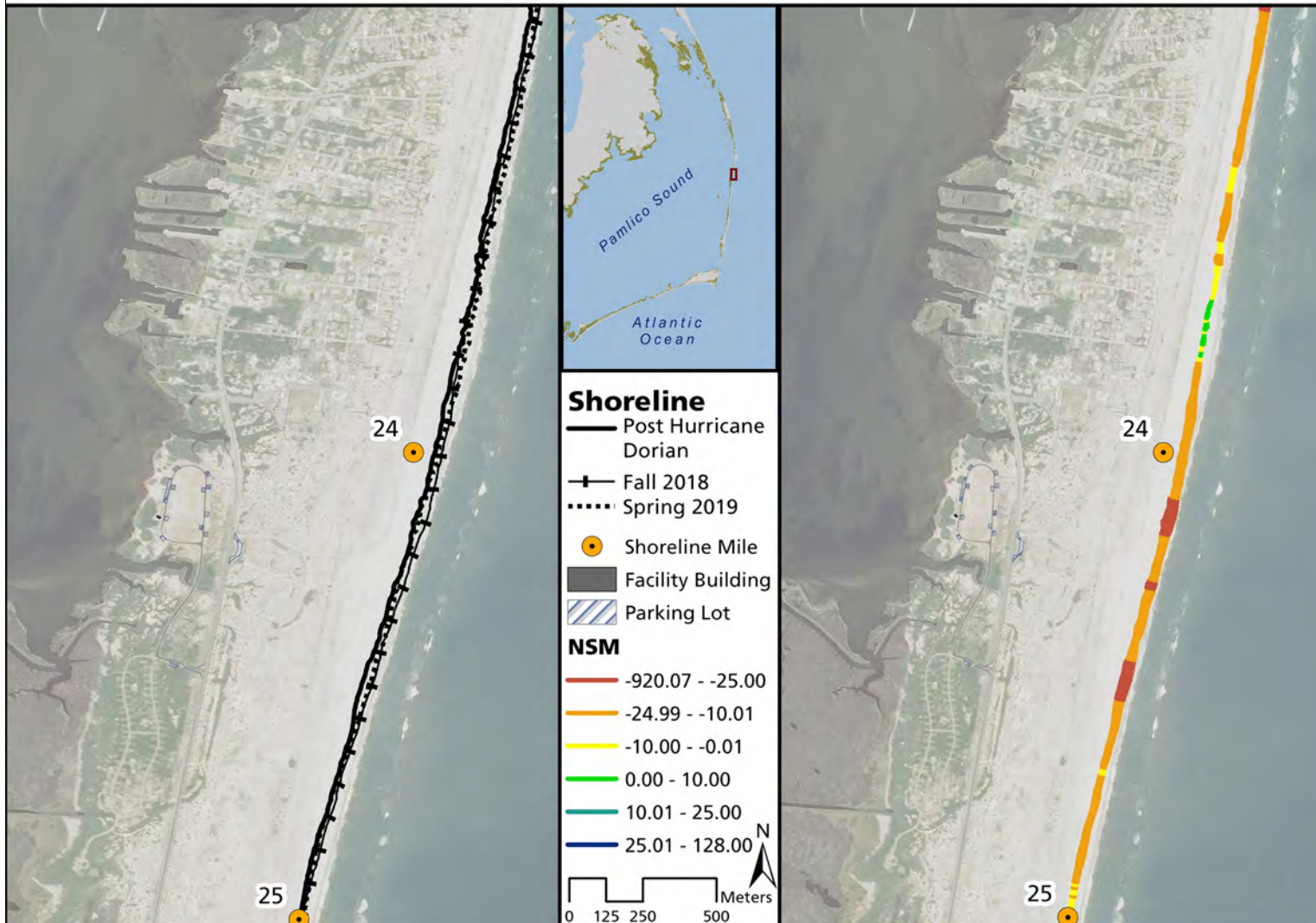


Figure B-17. Shoreline change in the vicinity of mile markers 24 and 25.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

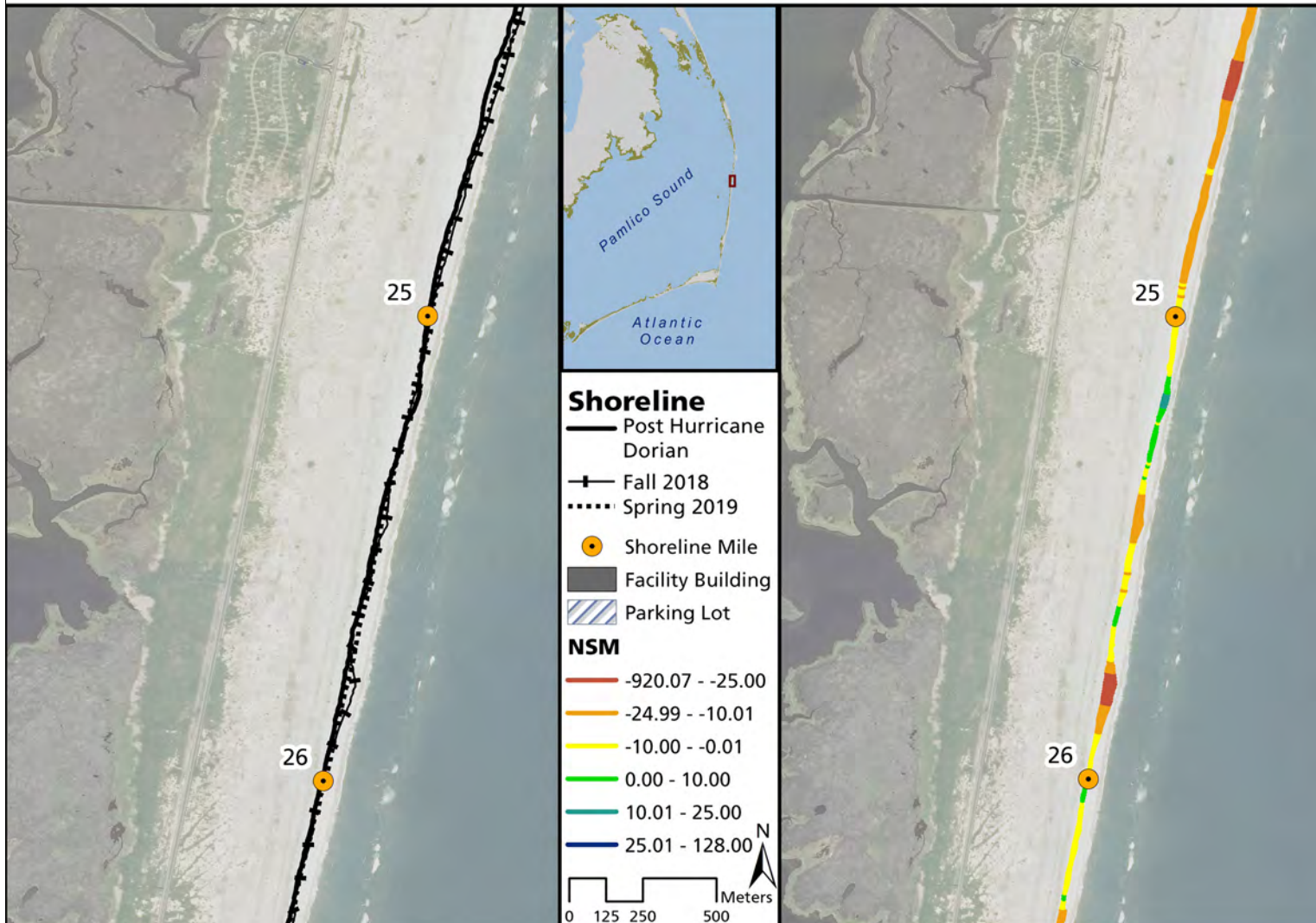


Figure B-18. Shoreline change in the vicinity of mile markers 25 and 26.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

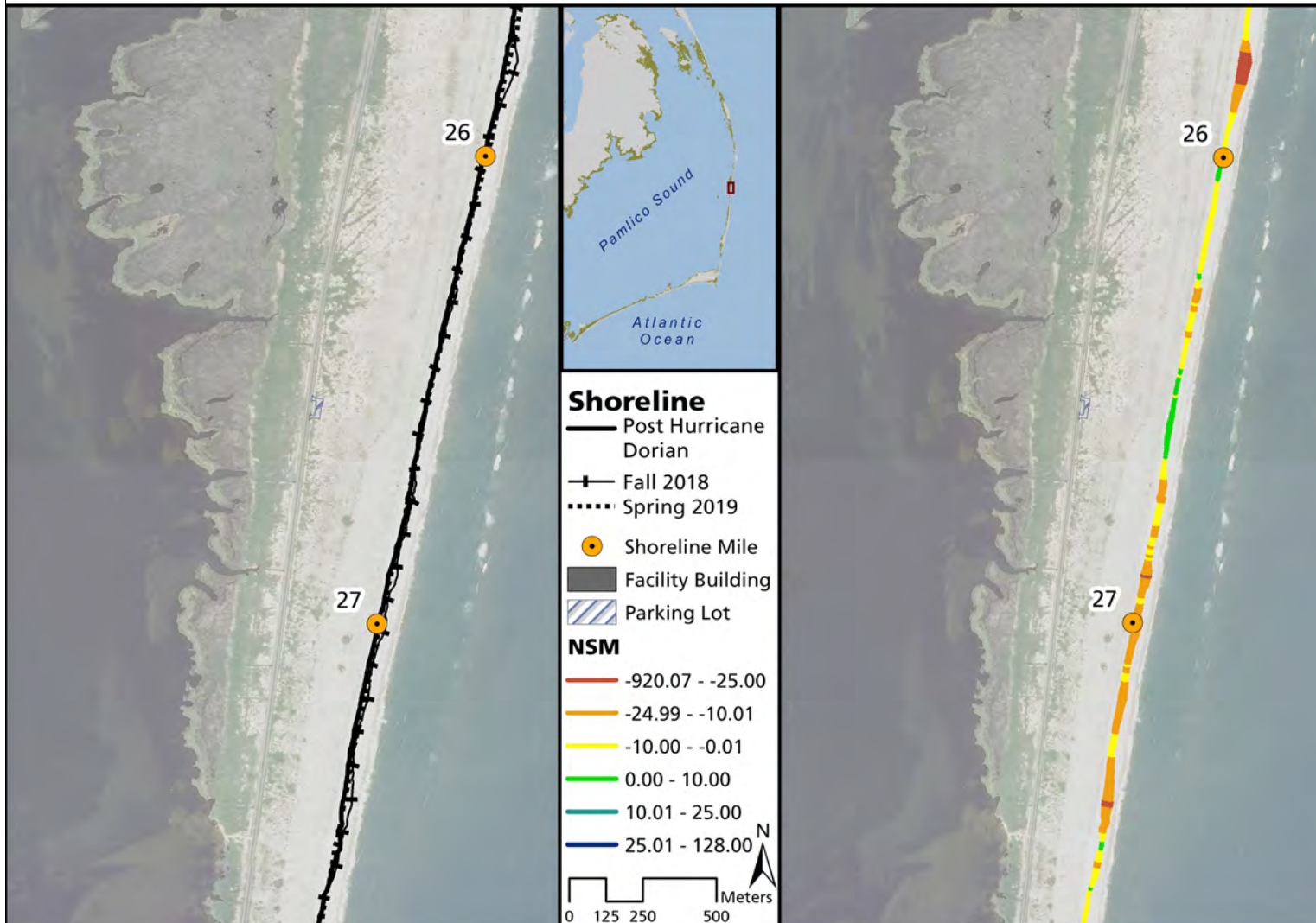


Figure B-19. Shoreline change in the vicinity of mile markers 26 and 27.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

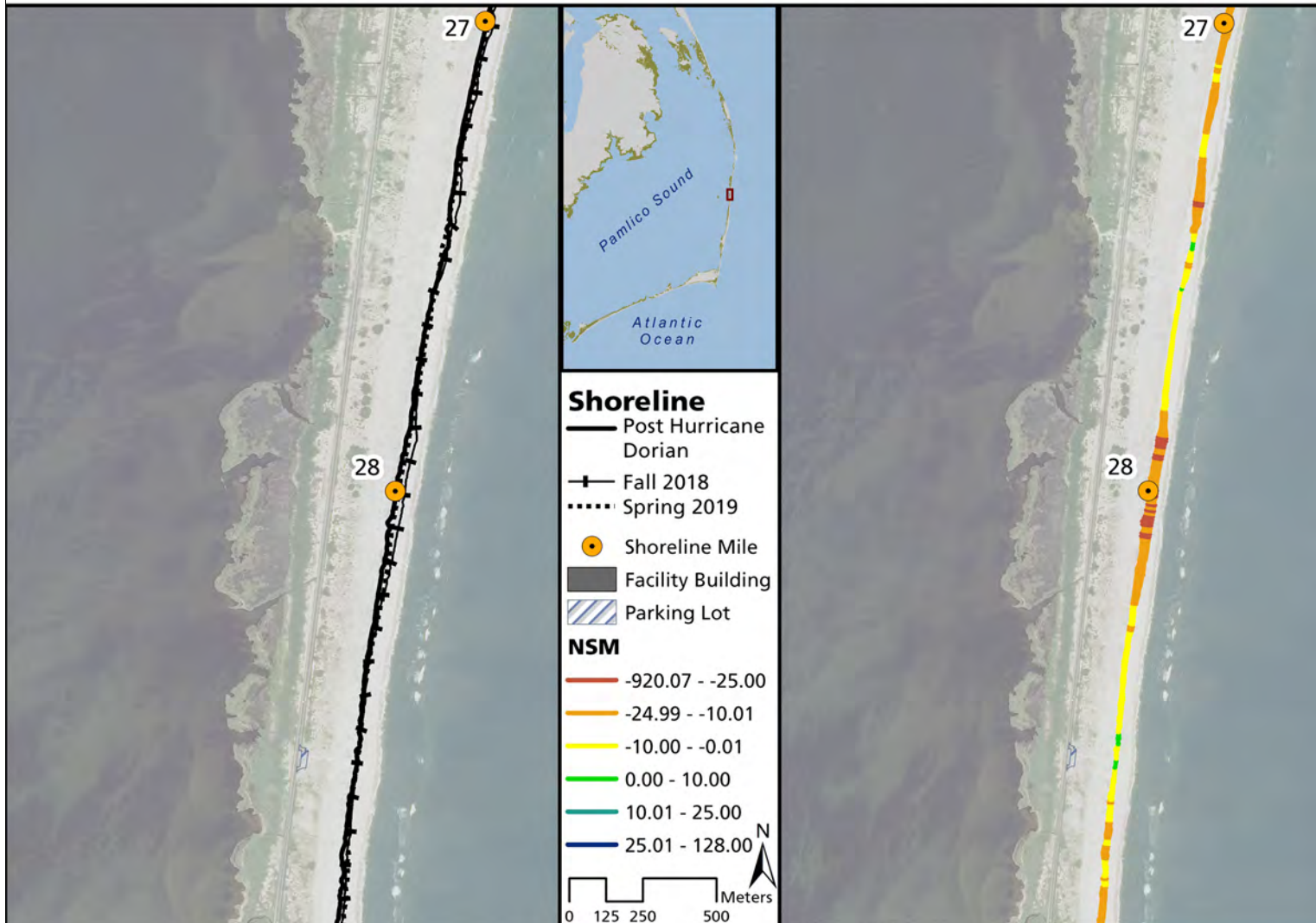


Figure B-20. Shoreline change in the vicinity of mile markers 27 and 28.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

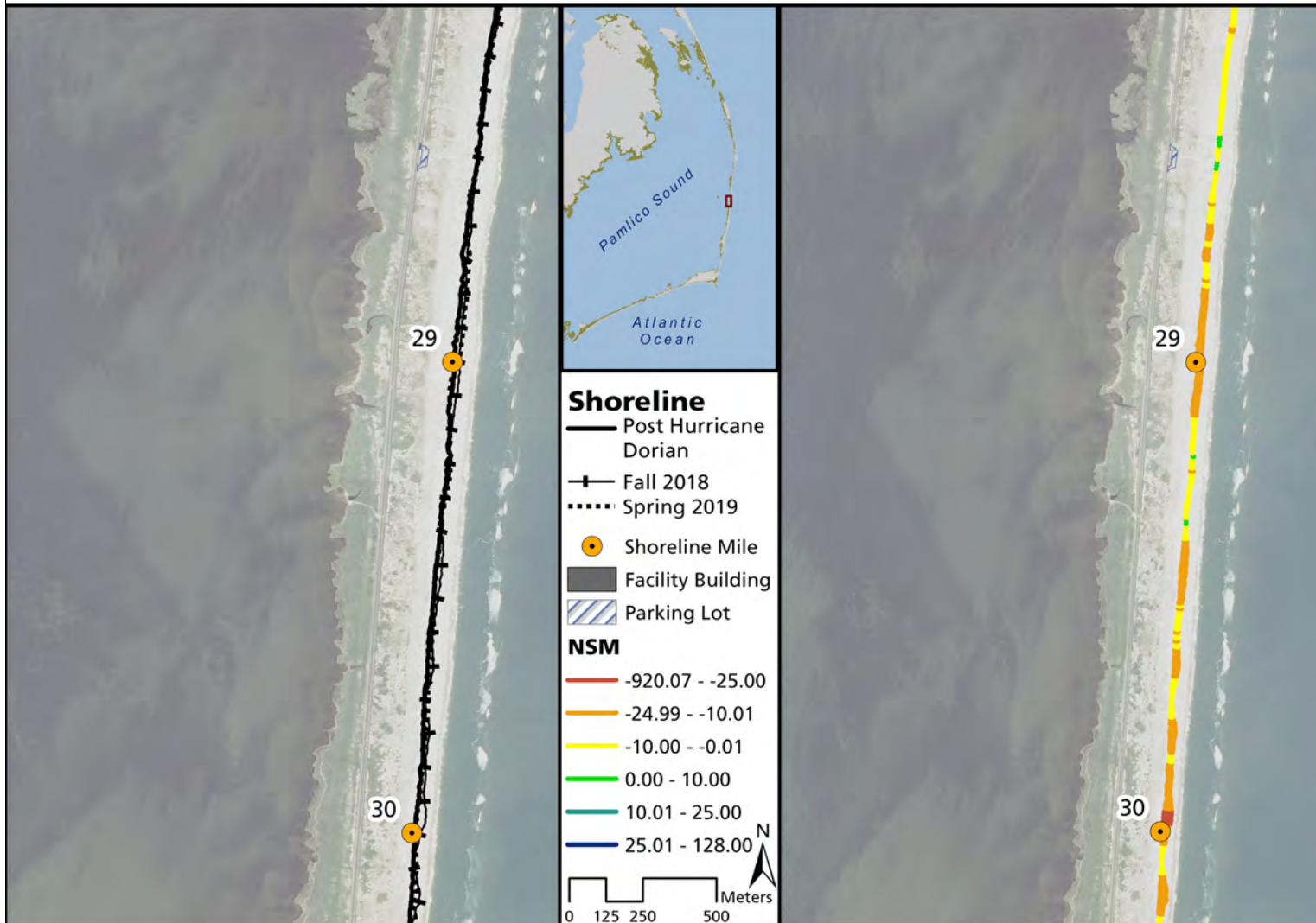


Figure B-21. Shoreline change in the vicinity of mile marker 29 and 30.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

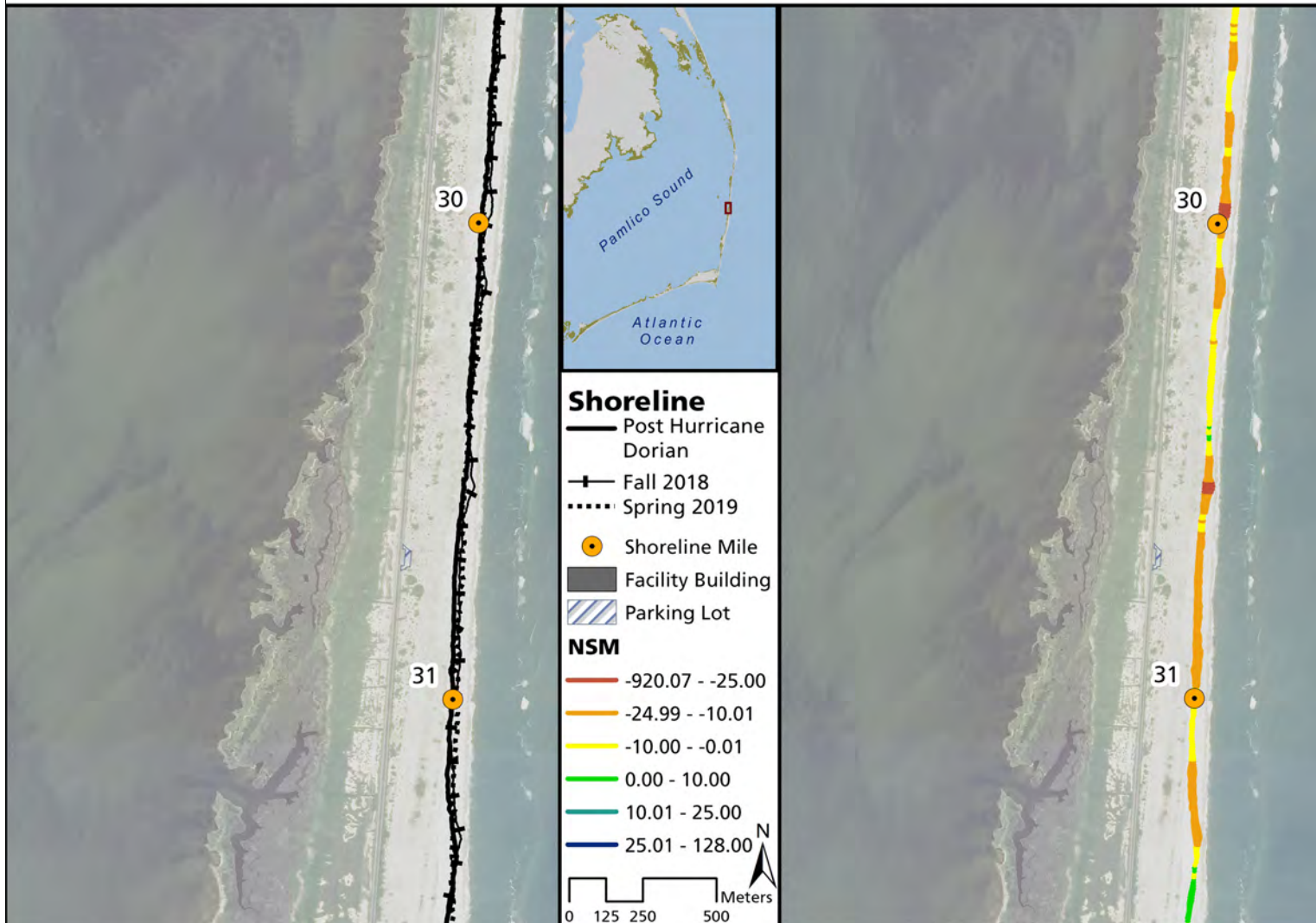


Figure B-22. Shoreline change in the vicinity of mile markers 30 and 31.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

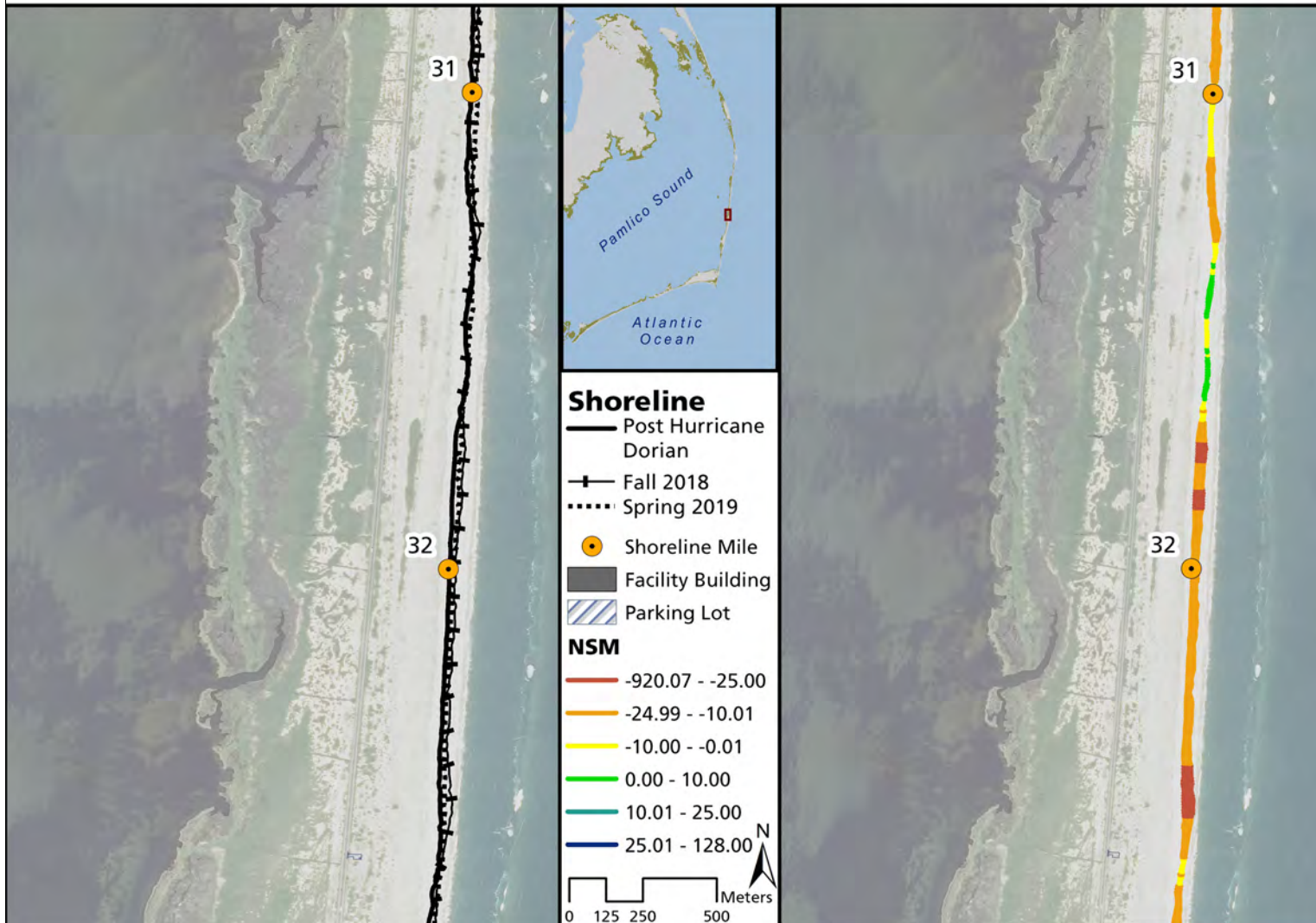


Figure B-23. Shoreline change in the vicinity of mile markers 31 and 32.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

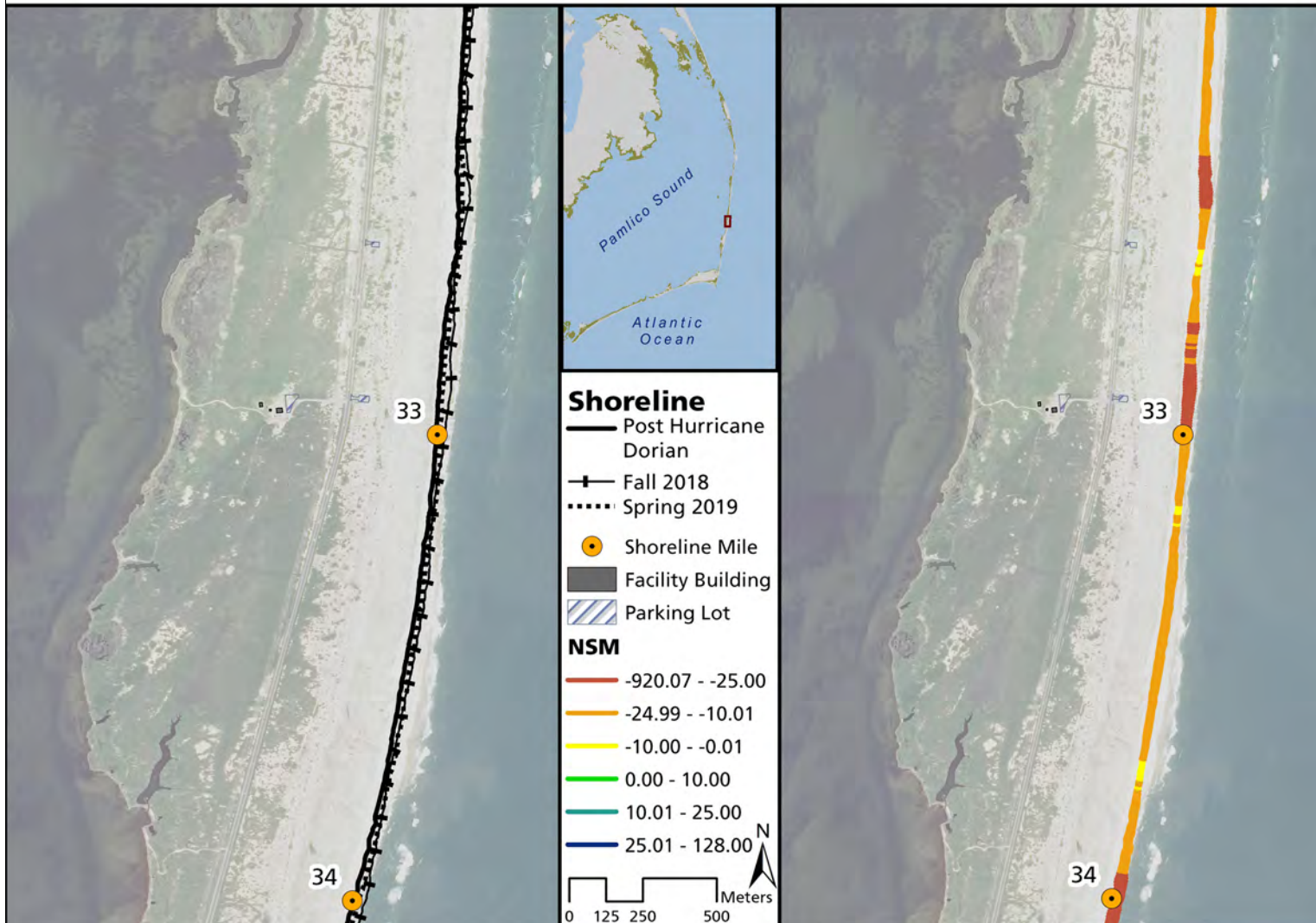


Figure B-24. Shoreline change in the vicinity of mile markers 33 and 34.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

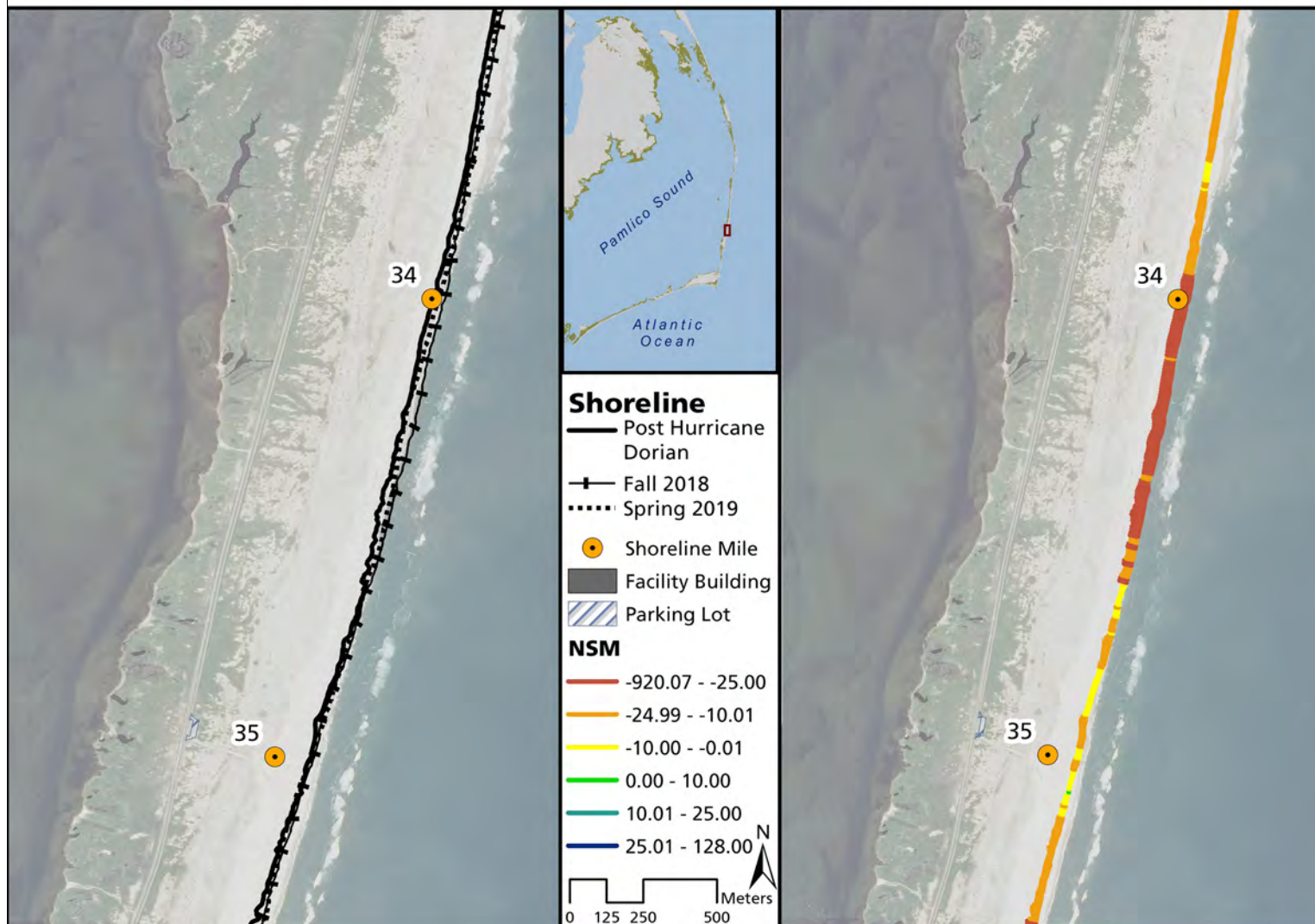


Figure B-25. Shoreline change in the vicinity of mile markers 34 and 35.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

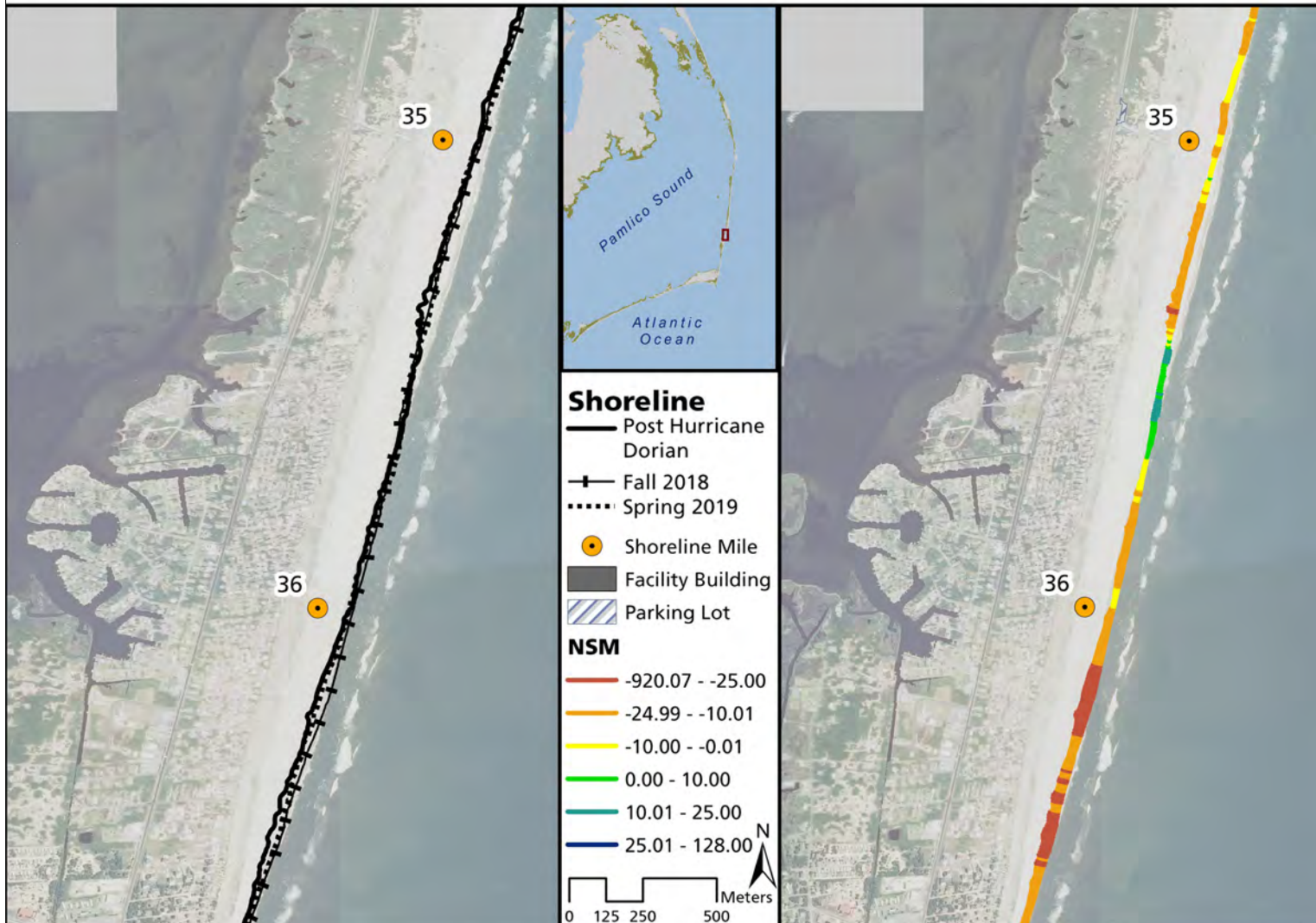


Figure B-26. Shoreline change in the vicinity of mile markers 35 and 36.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

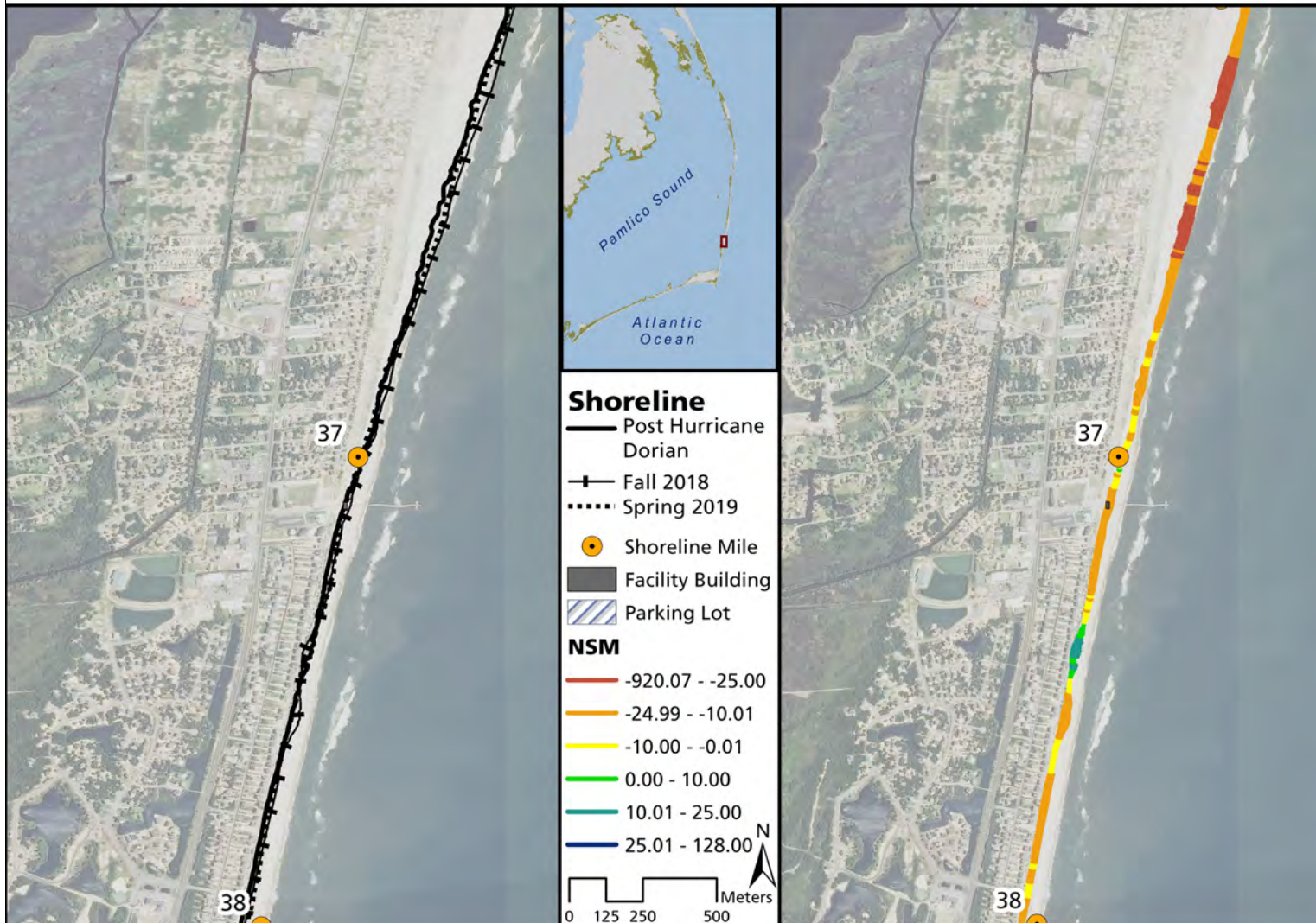


Figure B-27. Shoreline change in the vicinity of mile markers 37 and 38.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

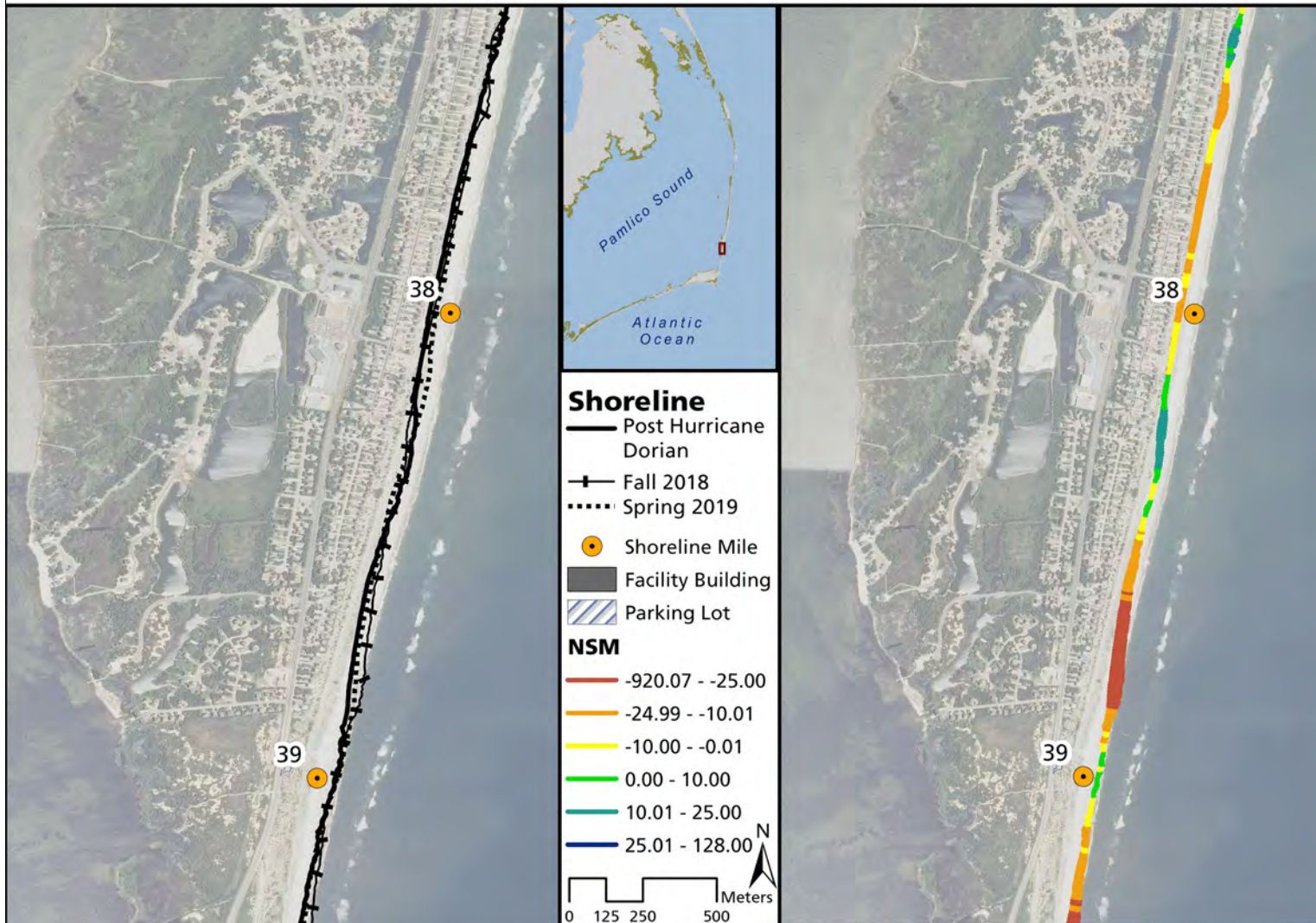


Figure B-28. Shoreline change in the vicinity of mile markers 38 and 39.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

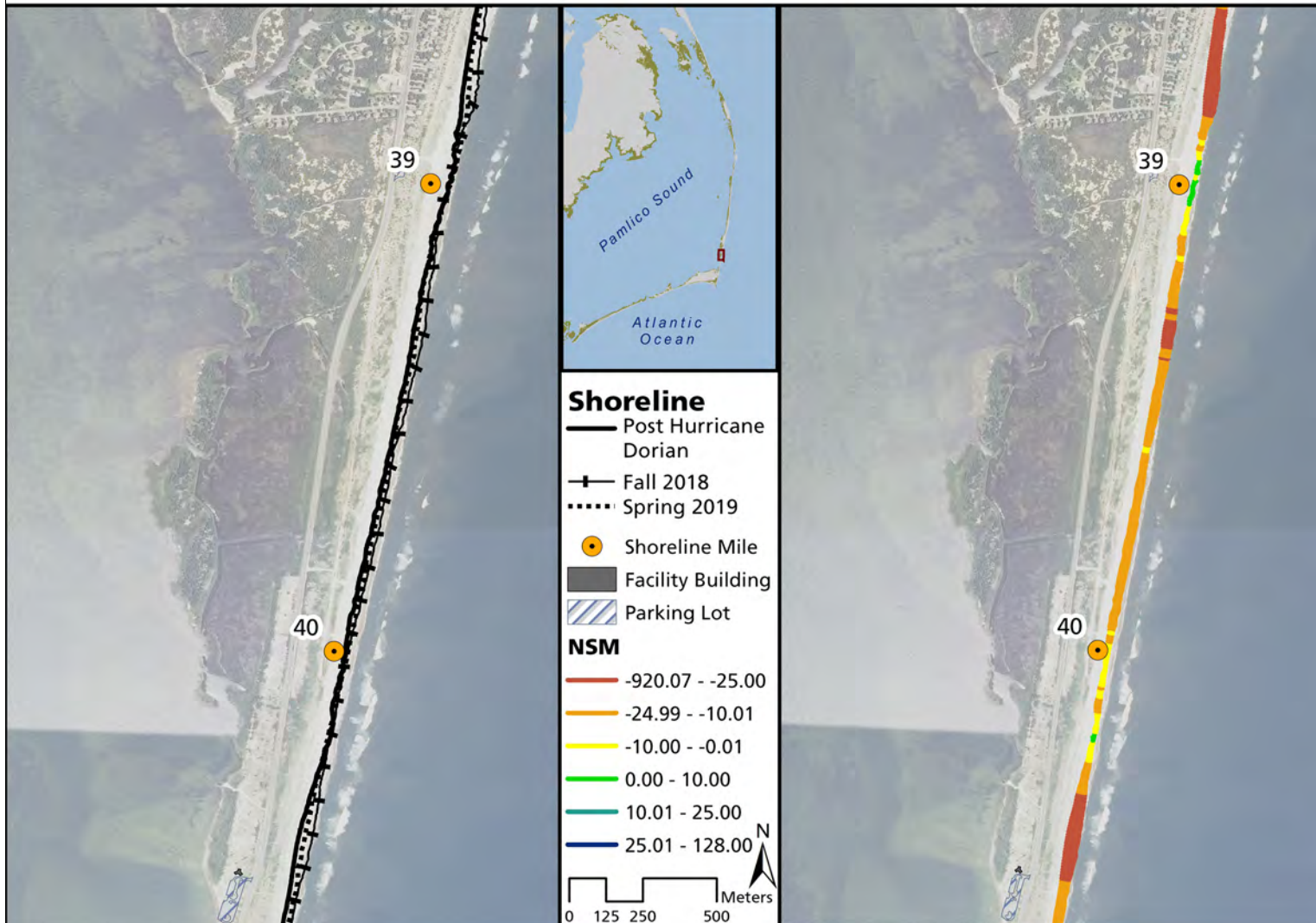


Figure B-29. Shoreline change in the vicinity of mile markers 39 and 40.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

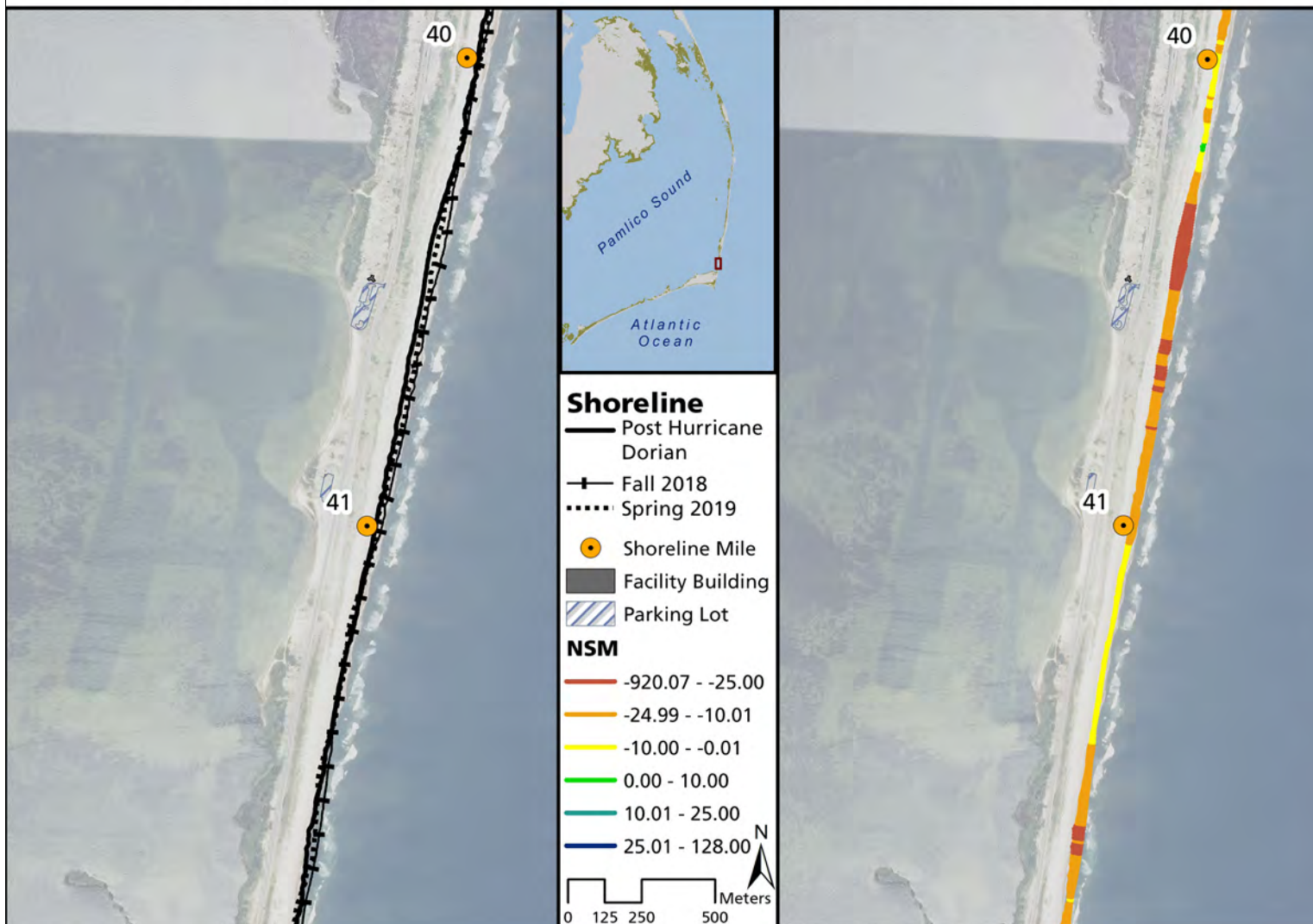


Figure B-30. Shoreline change in the vicinity of mile markers 40 and 41.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

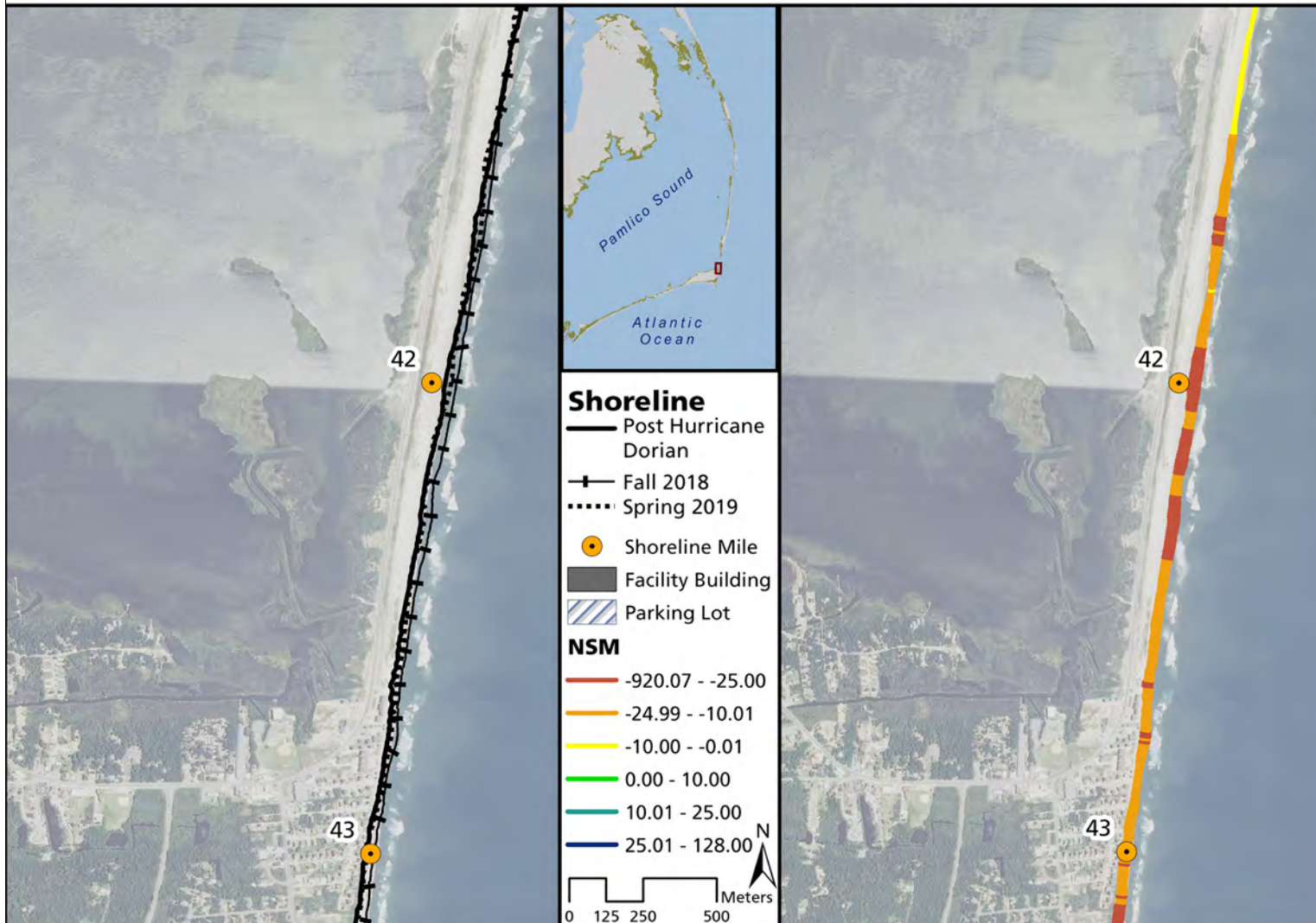


Figure B-31. Shoreline change in the vicinity of mile markers 42 and 43.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

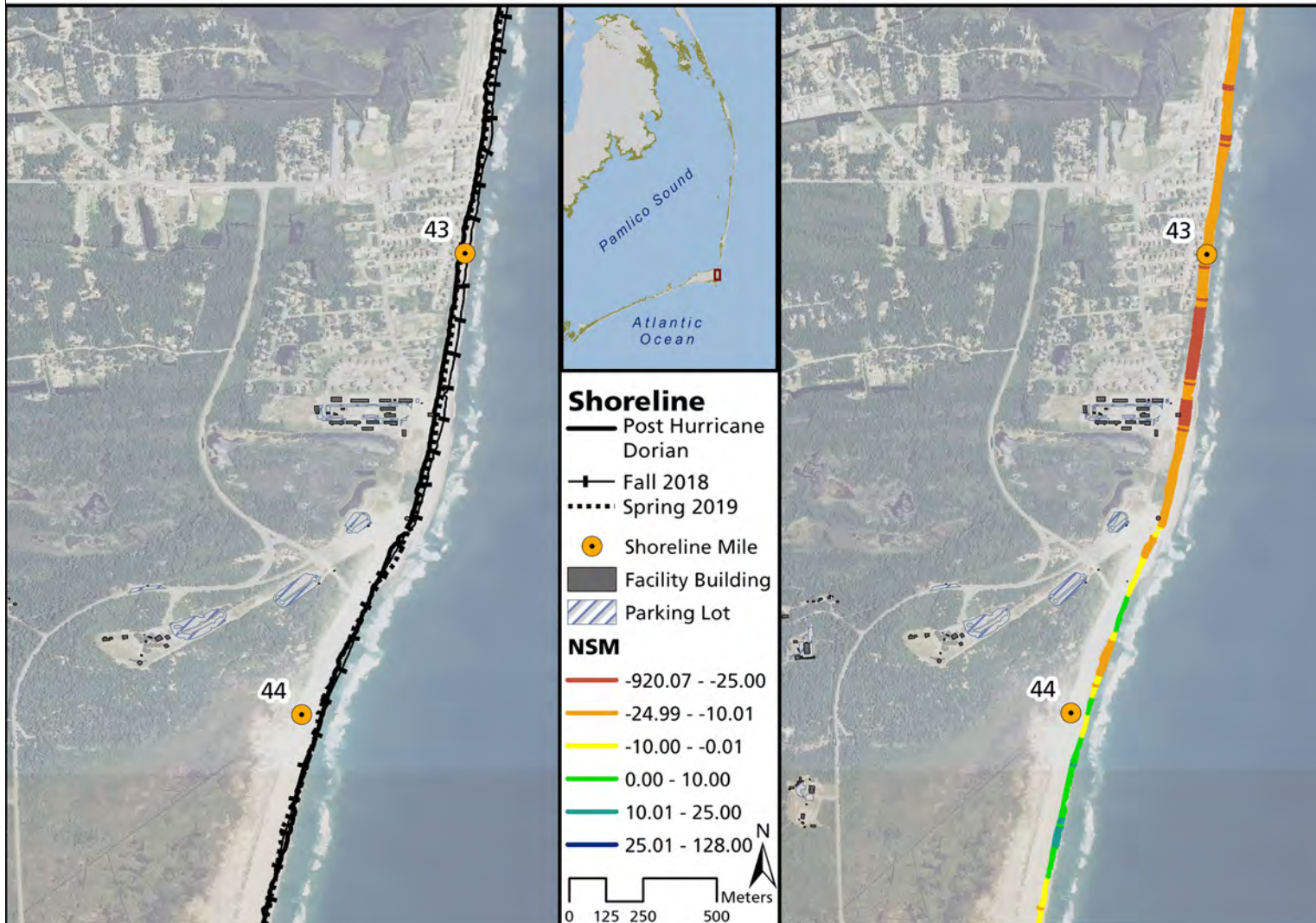


Figure B-32. Shoreline change in the vicinity of mile markers 43 and 44.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

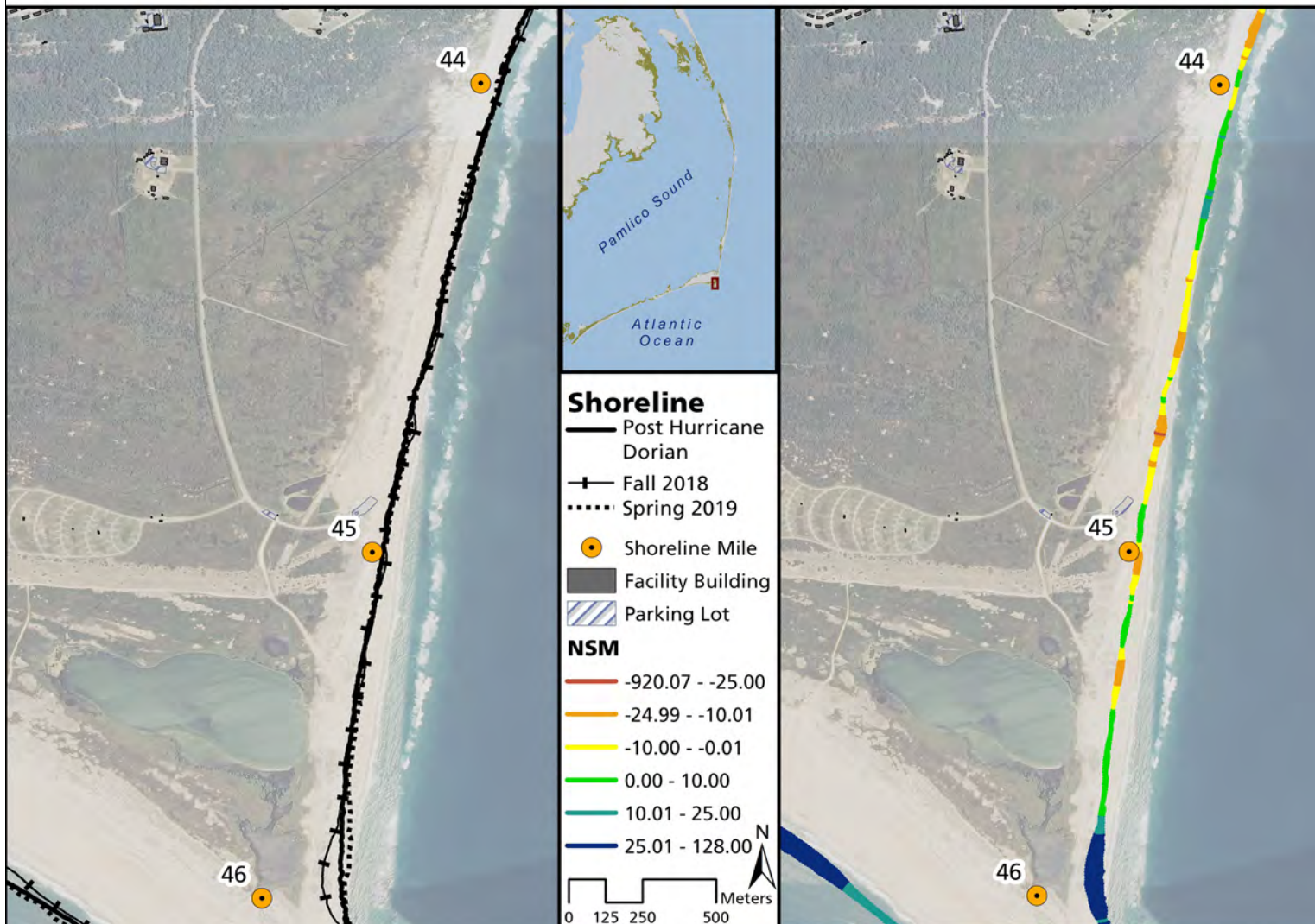


Figure B-33. Shoreline change in the vicinity of mile markers 44 through 46.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

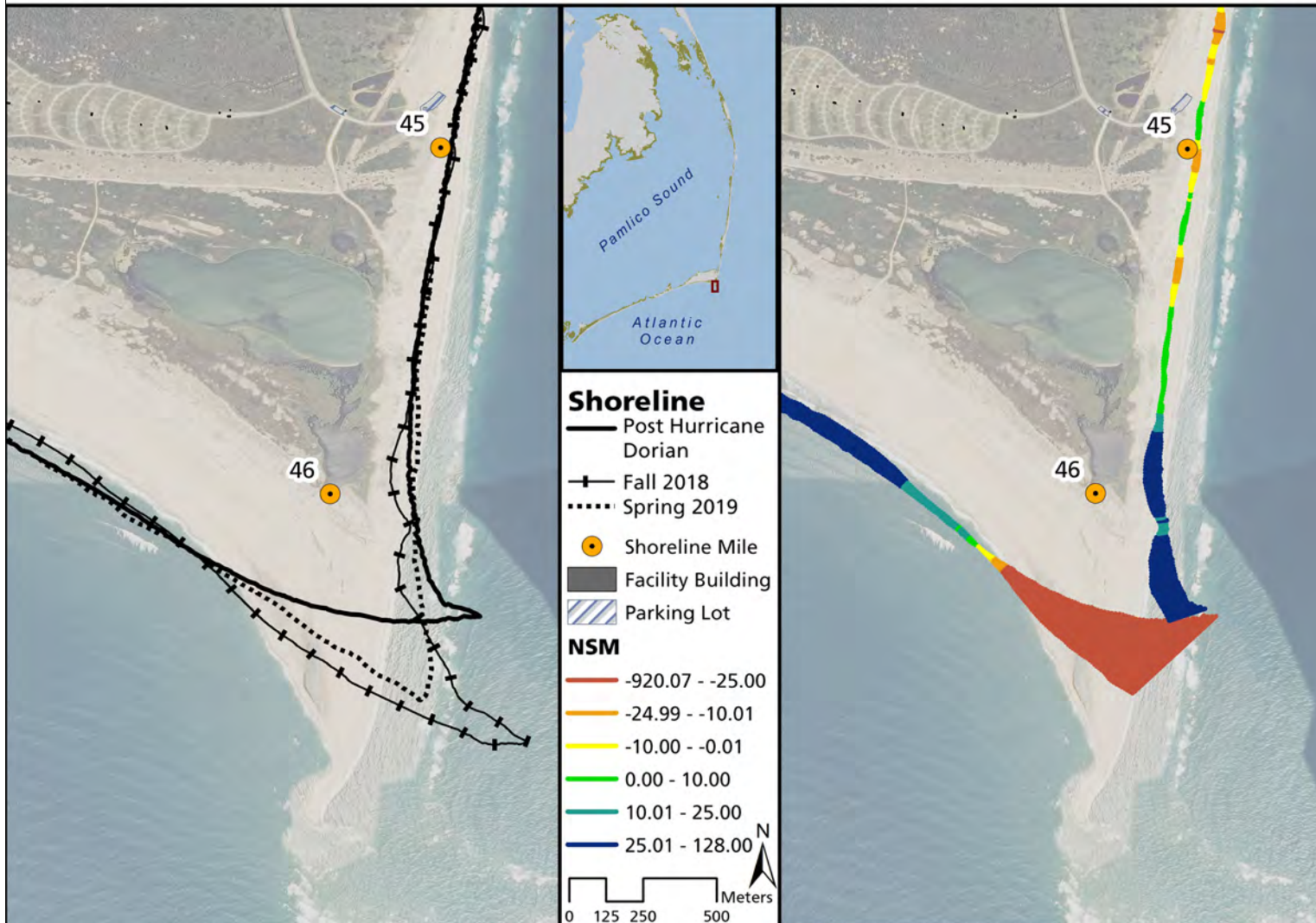


Figure B-34. Shoreline change in the vicinity of mile markers 45 and 46.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

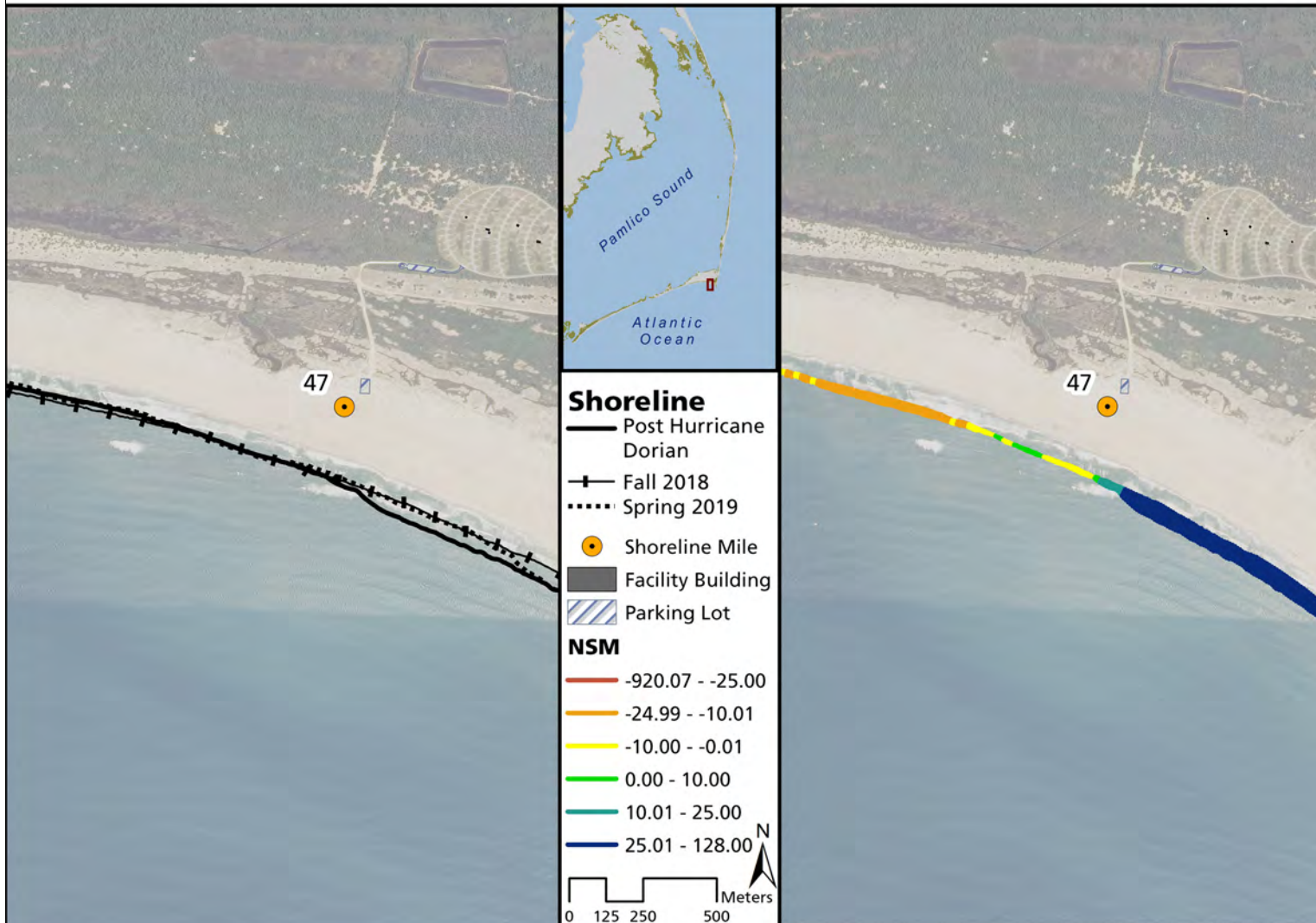


Figure B-35. Shoreline change in the vicinity of mile marker 47.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

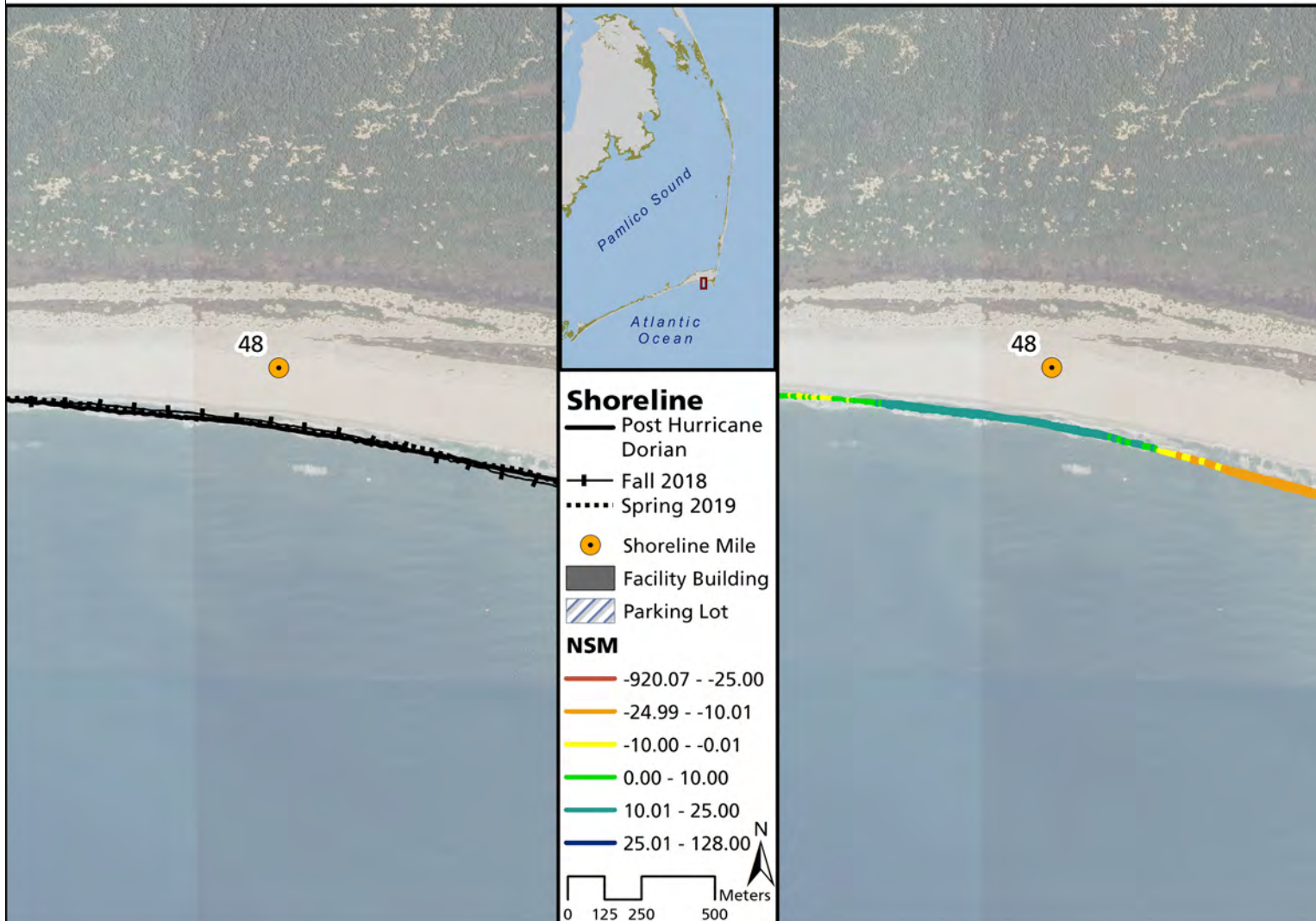


Figure B-36. Shoreline change in the vicinity of mile marker 48.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

68

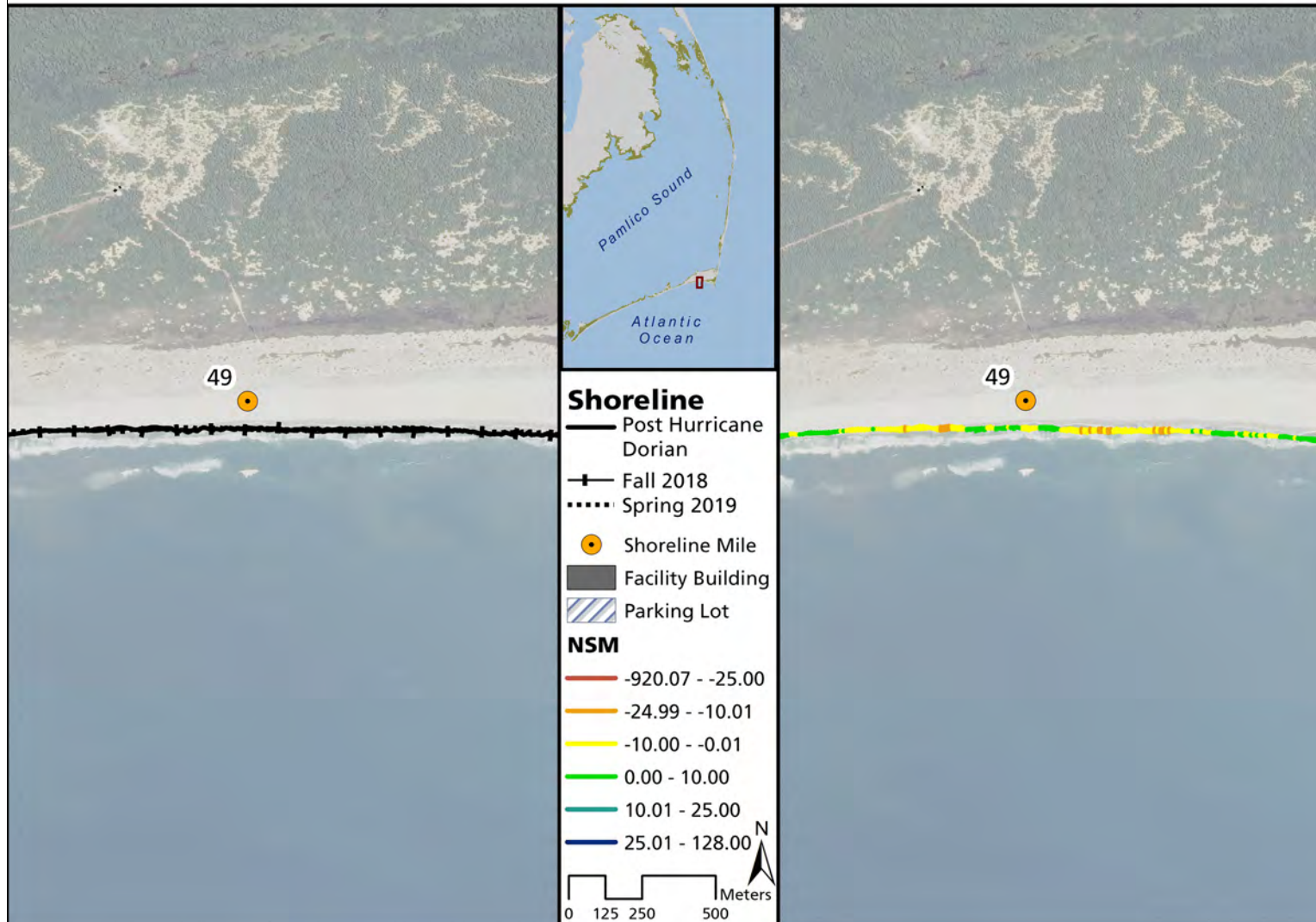


Figure B-37. Shoreline change in the vicinity of mile marker 49.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

69

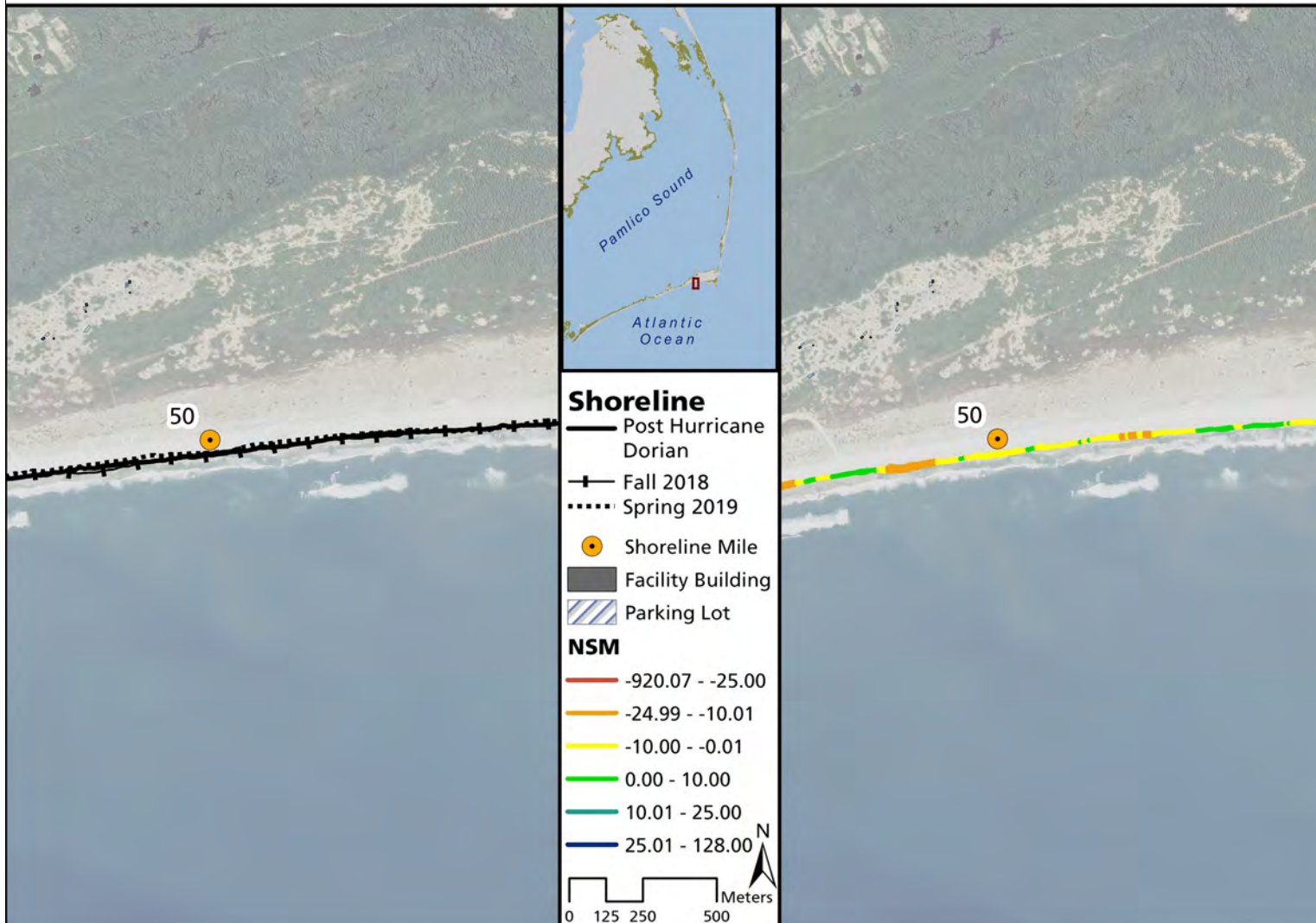


Figure B-38. Shoreline change in the vicinity of mile maker 50.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

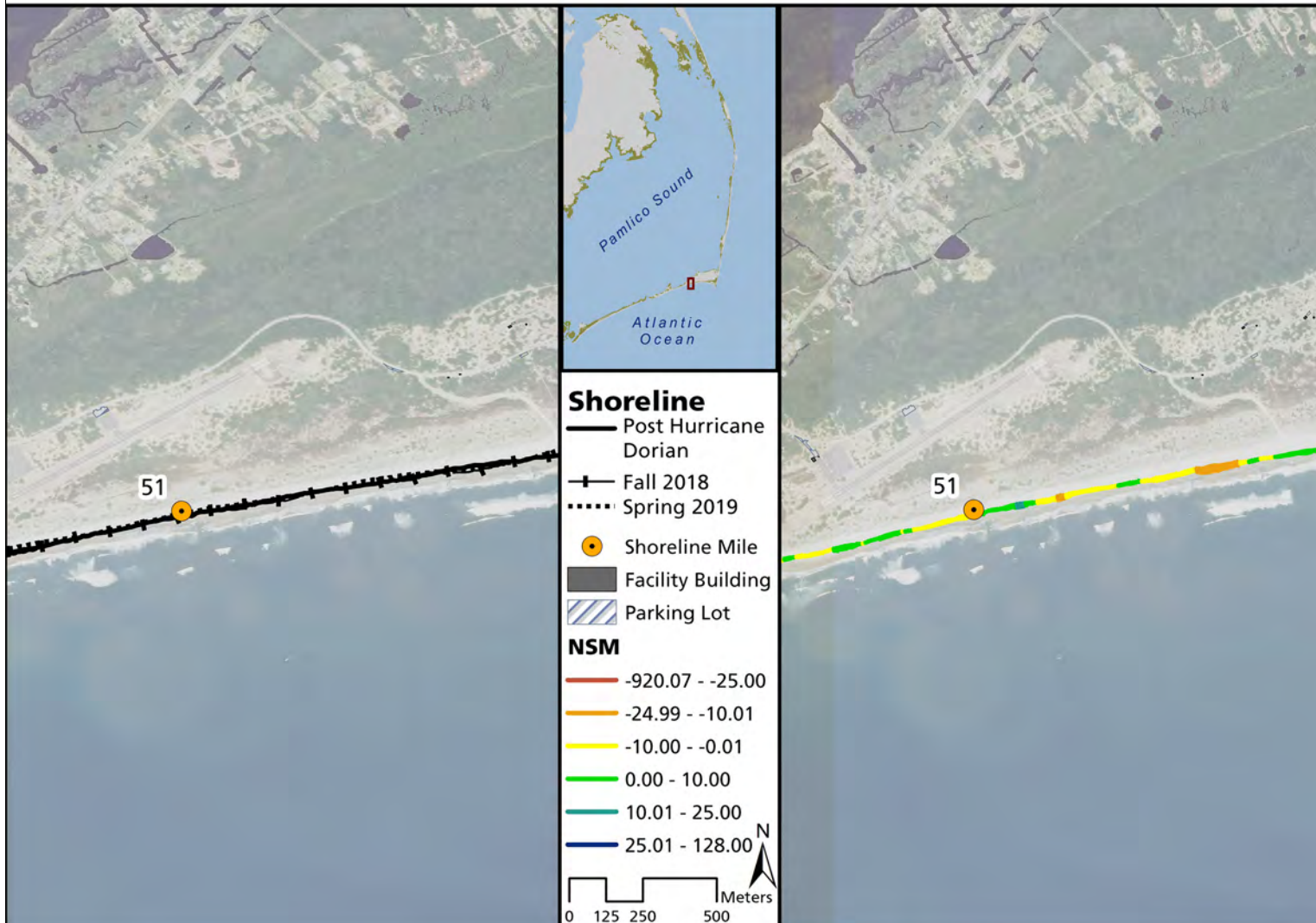


Figure B-39. Shoreline change in the vicinity of mile marker 51.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

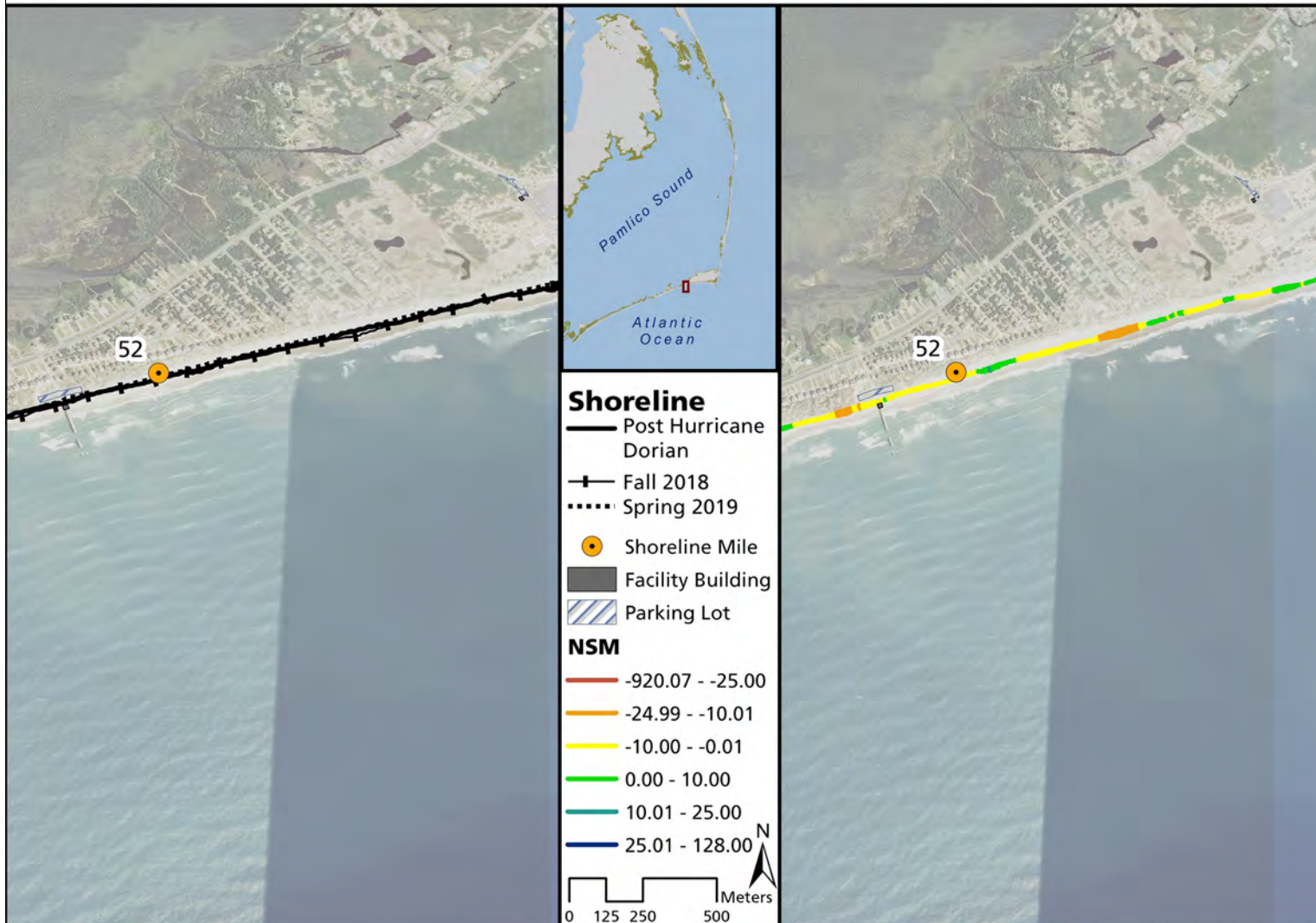


Figure B-40. Shoreline change in the vicinity of mile marker 52.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

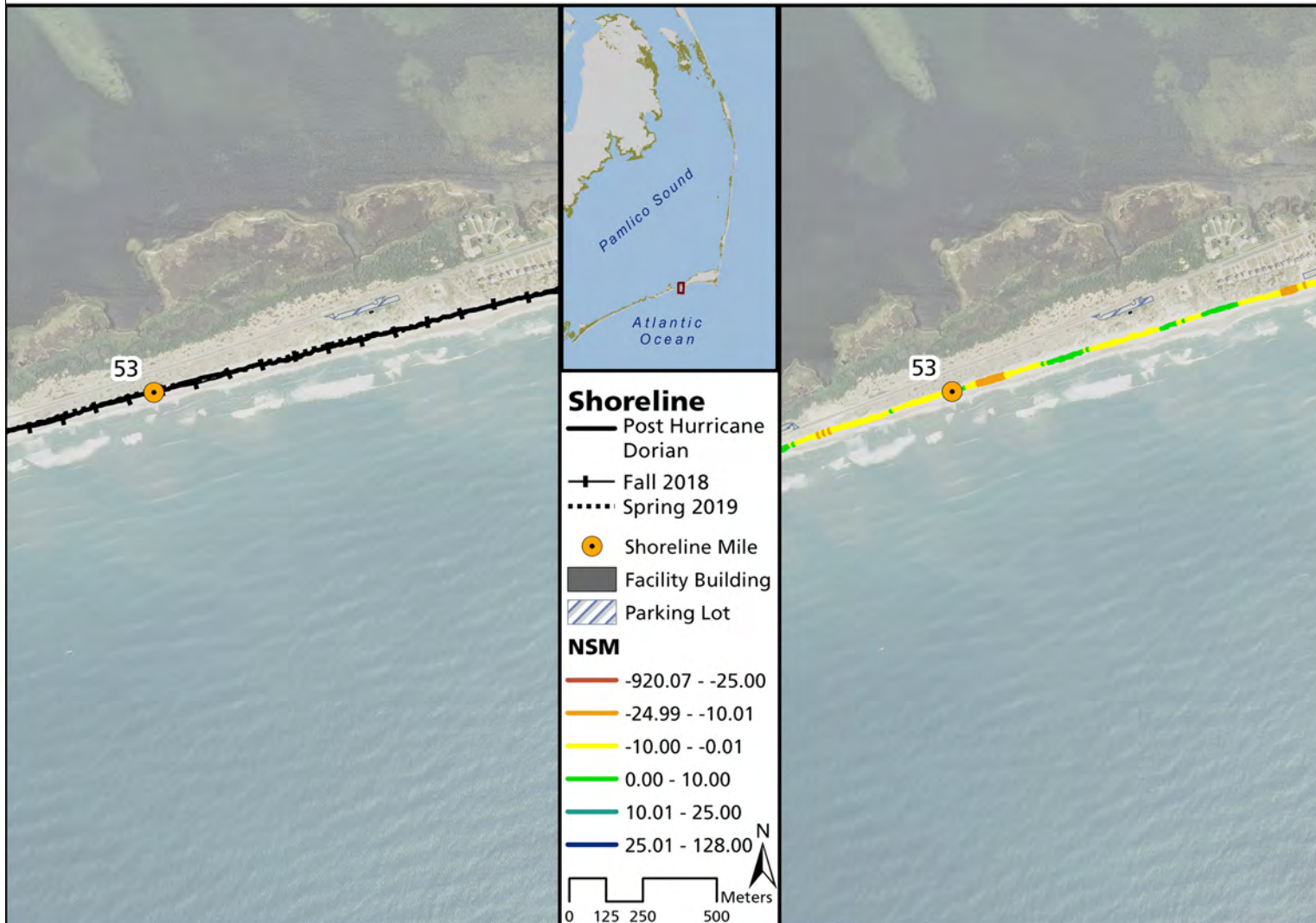


Figure B-41. Shoreline change in the vicinity of mile marker 53.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

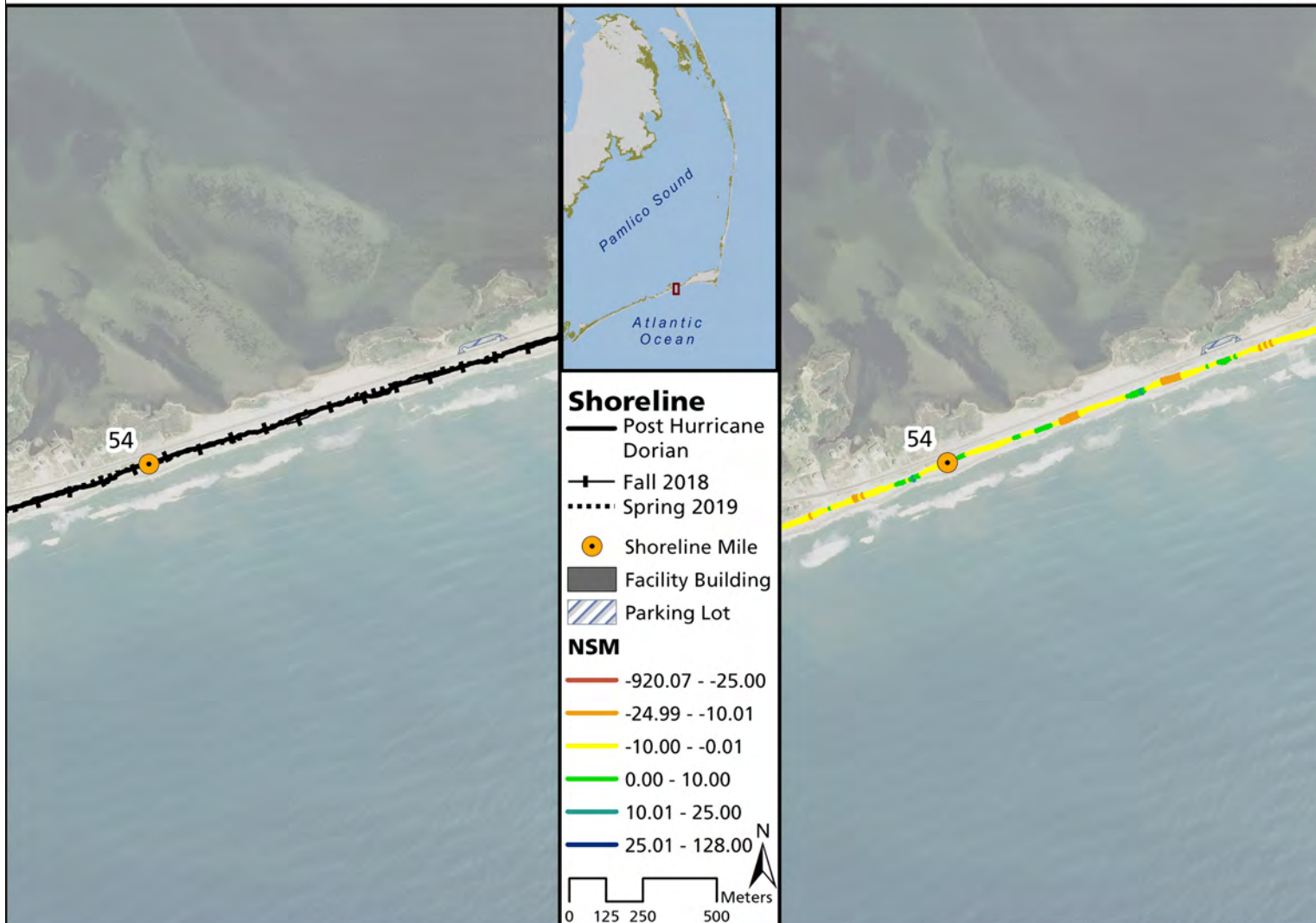


Figure B-42. Shoreline change in the vicinity of mile marker 54.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
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U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019



Figure B-43. Shoreline change in the vicinity of mile marker 55.

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U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019



Figure B-44. Shoreline change in the vicinity of mile marker 56.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

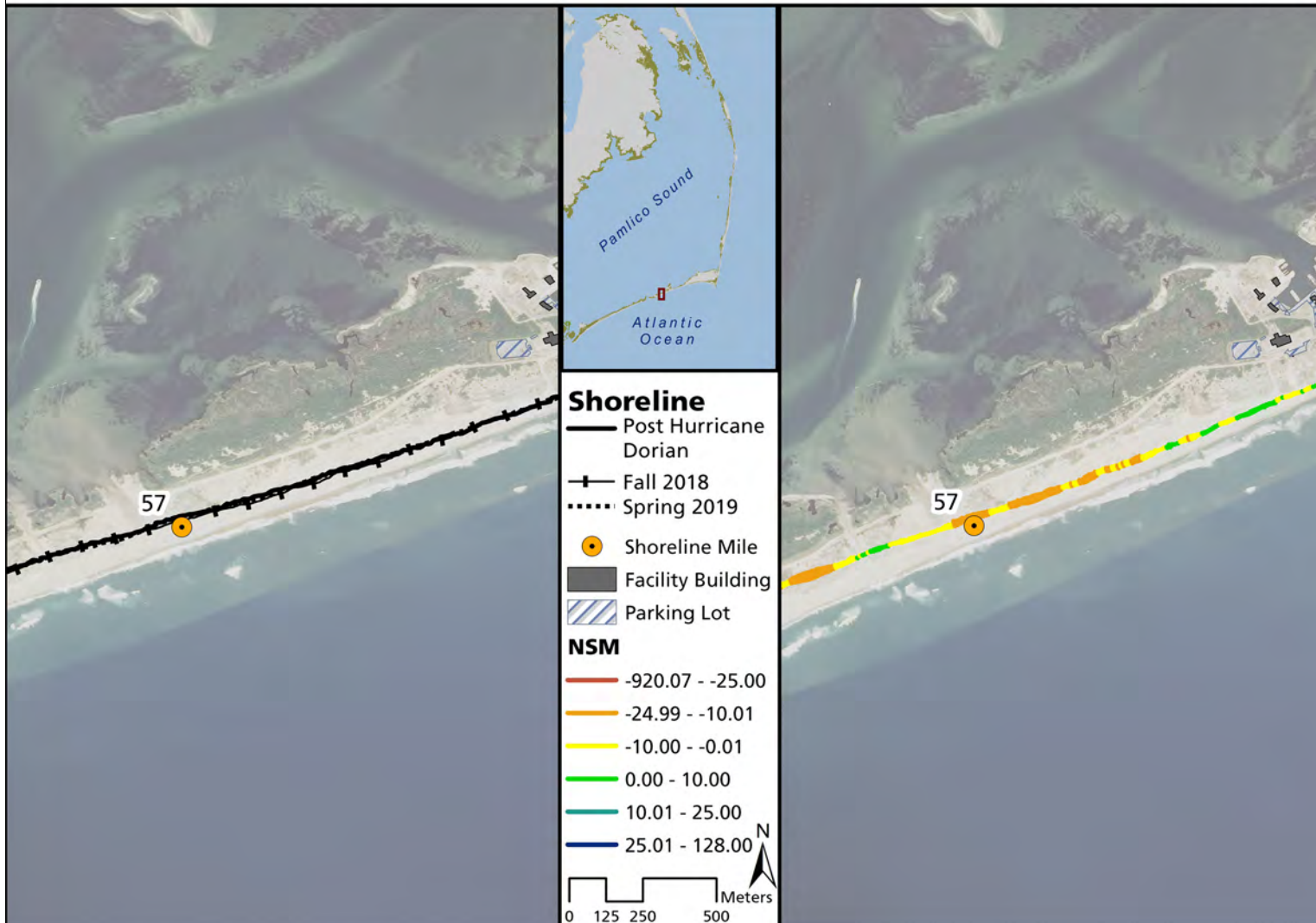


Figure B-45. Shoreline change in the vicinity of mile marker 57.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

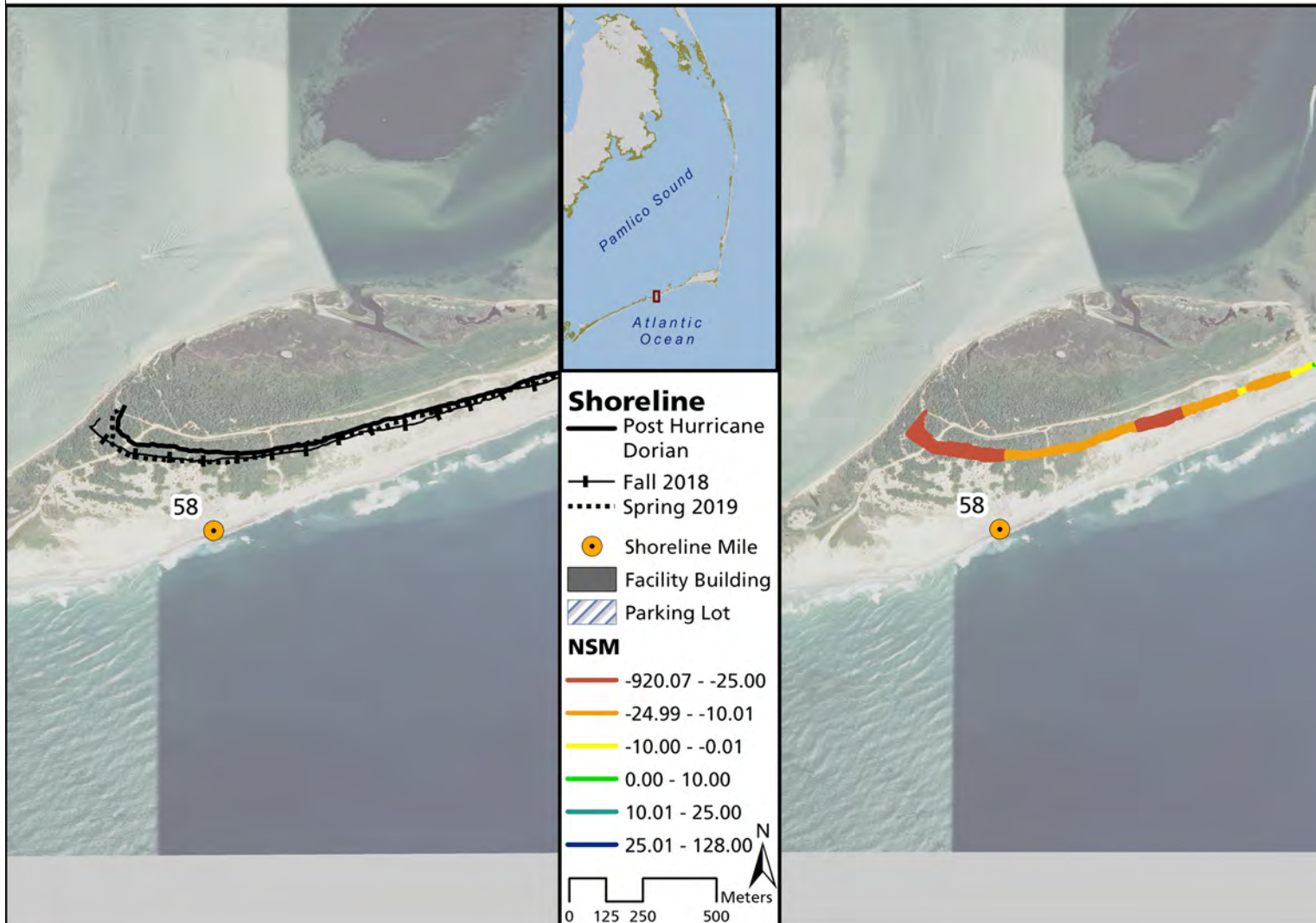


Figure B-46. Shoreline change in the vicinity of mile marker 58.

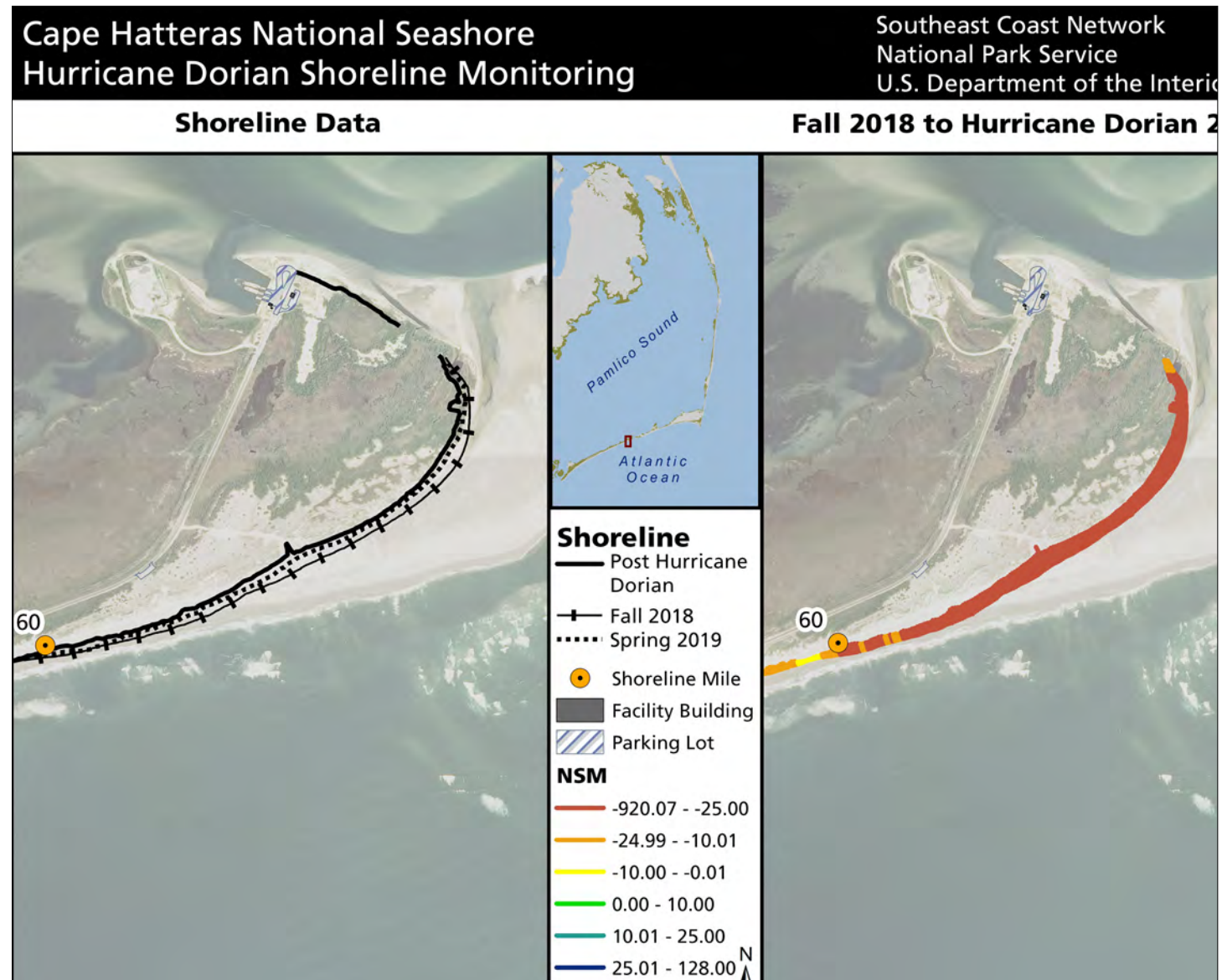


Figure B-47. Shoreline change in the vicinity of mile marker 60.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

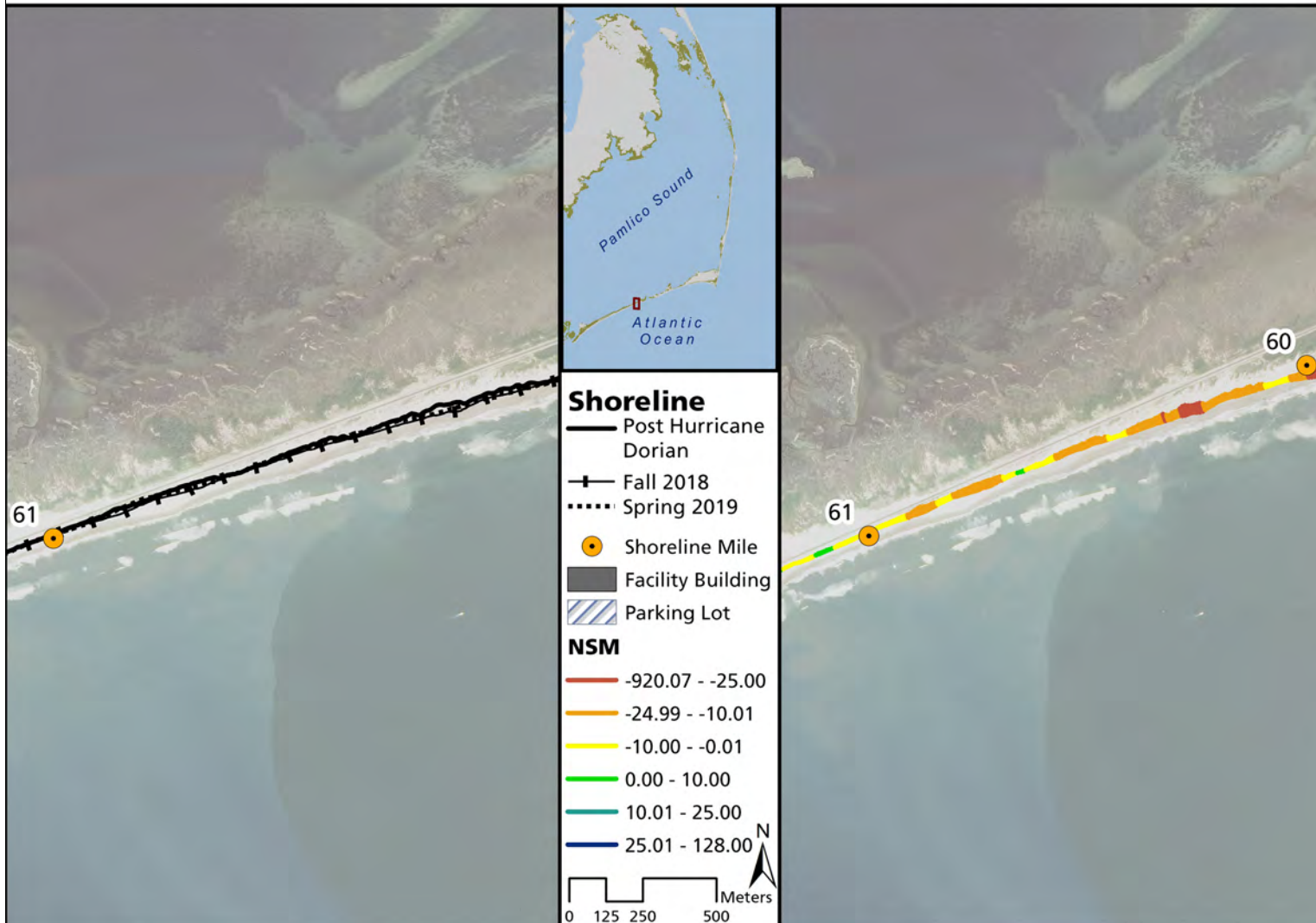


Figure B-48. Shoreline change in the vicinity of mile markers 60 and 61.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

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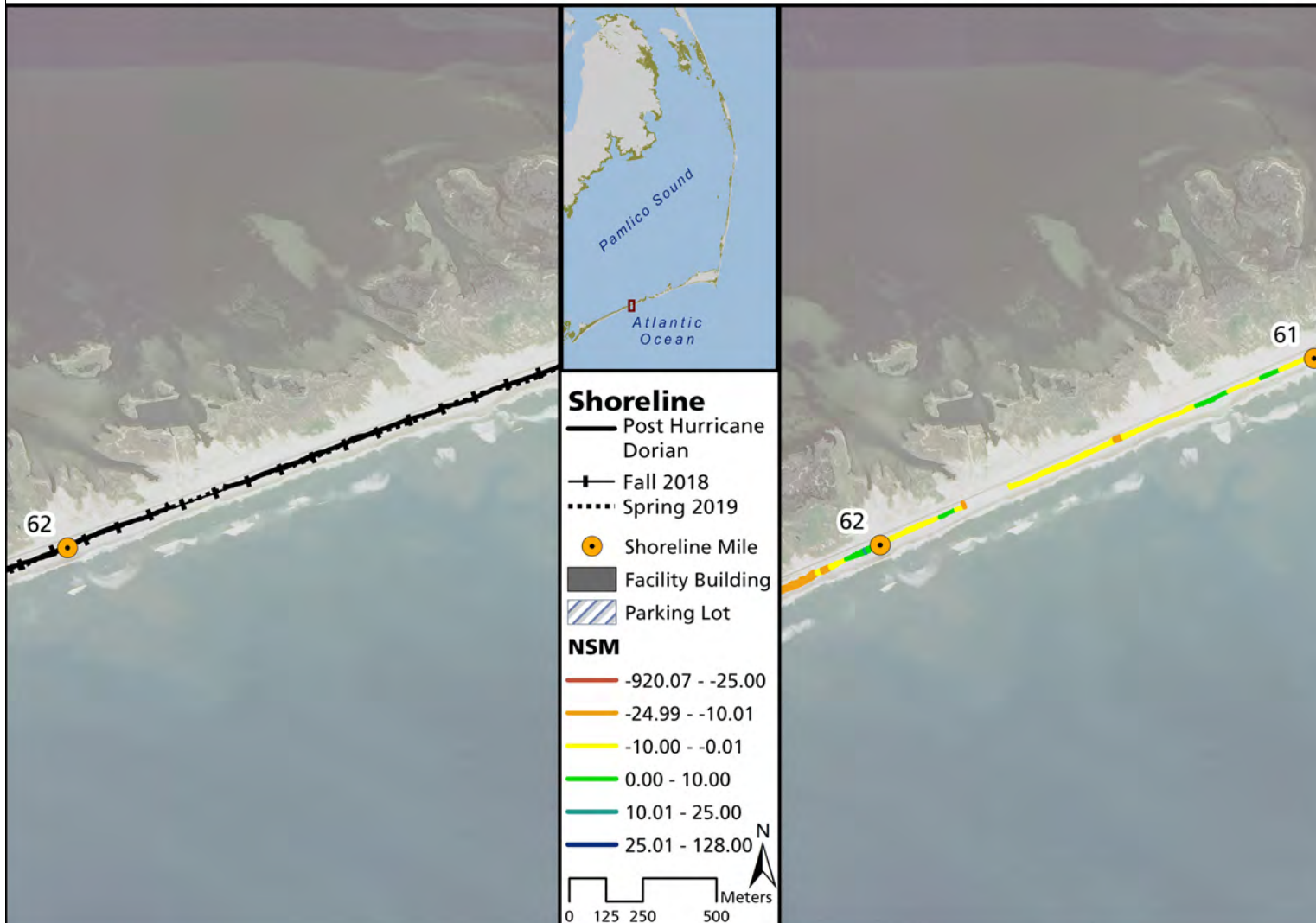


Figure B-49. Shoreline change in the vicinity of mile markers 61 and 62.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

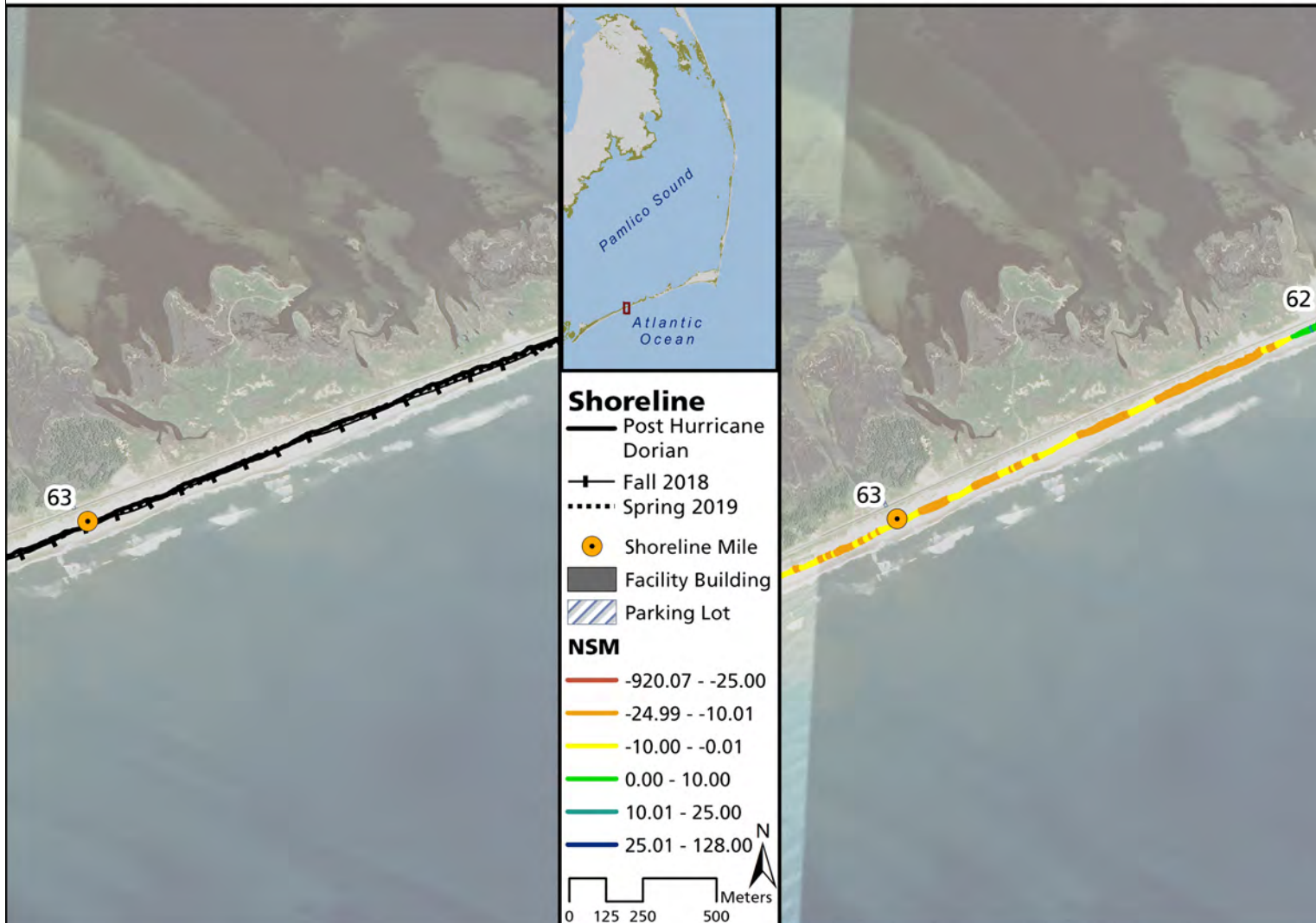


Figure B-50. Shoreline change in the vicinity of mile markers 62 and 63.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

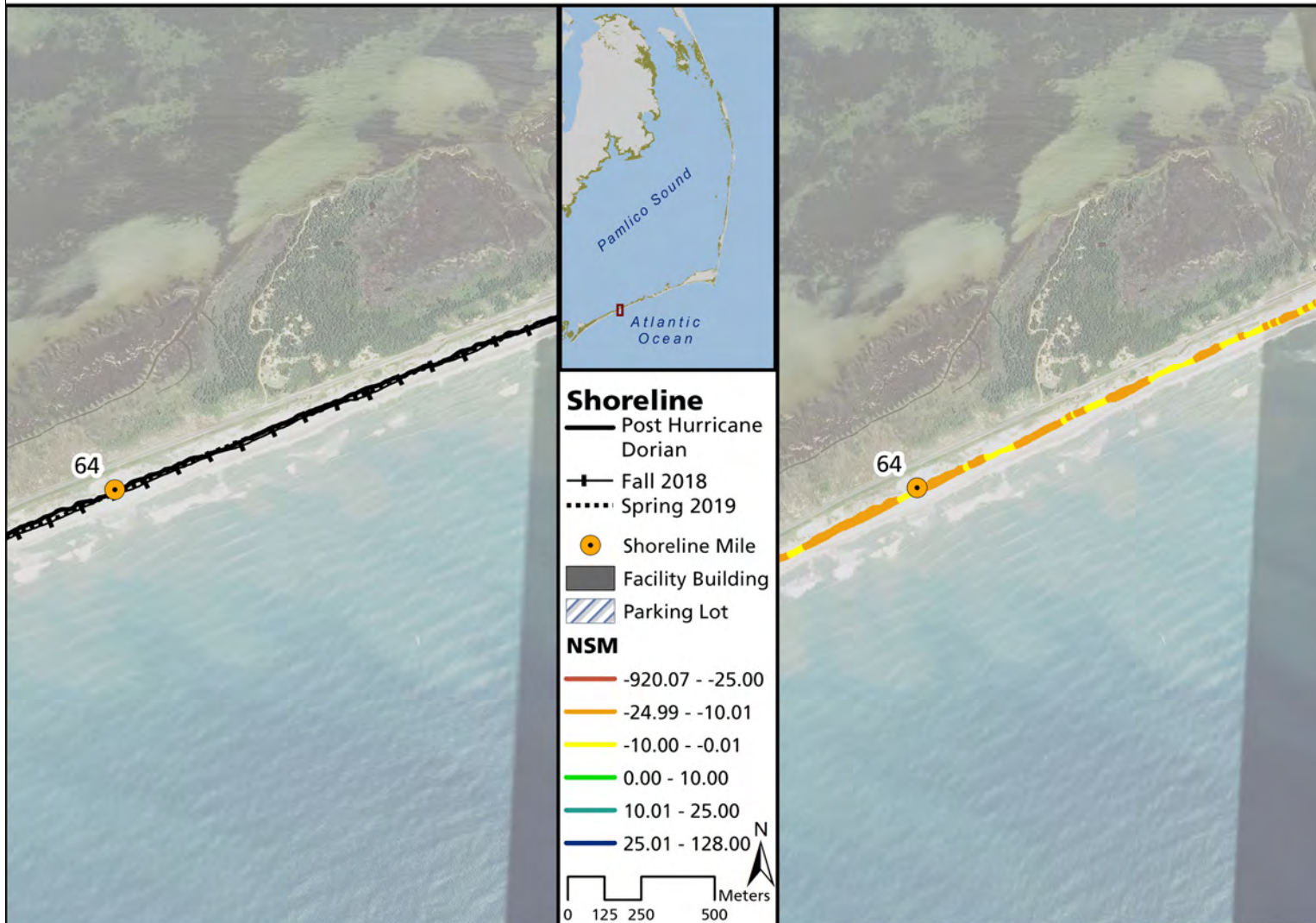


Figure B-51. Shoreline change in the vicinity of mile marker 64.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

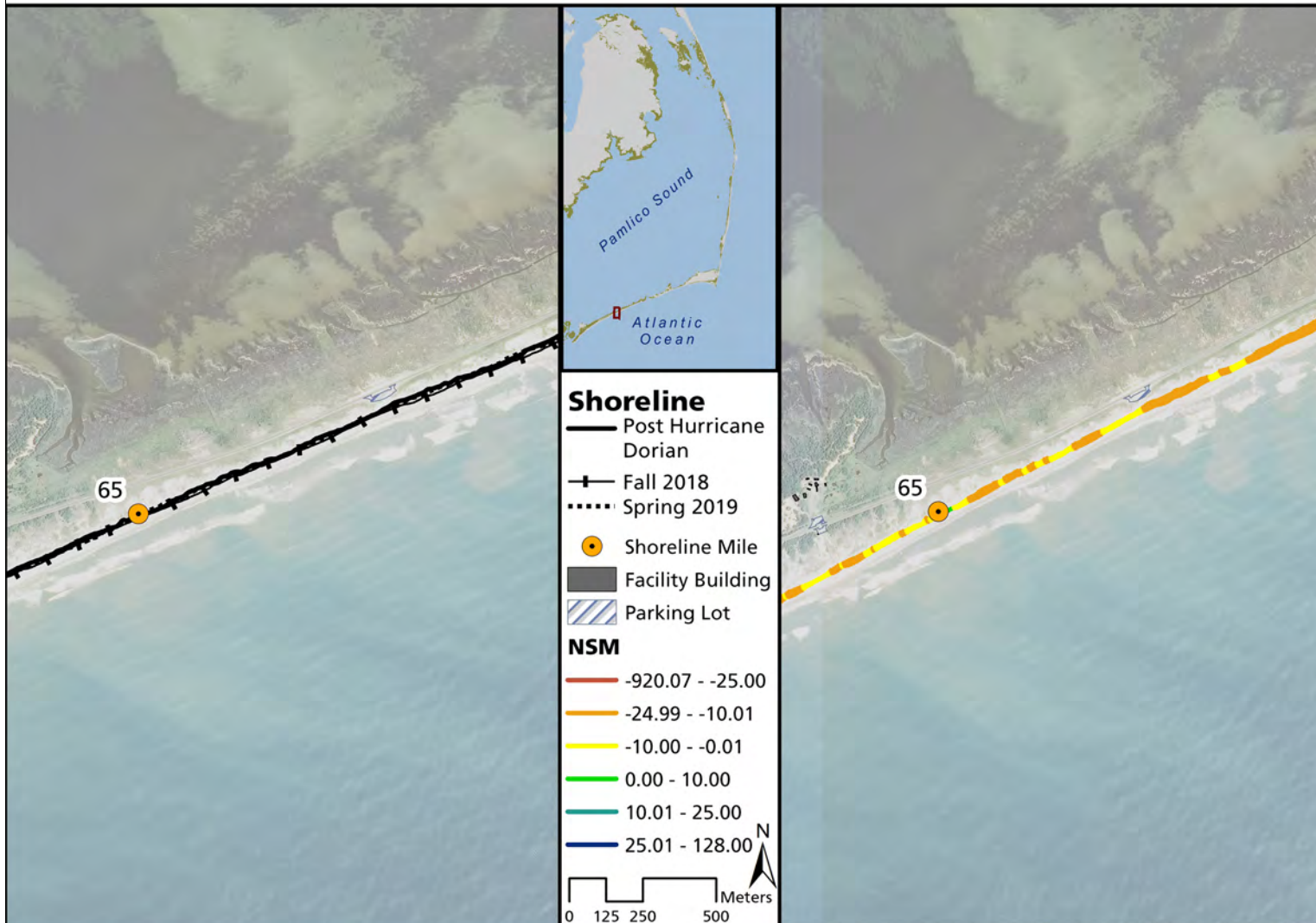


Figure B-52. Shoreline change in the vicinity of mile marker 65.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

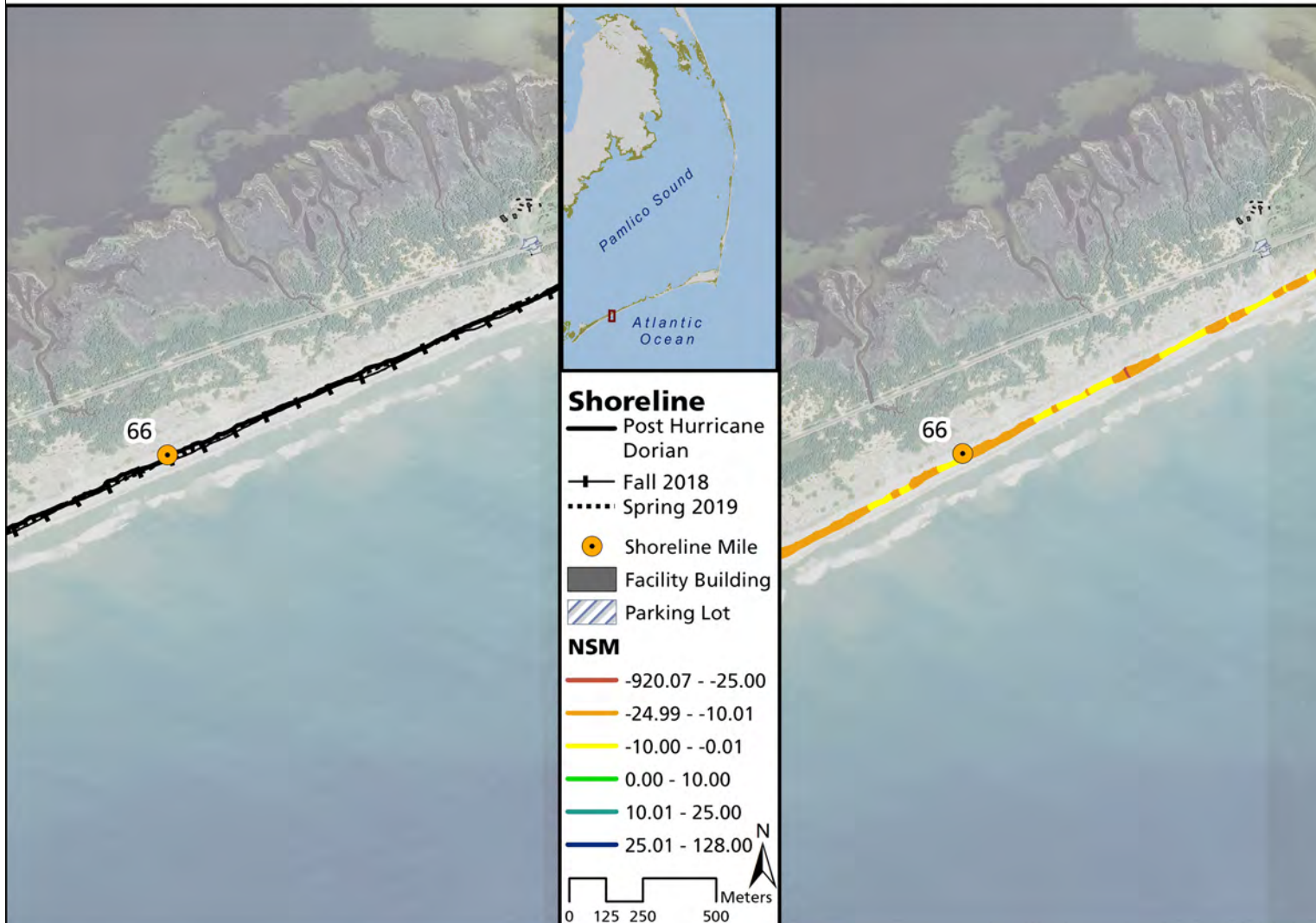


Figure B-53. Shoreline change in the vicinity of mile marker 66.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
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U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

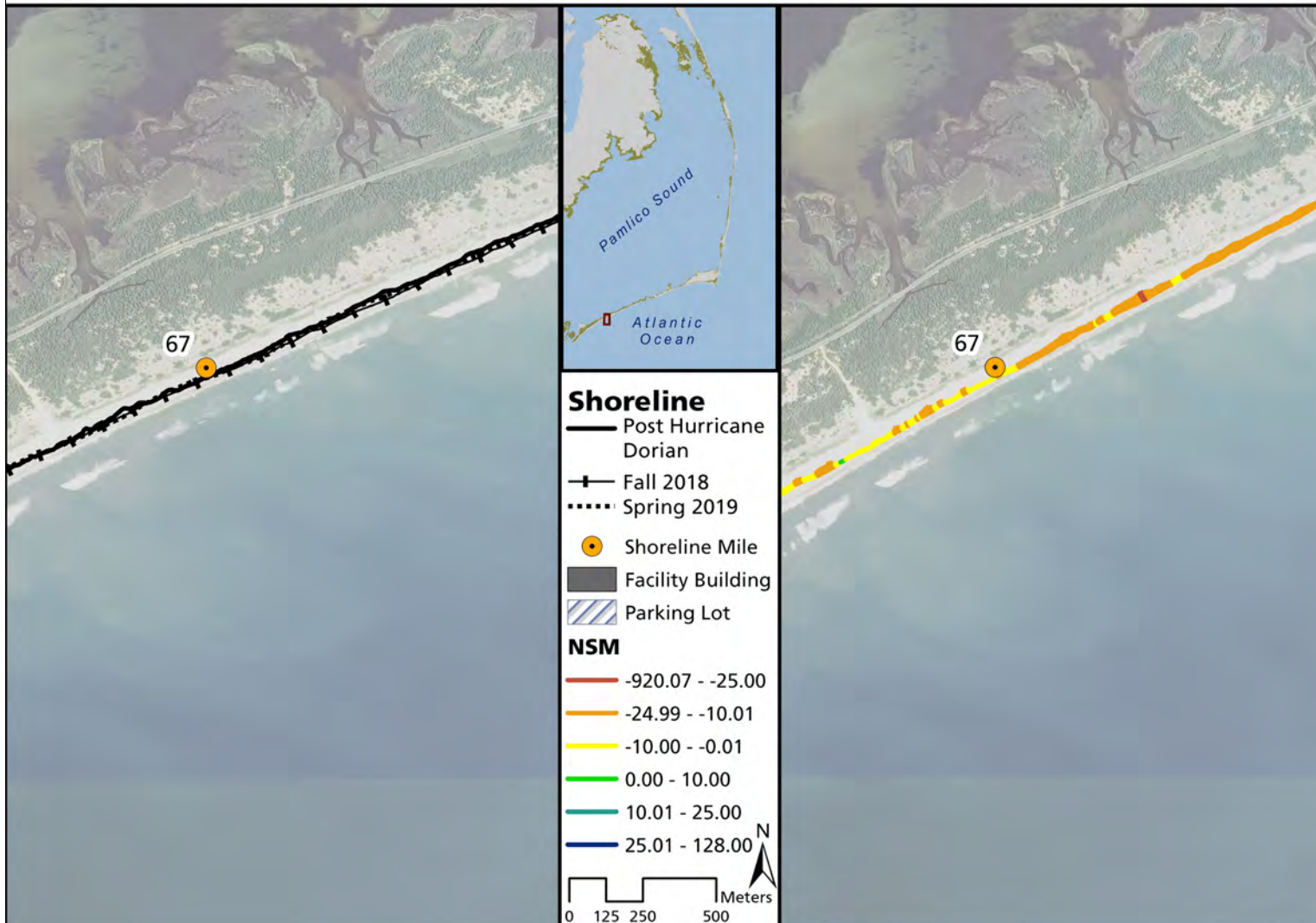


Figure B-54. Shoreline change in the vicinity of mile marker 67.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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National Park Service
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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

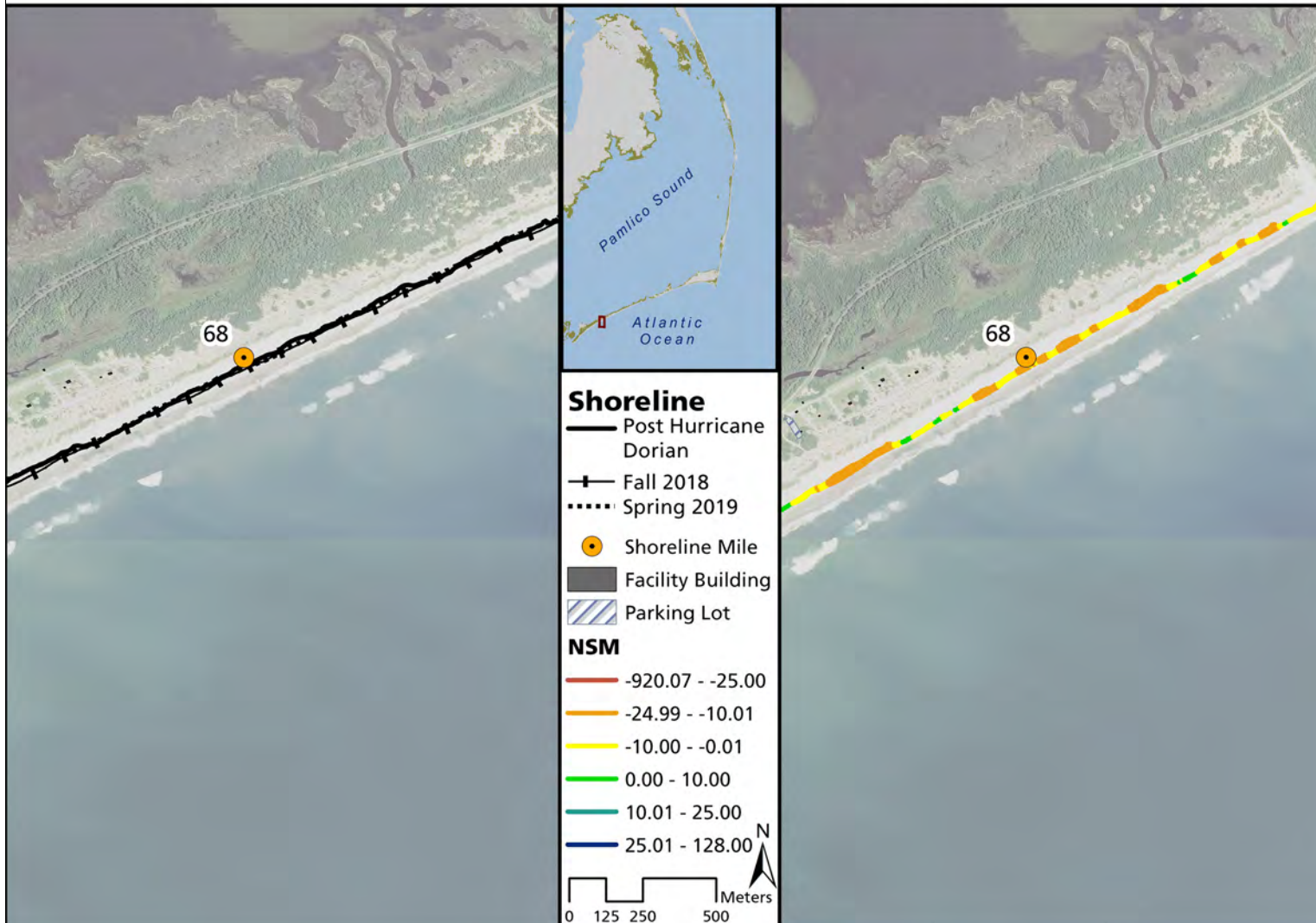


Figure B-55. Shoreline change in the vicinity of mile marker 68.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

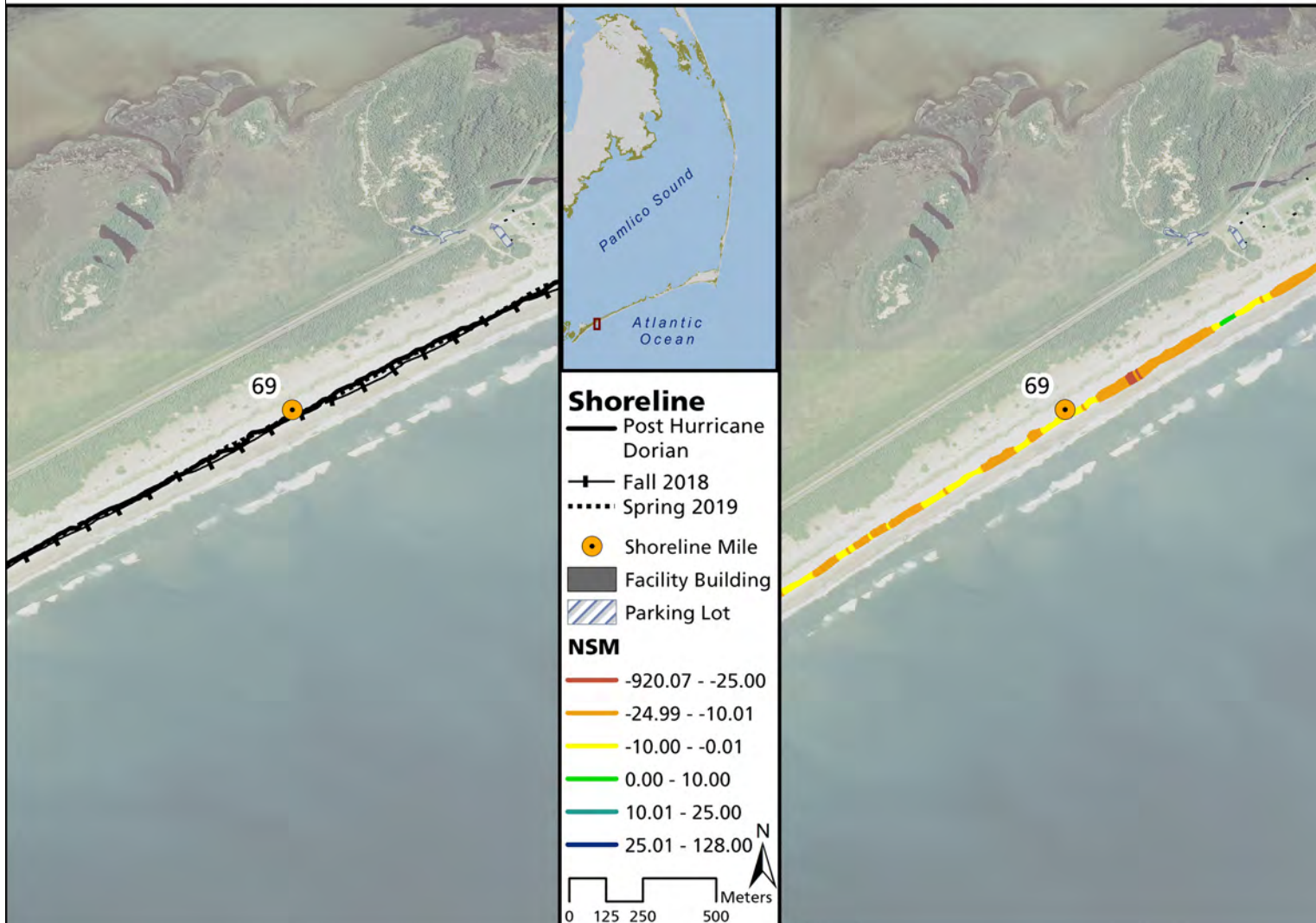


Figure B-56. Shoreline change in the vicinity of mile marker 69.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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National Park Service
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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

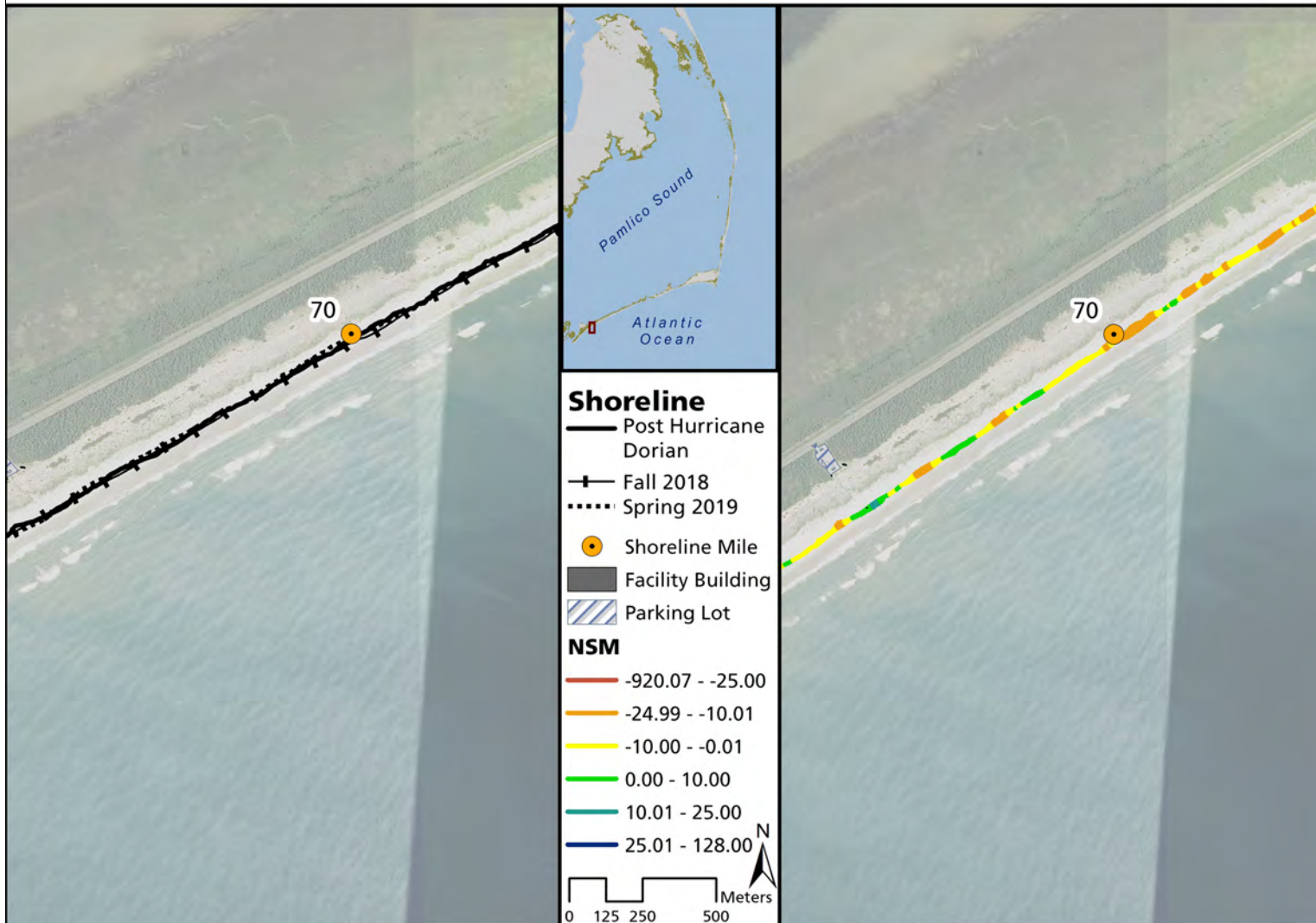


Figure B-57. Shoreline change in the vicinity of mile marker 70.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

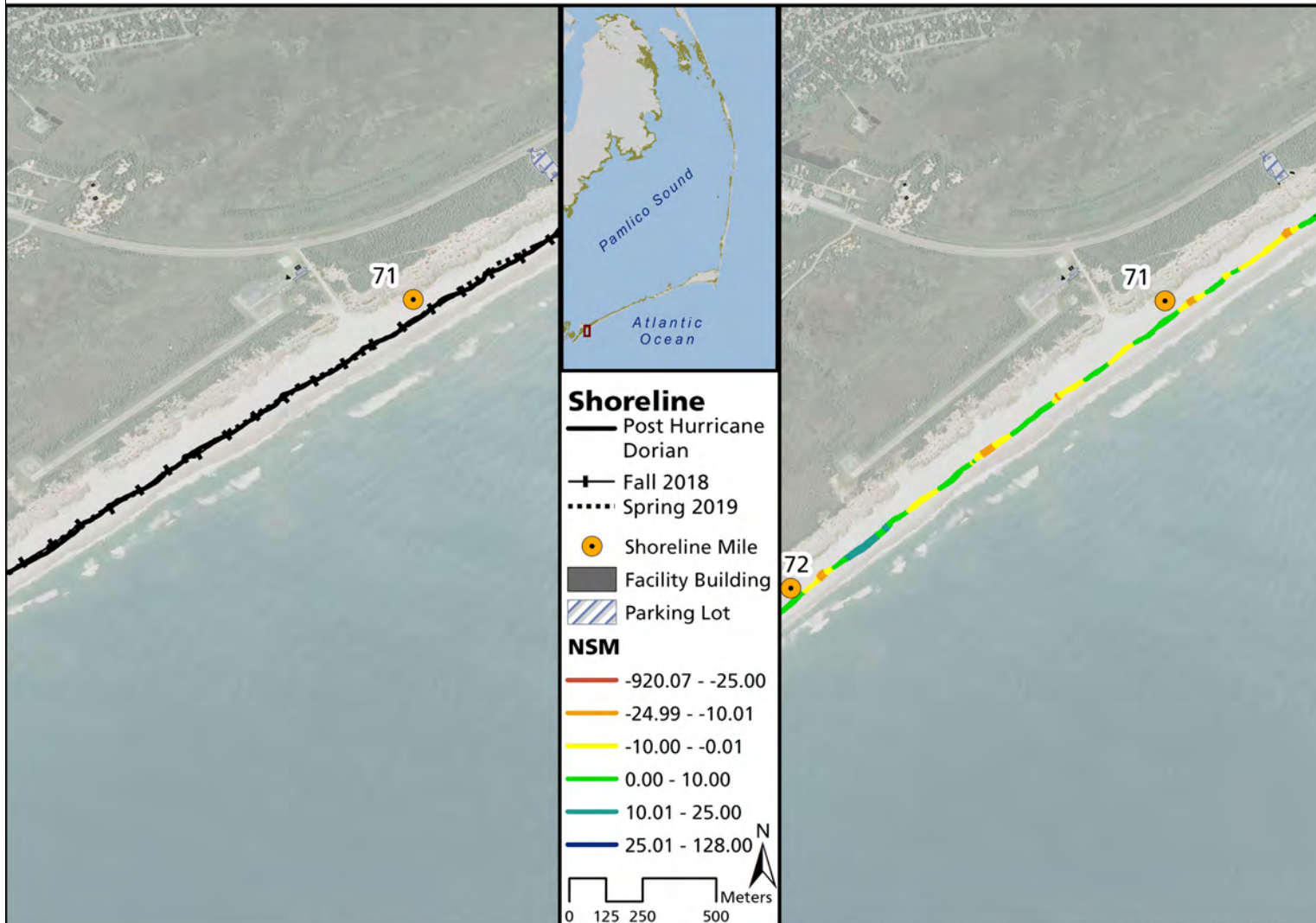


Figure B-58. Shoreline change in the vicinity of mile markers 71 and 72.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

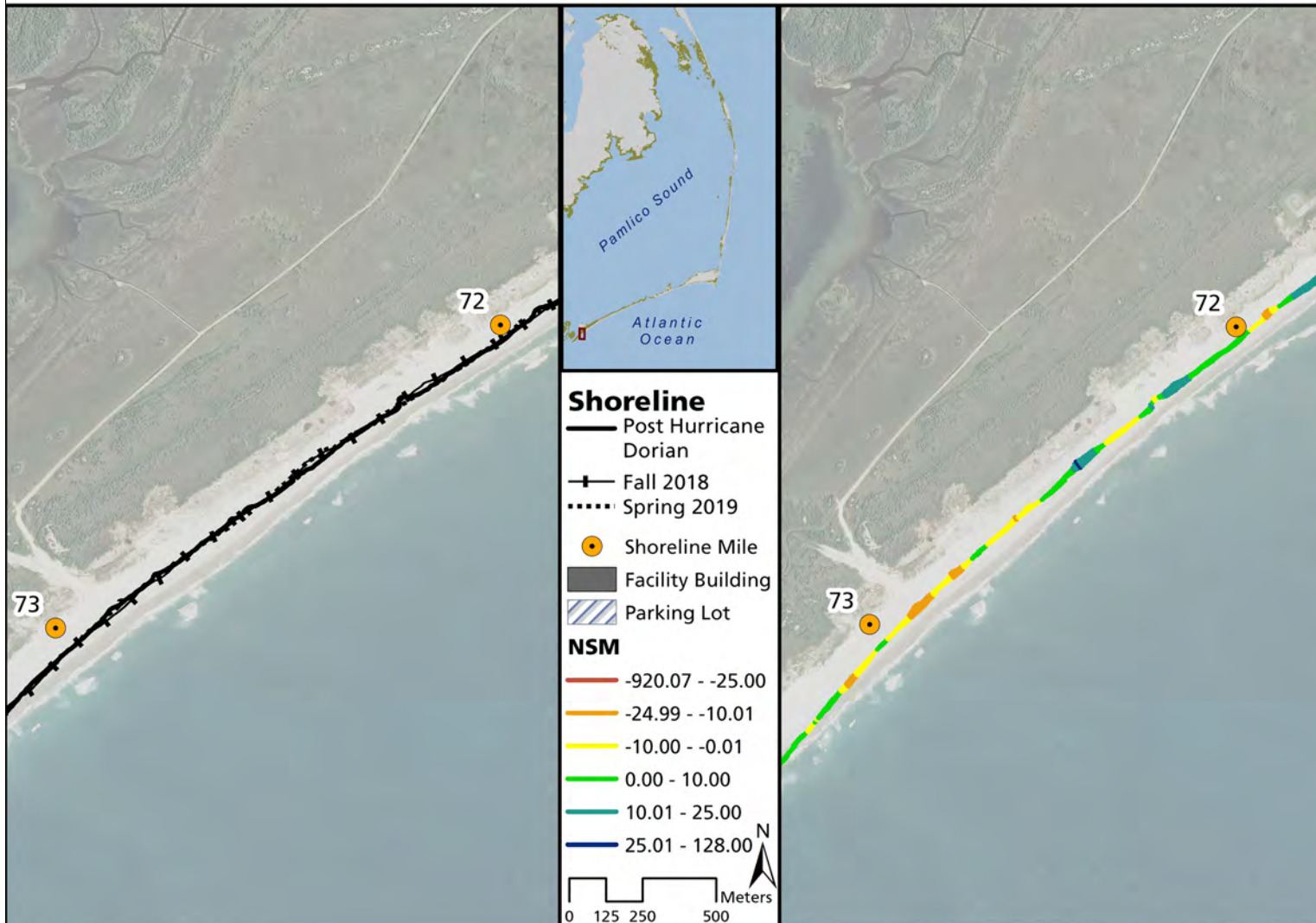


Figure B-59. Shoreline change in the vicinity of mile markers 72 and 73.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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National Park Service
U.S. Department of the Interior



Shoreline Data

Fall 2018 to Hurricane Dorian 2019

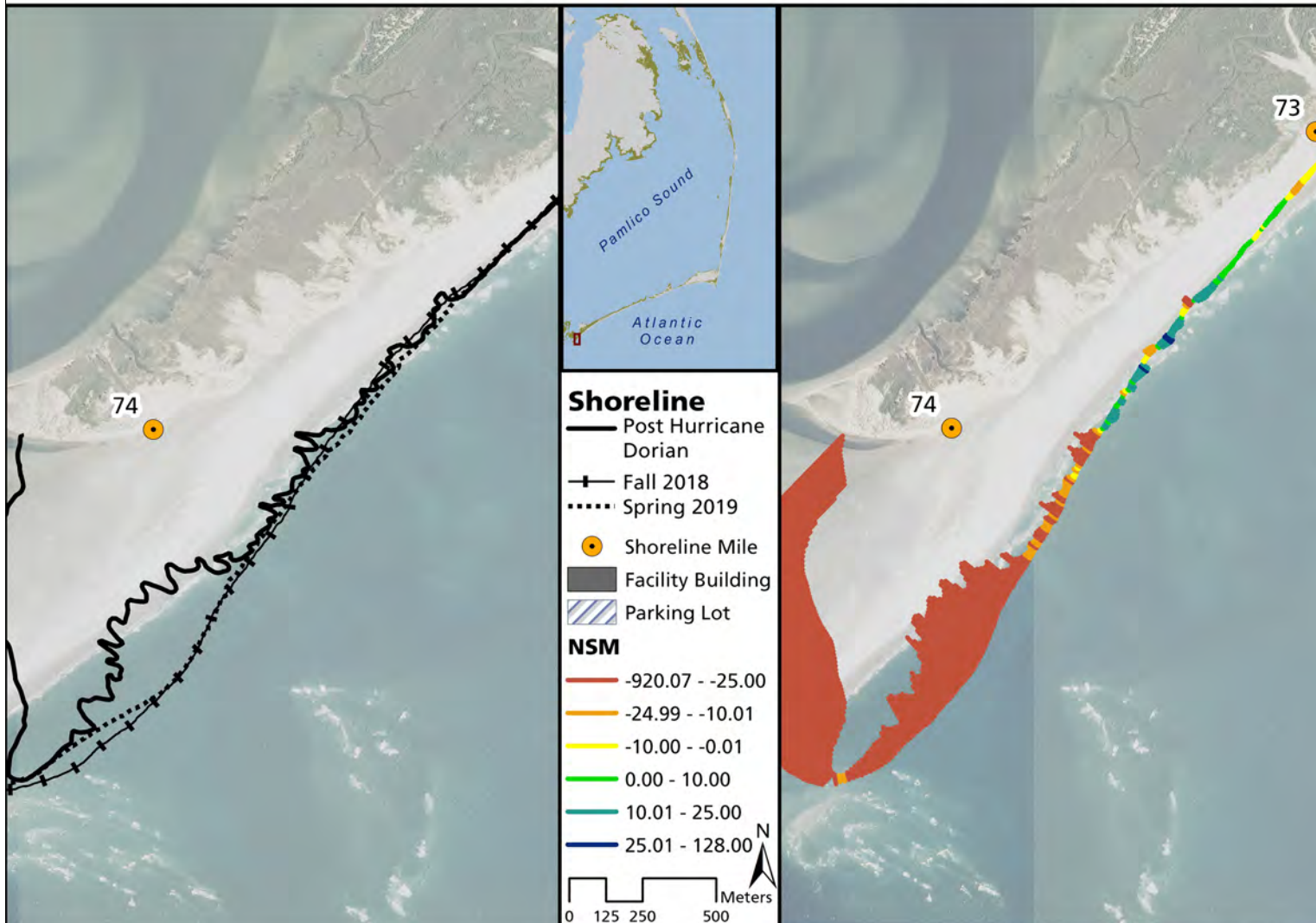


Figure B-60. Shoreline change in the vicinity of mile marker 68.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Fall 2018 to Hurricane Dorian 2019

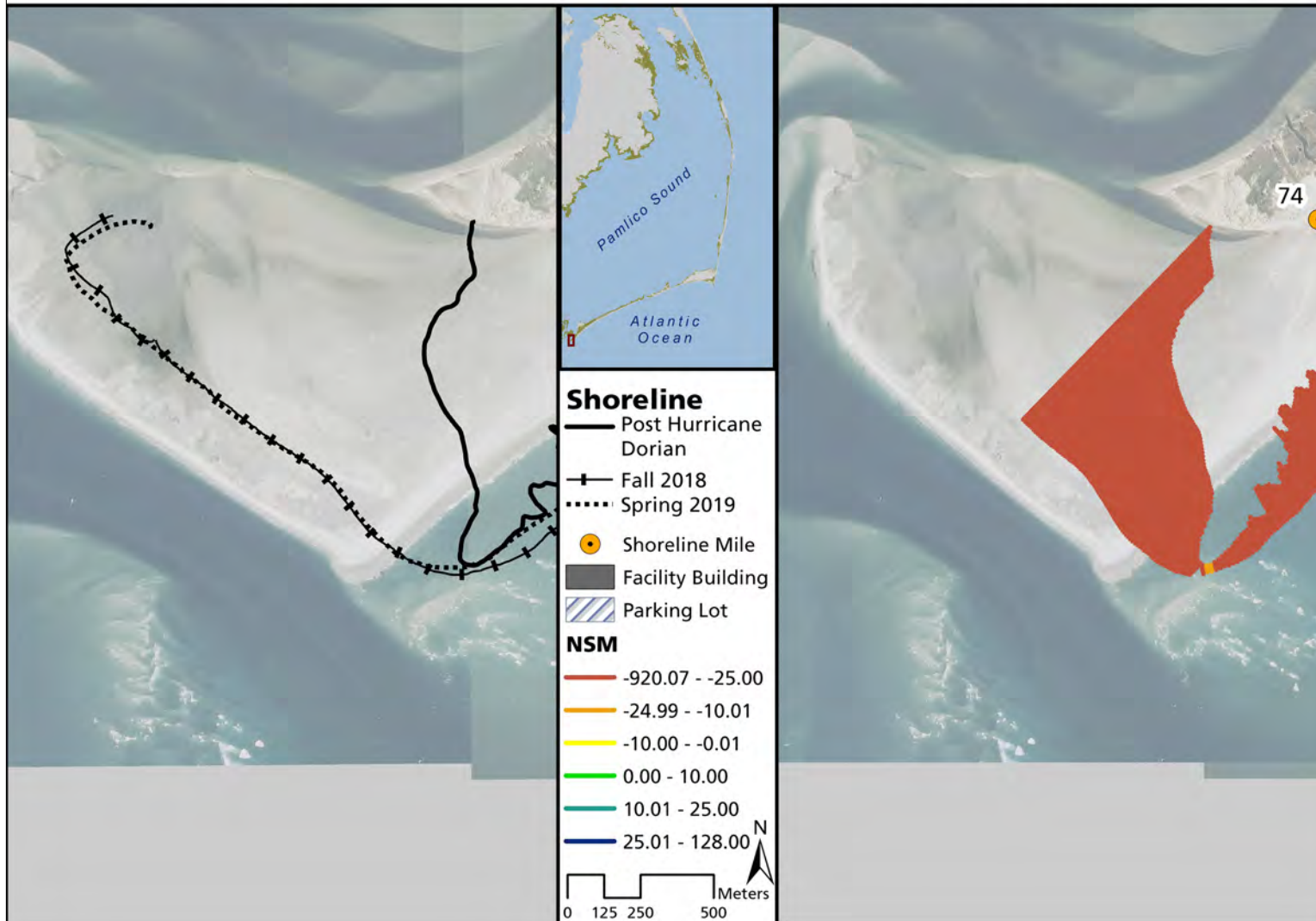


Figure B-61. Shoreline change in the vicinity of mile marker 74.

Appendix C. Spring 2019 to post-Dorian Shoreline Change Distance Maps

The following maps show the shoreline surveys collected and the spring 2019 to post-Dorian shoreline change at Cape Hatteras National Seashore. These maps show the post-Dorian (solid black line), fall 2018 (hatched line), and spring 2019 (dotted line) shoreline data collected. Additionally, these maps show the net shoreline movement (NSM), in meters, from spring 2019 to post-Dorian shoreline data collection. The red, orange, and yellow transects denote erosion and the light green, dark green, and blue transects denote accretion. The background image of these maps is from the 2012 National Agriculture Imagery Program. The inset map in the middle of the figure contains a red box that displays the location of the two map views, on the left and right side of the figure, within the park area.

Bodie Island

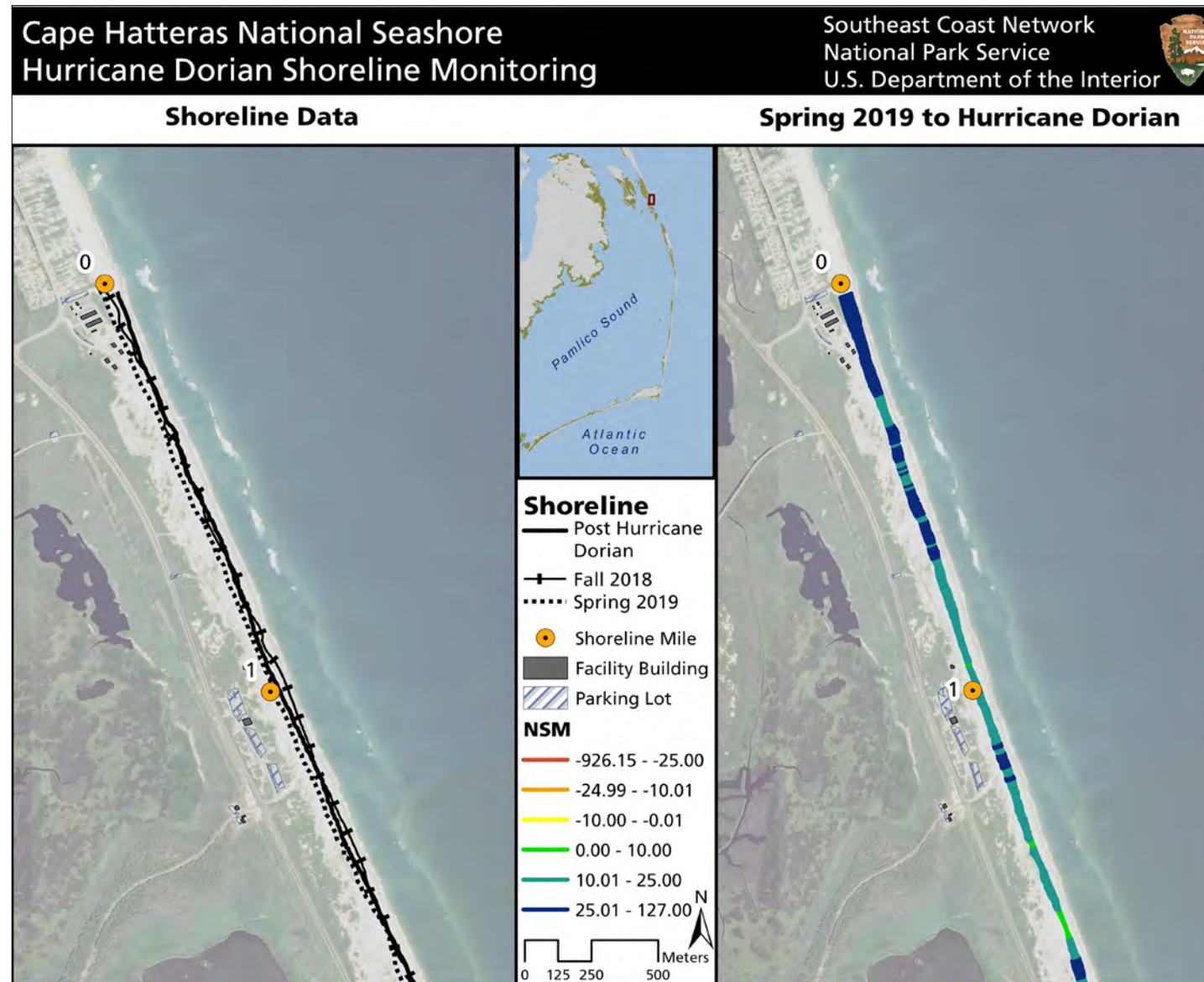


Figure C-1. Shoreline change in the vicinity of mile markers 0 and 1.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

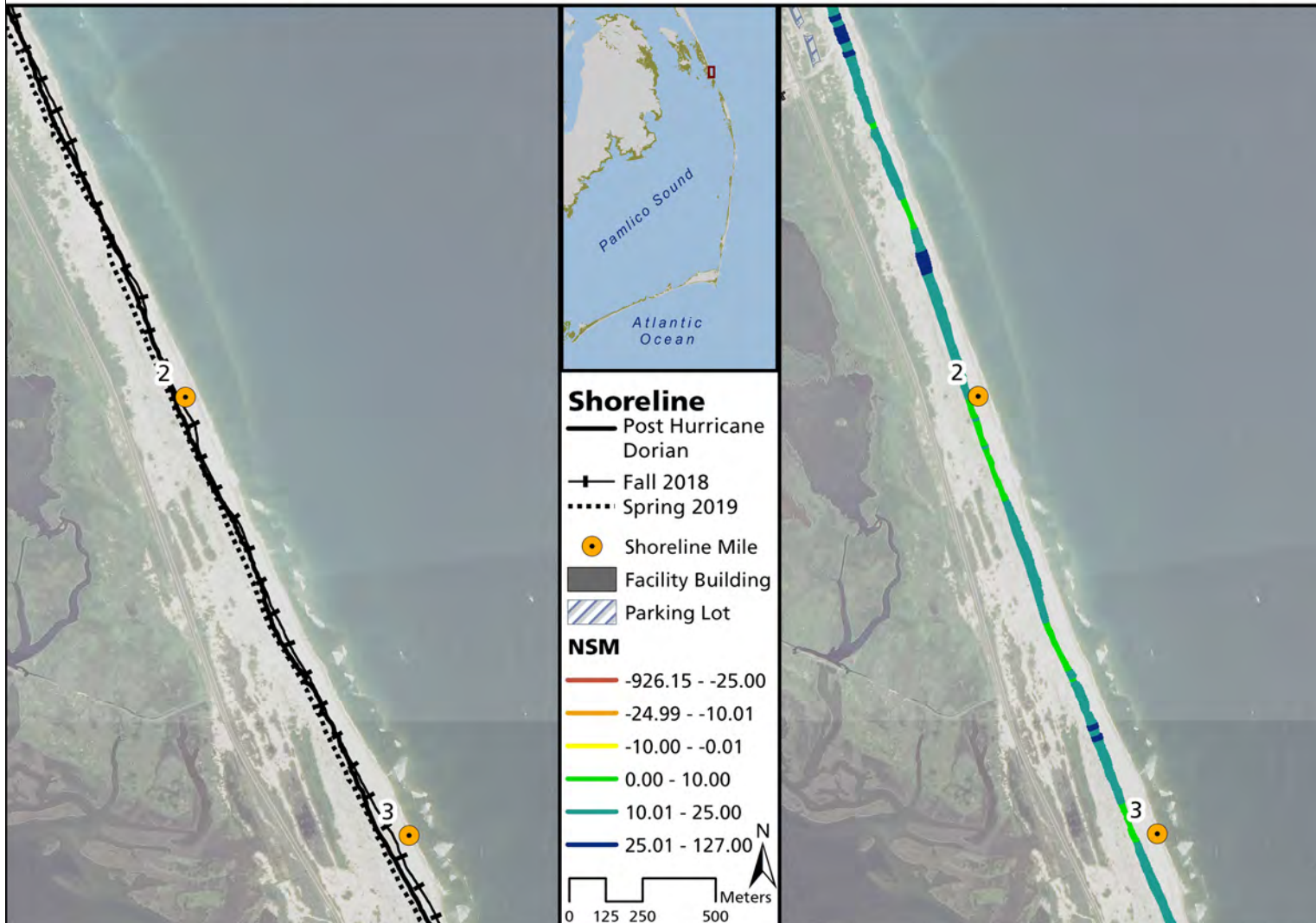


Figure C-2. Shoreline change in the vicinity of mile markers 2 and 3.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

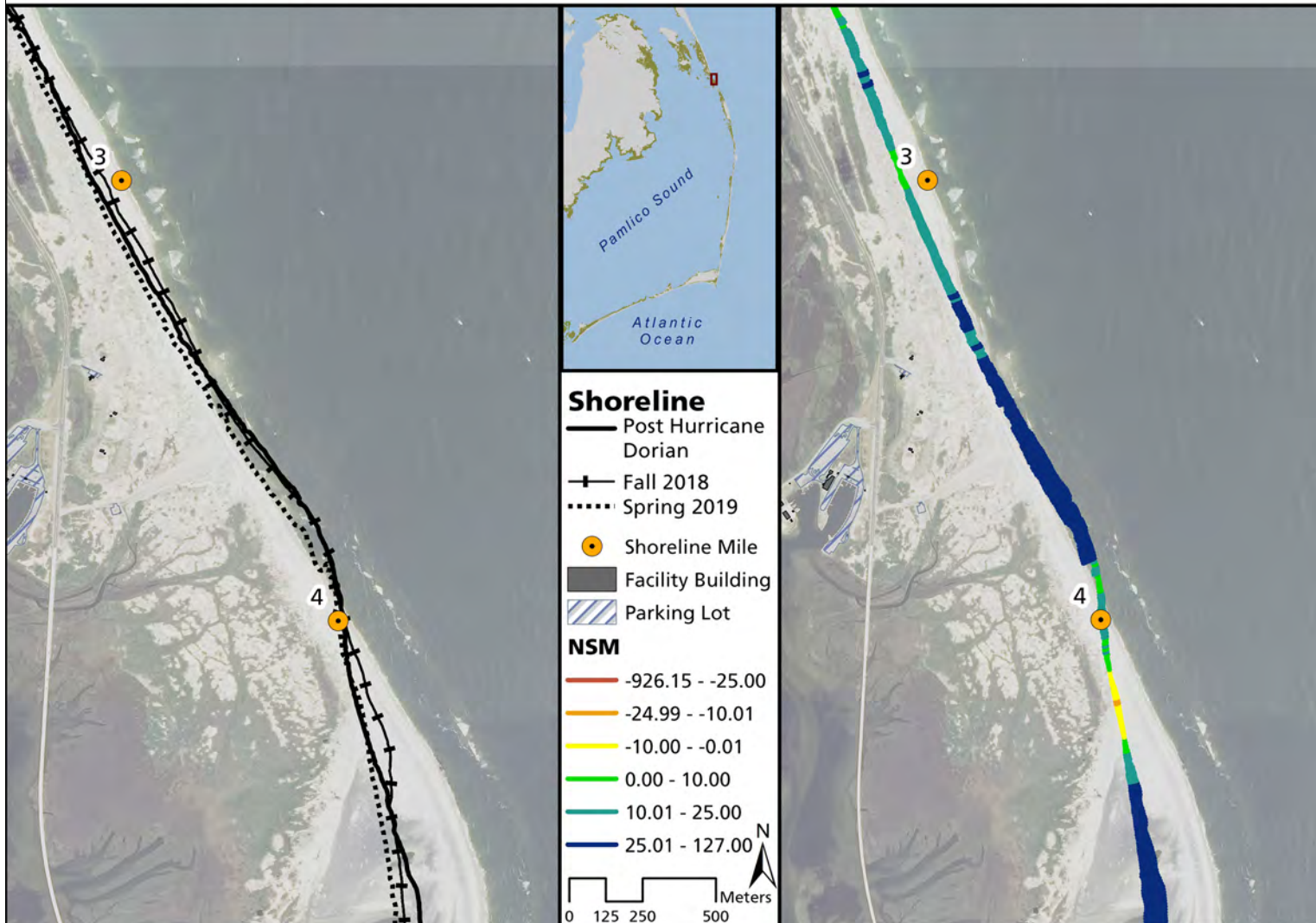


Figure C-3. Shoreline change in the vicinity of mile markers 3 and 4.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

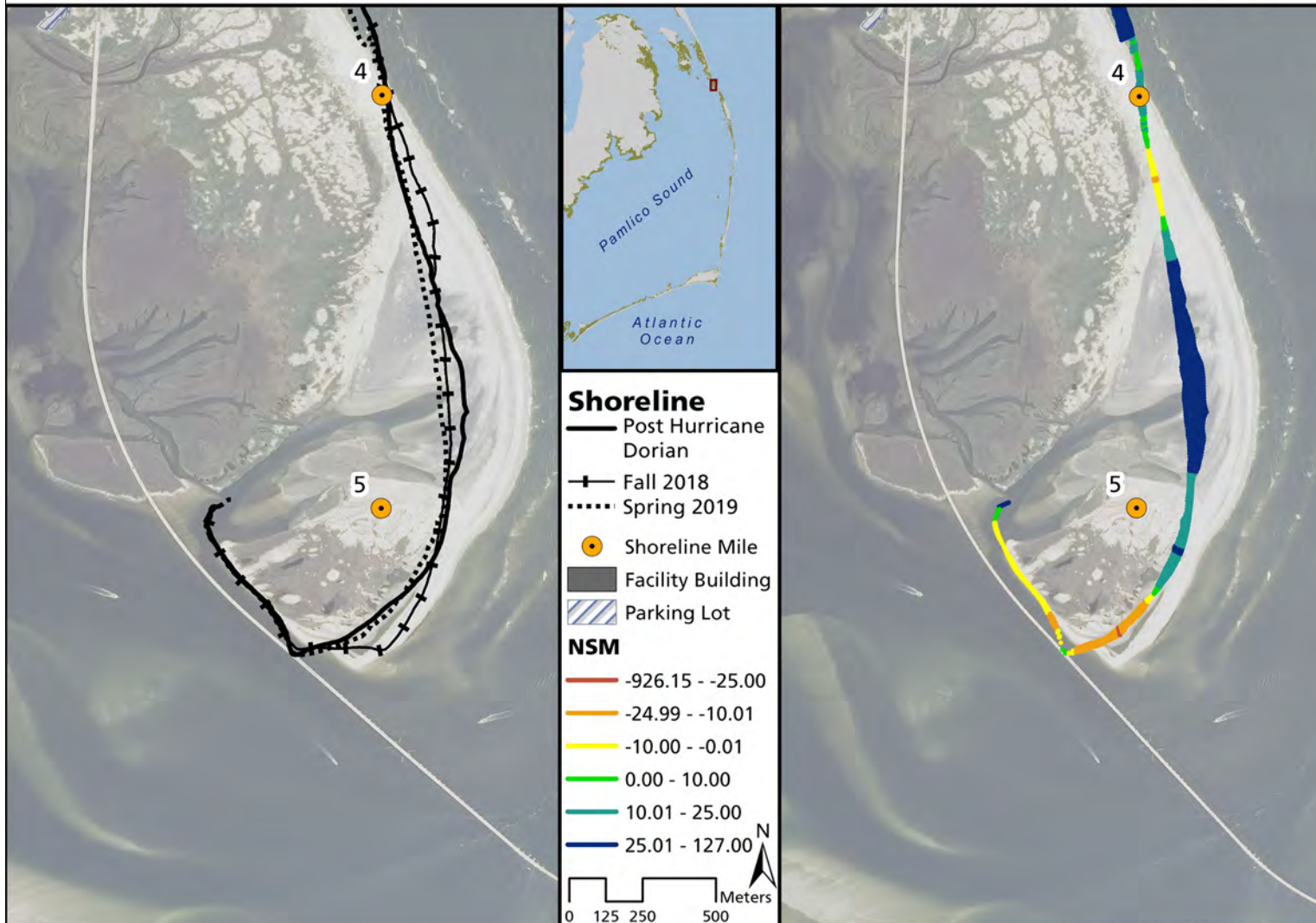


Figure C-4. Shoreline change in the vicinity of mile markers 4 and 5.

Hatteras Island

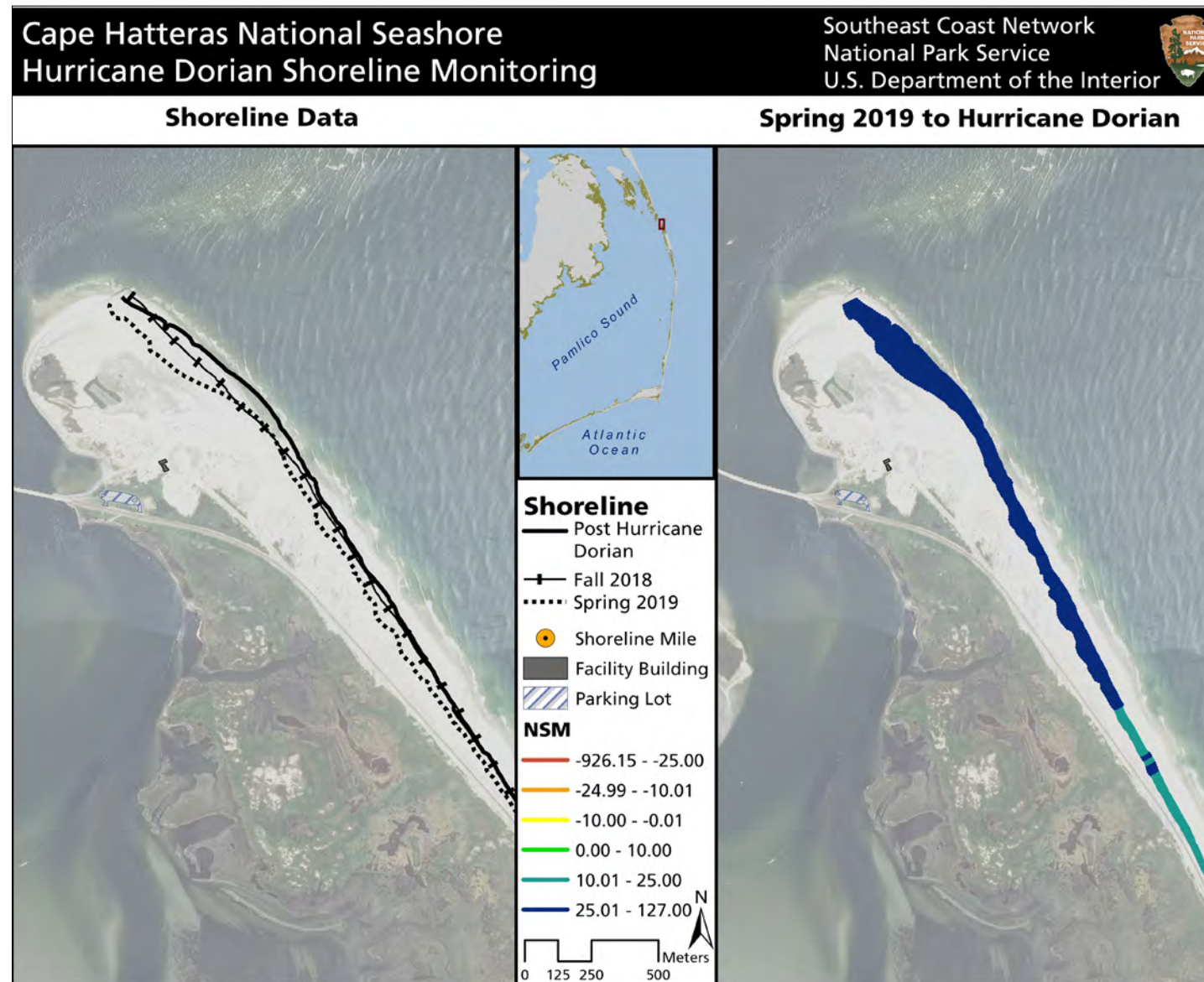


Figure C-5. Shoreline change in the vicinity of the north end of Hatteras Island, section 1.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
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Shoreline Data

Spring 2019 to Hurricane Dorian

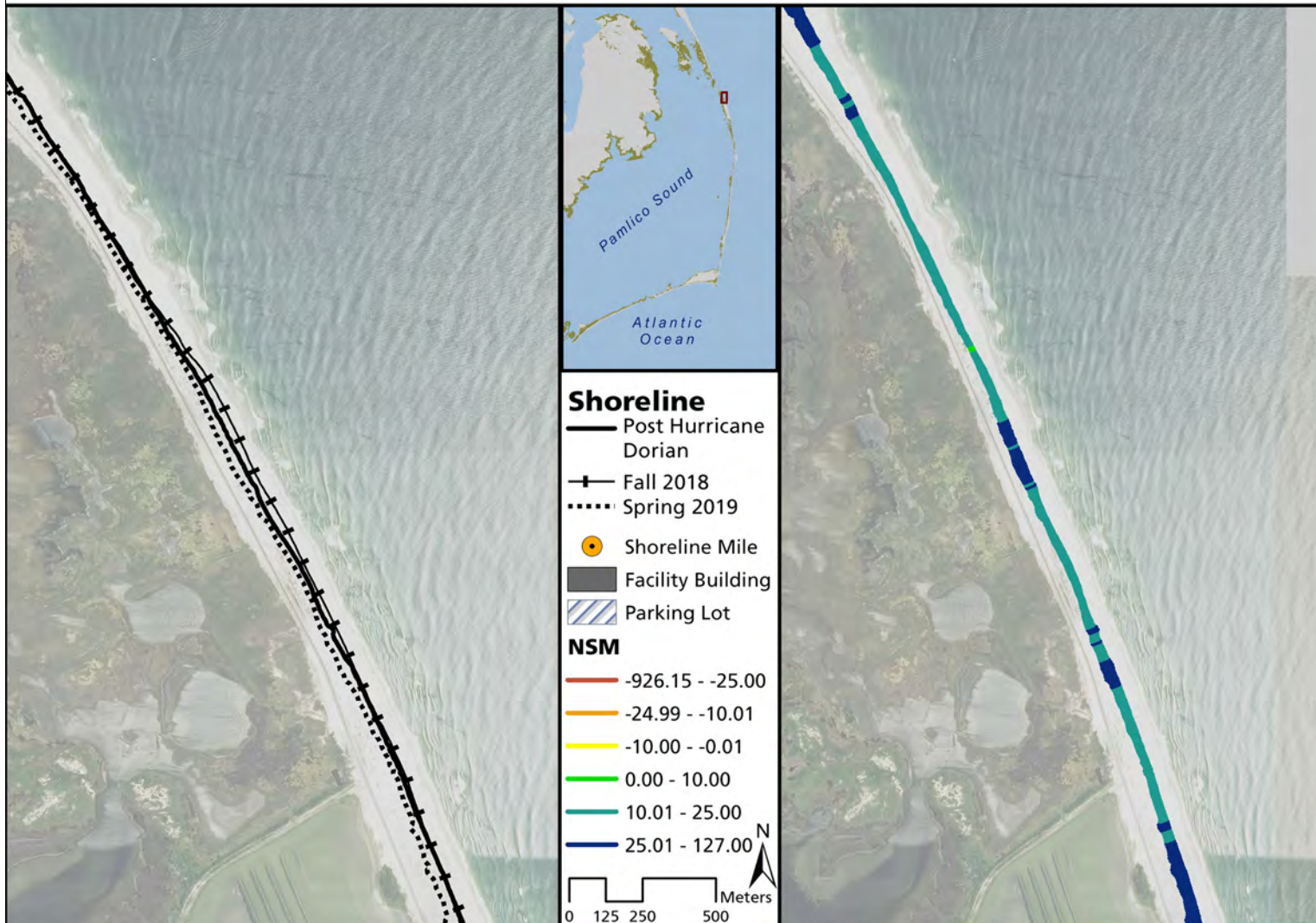


Figure C-6. Shoreline change in the vicinity of the north end of Hatteras Island, section 2.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

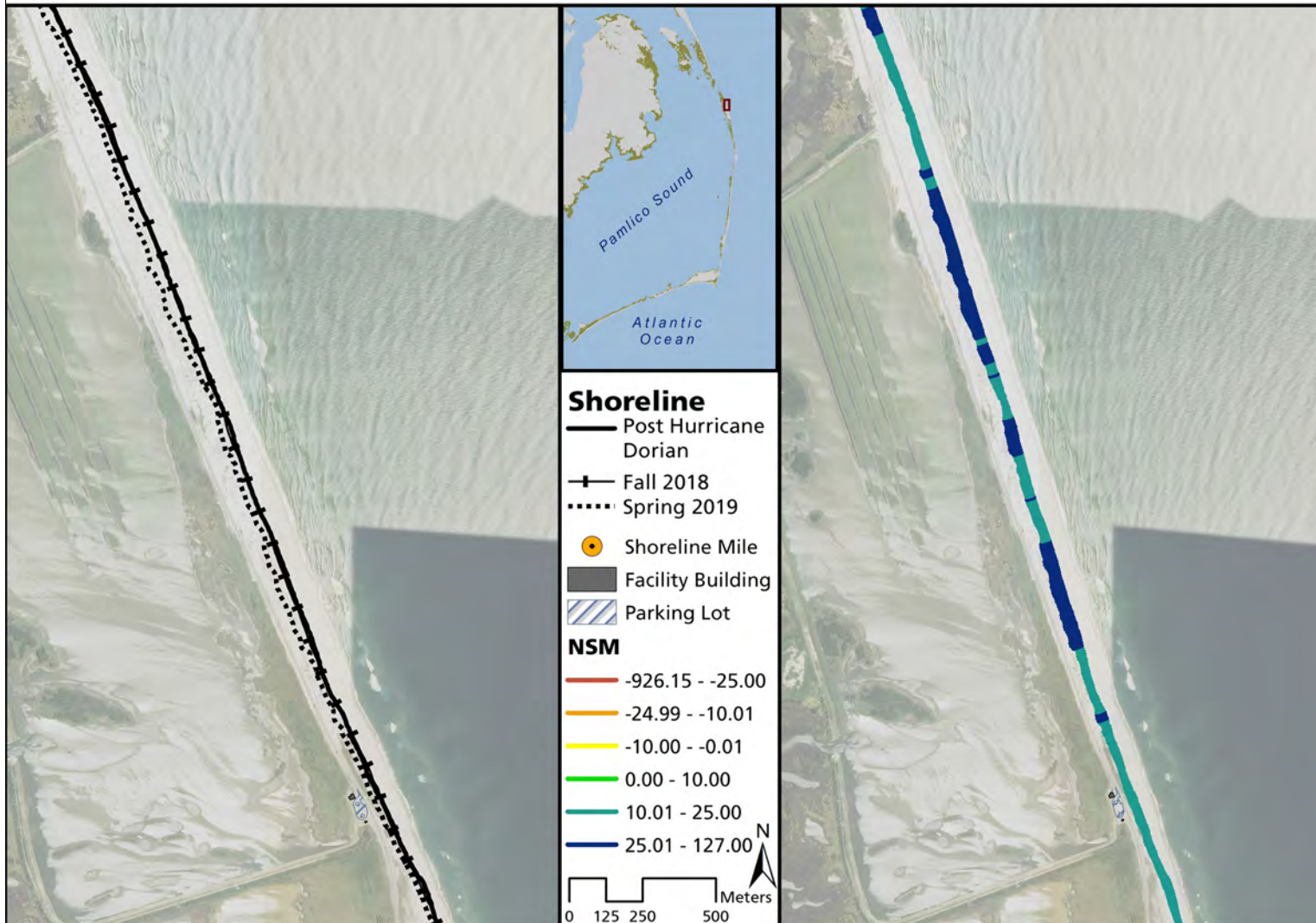


Figure C-7. Shoreline change in the vicinity of the north end of Hatteras Island, section 3.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

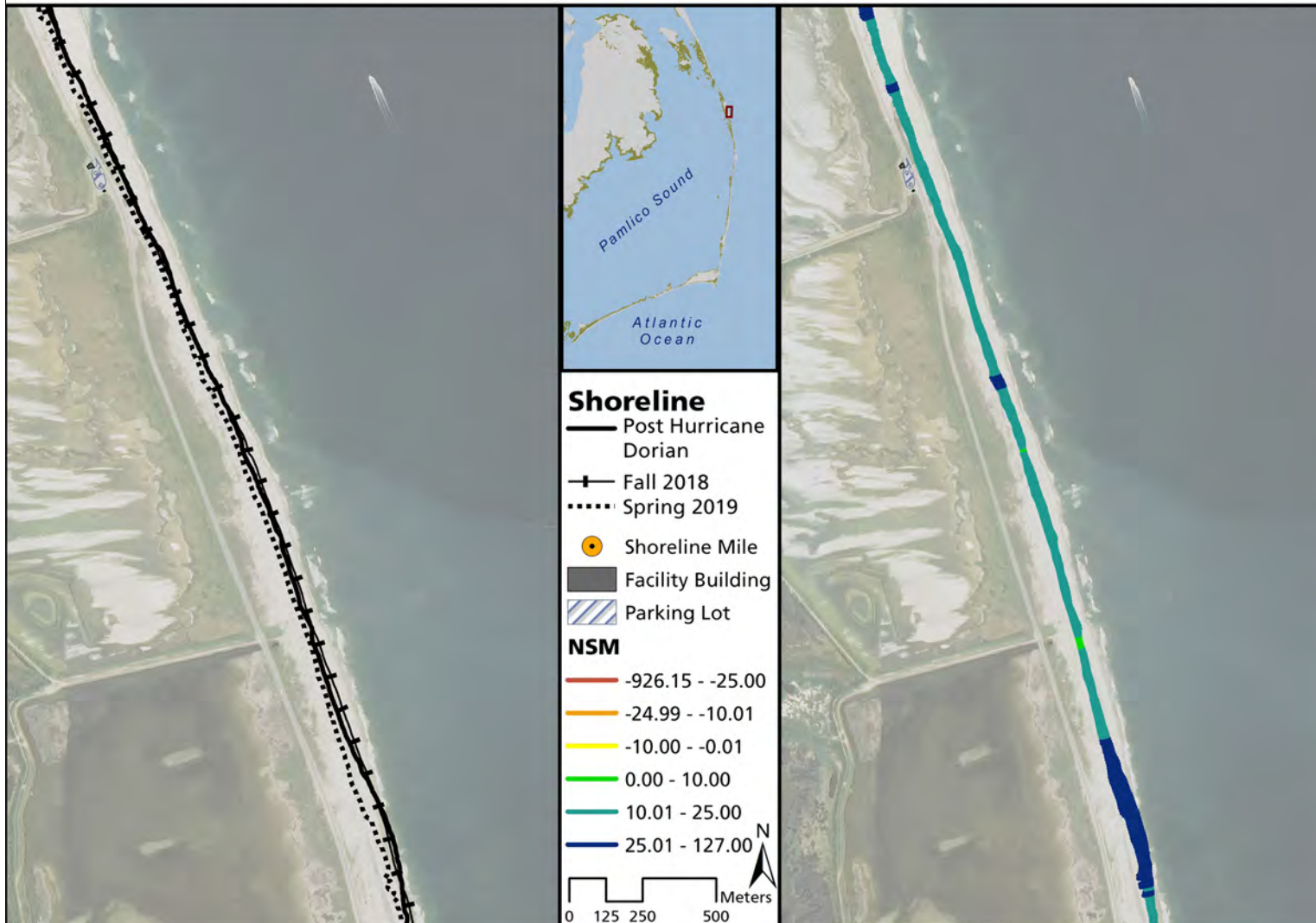


Figure C-8. Shoreline change in the vicinity of the north end of Hatteras Island, section 4.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

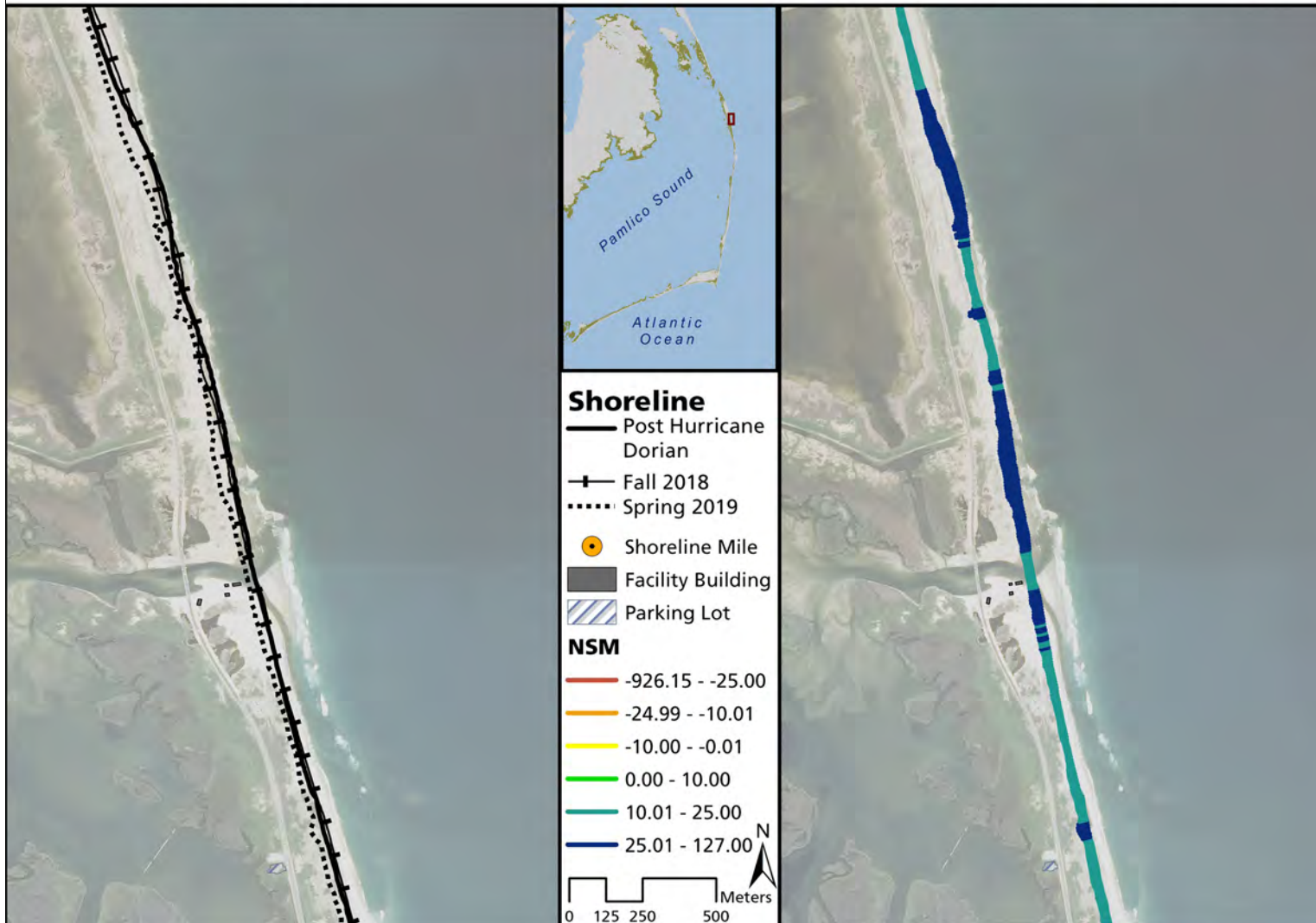


Figure C-9. Shoreline change in the vicinity of the north end of Hatteras Island, section 5.

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Shoreline Data

Spring 2019 to Hurricane Dorian

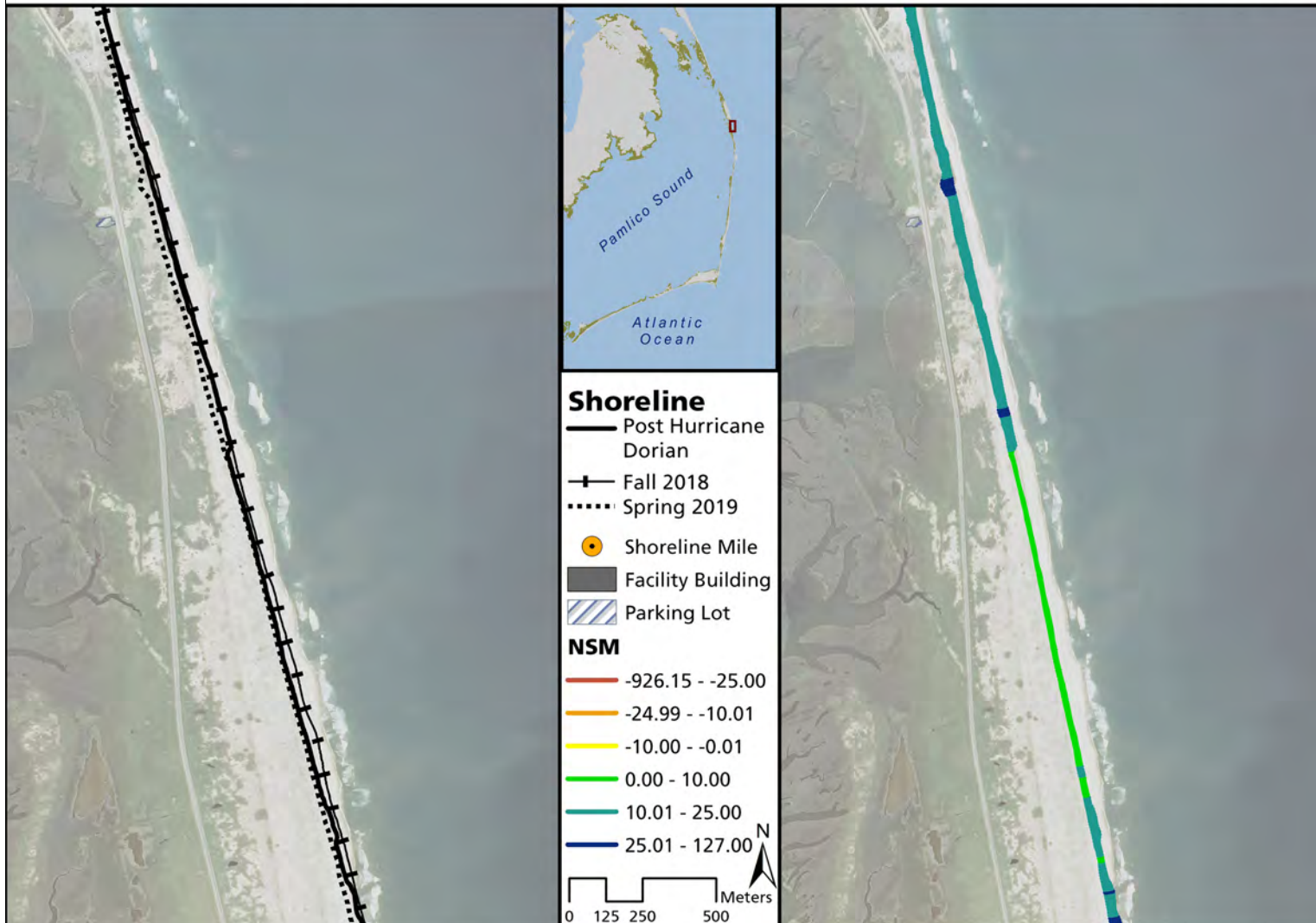


Figure C-10. Shoreline change in the vicinity of the north end of Hatteras Island, section 6.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

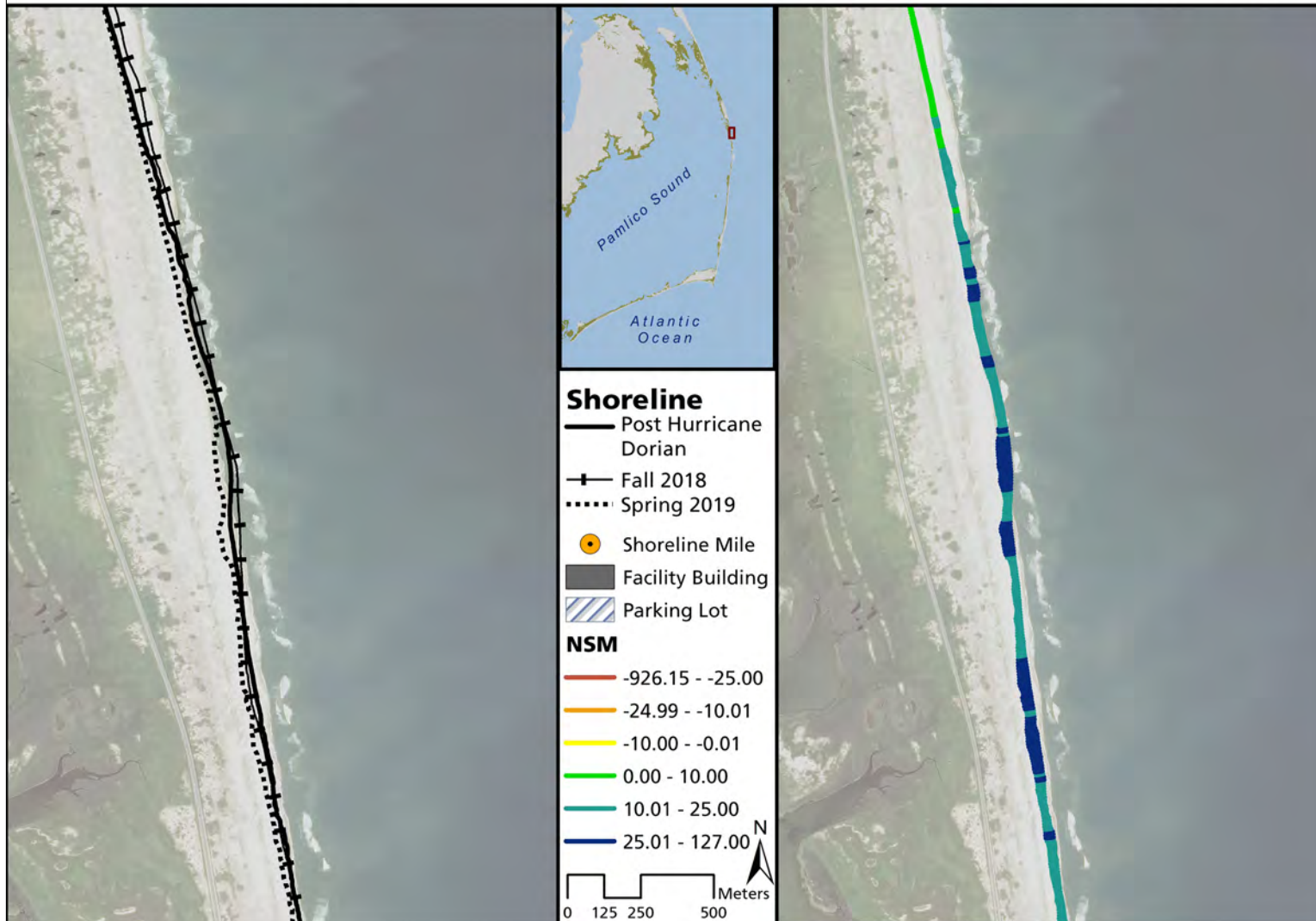


Figure C-11. Shoreline change in the vicinity of the north end of Hatteras Island, section 7.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

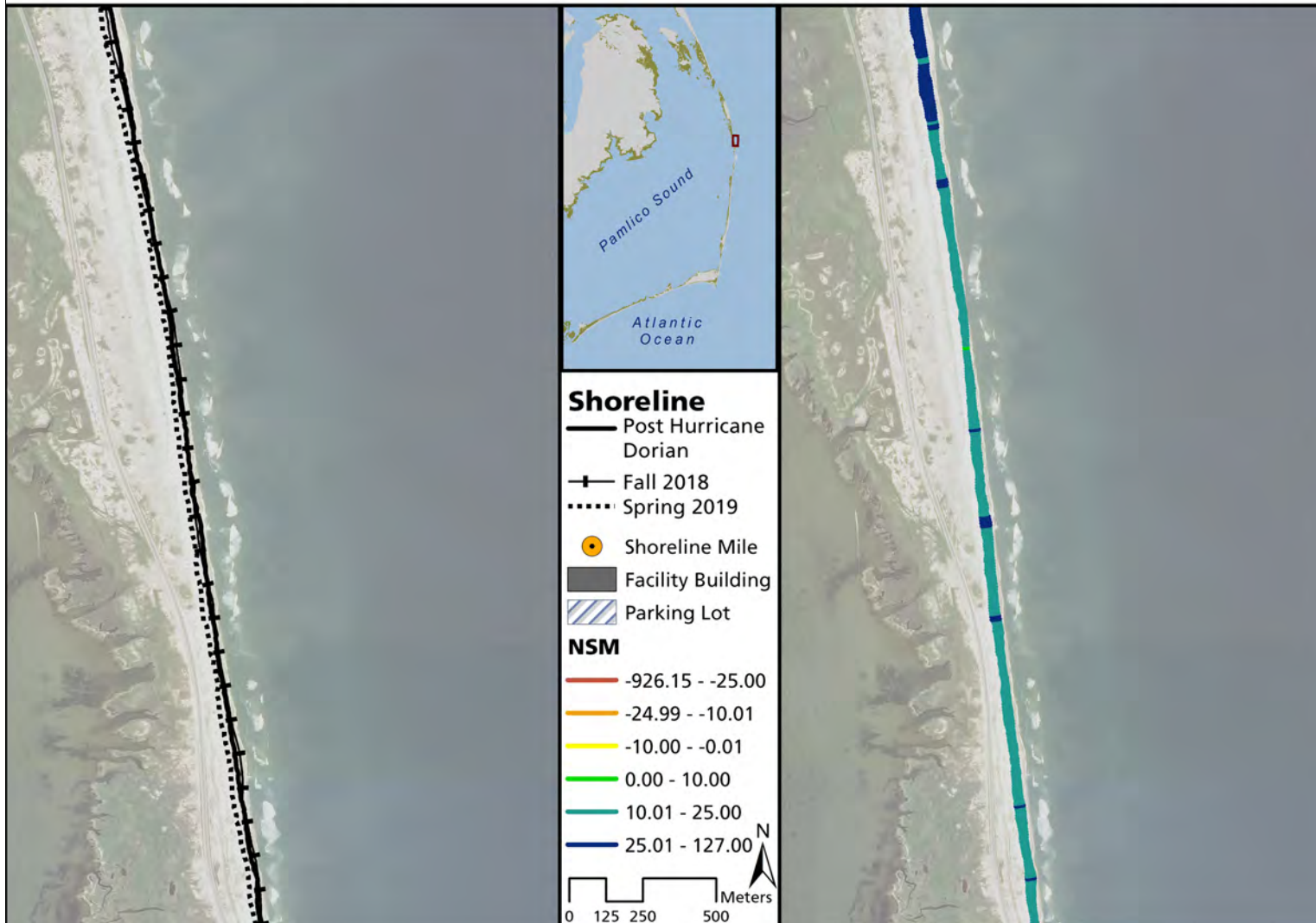


Figure C-12. Shoreline change in the vicinity of the north end of Hatteras Island, section 8.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

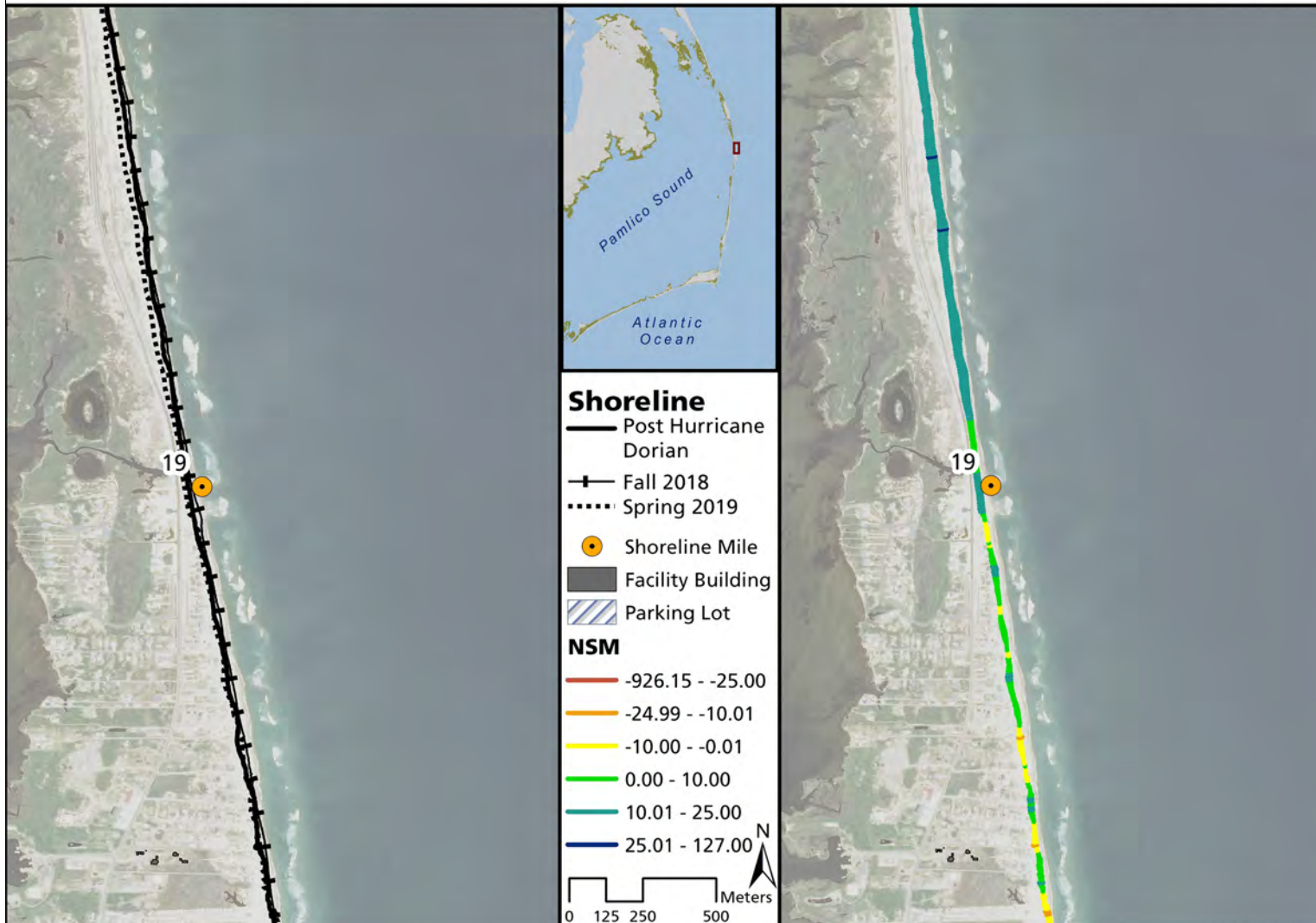


Figure C-13. Shoreline change in the vicinity of mile marker 19.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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U.S. Department of the Interior



Shoreline Data

Spring 2019 to Hurricane Dorian

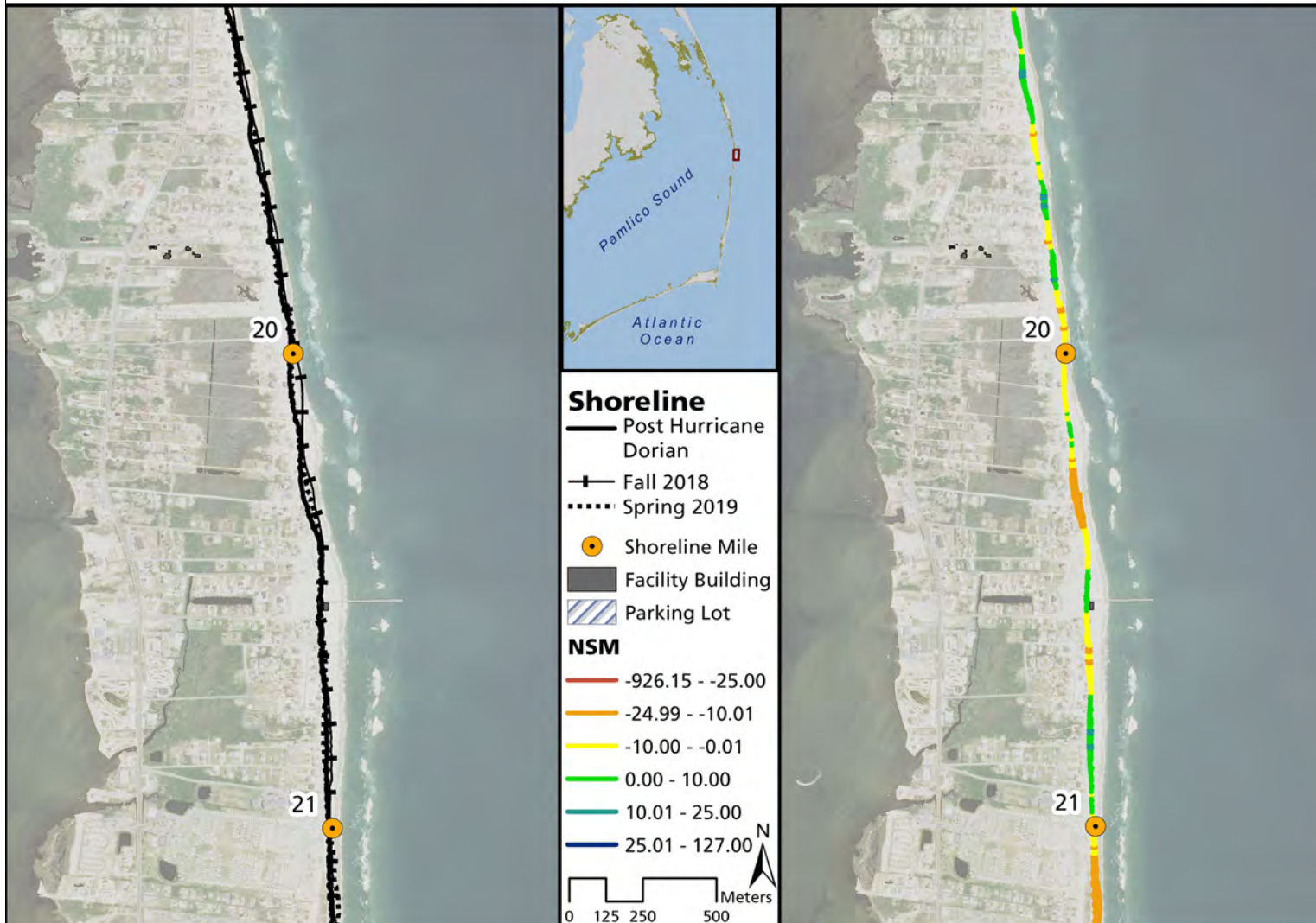


Figure C-14. Shoreline change in the vicinity of mile markers 20 and 21.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

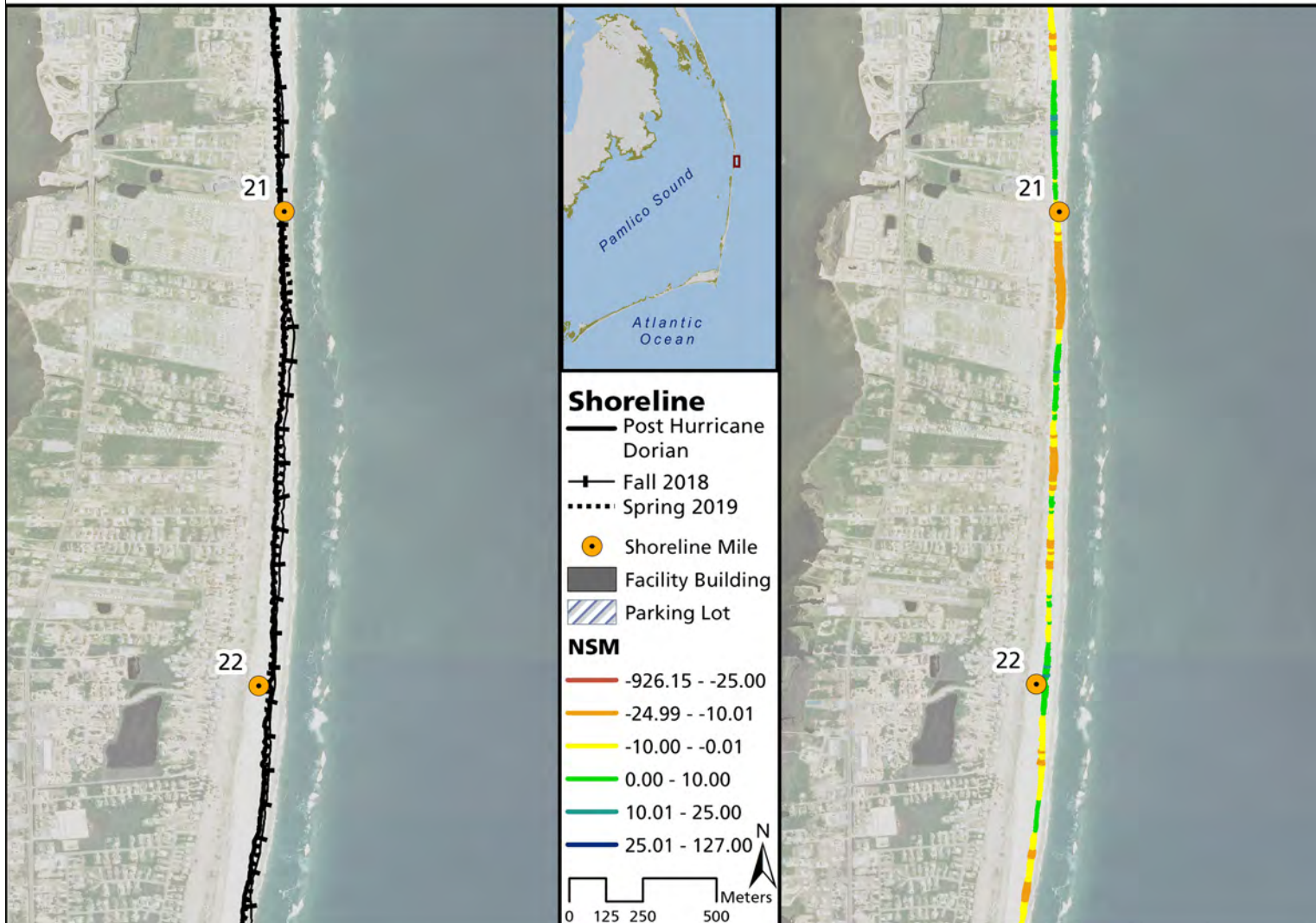


Figure C-15. Shoreline change in the vicinity of mile markers 21 and 22.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

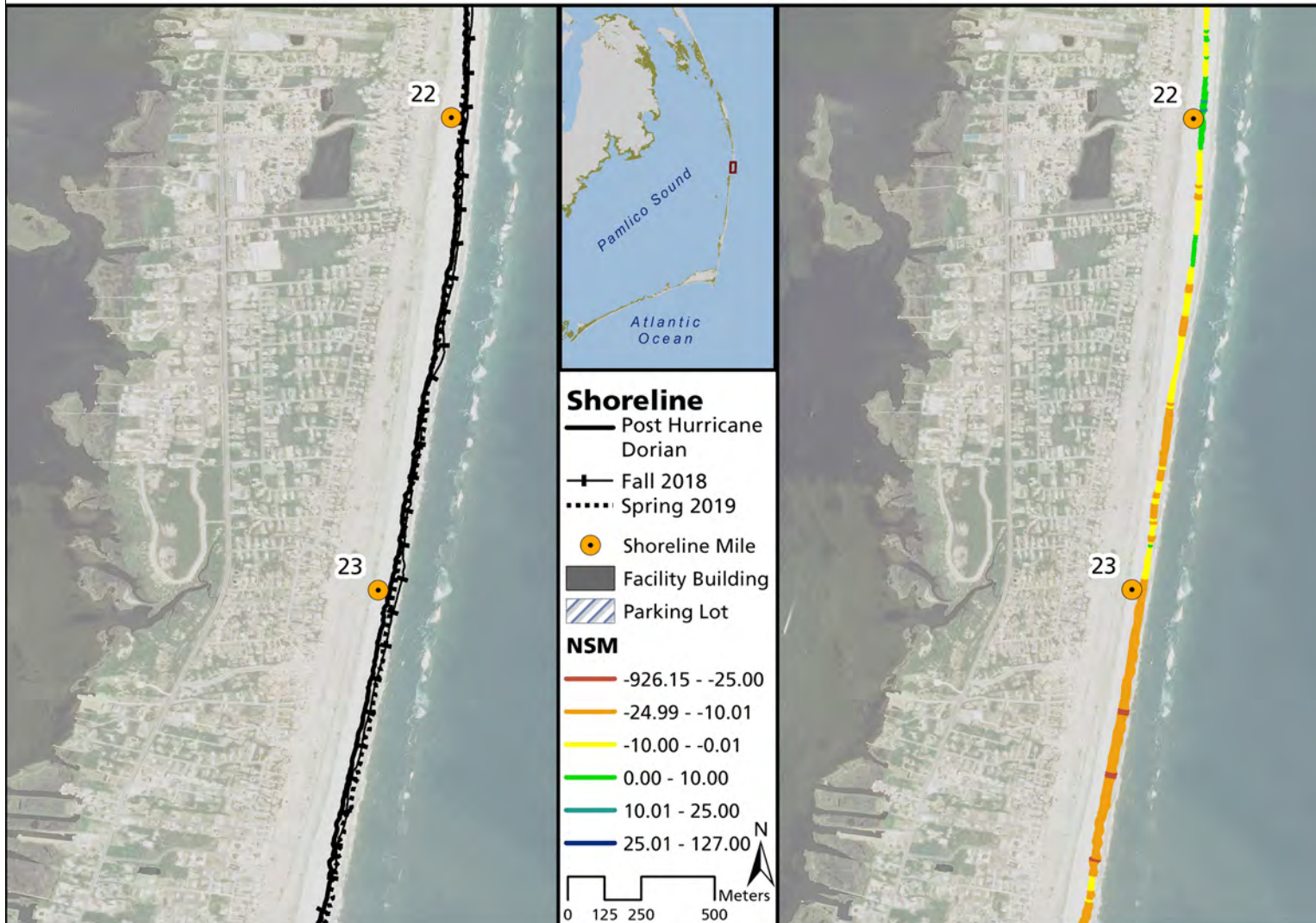


Figure C-16. Shoreline change in the vicinity of mile markers 22 and 23.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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National Park Service
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Shoreline Data

Spring 2019 to Hurricane Dorian

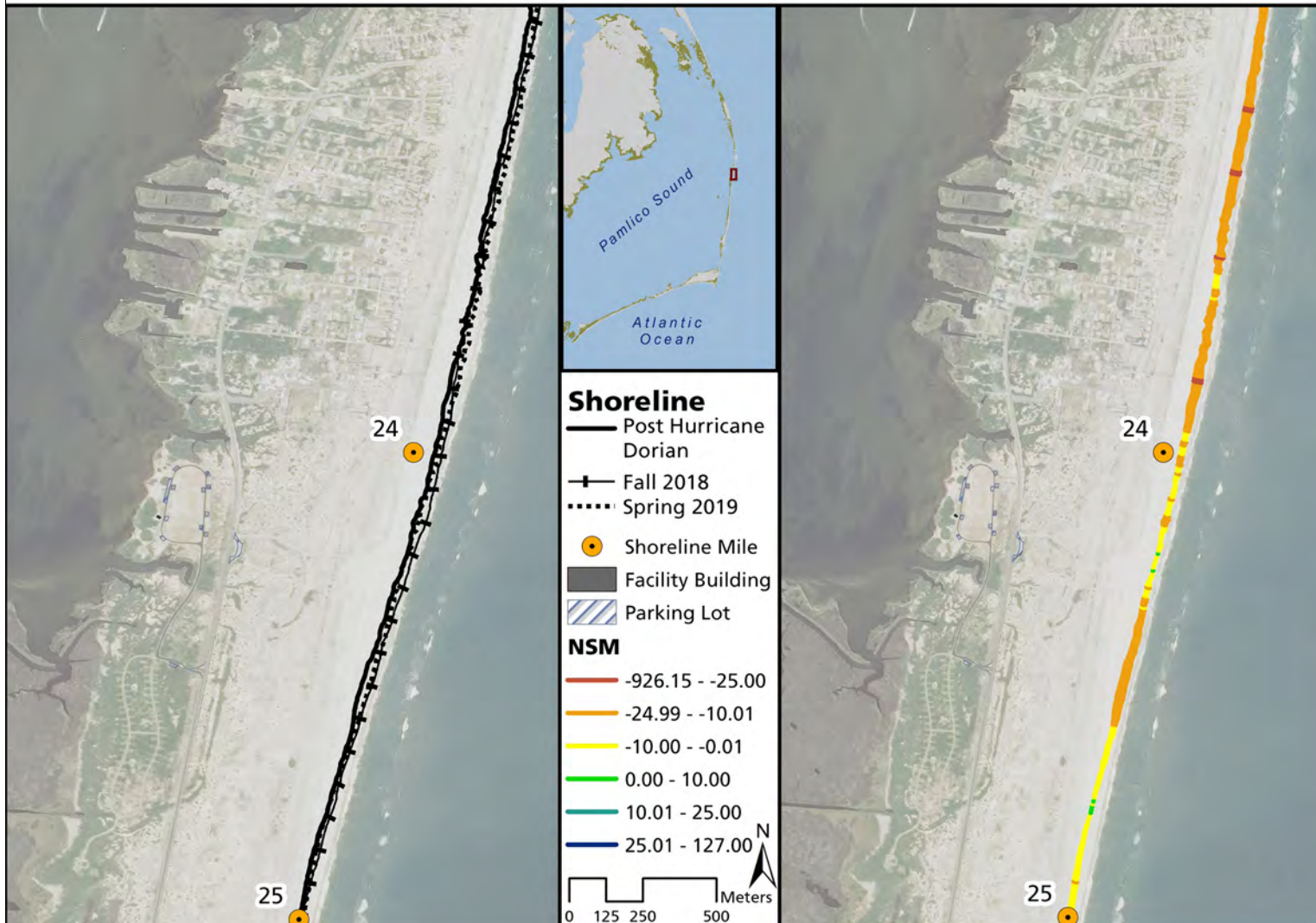


Figure C-17. Shoreline change in the vicinity of mile markers 24 and 25.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

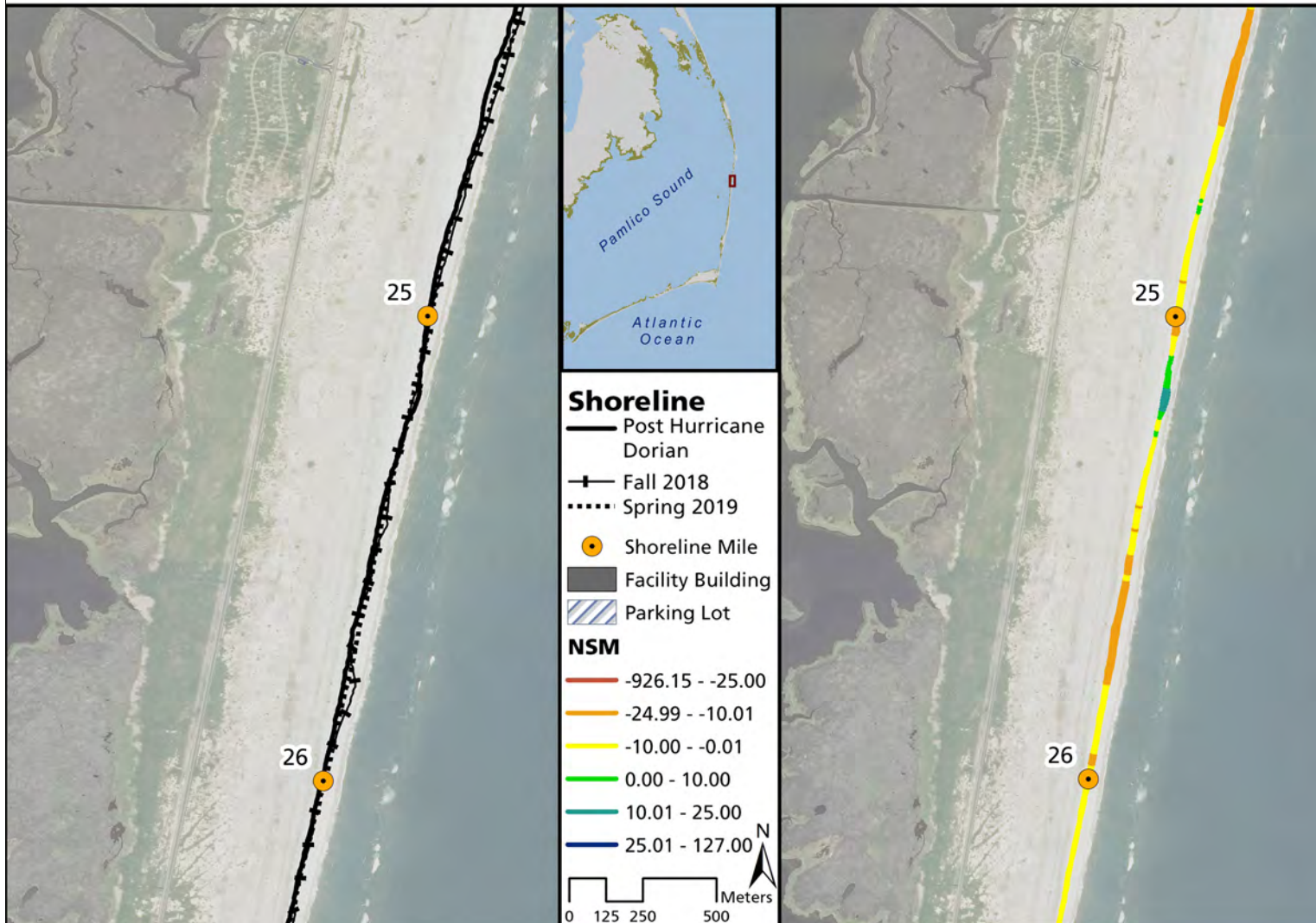


Figure C-18. Shoreline change in the vicinity of mile markers 25 and 26.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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National Park Service
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Shoreline Data

Spring 2019 to Hurricane Dorian

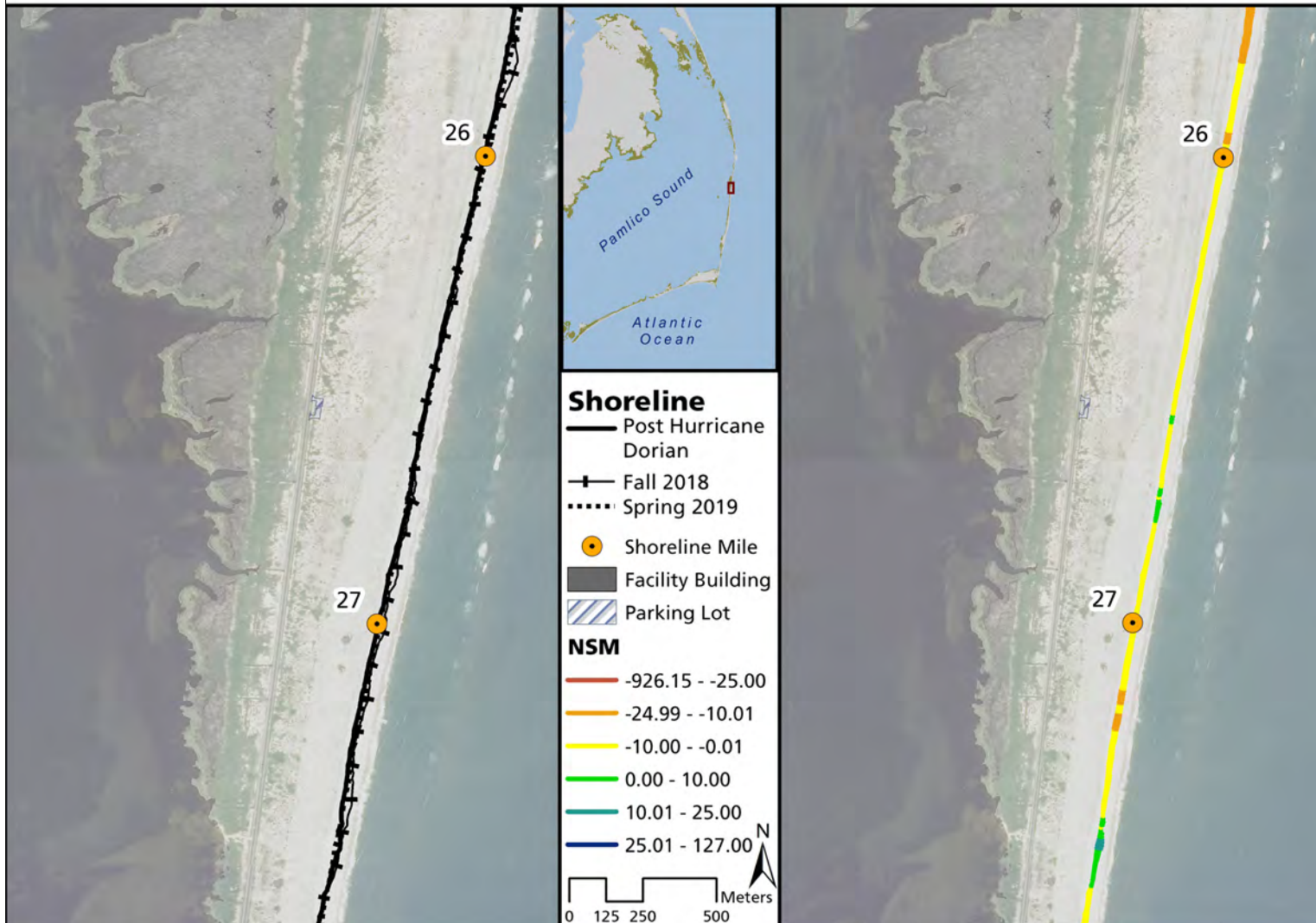


Figure C-19. Shoreline change in the vicinity of mile markers 26 and 27.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

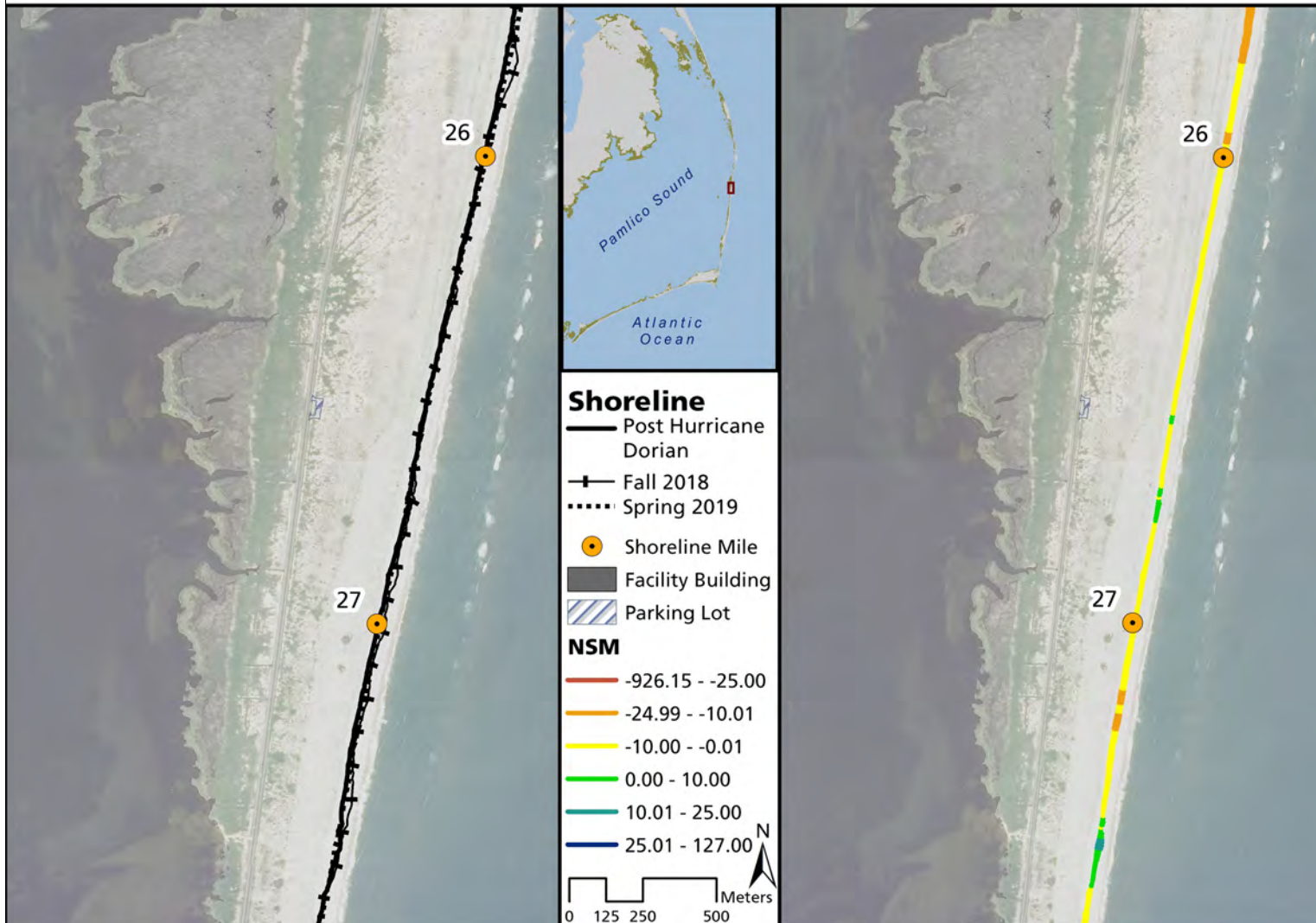


Figure C-20. Shoreline change in the vicinity of mile markers 27 and 28.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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National Park Service
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Shoreline Data

Spring 2019 to Hurricane Dorian

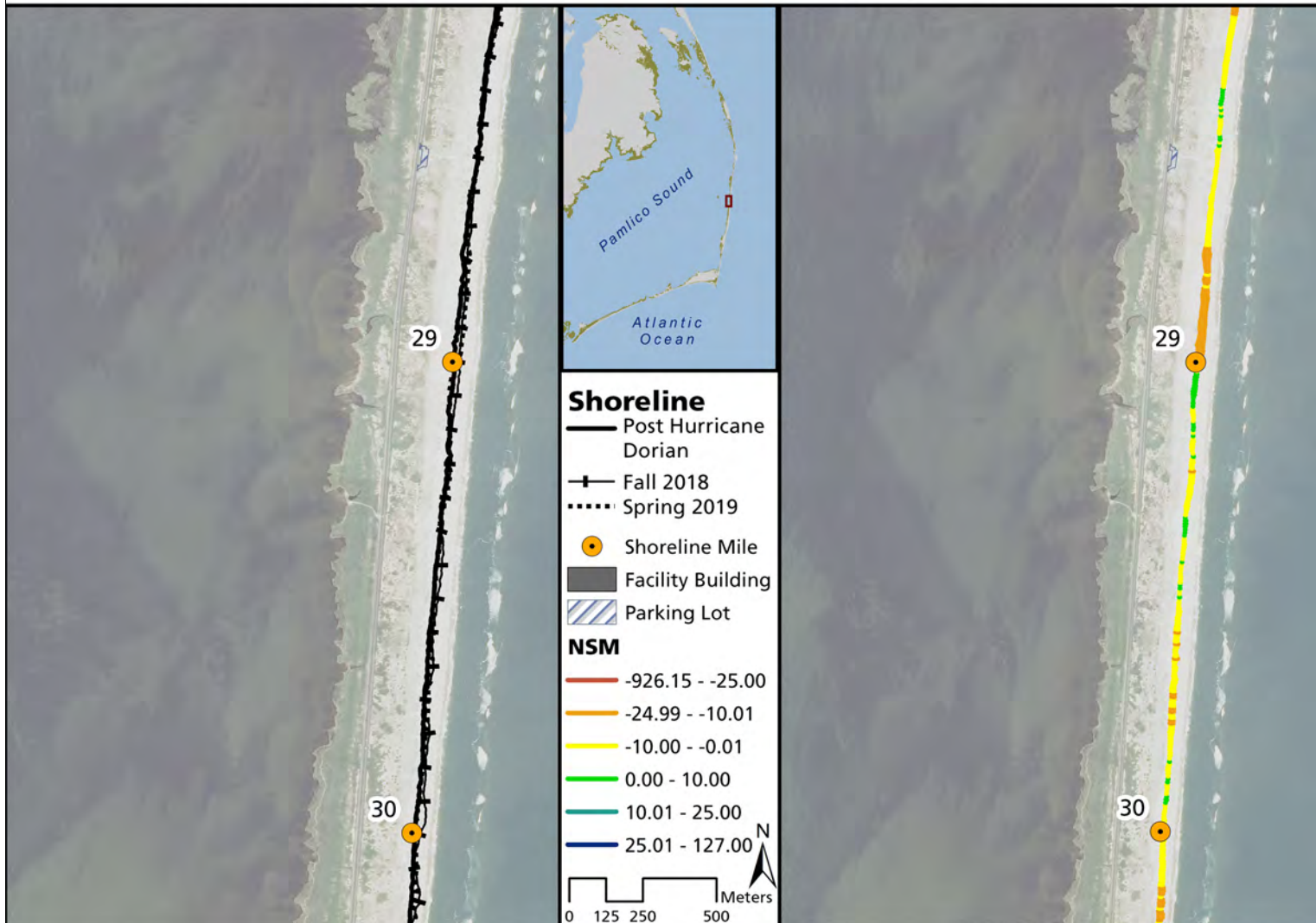


Figure C-21. Shoreline change in the vicinity of mile markers 29 and 30.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
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Shoreline Data

Spring 2019 to Hurricane Dorian

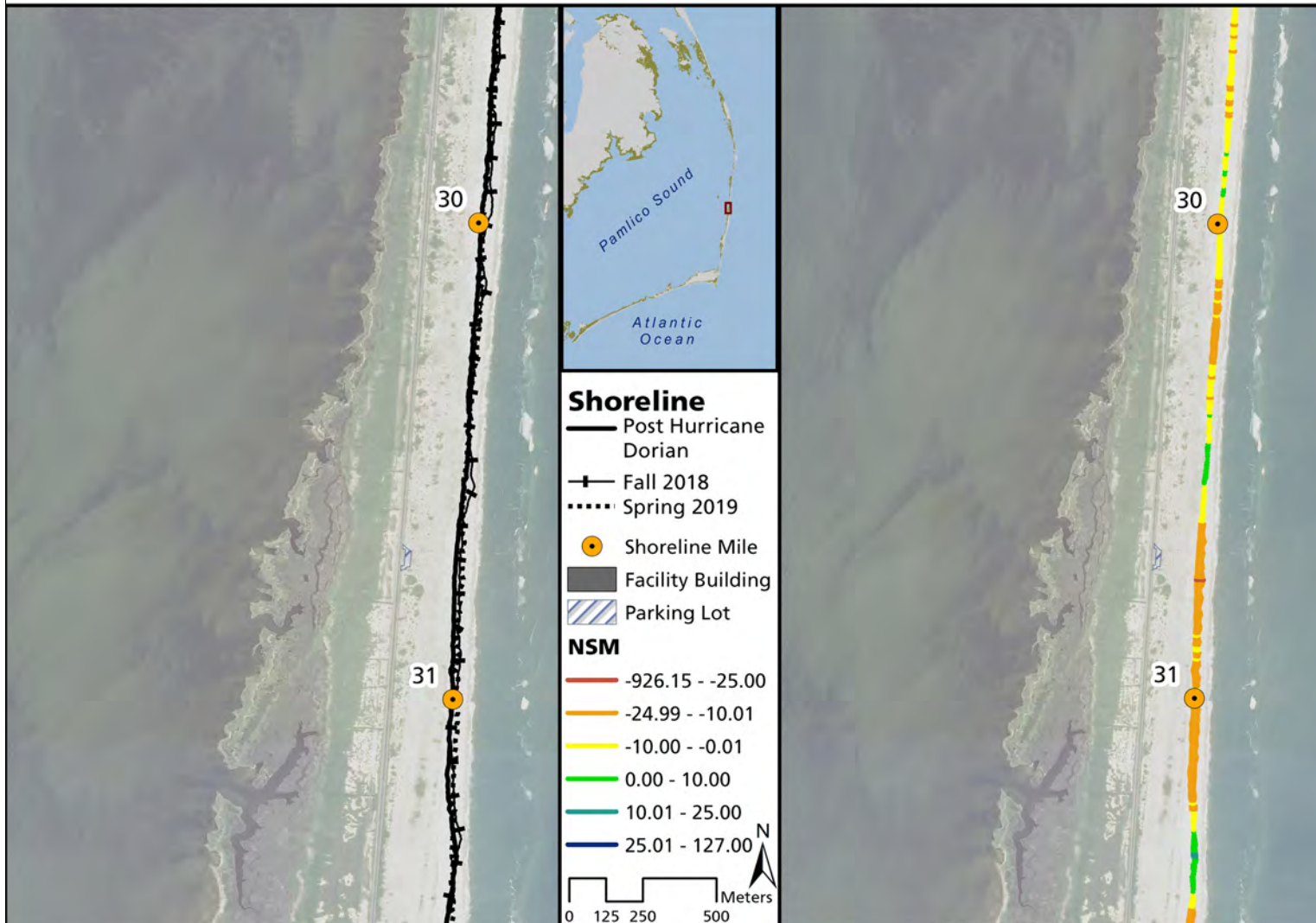


Figure C-22. Shoreline change in the vicinity of mile markers 30 and 31.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

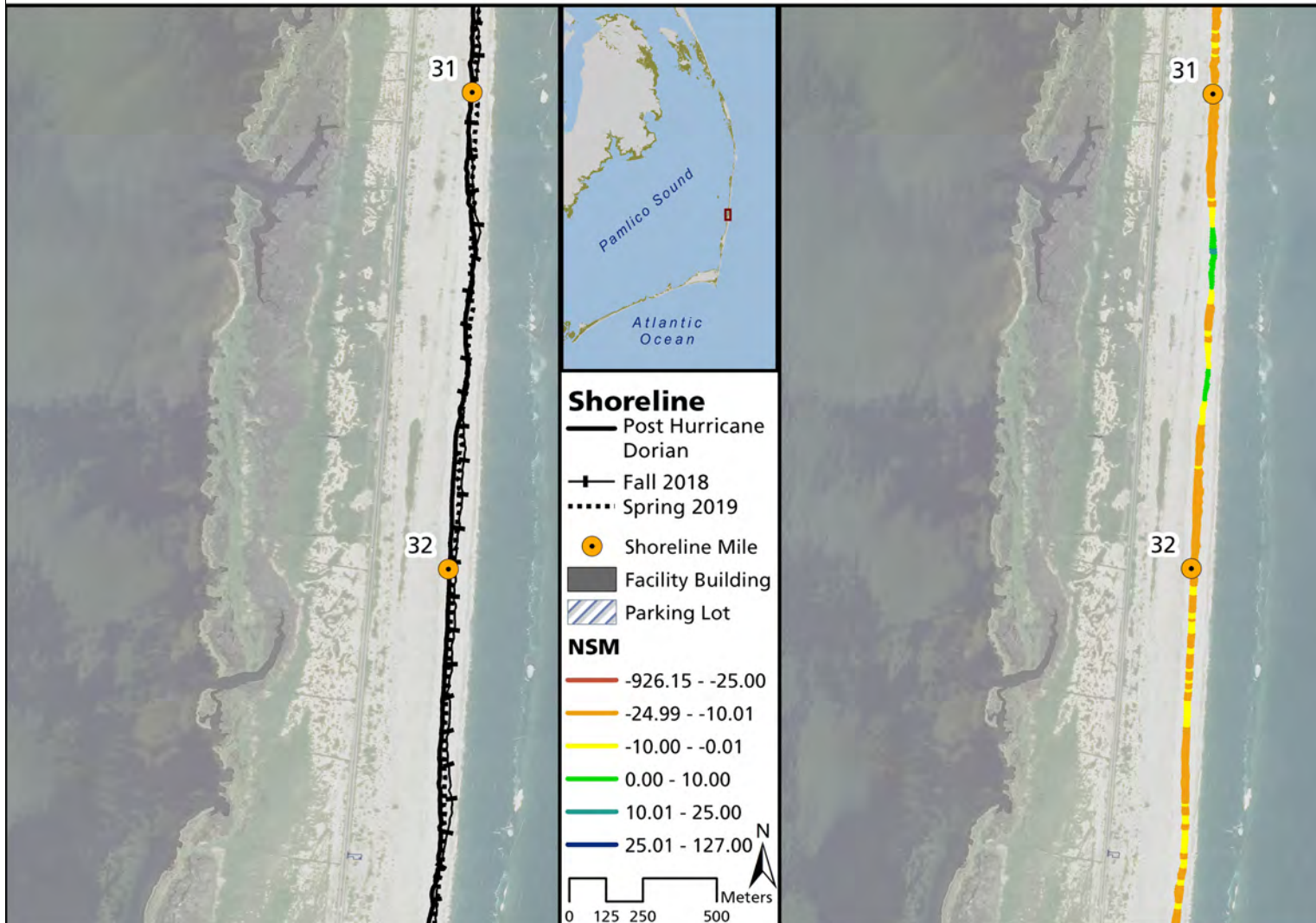


Figure C-23. Shoreline change in the vicinity of mile markers 31 and 32.

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Shoreline Data

Spring 2019 to Hurricane Dorian

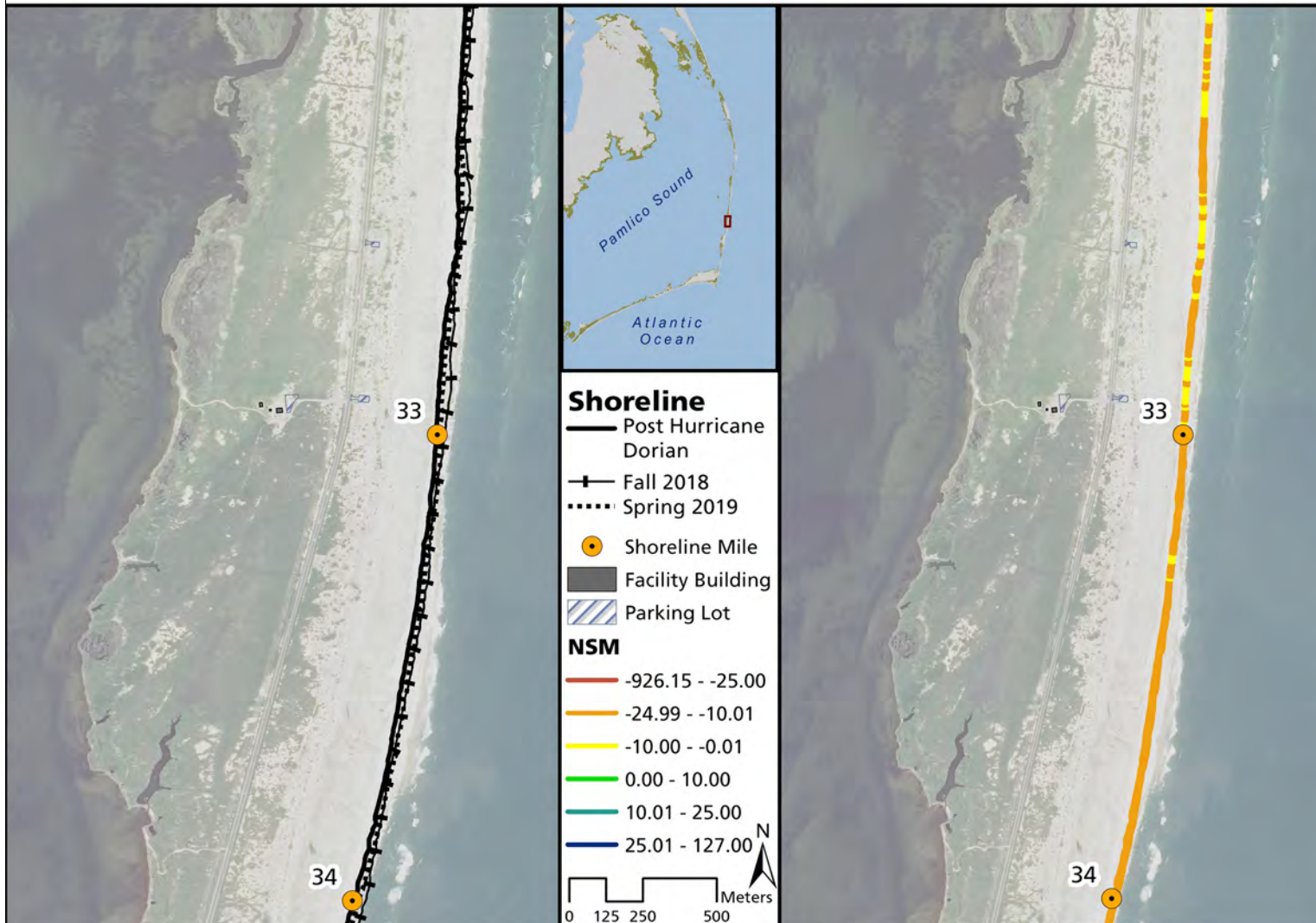


Figure C-24. Shoreline change in the vicinity of mile markers 33 and 34.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

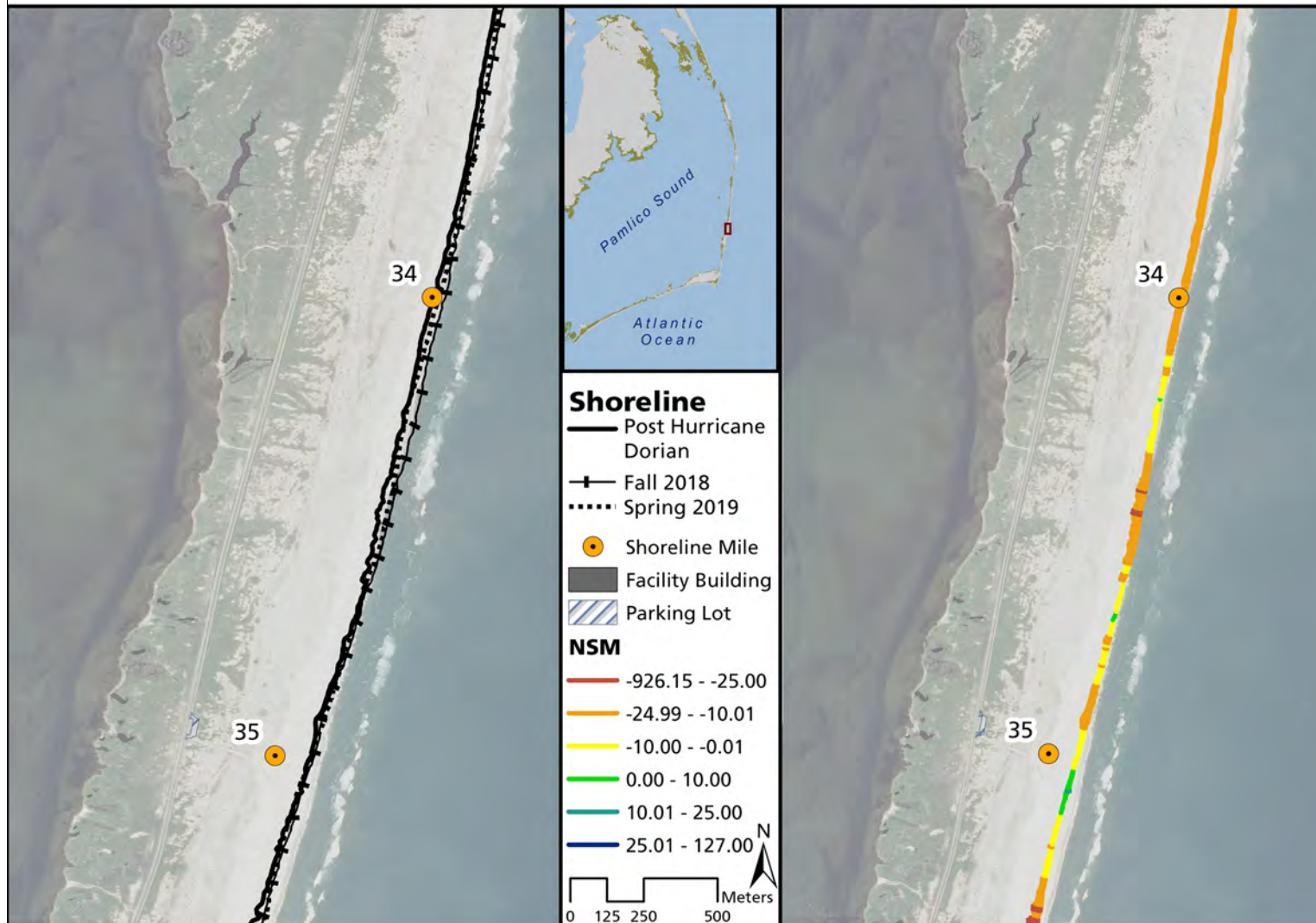


Figure C-25. Shoreline change in the vicinity of mile markers 34 and 35.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

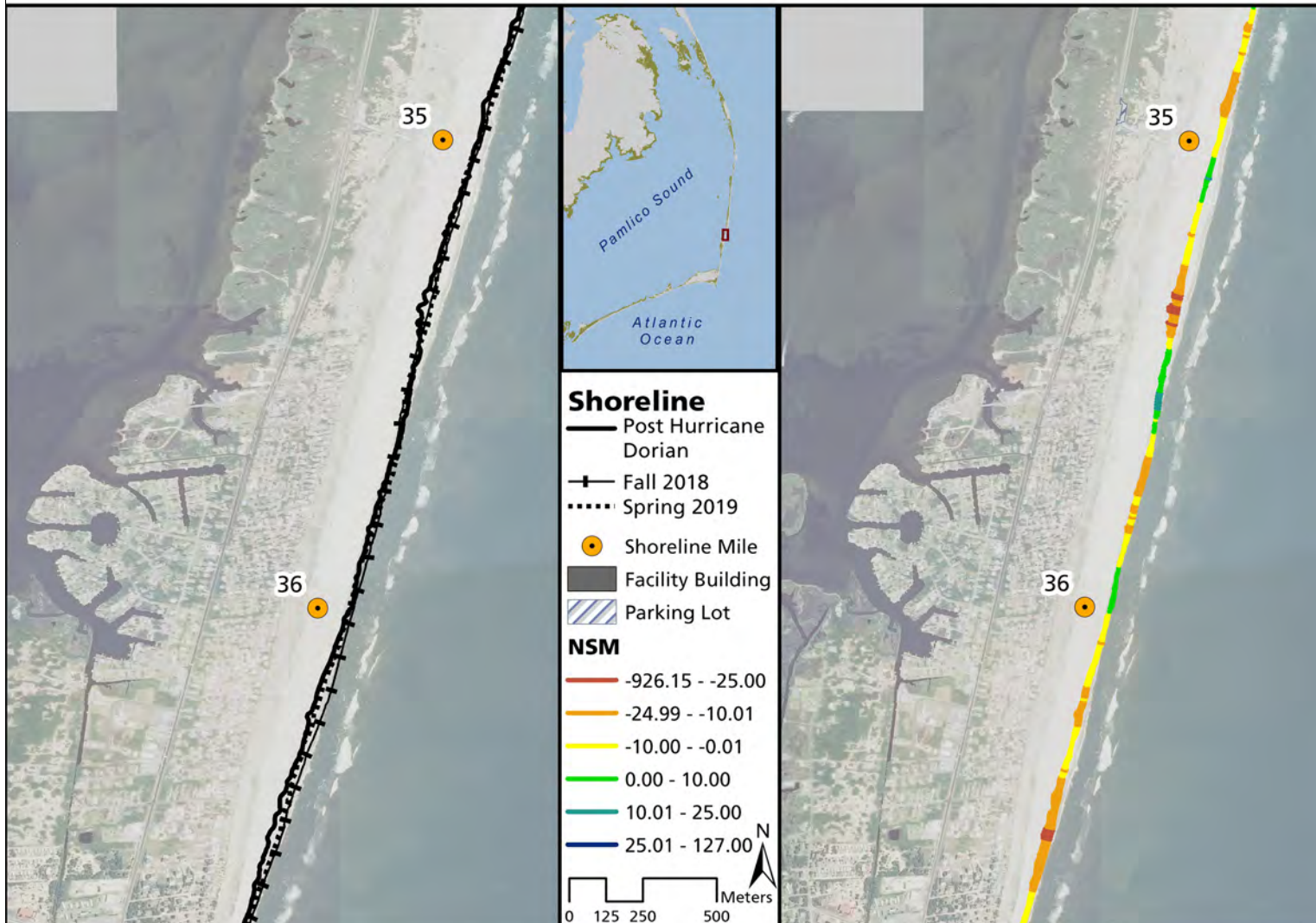


Figure C-26. Shoreline change in the vicinity of mile markers 35 and 36.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

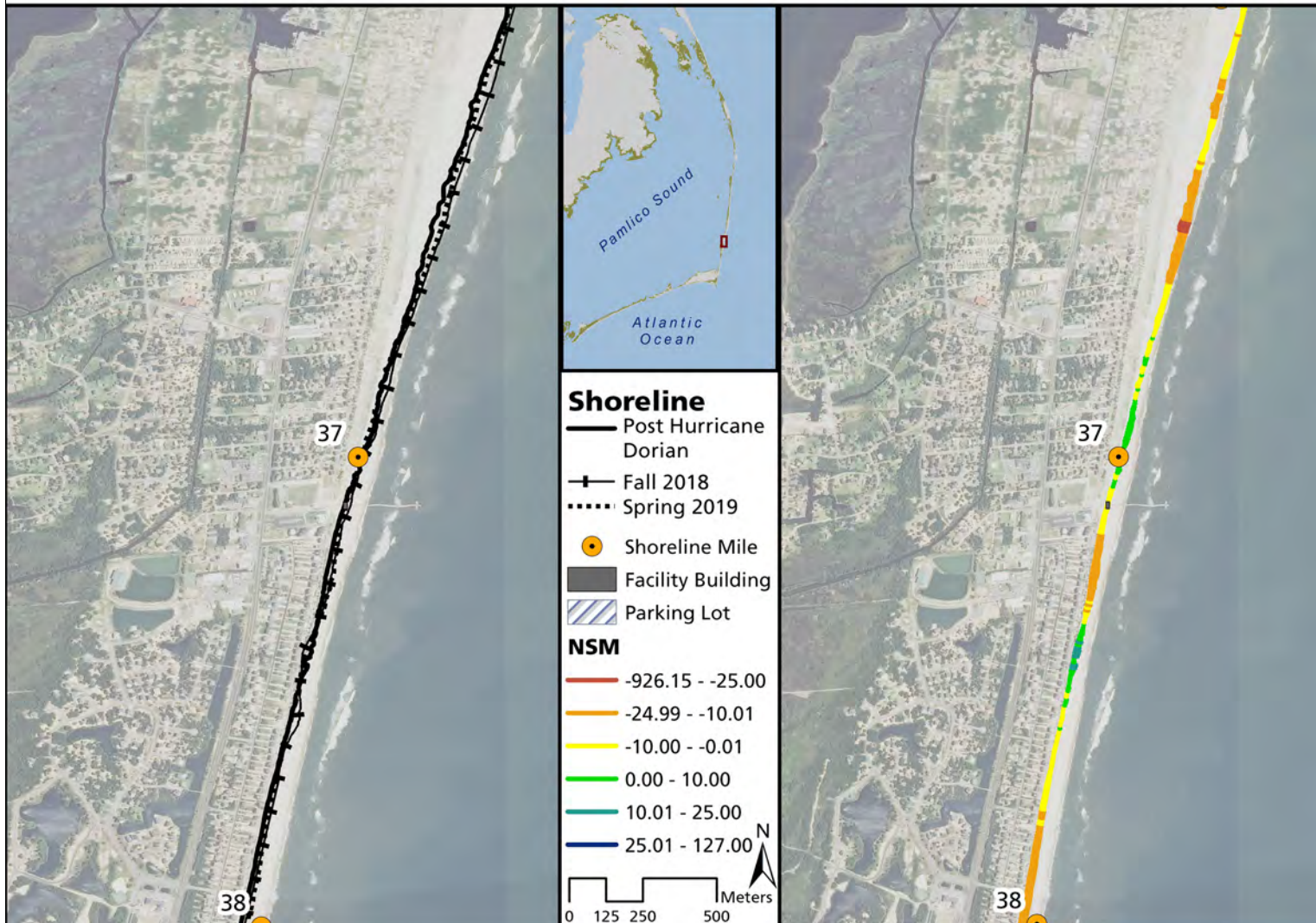


Figure C-27. Shoreline change in the vicinity of mile markers 37 and 38.

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Shoreline Data

Spring 2019 to Hurricane Dorian

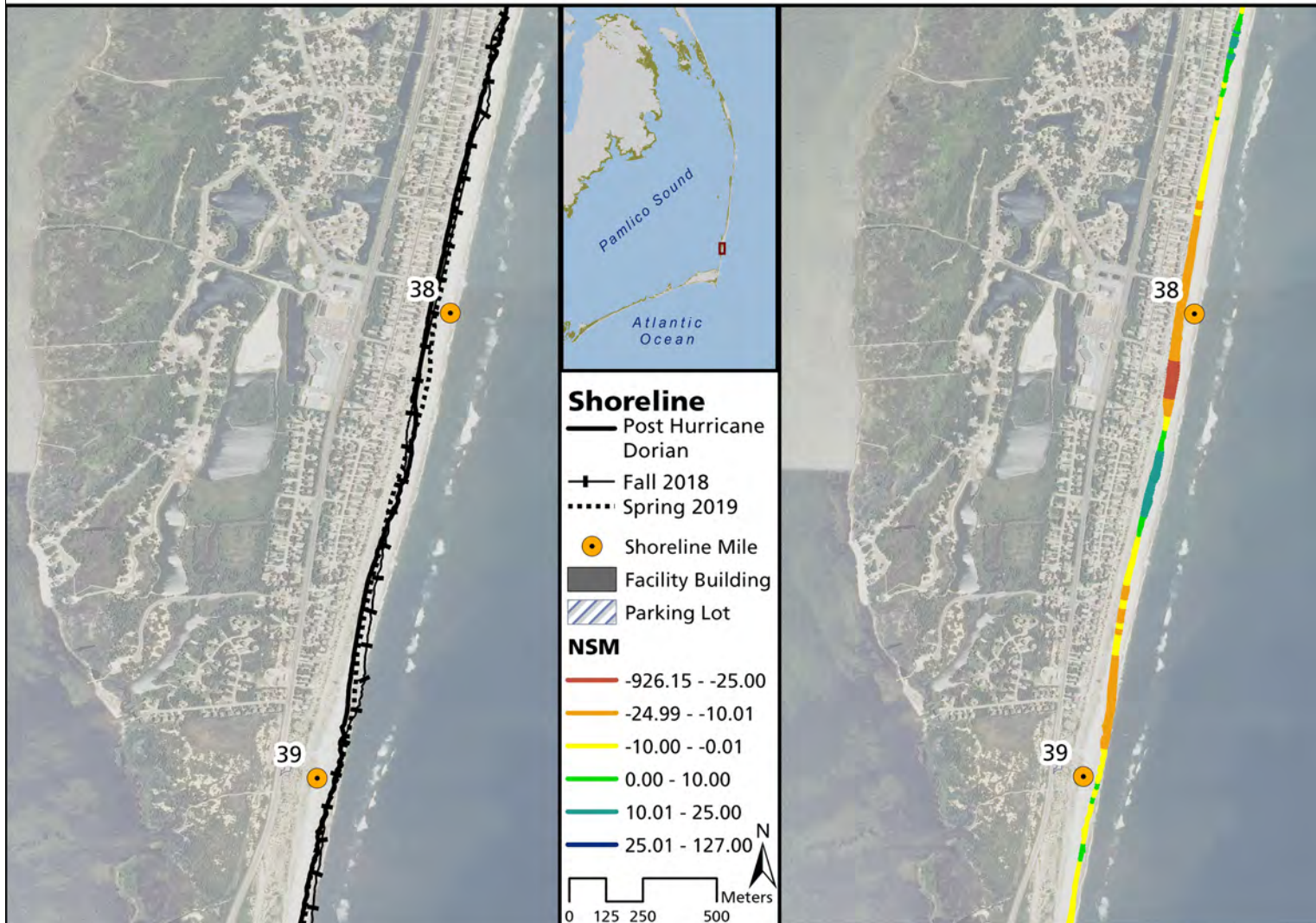


Figure C-28. Shoreline change in the vicinity of mile markers 38 and 39.

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Shoreline Data

Spring 2019 to Hurricane Dorian

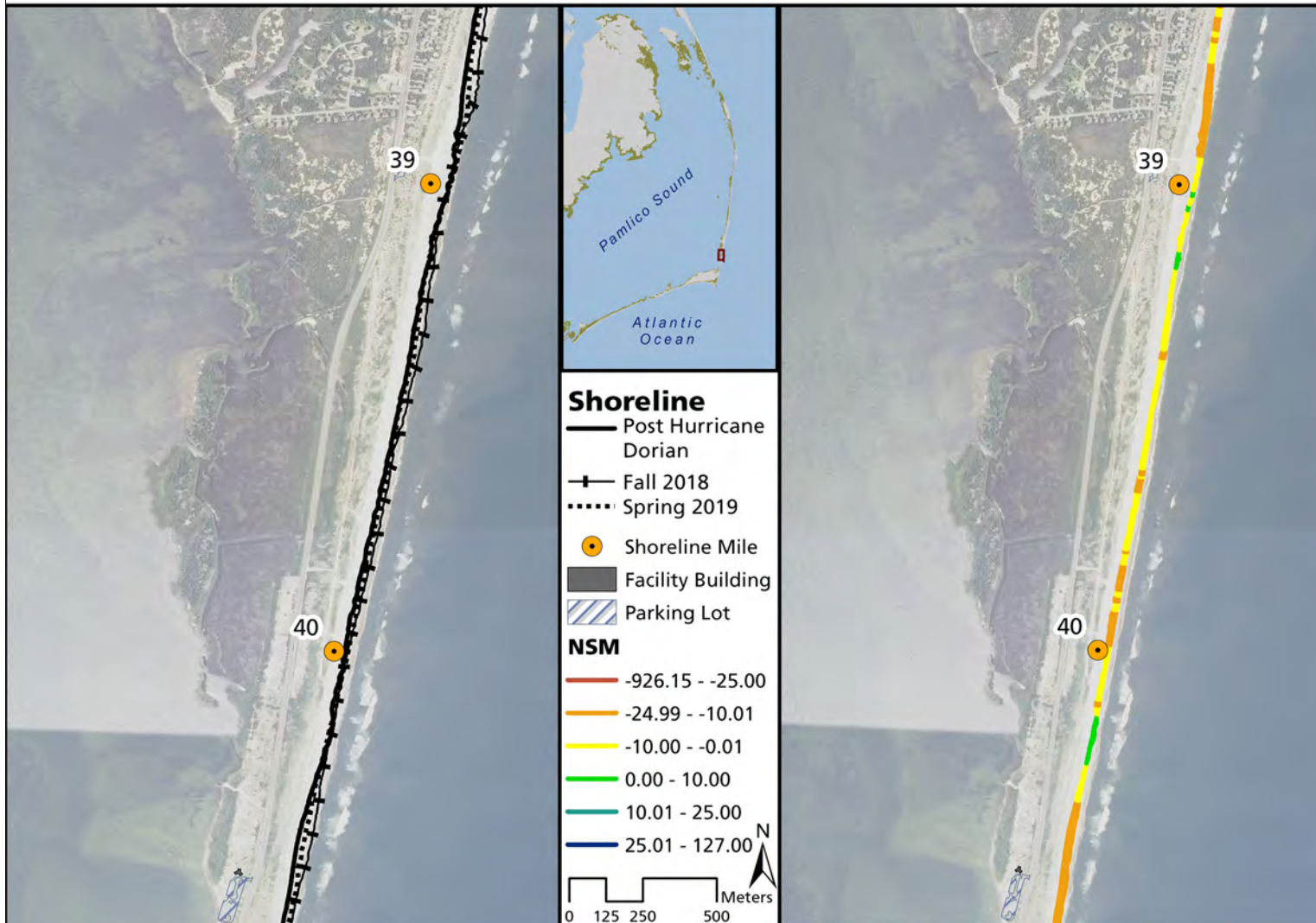


Figure C-29. Shoreline change in the vicinity of mile markers 39 and 40.

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Shoreline Data

Spring 2019 to Hurricane Dorian

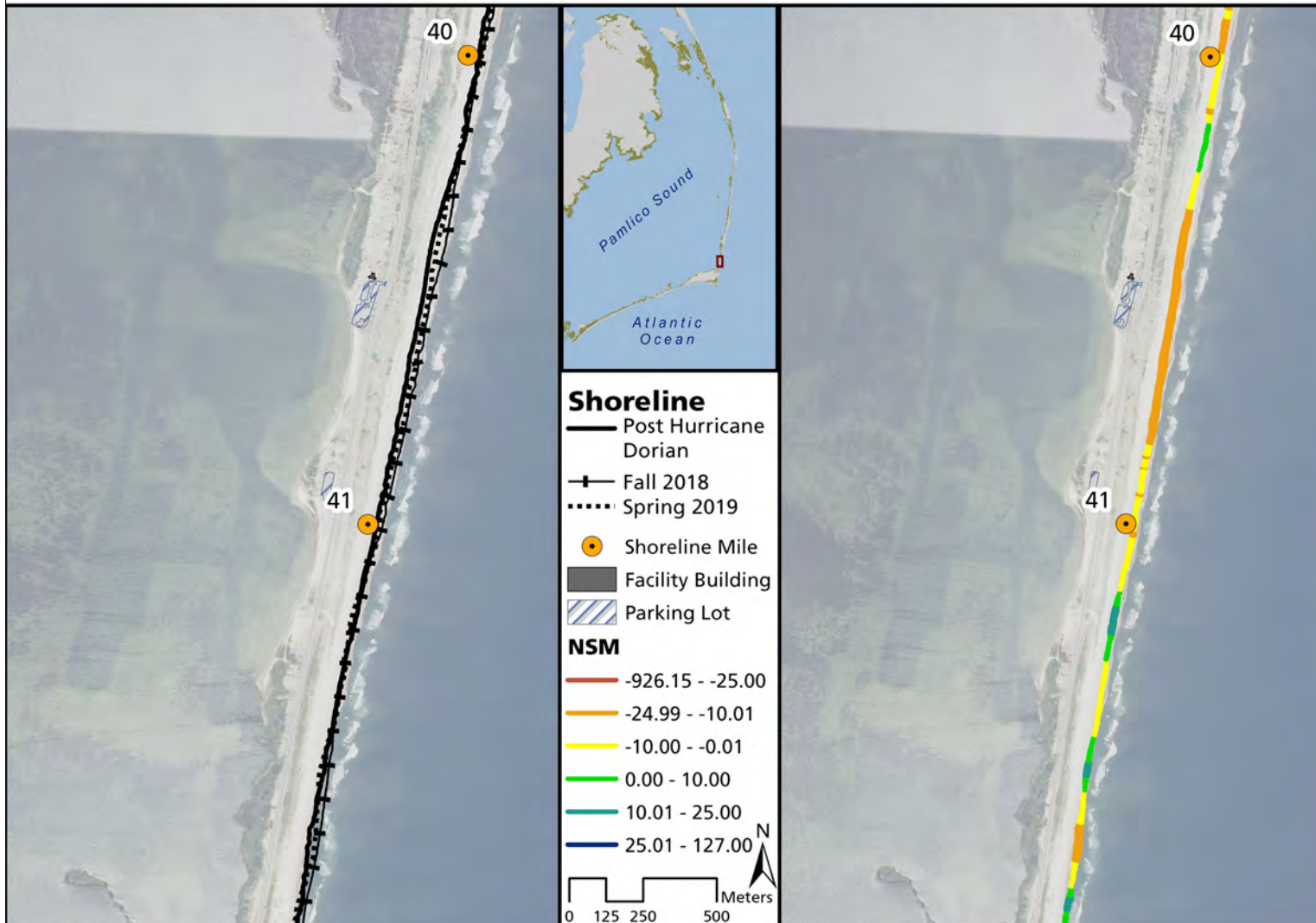


Figure C-30. Shoreline change in the vicinity of mile markers 40 and 41.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

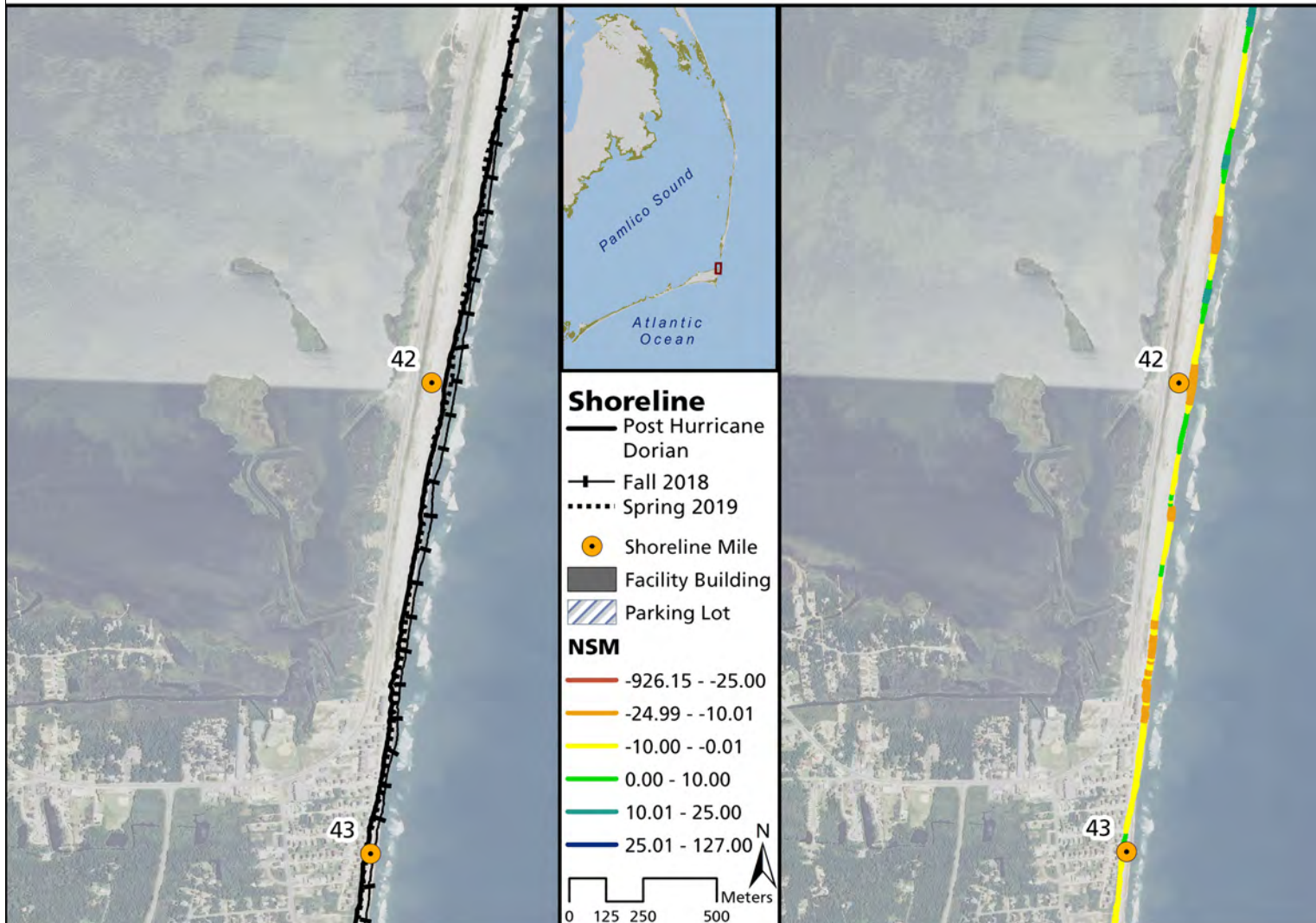


Figure C-31. Shoreline change in the vicinity of mile markers 42 and 43.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

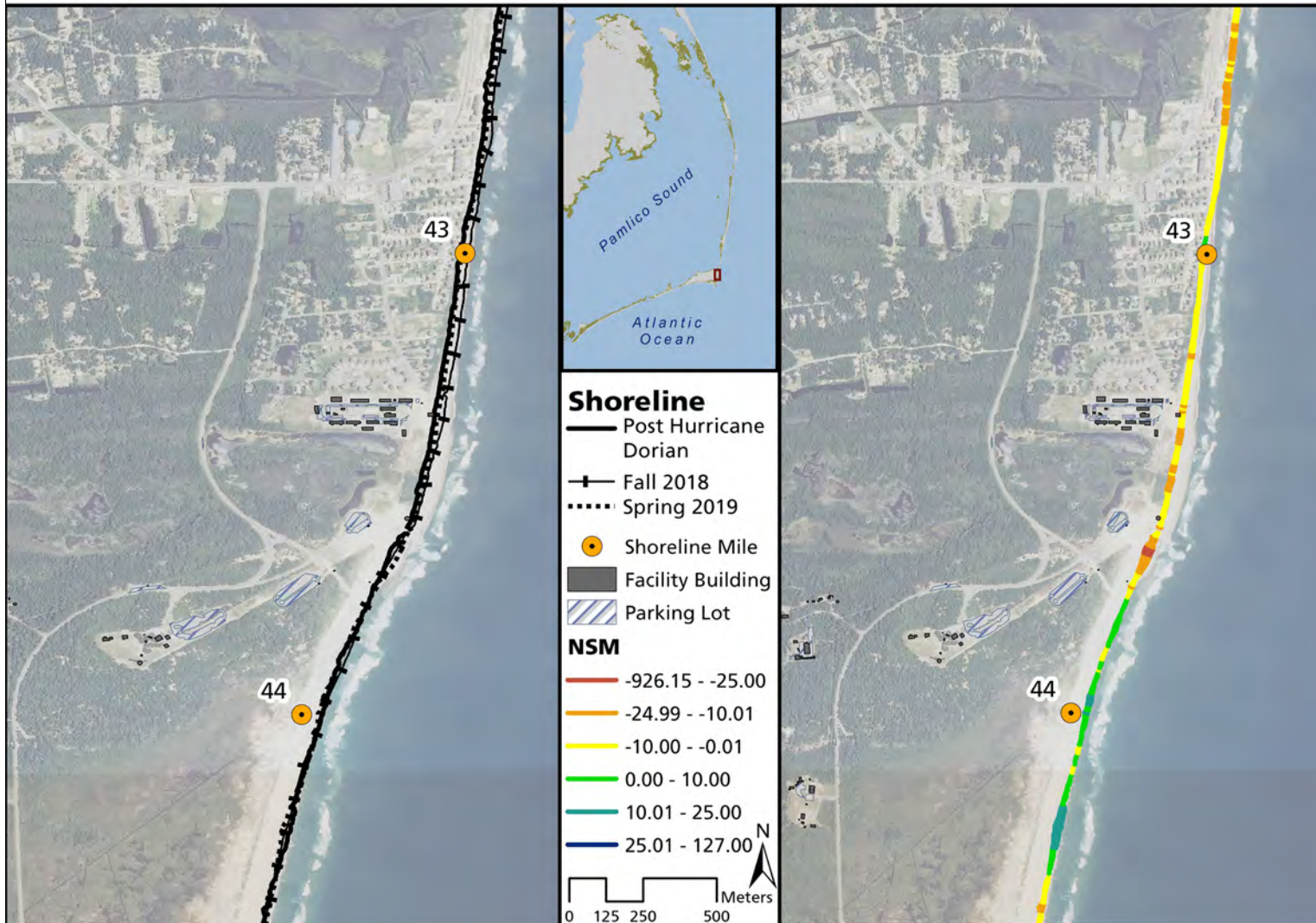


Figure C-32. Shoreline change in the vicinity of mile markers 43 and 44.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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National Park Service
U.S. Department of the Interior



Shoreline Data

Spring 2019 to Hurricane Dorian

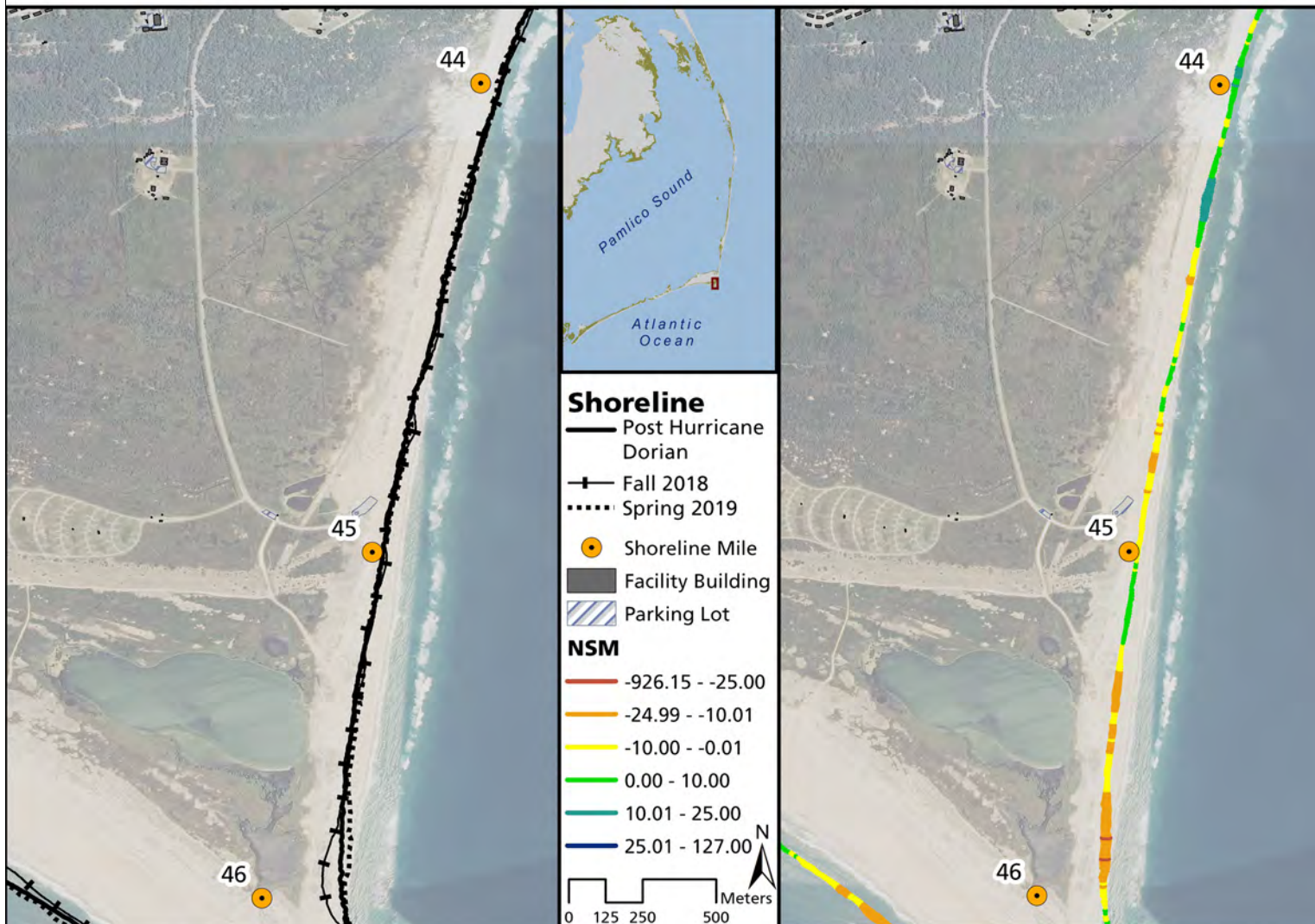


Figure C-33. Shoreline change in the vicinity of mile markers 44 through 46.

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U.S. Department of the Interior



Shoreline Data

Spring 2019 to Hurricane Dorian

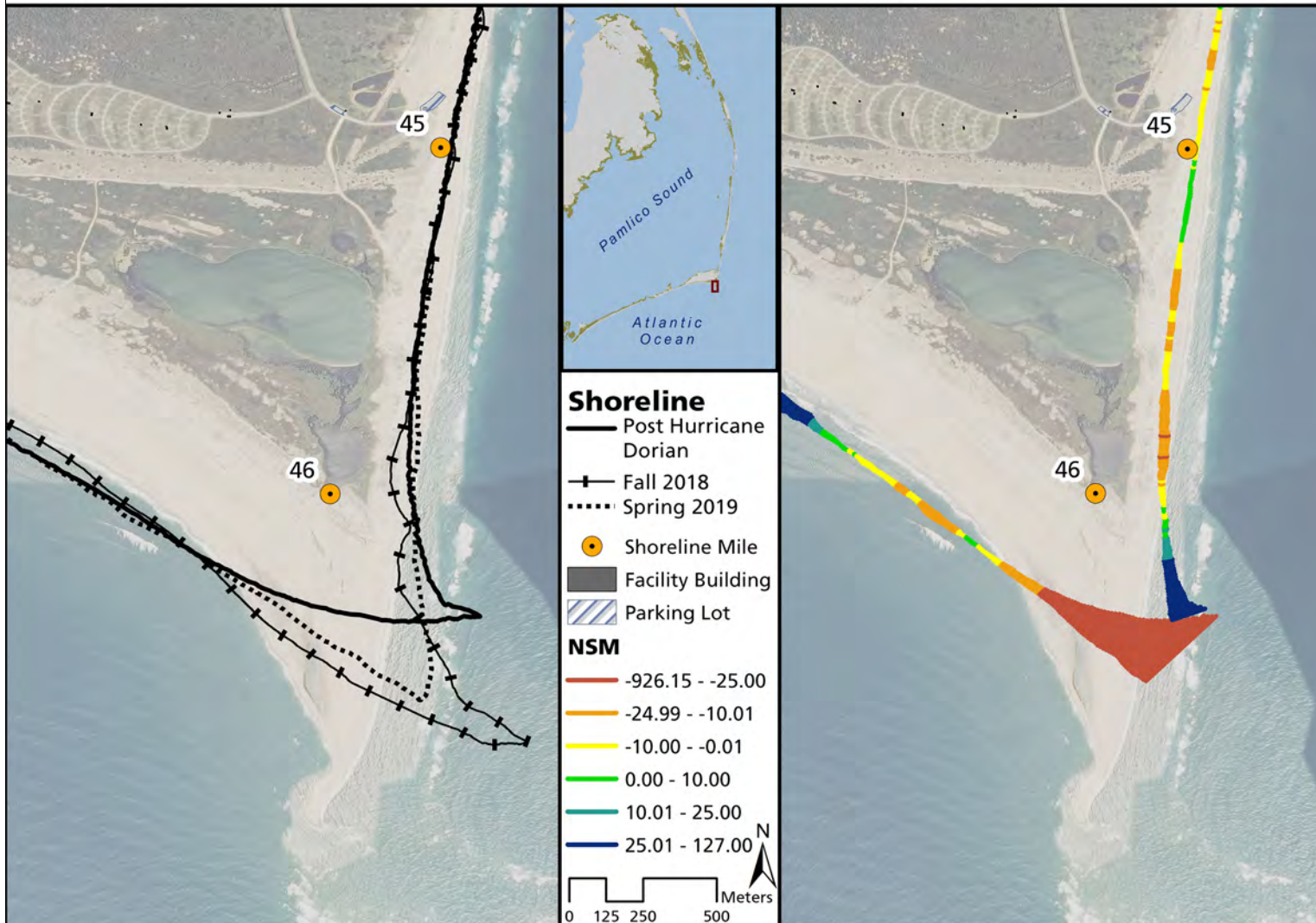


Figure C-34. Shoreline change in the vicinity of mile markers 45 and 46.

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Shoreline Data

Spring 2019 to Hurricane Dorian

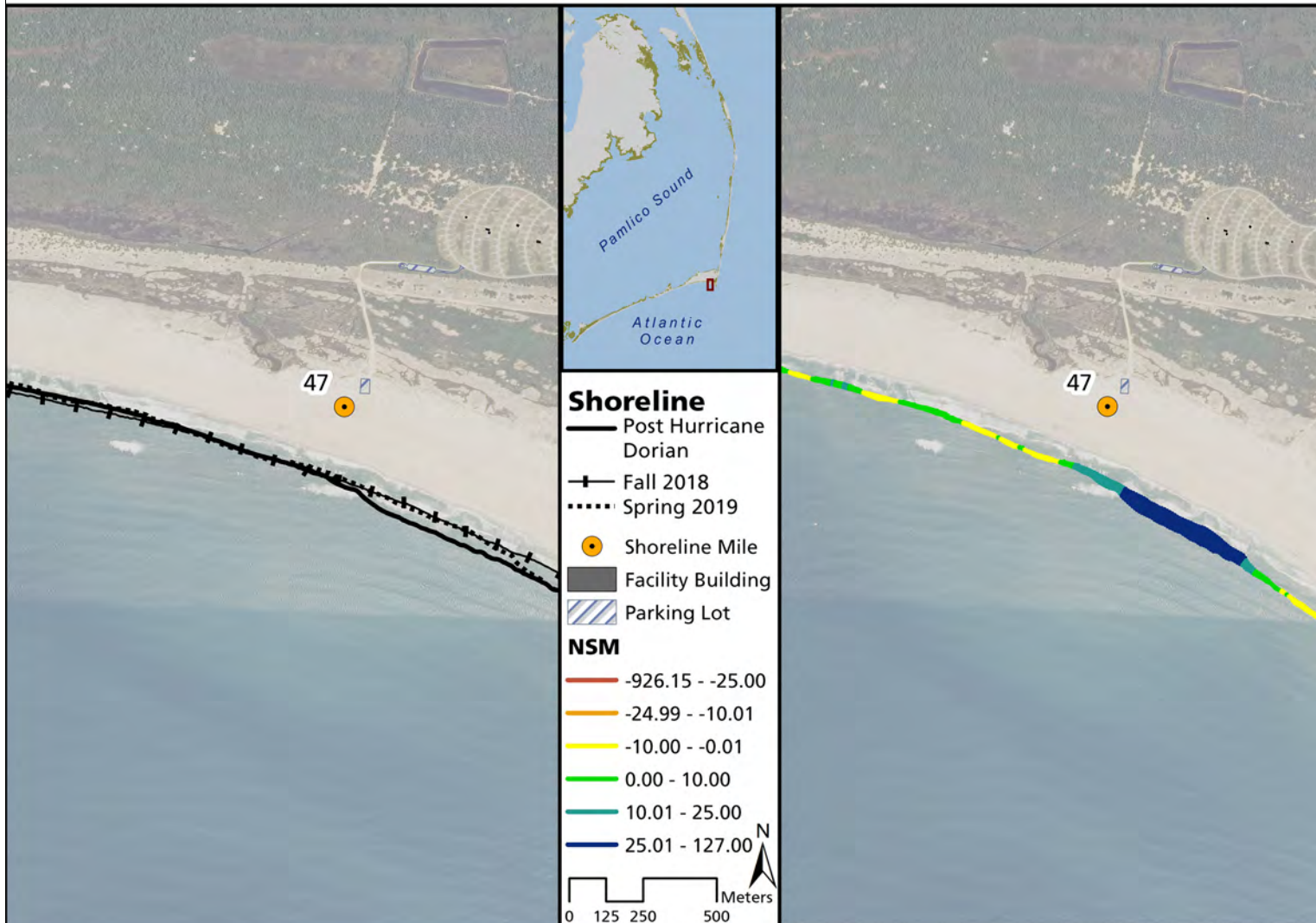


Figure C-35. Shoreline change in the vicinity of mile marker 47.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Spring 2019 to Hurricane Dorian

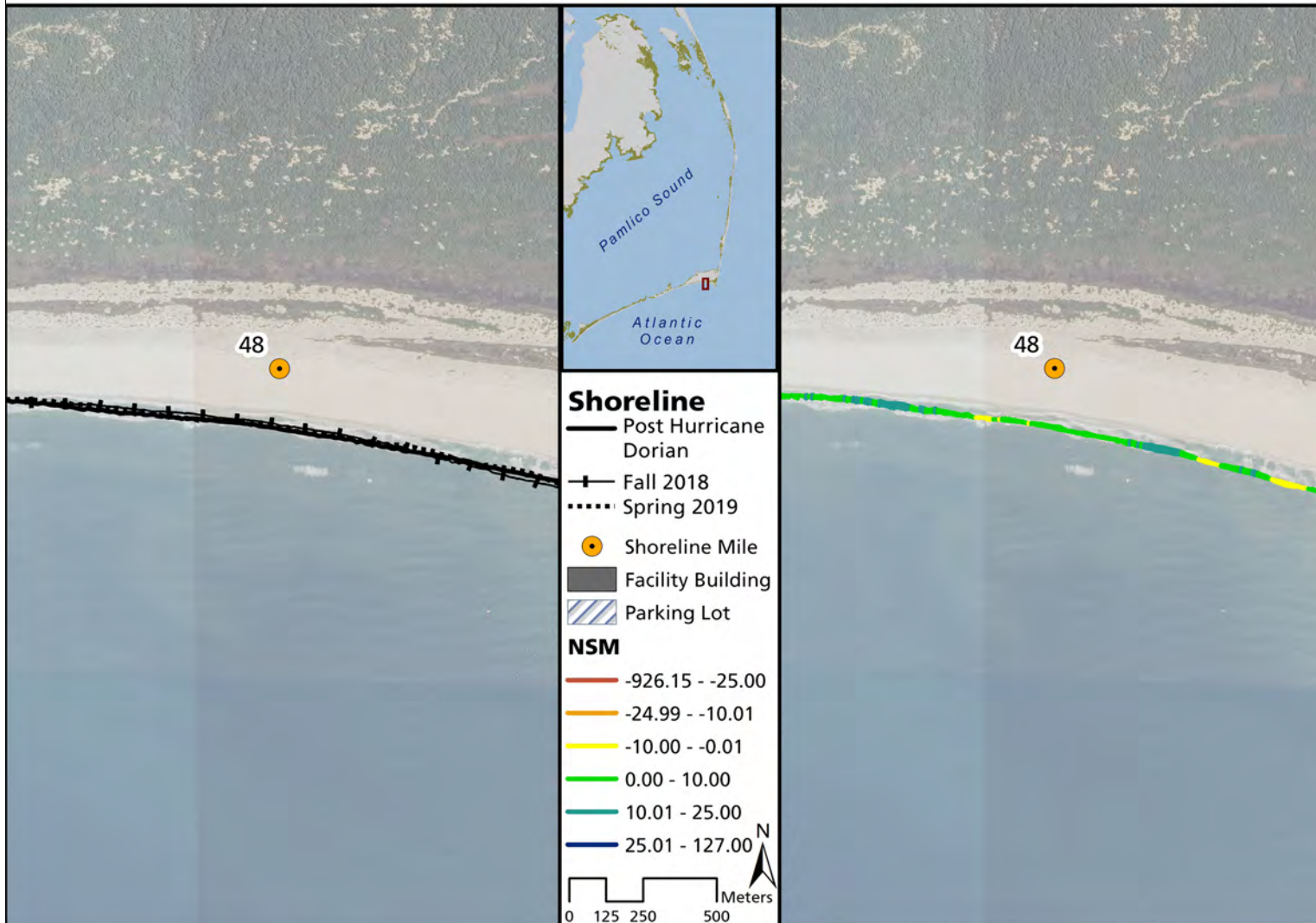


Figure C-36. Shoreline change in the vicinity of mile marker 48.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

130

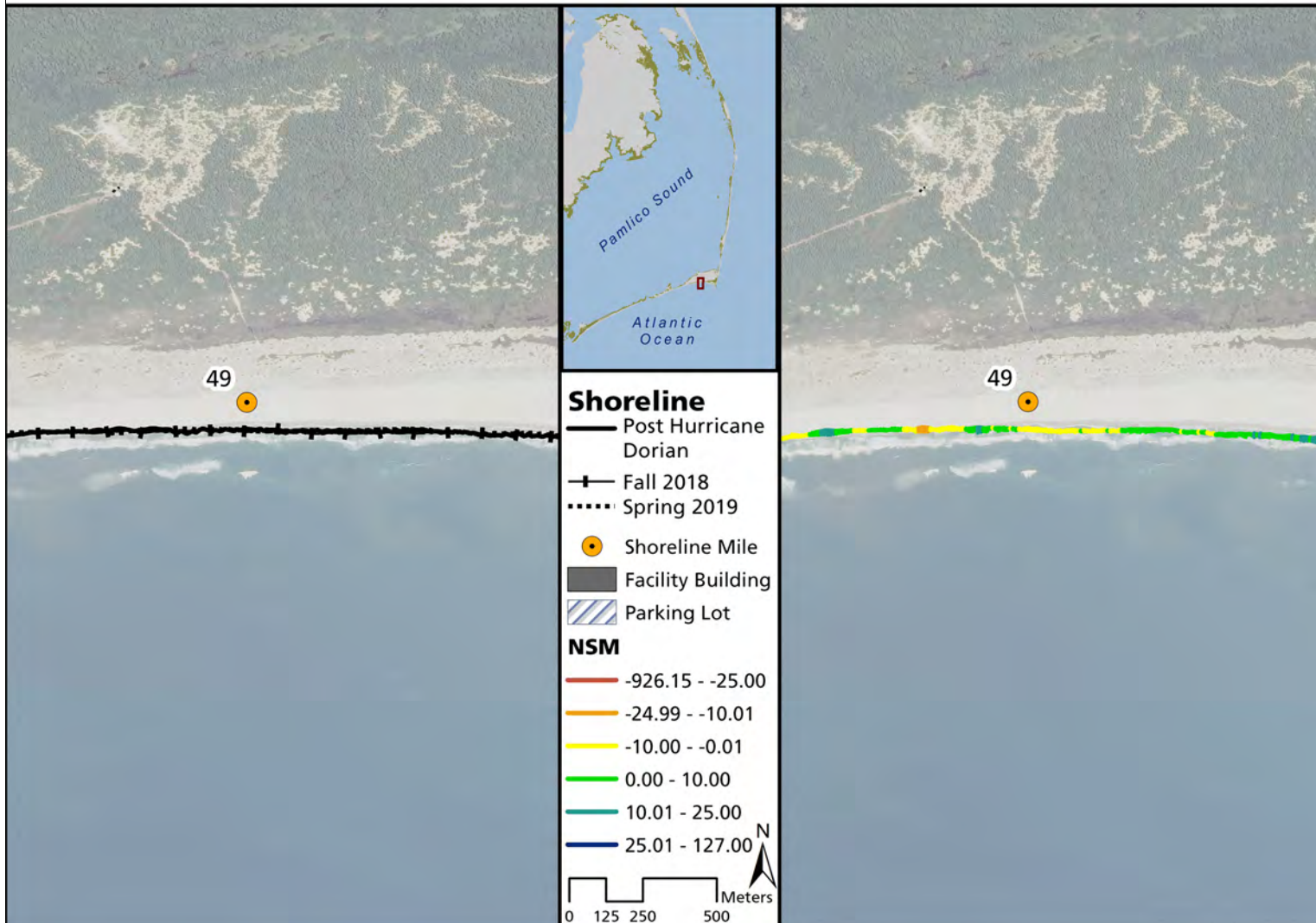


Figure C-37. Shoreline change in the vicinity of mile marker 49.

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Shoreline Data

Spring 2019 to Hurricane Dorian

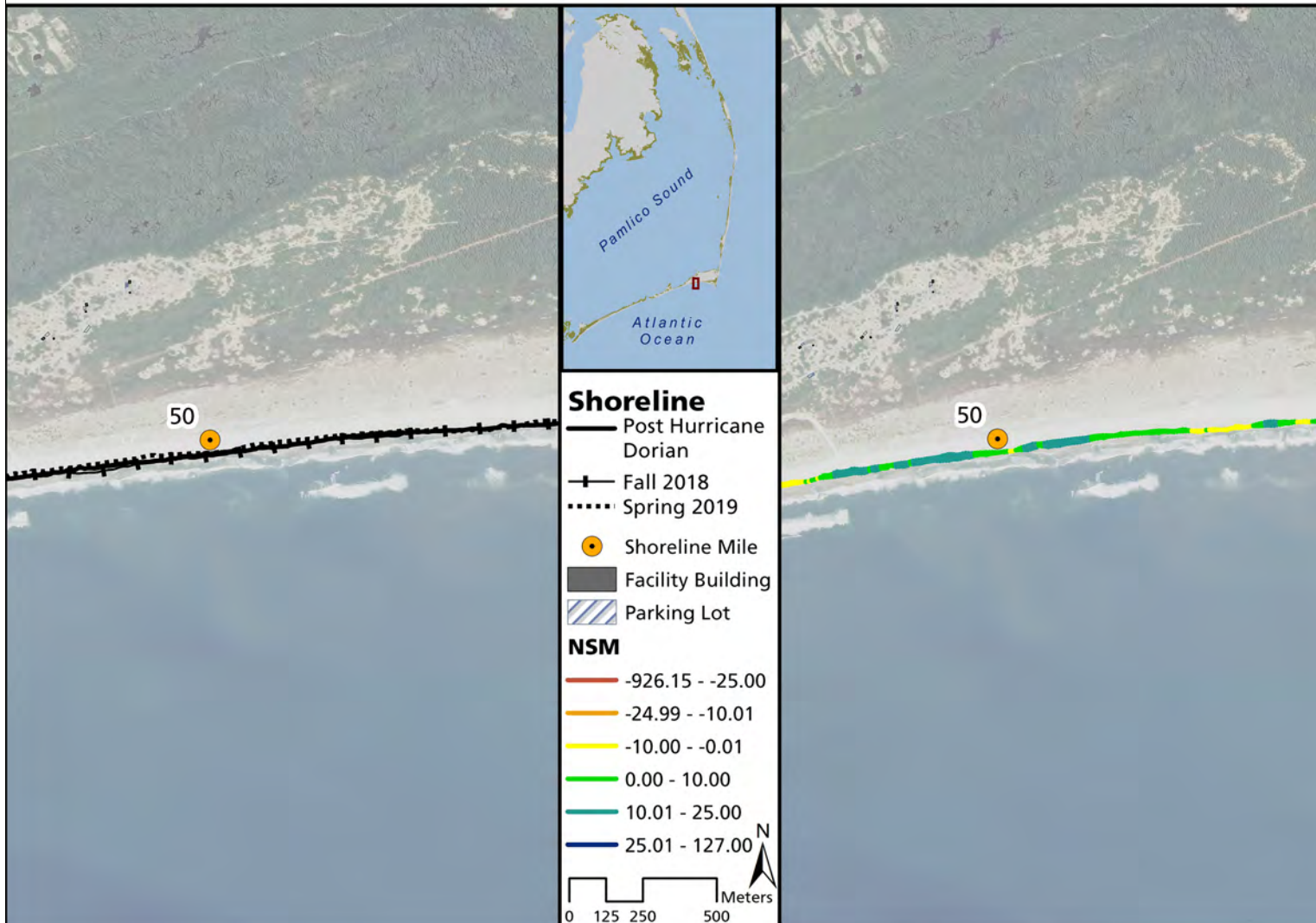


Figure C-38. Shoreline change in the vicinity of mile marker 50.

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Shoreline Data

Spring 2019 to Hurricane Dorian

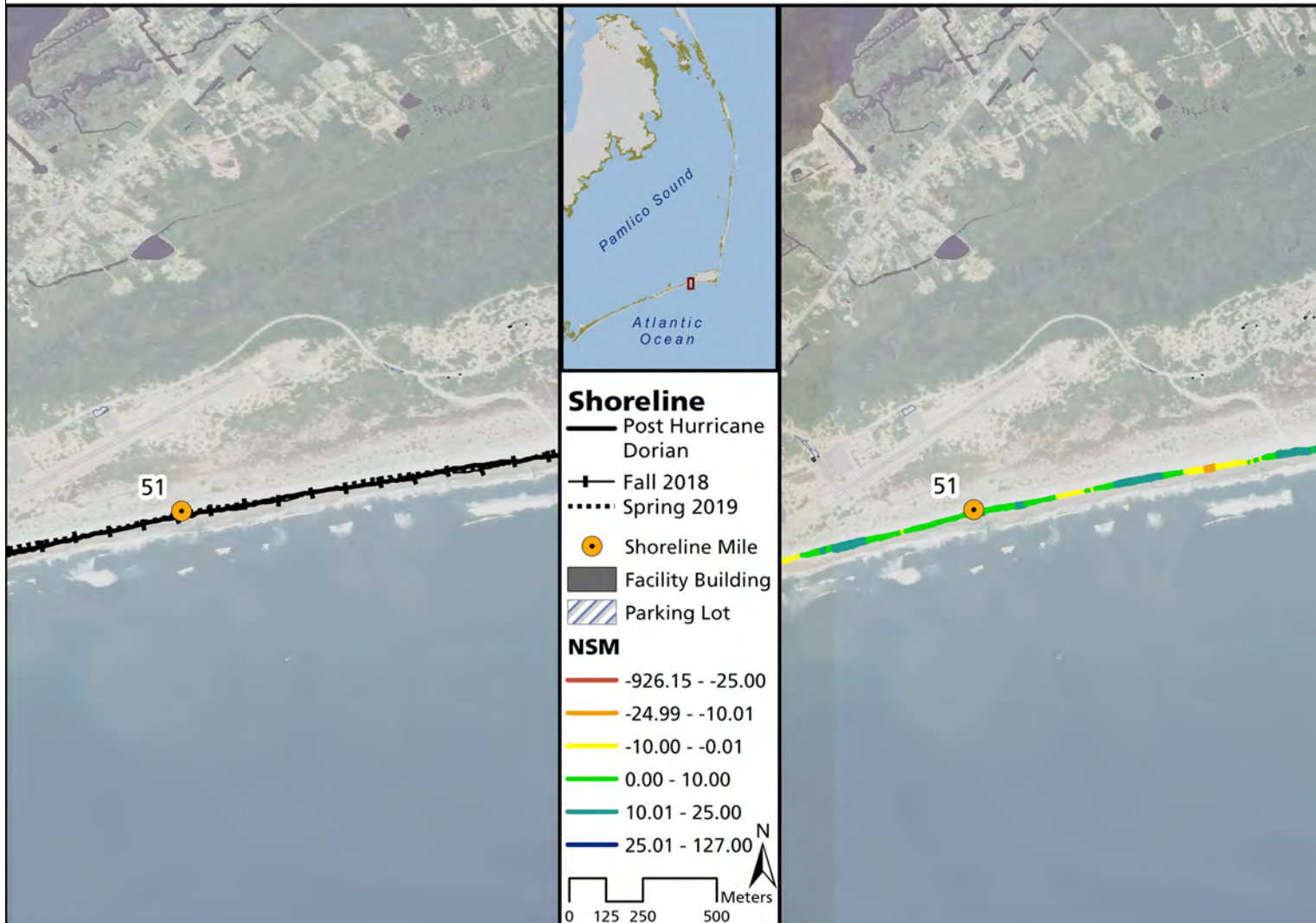


Figure C-39. Shoreline change in the vicinity of mile marker 51.

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Southeast Coast Network
National Park Service
U.S. Department of the Interior



Shoreline Data

Spring 2019 to Hurricane Dorian

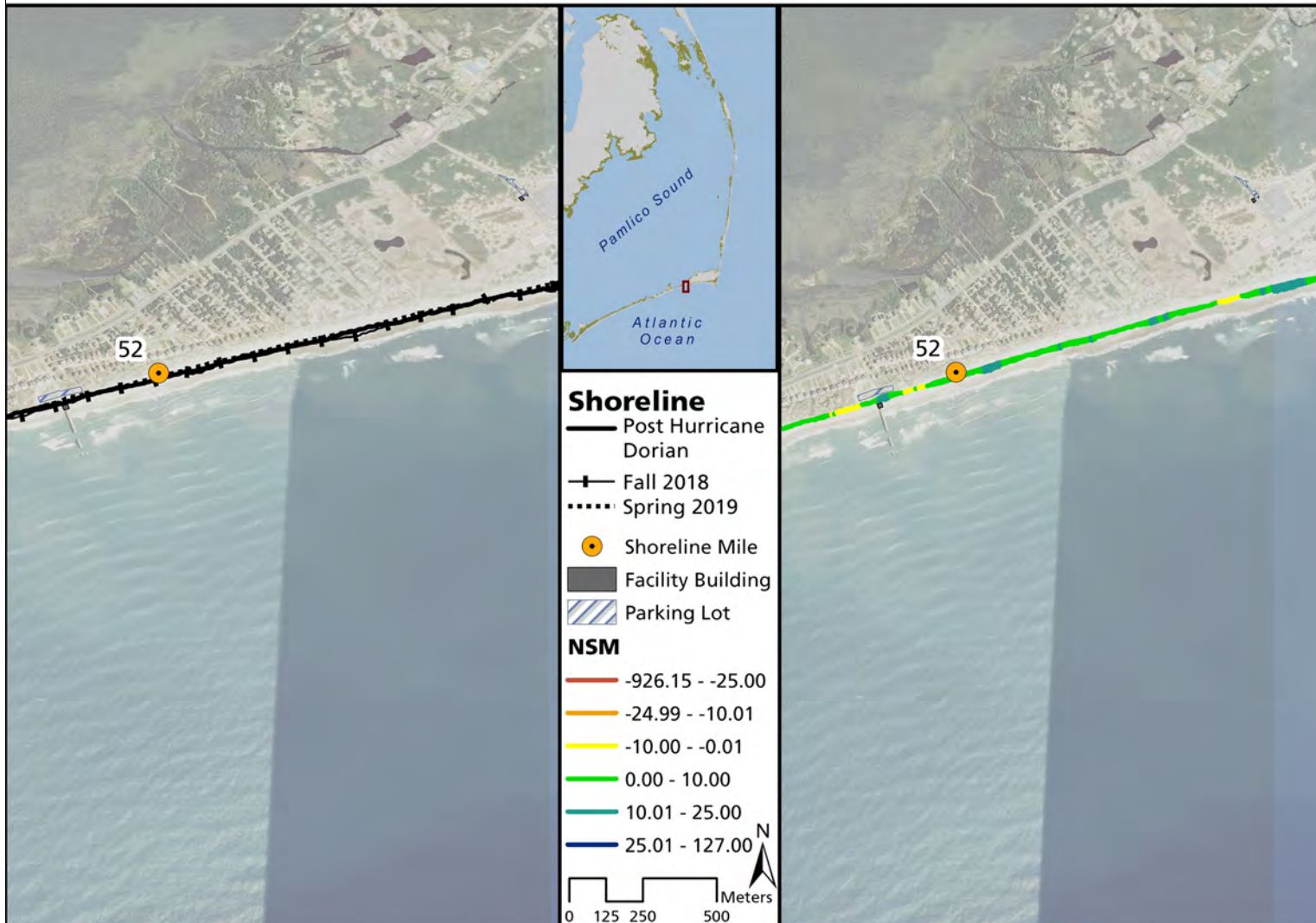


Figure C-40. Shoreline change in the vicinity of mile marker 52.

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Shoreline Data

Spring 2019 to Hurricane Dorian

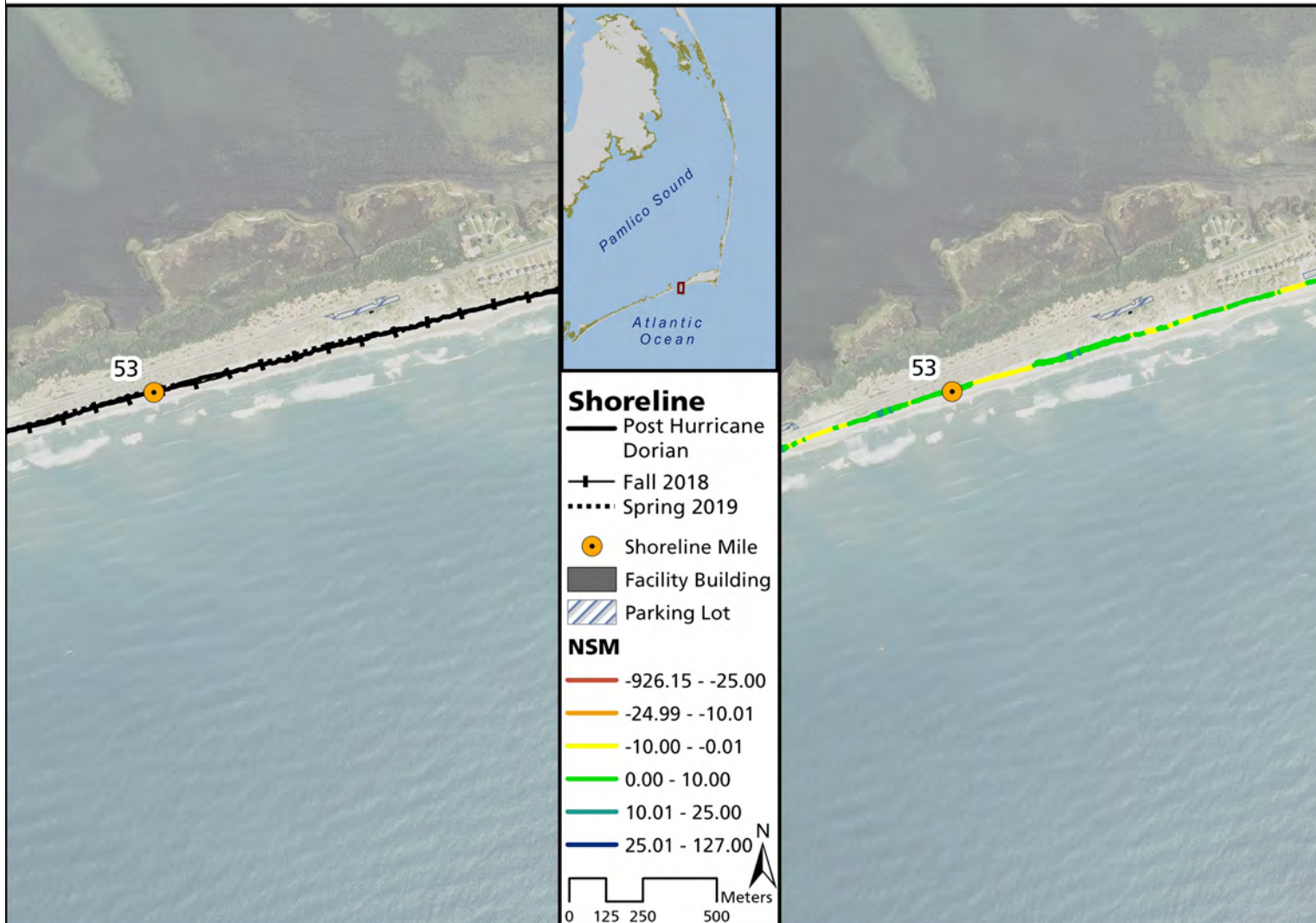


Figure C-41. Shoreline change in the vicinity of mile marker 53.

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Shoreline Data

Spring 2019 to Hurricane Dorian

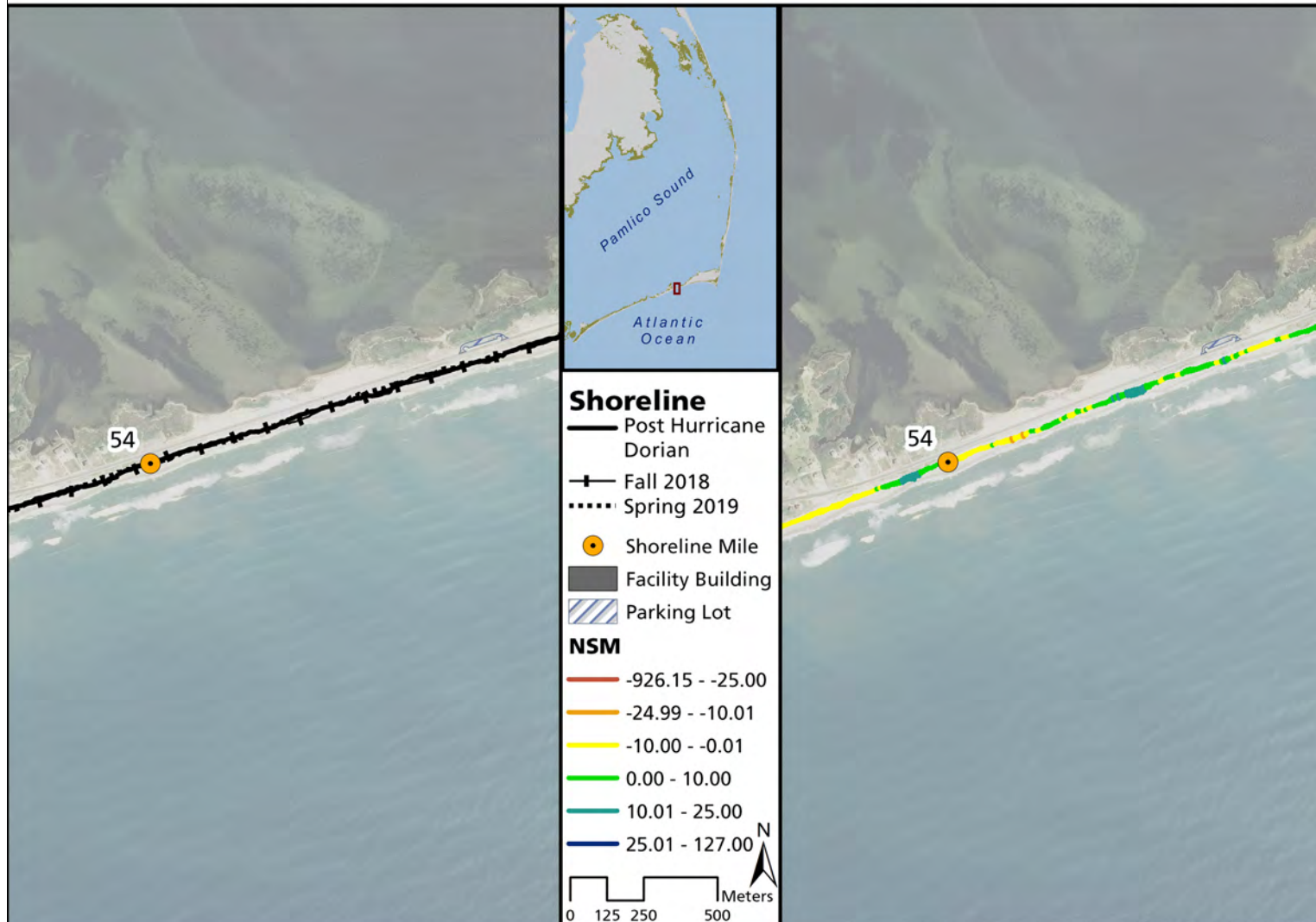


Figure C-42. Shoreline change in the vicinity of mile marker 54.

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Shoreline Data

Spring 2019 to Hurricane Dorian

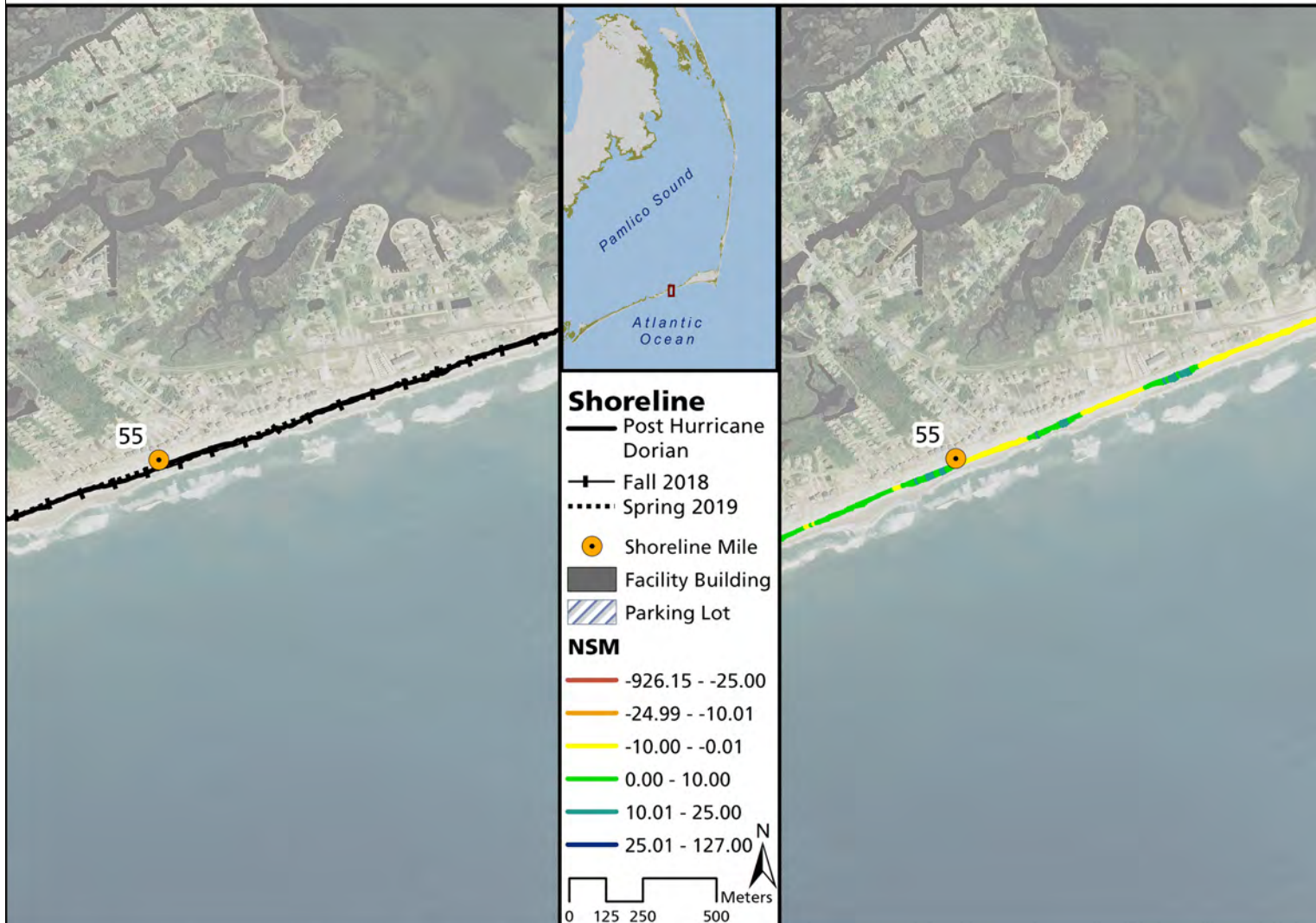


Figure C-43. Shoreline change in the vicinity of mile marker 55.

Cape Hatteras National Seashore Hurricane Dorian Shoreline Monitoring

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Shoreline Data

Spring 2019 to Hurricane Dorian

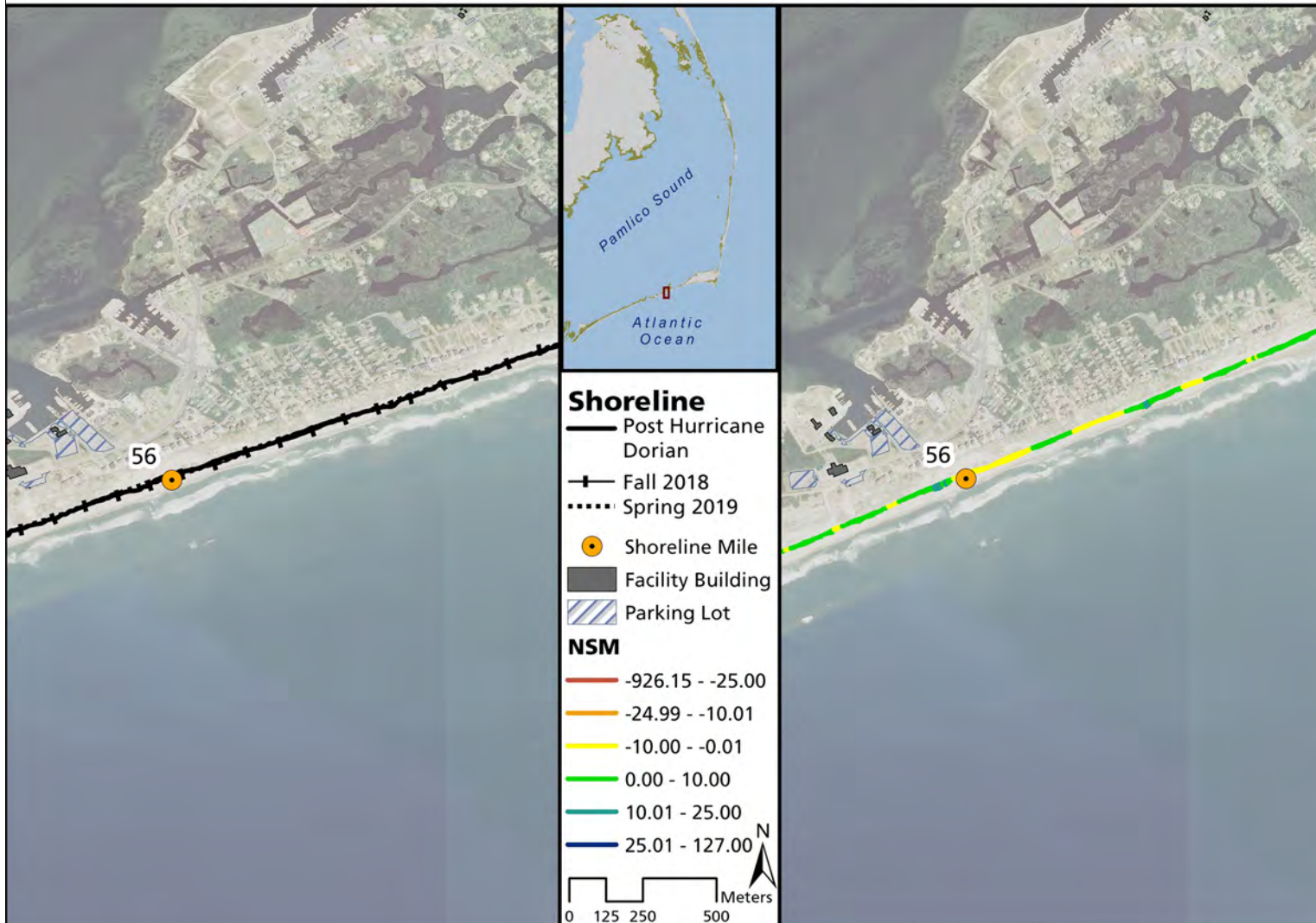


Figure C-44. Shoreline change in the vicinity of mile marker 56.

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Shoreline Data

Spring 2019 to Hurricane Dorian

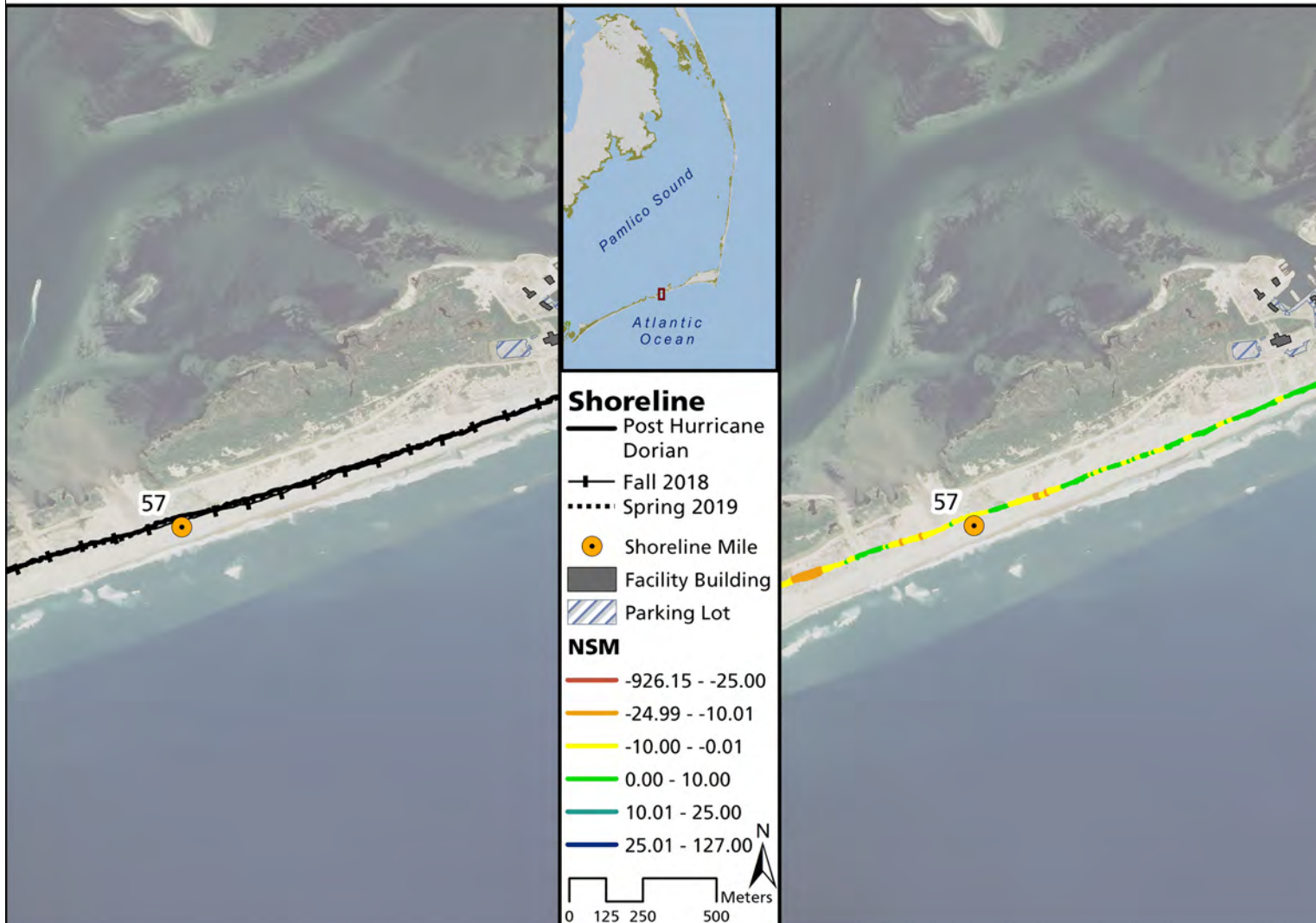


Figure C-45. Shoreline change in the vicinity of mile marker 57.

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Spring 2019 to Hurricane Dorian

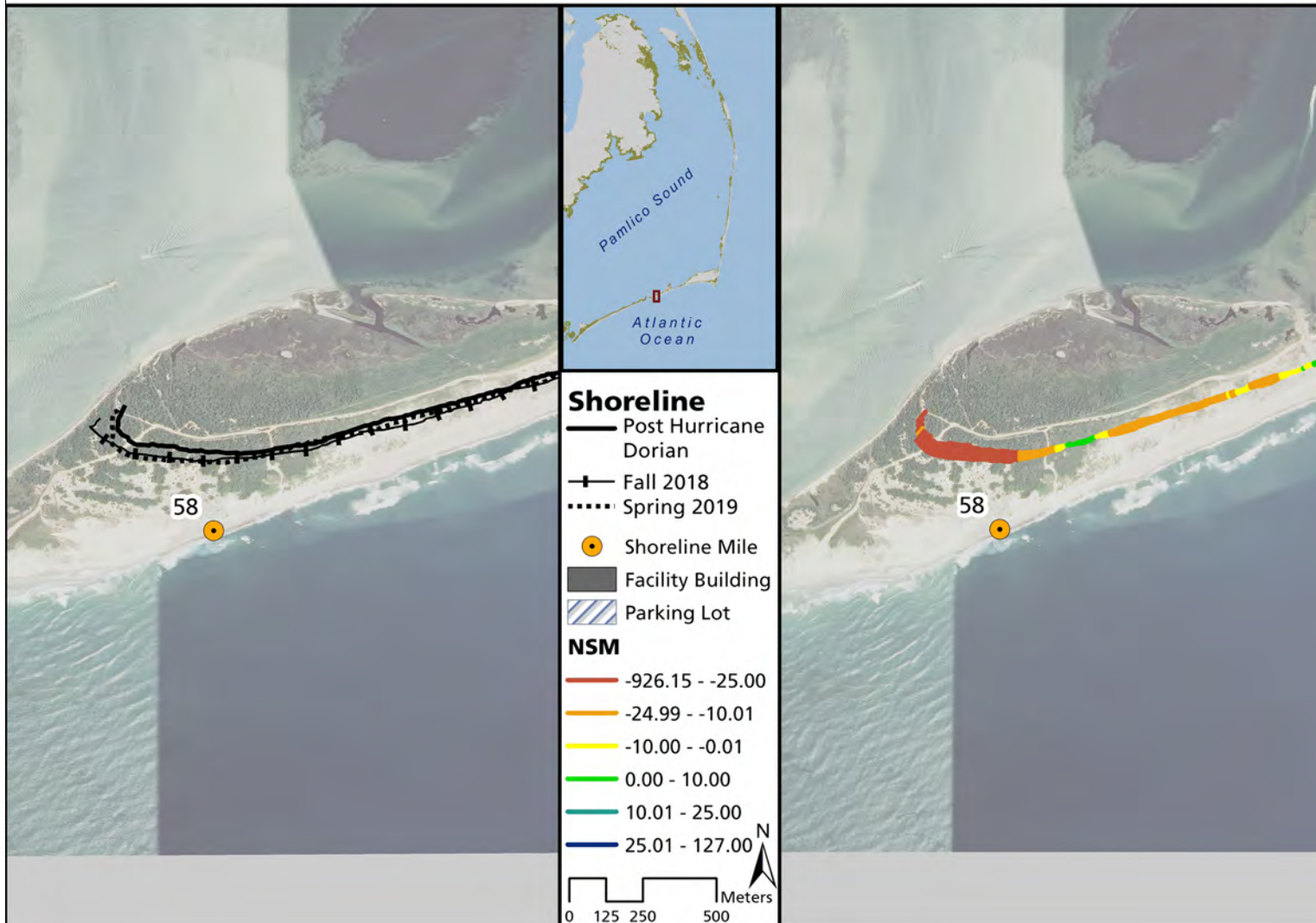


Figure C-46. Shoreline change in the vicinity of mile marker 58.

Ocracoke Island

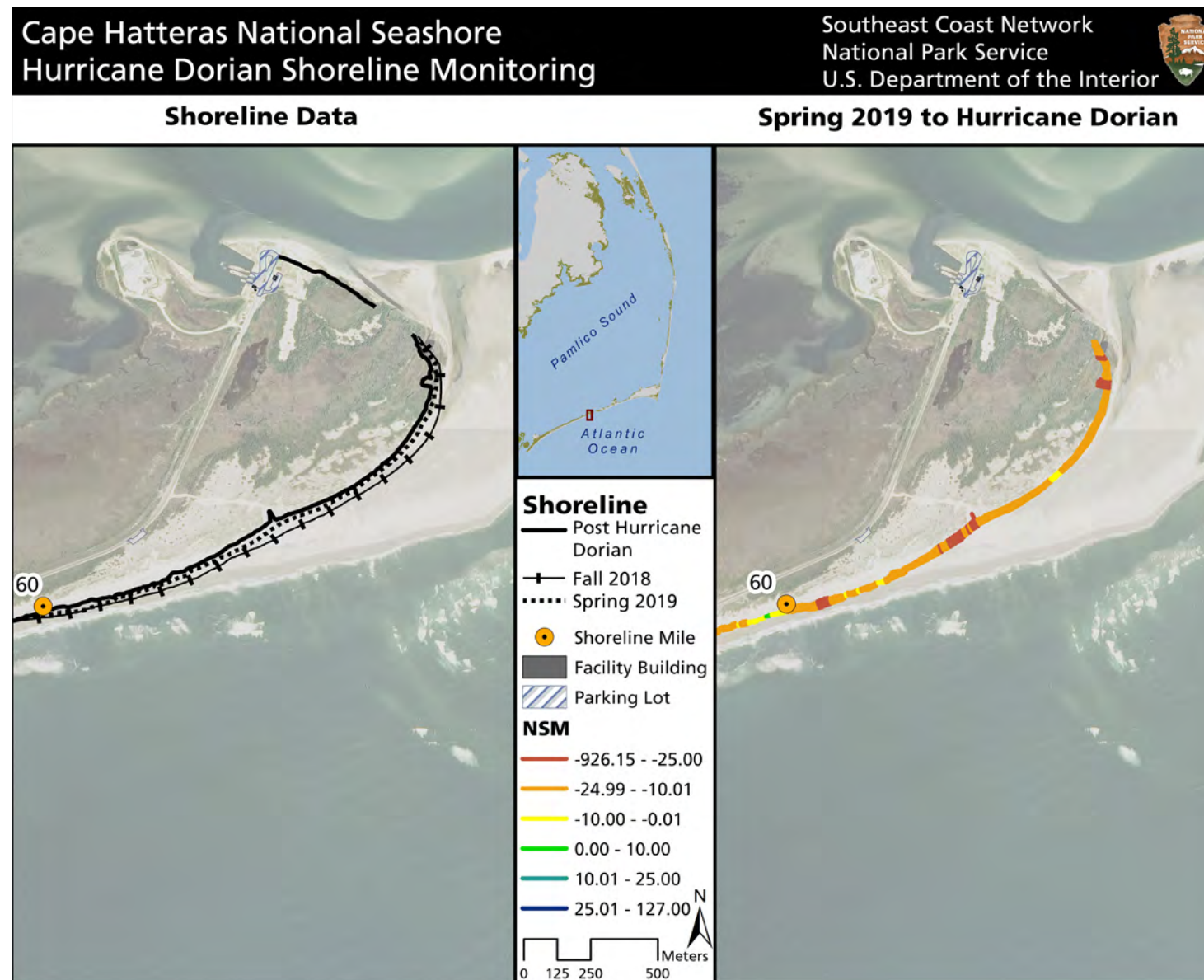


Figure C-47. Shoreline change in the vicinity of mile marker 60.

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Spring 2019 to Hurricane Dorian

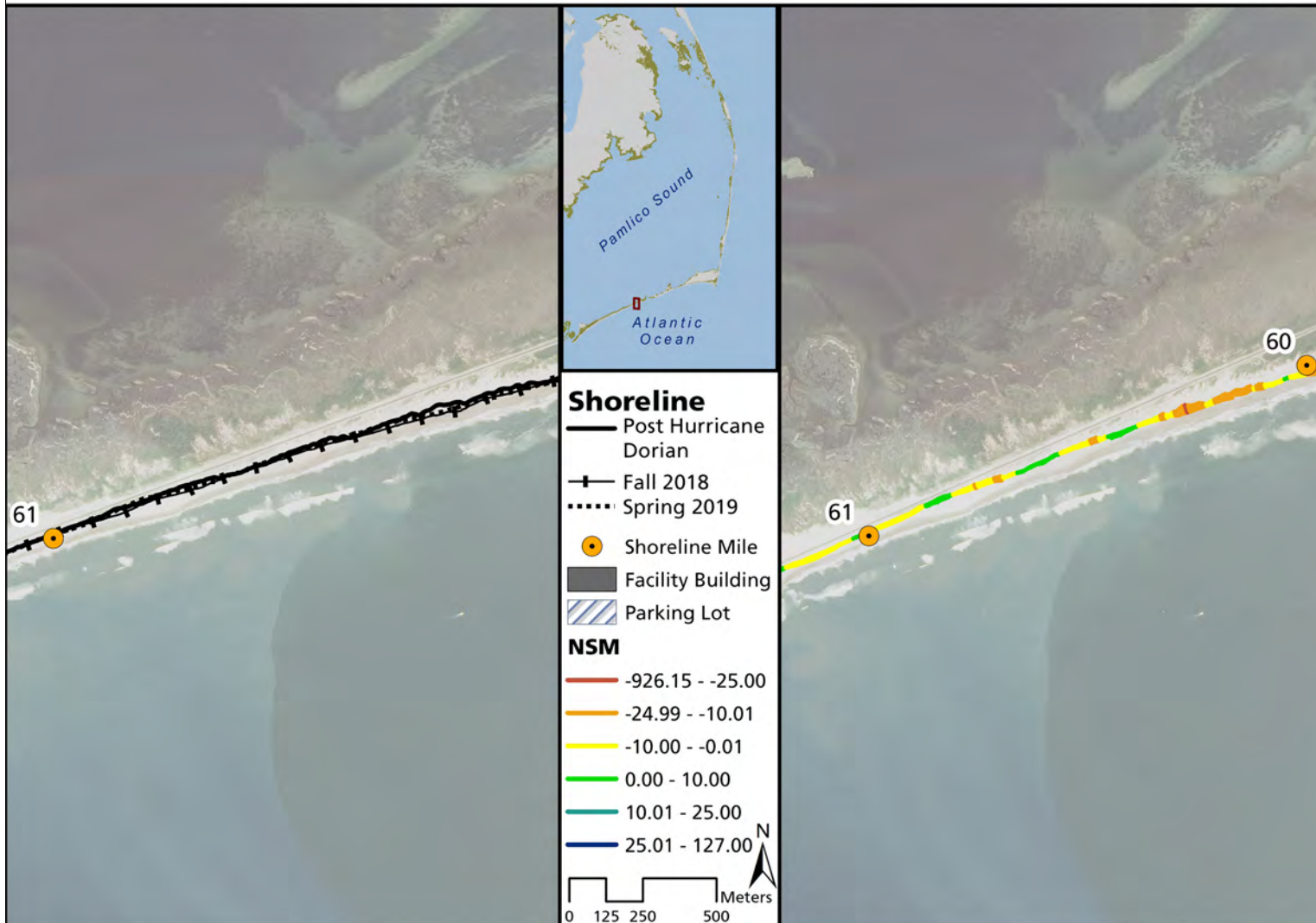


Figure C-48. Shoreline change in the vicinity of mile markers 60 and 61.

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Shoreline Data

Spring 2019 to Hurricane Dorian

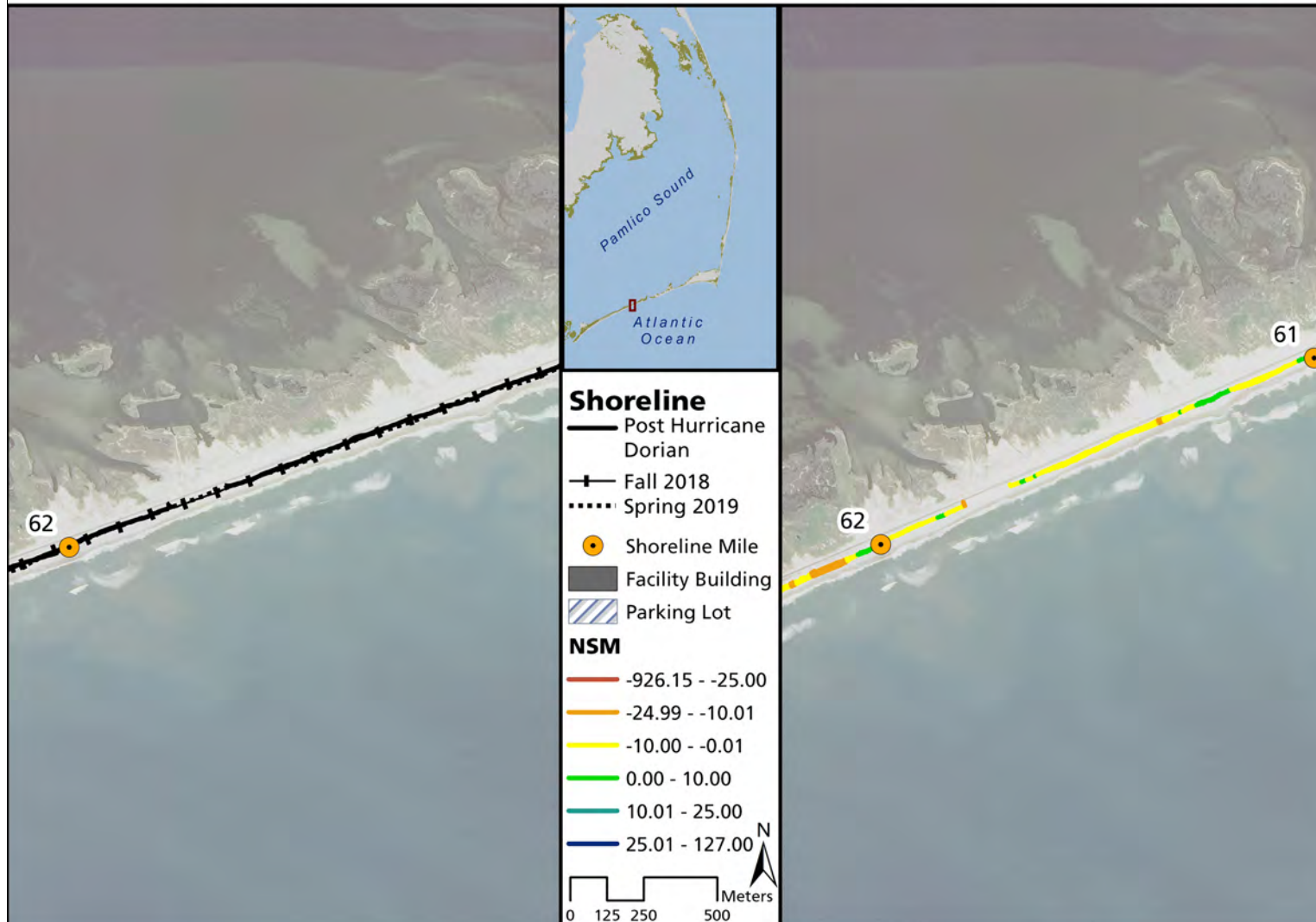


Figure C-49. Shoreline change in the vicinity of mile markers 61 and 62.

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Shoreline Data

Spring 2019 to Hurricane Dorian

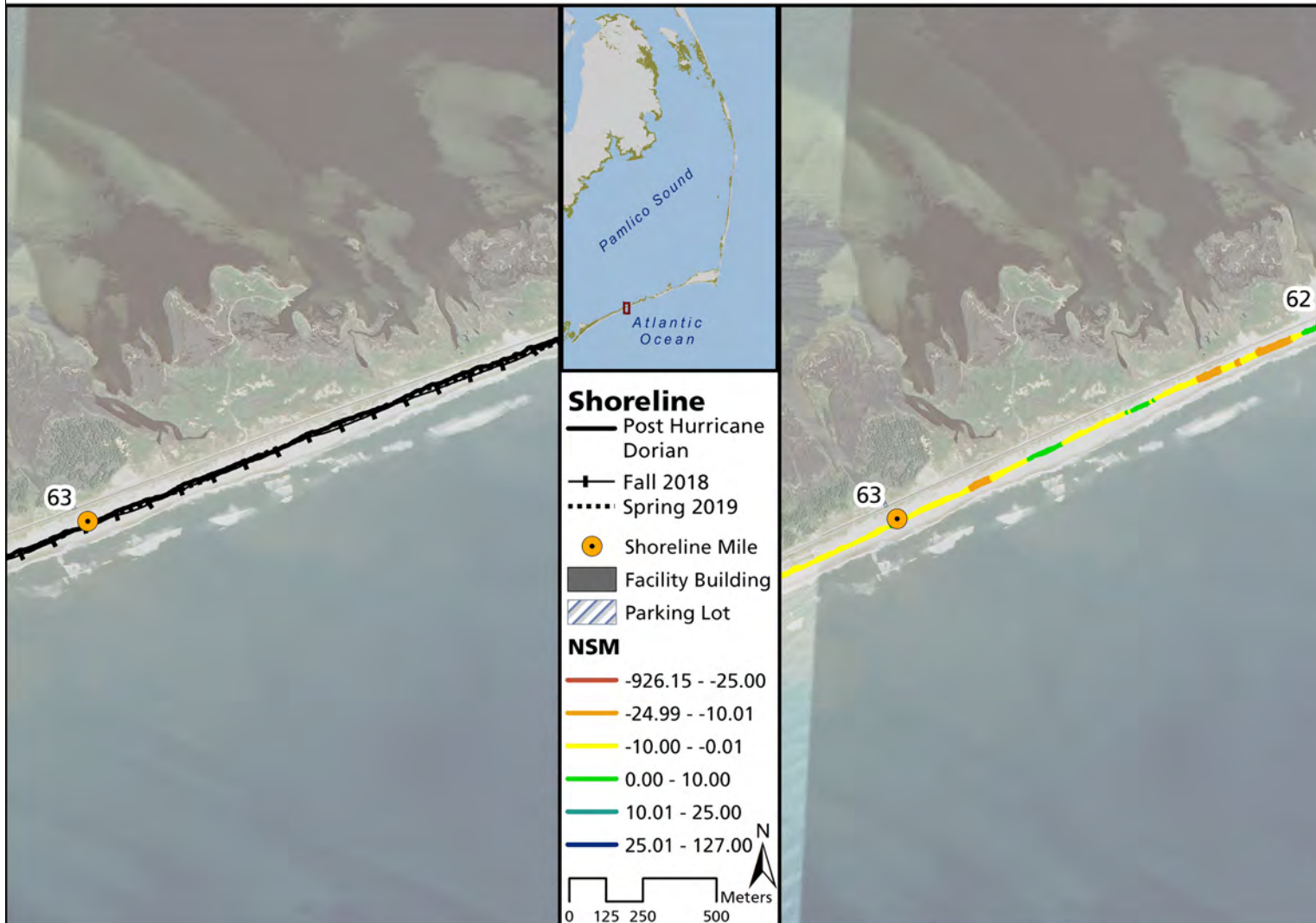


Figure C-50. Shoreline change in the vicinity of mile markers 62 and 63.

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Shoreline Data

Spring 2019 to Hurricane Dorian

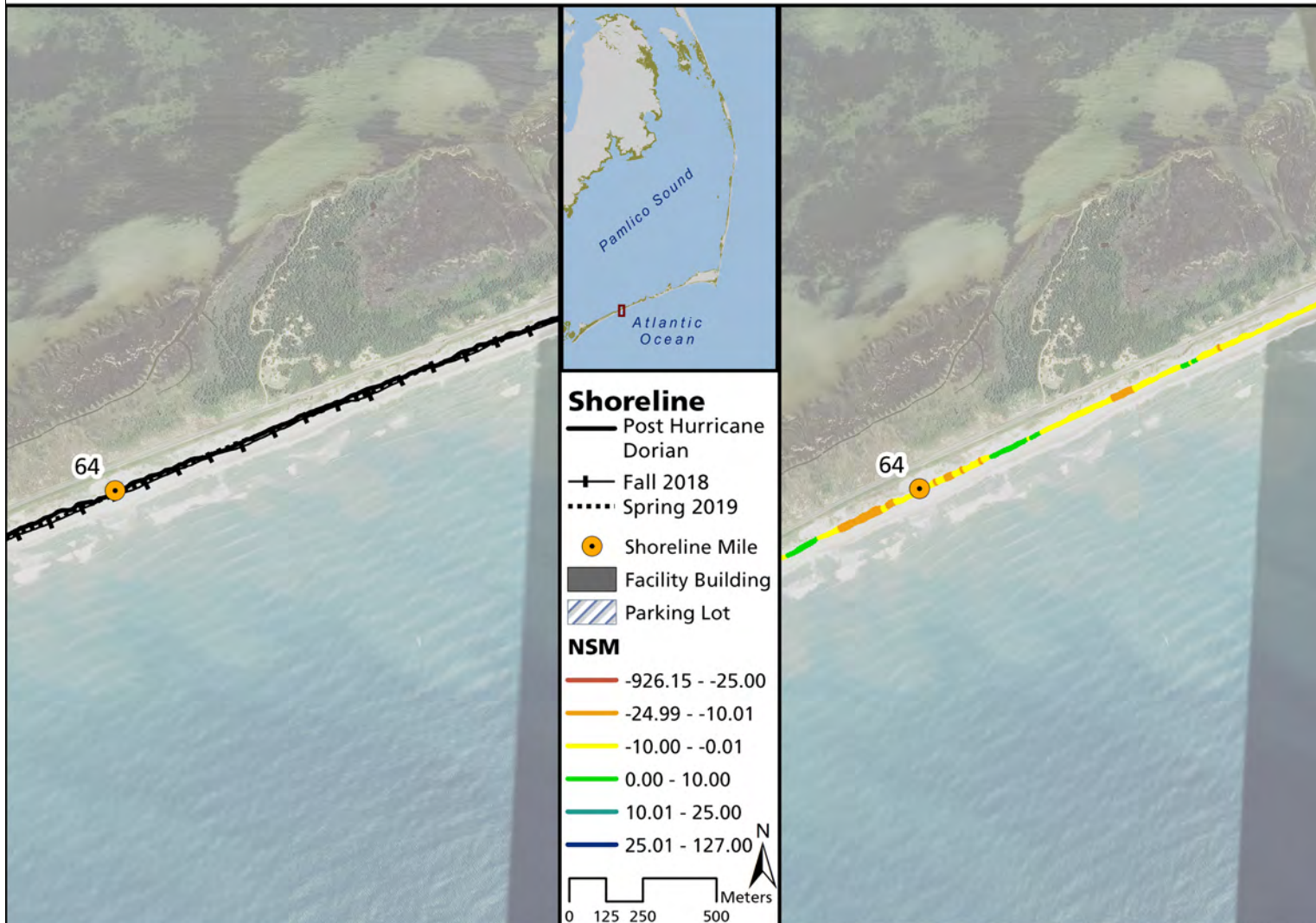


Figure C-51. Shoreline change in the vicinity of mile marker 64.

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Shoreline Data

Spring 2019 to Hurricane Dorian

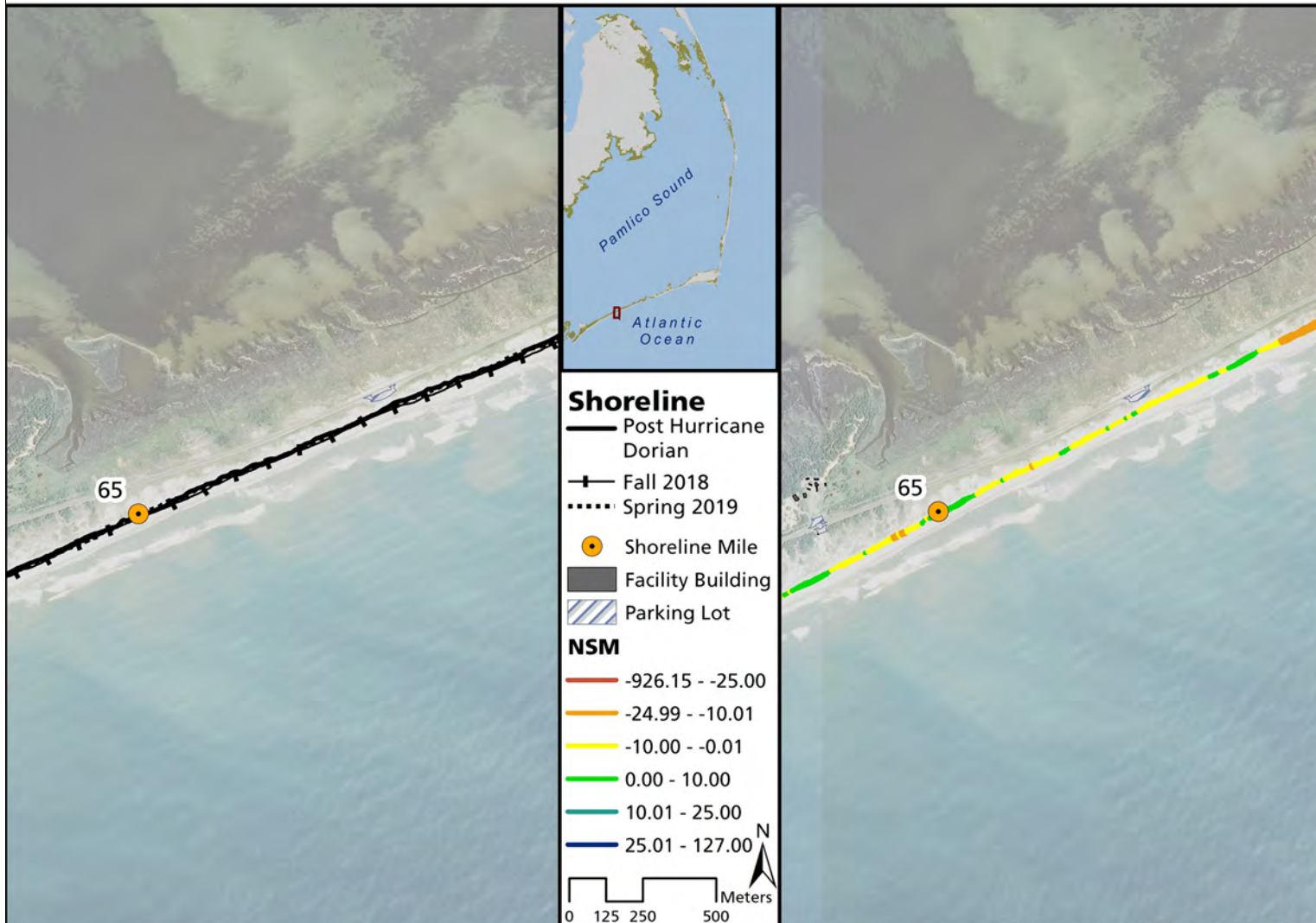


Figure C-52. Shoreline change in the vicinity of mile marker 65.

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Shoreline Data

Spring 2019 to Hurricane Dorian

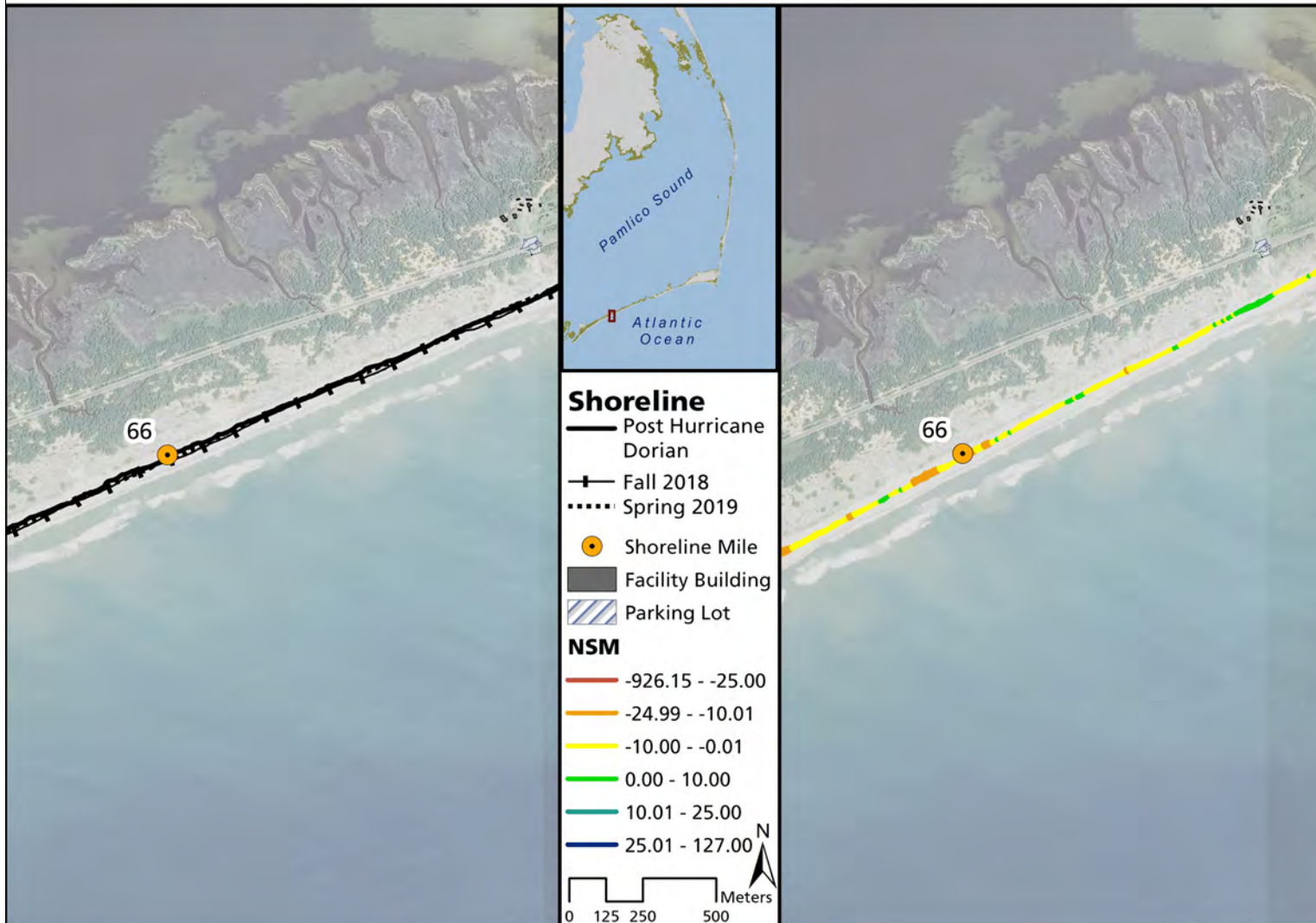


Figure C-53. Shoreline change in the vicinity of mile marker 66.

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Shoreline Data

Spring 2019 to Hurricane Dorian

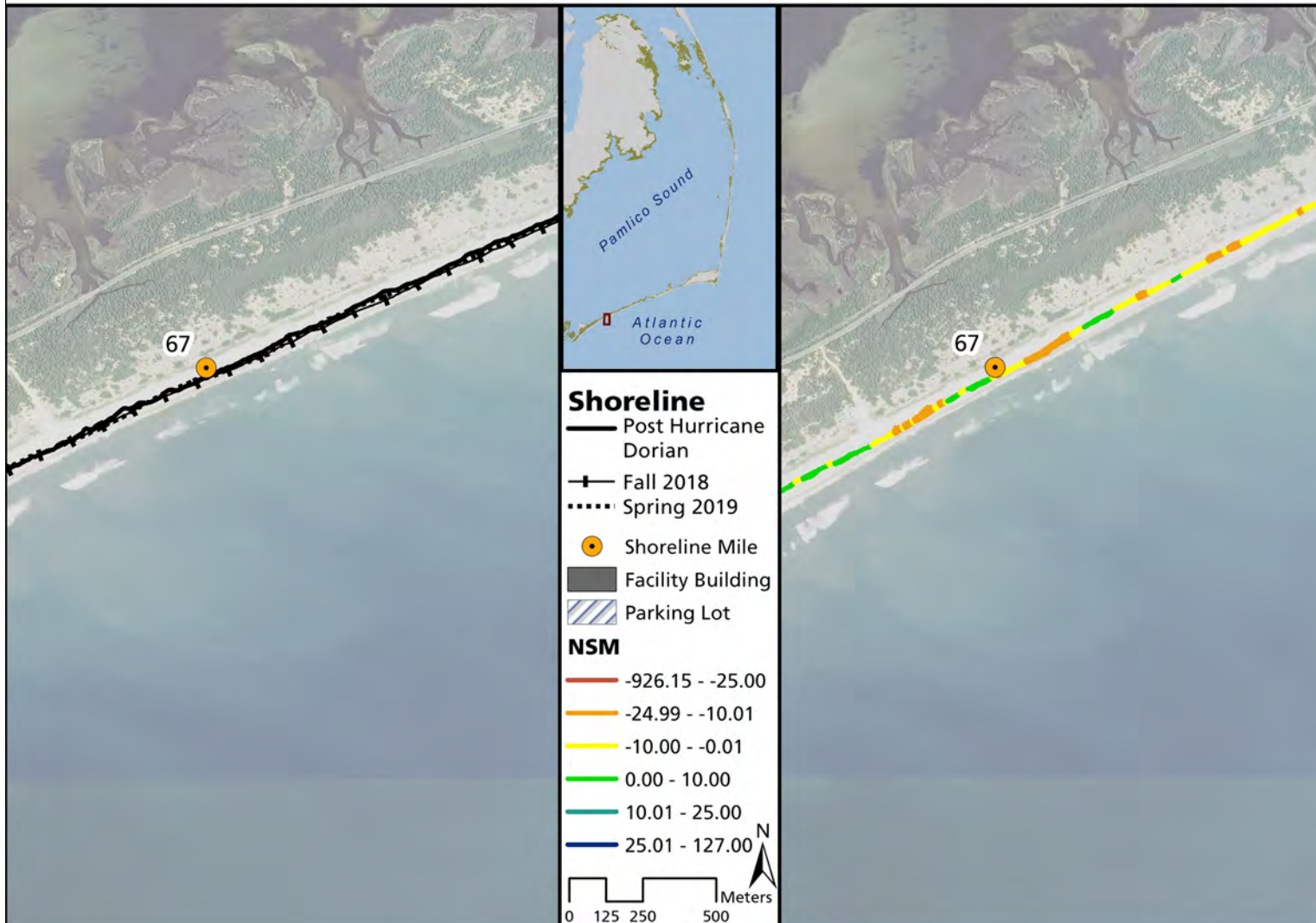


Figure C-54. Shoreline change in the vicinity of mile marker 67.

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Shoreline Data

Spring 2019 to Hurricane Dorian

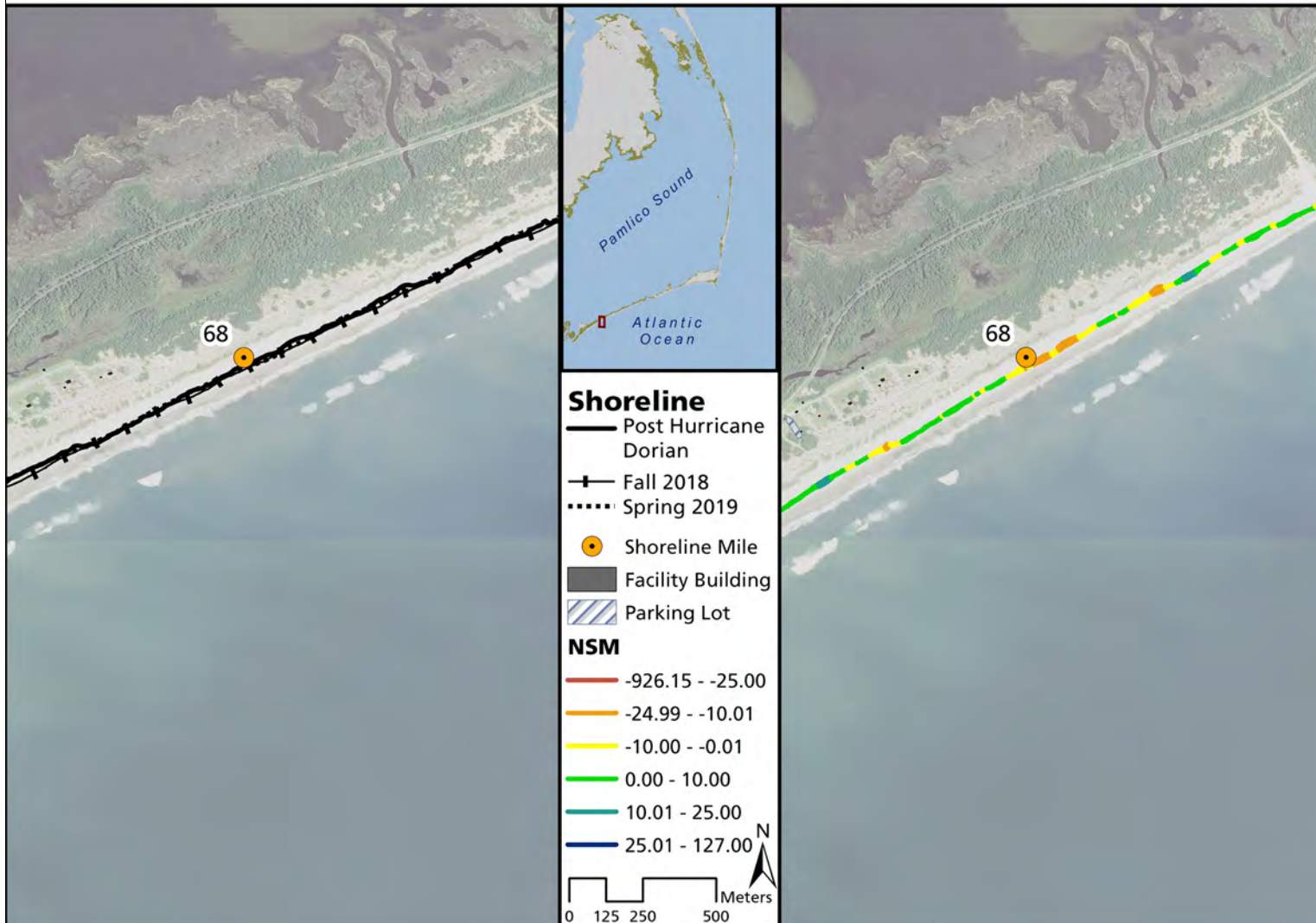


Figure C-55. Shoreline change in the vicinity of mile marker 68.

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Shoreline Data

Spring 2019 to Hurricane Dorian

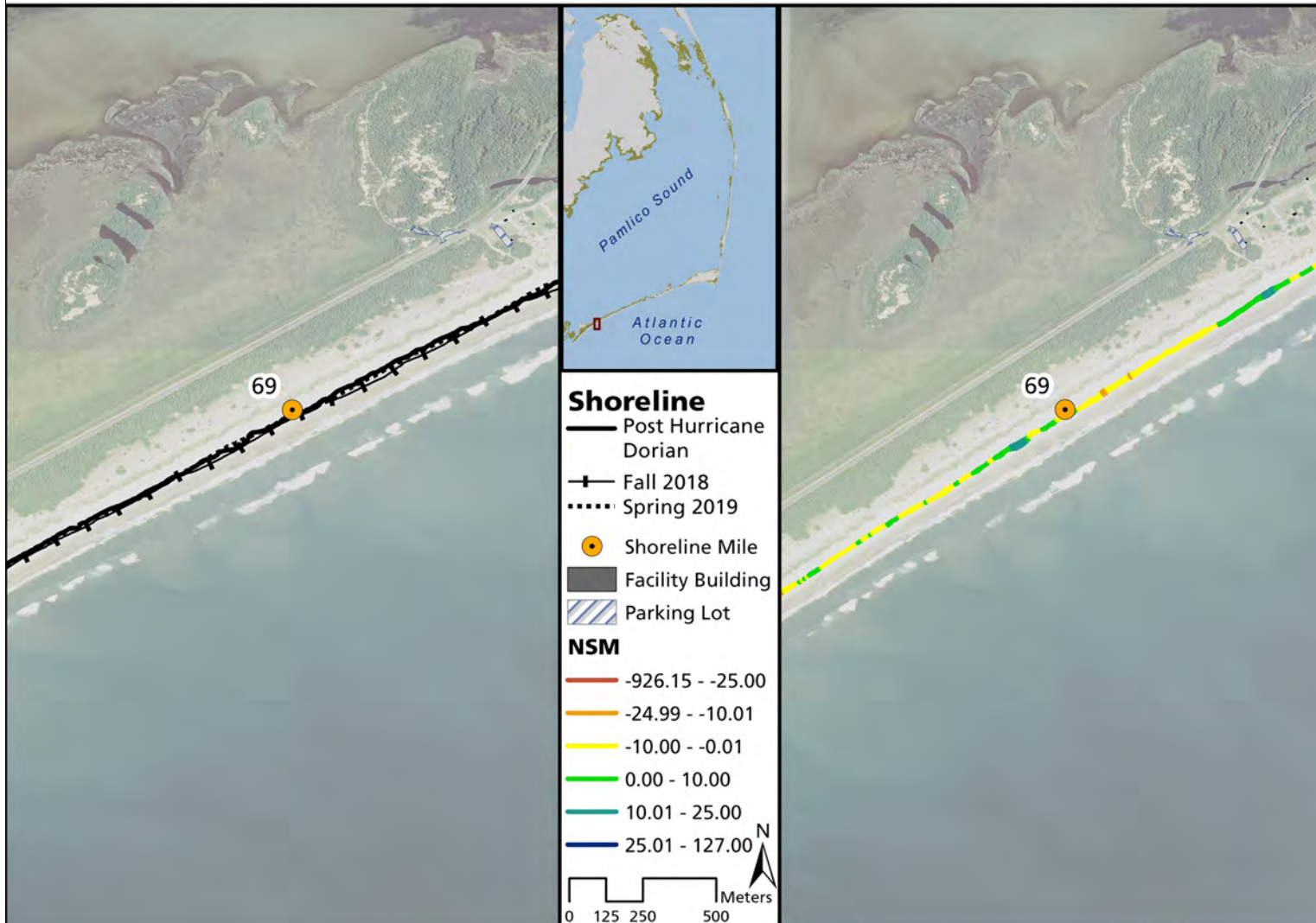


Figure C-56. Shoreline change in the vicinity of mile marker 69.

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Shoreline Data

Spring 2019 to Hurricane Dorian

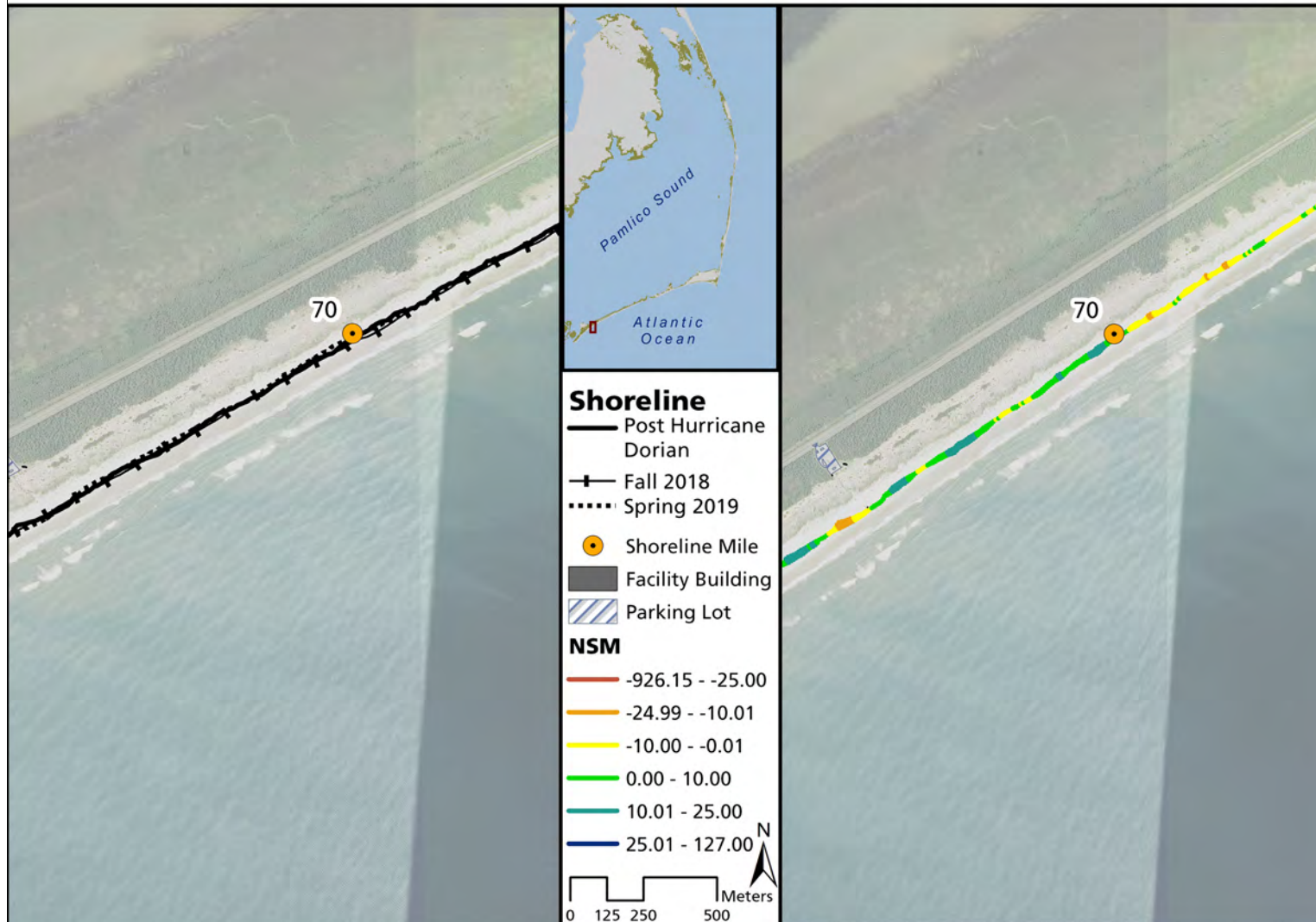


Figure C-57. Shoreline change in the vicinity of mile marker 70.

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Shoreline Data

Spring 2019 to Hurricane Dorian

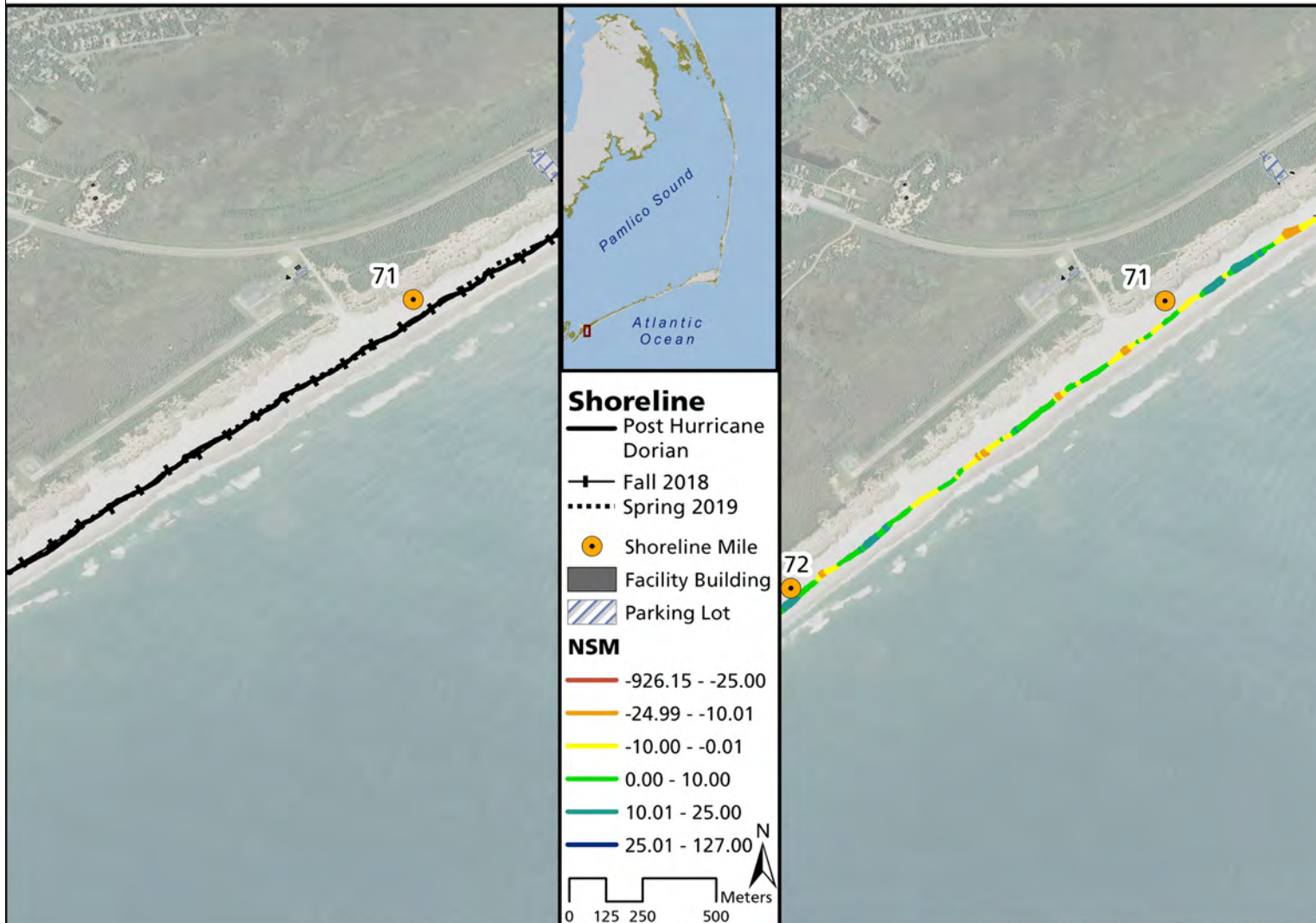


Figure C-58. Shoreline change in the vicinity of mile markers 71 and 72.

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Spring 2019 to Hurricane Dorian

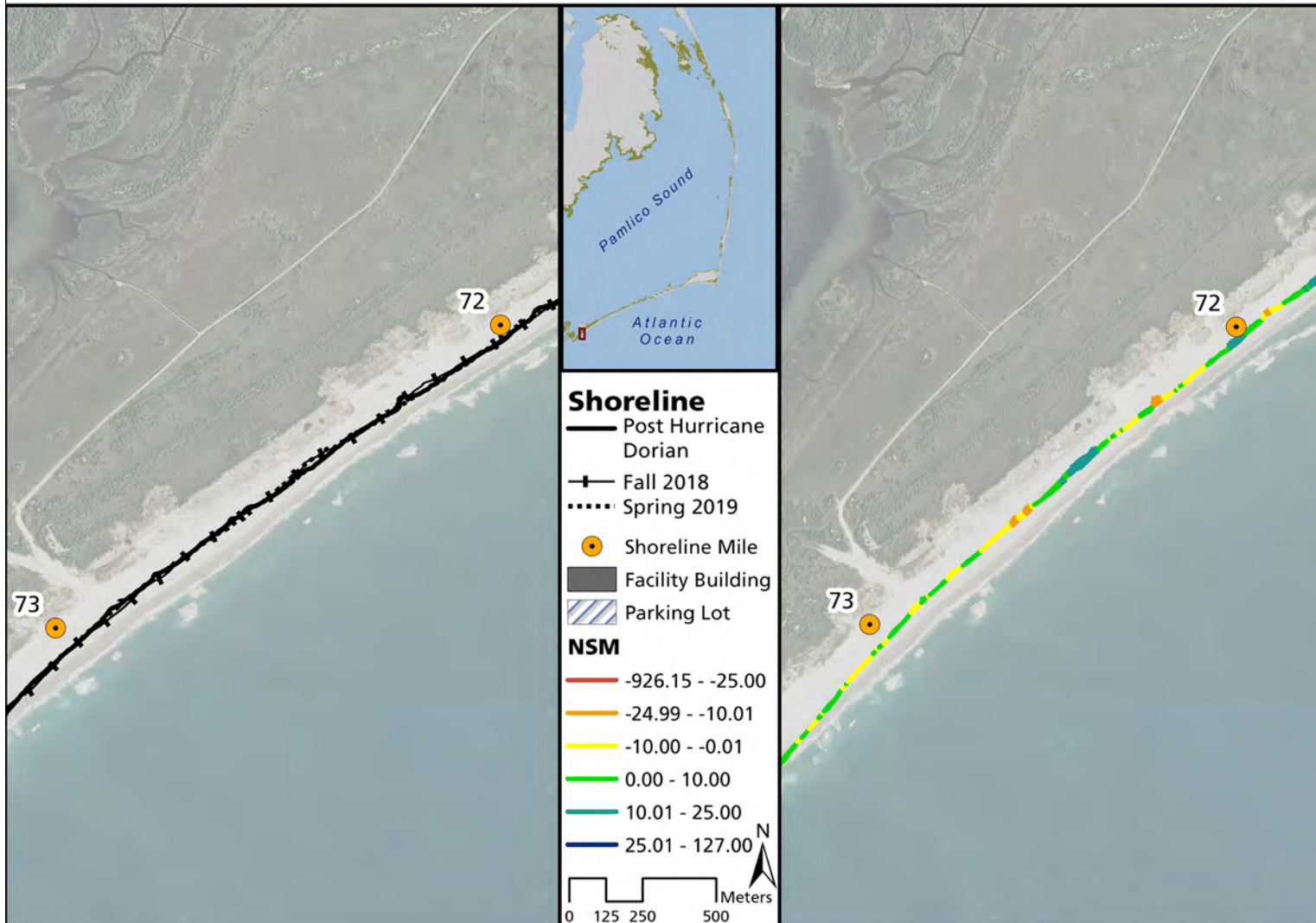


Figure C-59. Shoreline change in the vicinity of mile markers 72 and 73.

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Shoreline Data

Spring 2019 to Hurricane Dorian

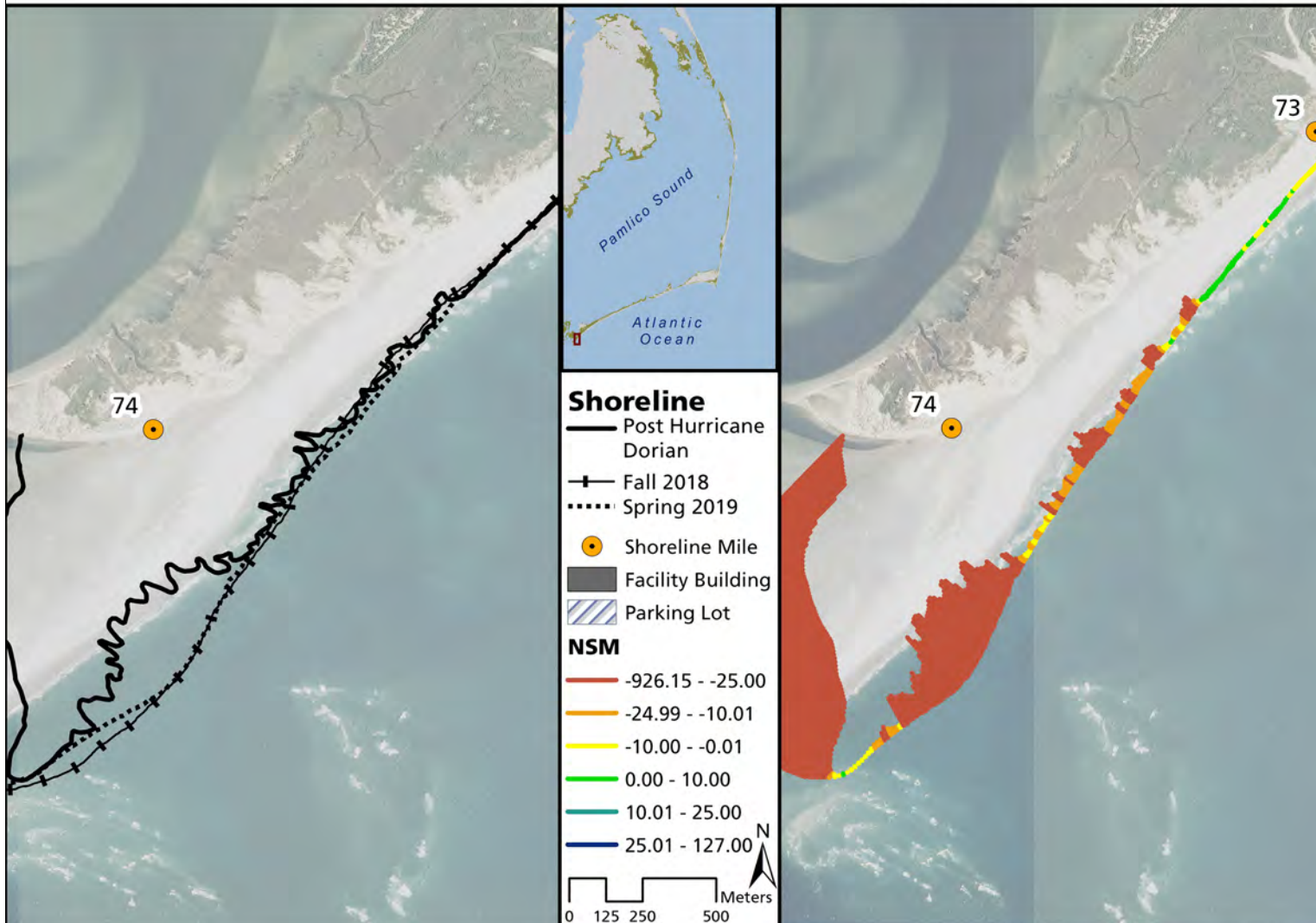


Figure C-60. Shoreline change in the vicinity of mile markers 73 and 74.

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Shoreline Data

Spring 2019 to Hurricane Dorian

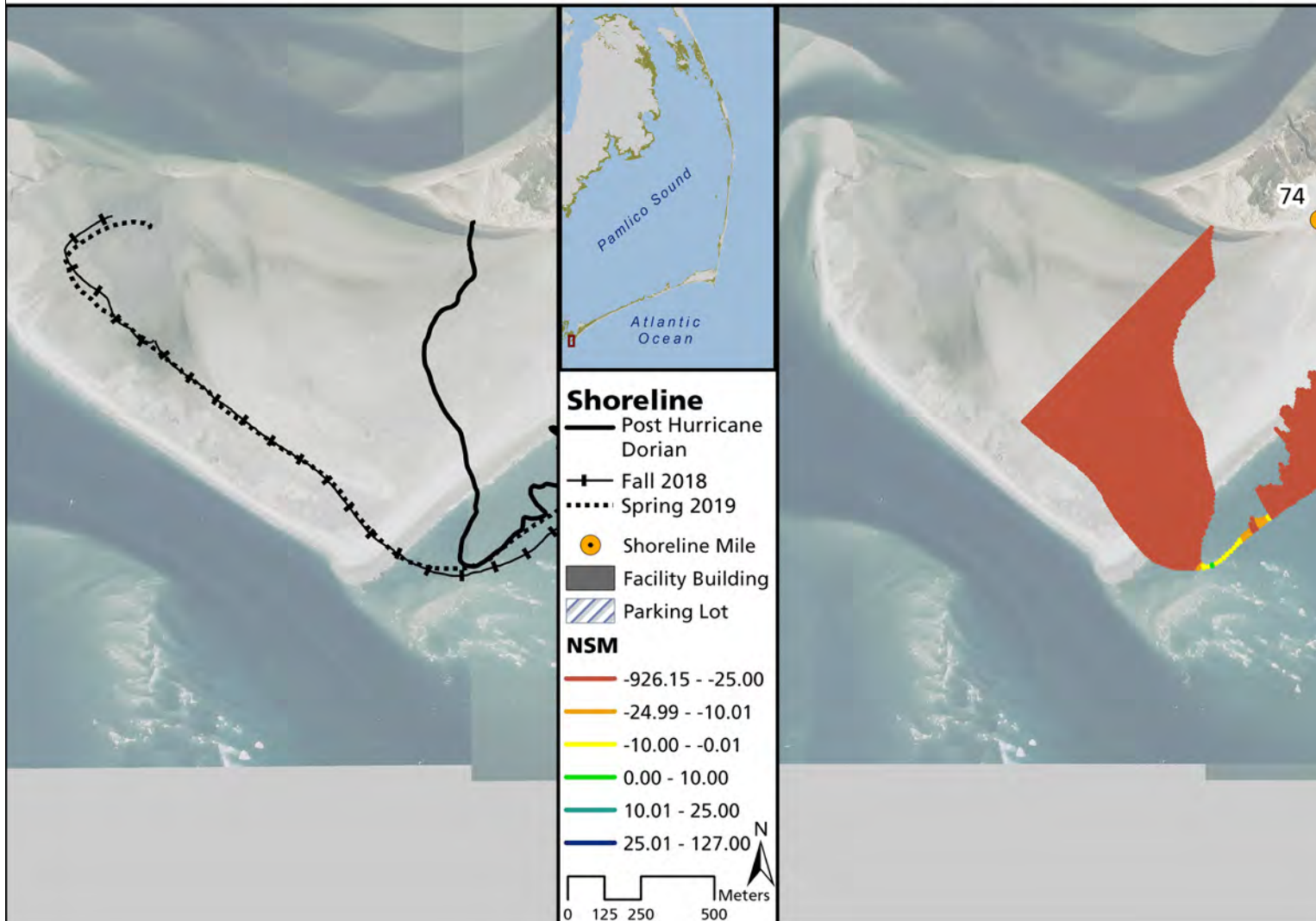


Figure C-61. Shoreline change in the vicinity of mile marker 74.

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

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Natural Resource Stewardship and Science

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