National Park Service
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Natural Resource Stewardship and Science

Shoreline Change at Gulf Islands National Seashore, Florida and Mississippi

2018–2021 Data Summary

Natural Resource Data Series NPS/GULN/NRDS—2022/1348

ON THE COVER
A surveyor records shoreline position at the west end of Fort Pickens in Florida. NPS photo / GULN staff.

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible and technically accurate.

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Summary and Key Findings

In May and June 2018, and April 2021, the Gulf Coast Network (GULN) surveyed shoreline position at Gulf Islands National Seashore (GUIS) as a part of the NPS Vital Signs Monitoring Program. Monitoring was conducted following methods detailed in Monitoring Shoreline Position at Gulf Coast Network Parks: Protocol Implementation Plan (PIP; Bracewell 2017). Shoreline change was calculated using the Digital Shoreline Analysis System developed by USGS (Theiler et al. 2008).

Key findings from this effort are as follows:

- In Florida, the mean shoreline change rate from 2018 to 2021 was -7.10 meters/year (-23.3 feet[ft]/year) with a standard deviation of 5.01 meters (16.4 ft) with approximately 95% of transects exhibiting landward retreat.
- In Mississippi, the mean change in island width from 2018 to 2021 was -7.46 meters/year (-24.5 ft/year) with a standard deviation of 12.49 meters (41.0 ft) with approximately 73% of transects exhibiting a loss in width.

This project is in the early phases of implementation and will benefit from future surveys to better understand the influence of slight changes in survey timing and other environmental variations.

Introduction

As stated by Psuty et al. (2010)

> *Changes in shoreline position are recognized as interacting with many other elements of the ocean beach-dune ecosystem and are thus both driving and responding to the variety of natural and cultural factors active at the coast at a variety of temporal and spatial scales. The direction and magnitude of shoreline change can be monitored through the application of a protocol that tracks the spatial position of the neap-tide, high tide swash line under conditions of temporal sampling.*

The Gulf Coast Network monitors shoreline position at Gulf Islands National Seashore and Padre Island National Seashore (PAIS) using modified procedures developed for the Northeast Coastal and Barrier Network (NCBN). Handheld and utility task vehicle (UTV)-mounted Global Positioning Systems (GPS) or Global Navigation Satellite Systems (GNSS) are used to record shoreline position by walking or driving the high tide swash line. The Gulf Coast Network's monitoring objective is to identify the biennial and long-term trends and variability of shoreline position in network seashore parks.

This report provides a summary of shoreline monitoring data collected to address this objective at Gulf Islands National Seashore from April 2018 through May 2021.

Study Area

Gulf Islands National Seashore (GUIS) consists of several units in Florida and Mississippi. The Mississippi section (GUIS-MS) consists of five islands and a small mainland headquarters area. The authorized boundary includes not only the barrier islands themselves, but also portions of the Gulf of Mexico and Misssissippi Sound. From the west to east, the islands of GUIS-MS are: Cat, Ship, Horn, West Petit Bois, and Petit Bois Islands and are only accessible by boat. Horn Island is the largest and Cat is the most recently acquired of the GUIS-MS islands. Davis Bayou is the only mainland area in the GUIS-MS park section.

The Florida section (GUIS-FL) consists of portions of two islands (Santa Rosa Island and Perdido Key) and two small mainland areas. Three park units are located on Santa Rosa Island: Fort Pickens, Santa Rosa Area, and Okaloosa Area. The Naval Live Oaks Reservation is on a peninsula forming part of the eastern mouth of Pensacola Bay. Unlike the GUIS-MS park section, all areas of the GUIS-FL park section, including the islands, are accessible to vehicles. The water bodies surrounding the Florida section include Santa Rosa Sound, Big Lagoon, Pensacola Bay, Choctawhatchee Bay, and the Gulf of Mexico (Cooper et al. 2005).

There are a number of aquatic and terrestrial ecosystems in Gulf Islands National Seashore, including Gulf, bay, dunes, salt marsh, maritime forest, barrier islands, seagrass beds, and other marine systems. Hydrology and water-related issues are of central importance because 80% of the park is submerged land (Anderson et al. 2005). The mainland portion of the GUIS-FL park section consists of live oak, sandhill, and marsh communities; the mainland portion of the GUIS-MS park section consists of pine/palmetto flatwoods, mixed pine/hardwood, lowland hardwood, and tidal marsh.

Hurricanes are one of the biggest concerns for the park, as they can have devastating effects on biological communities as well as park structures and facilities and cause rapid morphological shoreline changes through erosion and overwash of the islands. Hydrologic alternations (e.g., jetties and navigation channels) alter sediment input and transport, limiting the ability of these systems to recover on their own between storms. To combat erosion, the beaches of Gulf Islands National Seashore have been regularly nourished with sand, which generally comes from the dredging of navigation channels. Although these nourishment projects are beneficial for the reduction of erosion, there is concern regarding the rates of revegetation, adverse effects on macroinvertebrates, and reduction of the vegetative seed bank (Cooper et al. 2005).

The purpose of this document is to report the most recently collected data from within the park as part of an ongoing long-term shoreline-change monitoring program. Other data collected during this survey are available at the Gulf Coast Network Shoreline Monitoring Project.

Methods

The position of selected GUIS shorelines, are mapped in the spring of every other year using methods developed by National Park Service Northeast Coast Barrier Network (Psuty et al. 2010) and adapted by the Gulf Coast Network (Bracewell 2017). Due to COVID 19 related travel restrictions, the Gulf Coast Network was not able to survey Gulf Islands National Seashore in 2020 as prescribed in the protocol implementation plan. As an adaptive measure, the the network surveyed Gulf Islands National Seashore in 2021 and will resume the normal even-year schedule with a survey in 2022. Figures 1–3 show the extent of the shoreline mapping effort at Gulf Islands National Seashore. The high tide swash line is mapped using a GNSS (GPS) unit, then differentially corrected results are exported into a standard GIS format. Digital Shoreline Analysis System (DSAS; Theiler et al. 2008) is used to analyze the shoreline change along spatially fixed cross-shore transects distributed every 20 meters (65.6 ft). Annual shoreline change rates are calculated for the Florida Units using the End Point Rate (EPR) method, which addresses the change in shoreline by determining the distance between two shorelines and dividing the distance by the time between the shoreline surveys (Figure 4). In Mississippi, island width rate is calculated instead of EPR because of large amounts of variation in shoreline position on both Gulf and Sound sides of these islands. Figure 5 describes how the island width rate is calculated. This report addressed shoreline change between spring 2018 and spring 2021.

Figure 1. Shoreline Position monitoring extent—Horn Island.

Figure 2. Shoreline Position monitoring extent—West Petit Bois Island, Petit Bois Island.

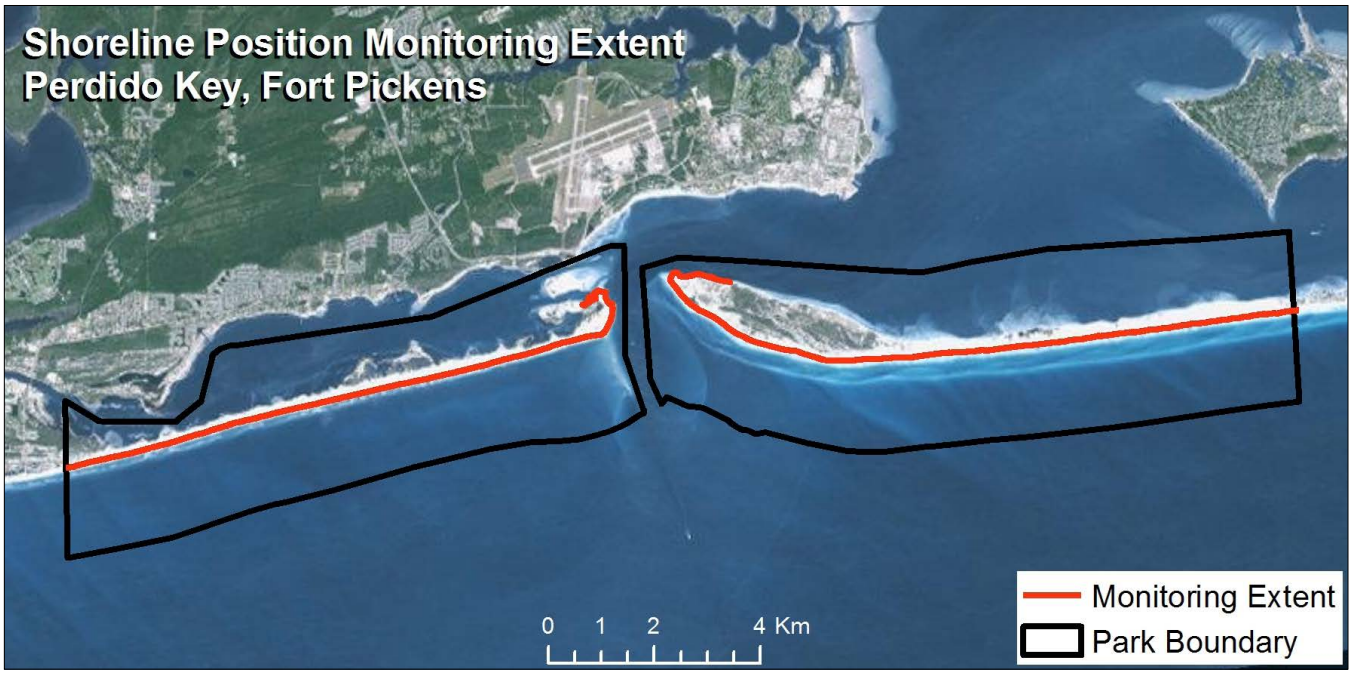

Figure 3. Shoreline Position monitoring extent—Perdido Key, Fort Pickens.

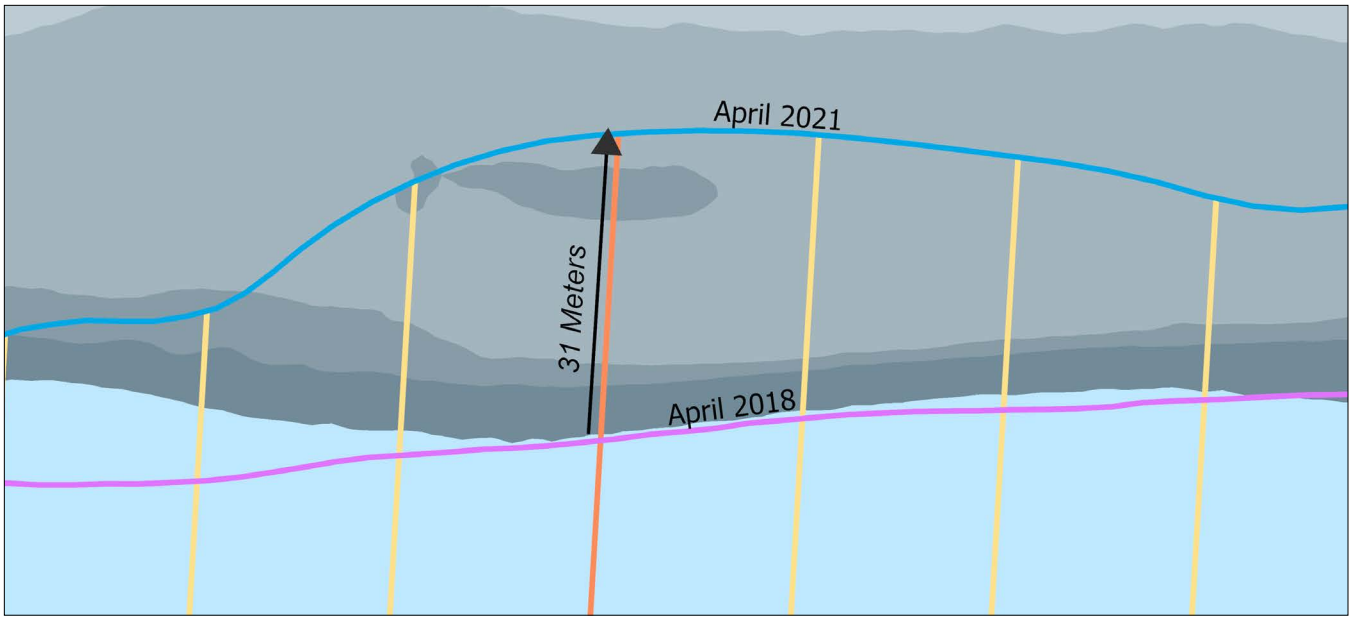

Figure 4. End Point Rate calculation is performed on distance between the first year and the current year. The result is then divided by the time interval between surveys. In the case of the transcect measured in this figure, the shoreline retreated a total of 31 meters (101.7 ft), or 10.3 meters (33.8 ft) per year.

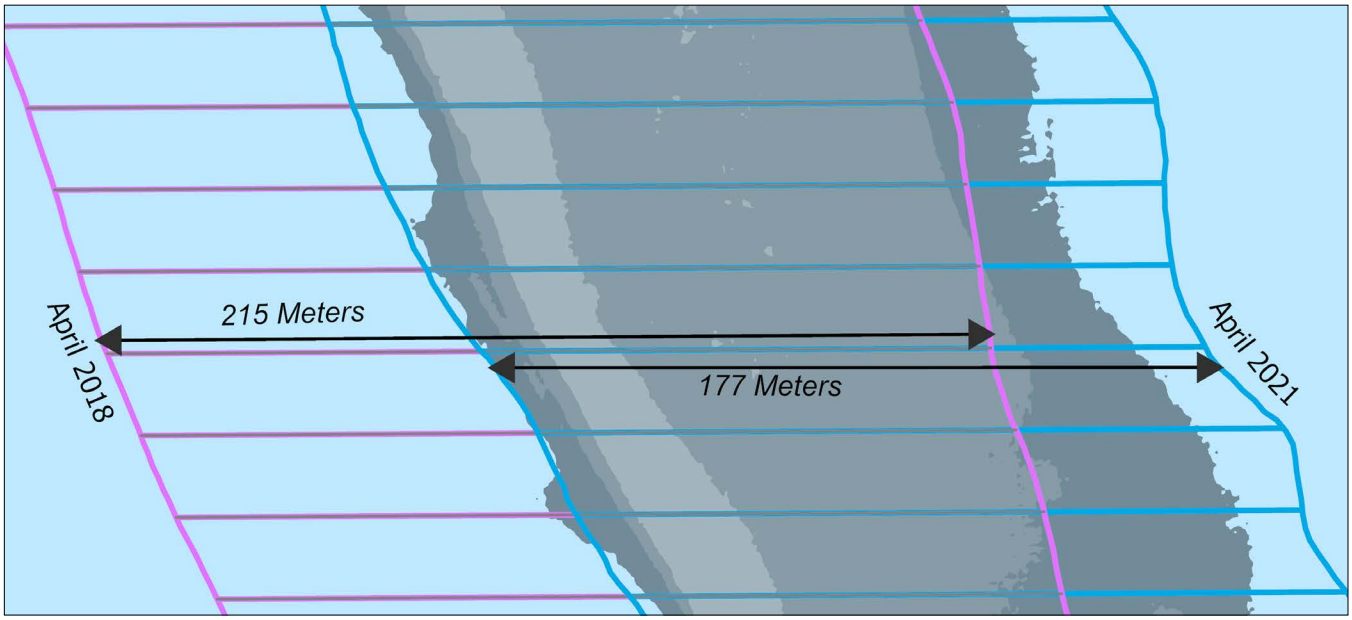

Figure 5. Island width rate calculation is performed on cross-shore width. The first year is subtracted from the current year, then the difference is divided by the time interval between surveys. In this figure, the island narrowed 12.7 meters (41.7 ft) per year; calculated as (177–215 meters) / 3 years = -12.7 meters per year or (580.7–705.4 ft) / 3 years = 41.6 ft per year.

Standard Operating Procedure

Table 1 presents the standard operation procedures considered critical to maintaining continuity between data sets across many surveys so results are comparable. No significant changes were made to SOPs between 2017 and 2021, and version numbers in the table apply to all datasets.

Table 1. Standard operating procedures used for shoreline position data collection, processing, and reporting.

SOP number	SOP title	SOP version
SHR03	Survey Timing and GPS Mission Planning	1.0
SHR04	Basic GPS Settings for Position Collection	1.0
SHR05	Conducting the Survey	1.0
SHR06	Initial Post Survey Processing	1.0
SHR07	Change Calculation, Data Analysis and Reporting	1.0

Timing of the Shoreline Position Survey

Shoreline surveys of the high tide swash line are conducted during neap tides in April and May. Neap tides are the two periods per month when high and low tides are least different. For a given survey season, these neap tide periods are determined based on predicted water levels using the closest NOAA monitoring stations: Pascagoula NOAA Lab MS in Mississippi and Pensacola FL in Florida (NOAA 2018). The verified water levels occurring before the 2018 and 2021 surveys are listed in Table 2. Graphs of verified versus predicted water levels for the survey periods and the prior week are presented in Figures 6 through 9.

Table 2. List of verified high tide water levels occurring before shoreline position surveys were conducted [m—meters; *— NAVD 88].

Season	Survey Collection Date and Time	Survey Area	Previous High-Tide Height* (m)	Previous High-Tide Date and Local Time
Spring	4/26/2018 14:40–16:00	Perdido Key (Johnsons Beach)	0.160	4/26/2018 11:00
Spring	4/27/2018 10:45–15:10	Perdido Key (Pensacola Pass to Johnsons Beach)	0.146	4/27/2018 11:12
Spring	4/28/2018 13:40–16:00	Fort Pickens	0.174	4/28/2018 11:00
Spring	6/06/2018 08:30–12:00	Petit Bois Island/ West Petit Bois Island?	0.362	6/05/2018 17:18
Spring	6/06/2018 14:30–16:30	Horn Island	0.362	6/05/2018 17:18
Spring	6/07/2018 08:20–12:45	Horn Island	0.226	6/06/2021 15:00
Spring	4/10/2021 17:40–19:10	Fort Pickens	0.523	4/10/2021 06:36
Spring	4/11/2021 13:00–15:25	Perido Key	0.406	4/11/2021 11:48
Spring	4/25/2021 09:55–16:00	Horn Island	0.455	4/24/2021 12:48
Spring	4/26/2021 10:30–16:00	Petit Bois Island	0.326	4/25/2021 12:00
Spring	4/28/2021 10:00–12:00	Petit Bois Island/ West Petit Bois Island	0.514	4/27/2021 10:48

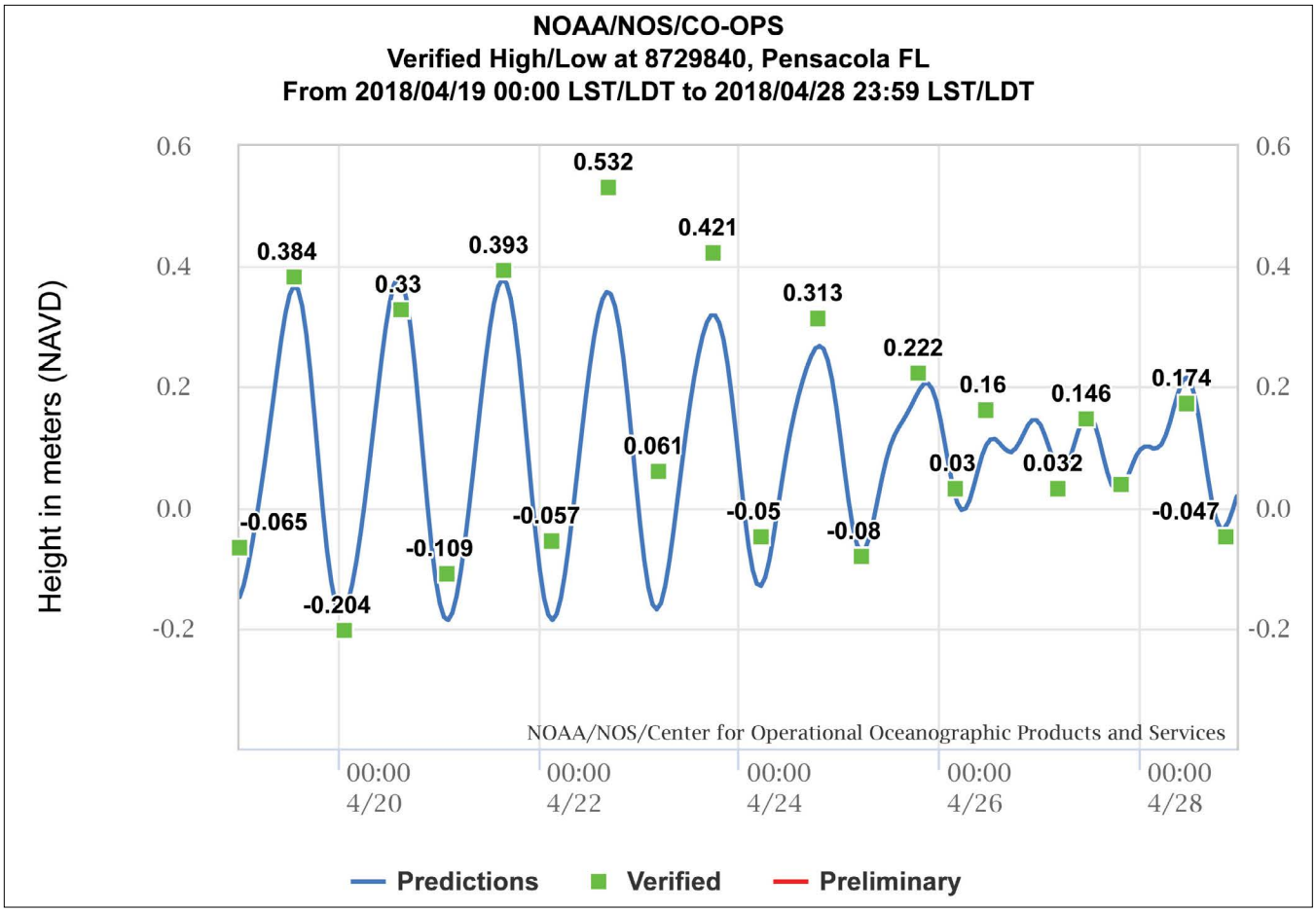

Figure 6. Water levels recorded at Pensacola FL NOAA monitoring station before and during the 2018 Florida shoreline survey.

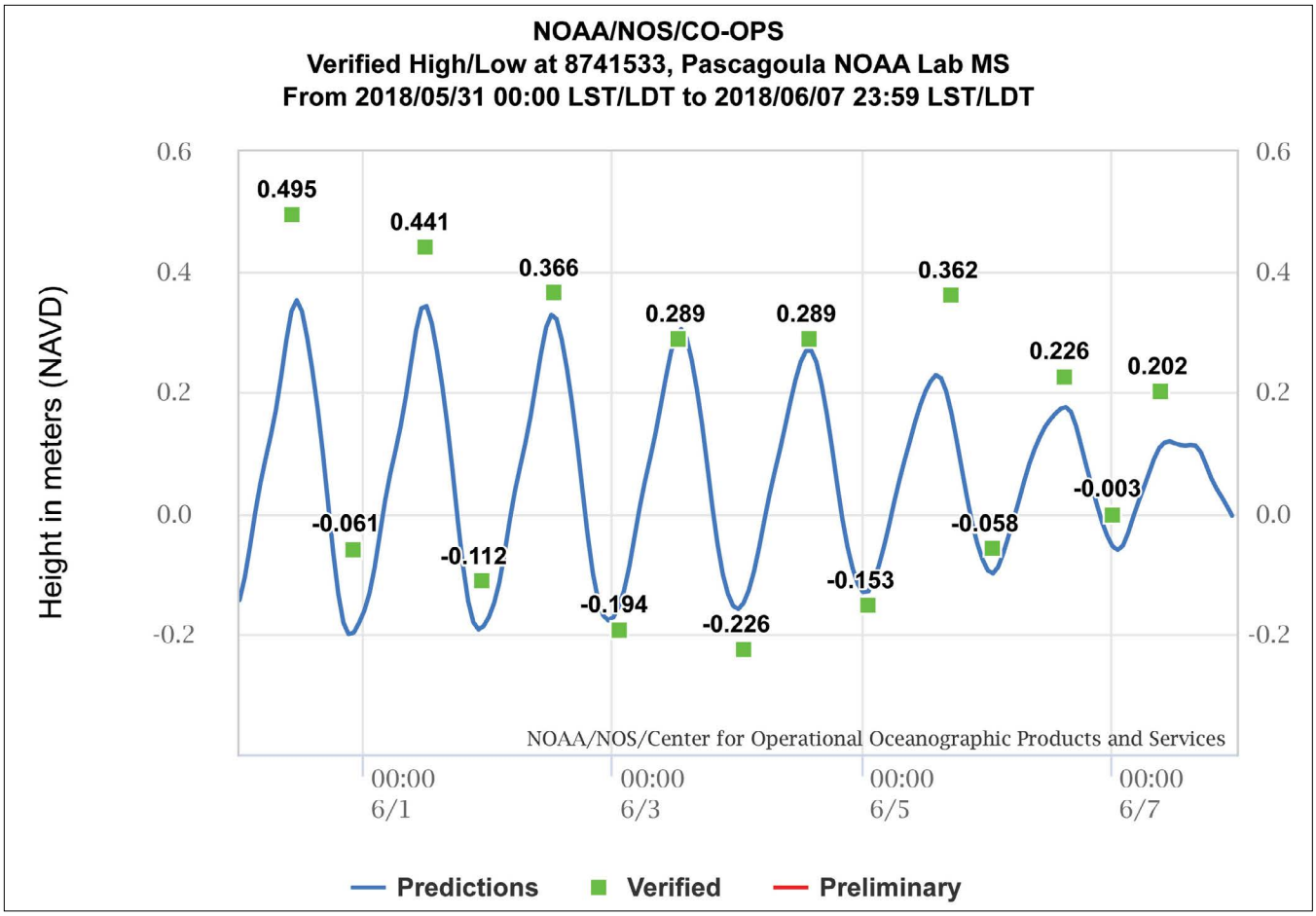

Figure 7. Water levels recorded at Pascagoula NOAA Lab MS before and during the 2018 Mississippi shoreline survey.

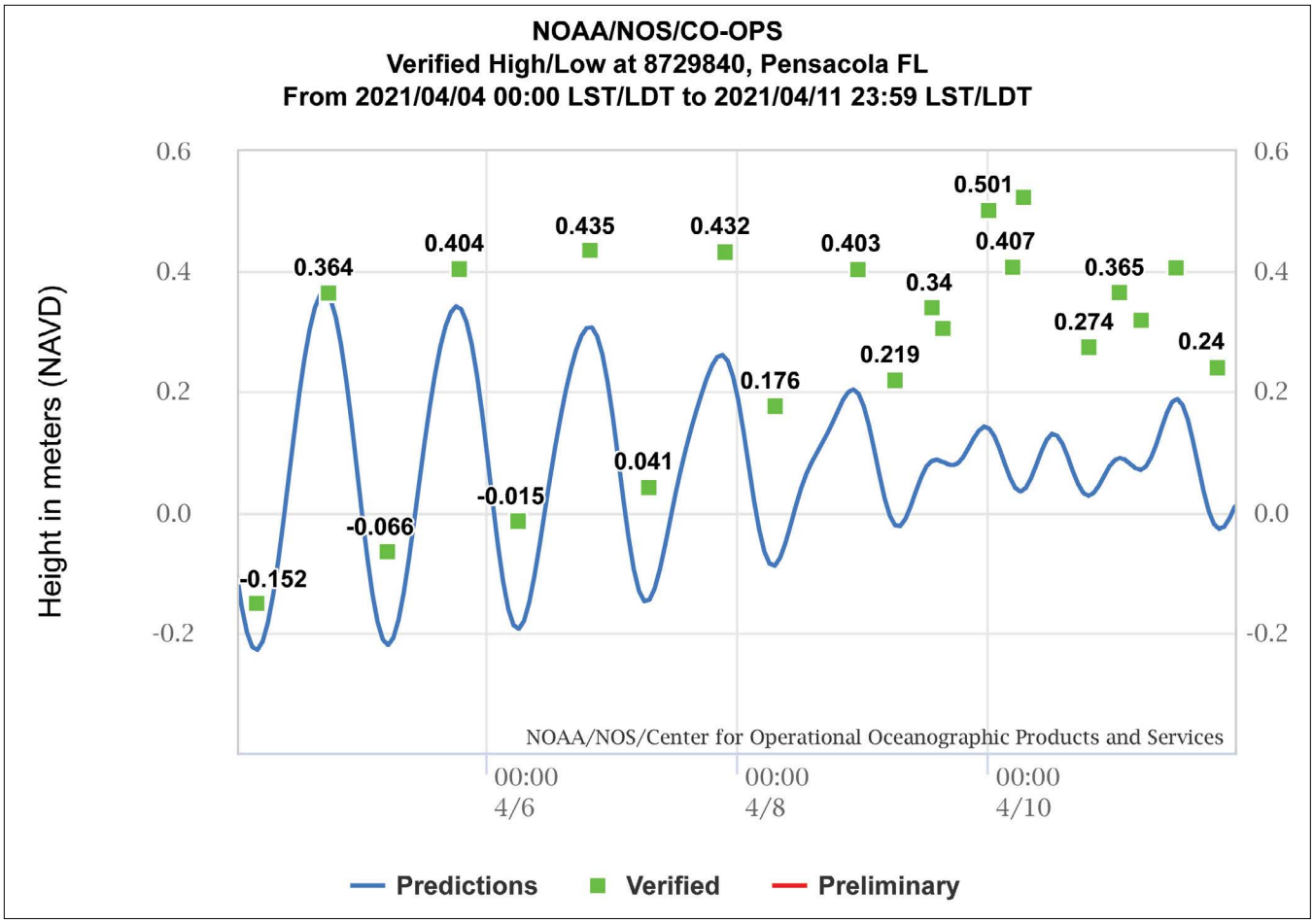

Figure 8. Water levels recorded at Pensacola FL NOAA monitoring station before and during the 2021 Florida shoreline survey.

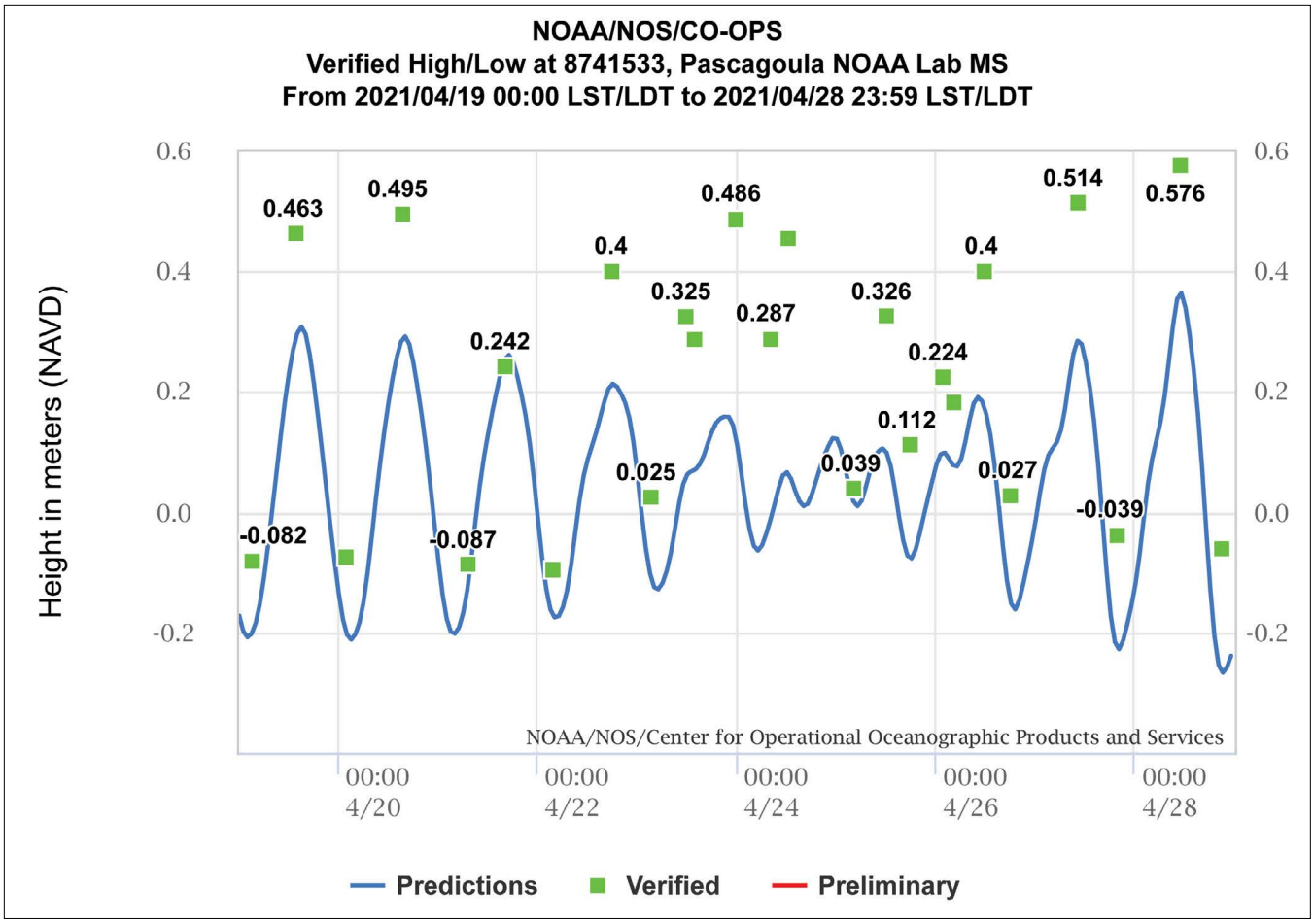

Figure 9. Water levels recorded at Pascagoula NOAA Lab MS before and during the Mississippi shoreline survey.

Natural and Anthropegenic Events Affecting Shoreline Position

Table 3 lists tropical storms that made landfall near Gulf Islands National Seashore from January 2017 to May 2021 with the associated water levels recorded at nearby tide stations. Figure 10 shows storm tracks for these and other storms in the northern Gulf of Mexico for the same period. These storms caused island overwash and breeching in some parts of the surveyed areas like those shown in Figures 11 and 12.

Table 3. Tropical storms making landfall near GUIS from January 2017 through May 2021.

Storm	Water Level (Meters NAVD88)	Water Level Date	Tide Station	Proximity of Landfall to Park
Nate	2.159	Oct 8	Pascagoula NOAA Lab, MS	About 12 miles west of the Davis Bayou Unit
Gordon	0.942	Sept 5	Pensacola FL	About 20 miles east of the Davis Bayou Unit
Sally	1.972	Sept 16	Pensacola FL	About 23 miles west of the Naval Live Oaks Unit

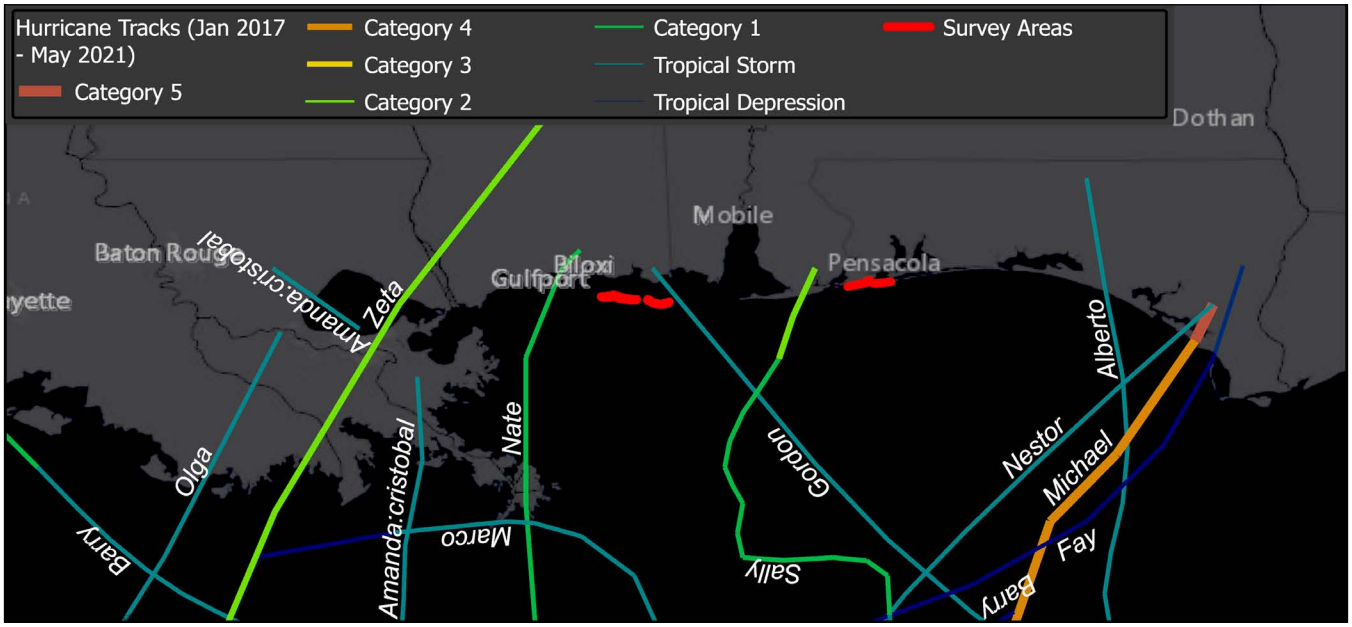

Figure 10. Map showing tropical storms making landfall near Gulf Islands National Seashore from January 2017 through May 2021.

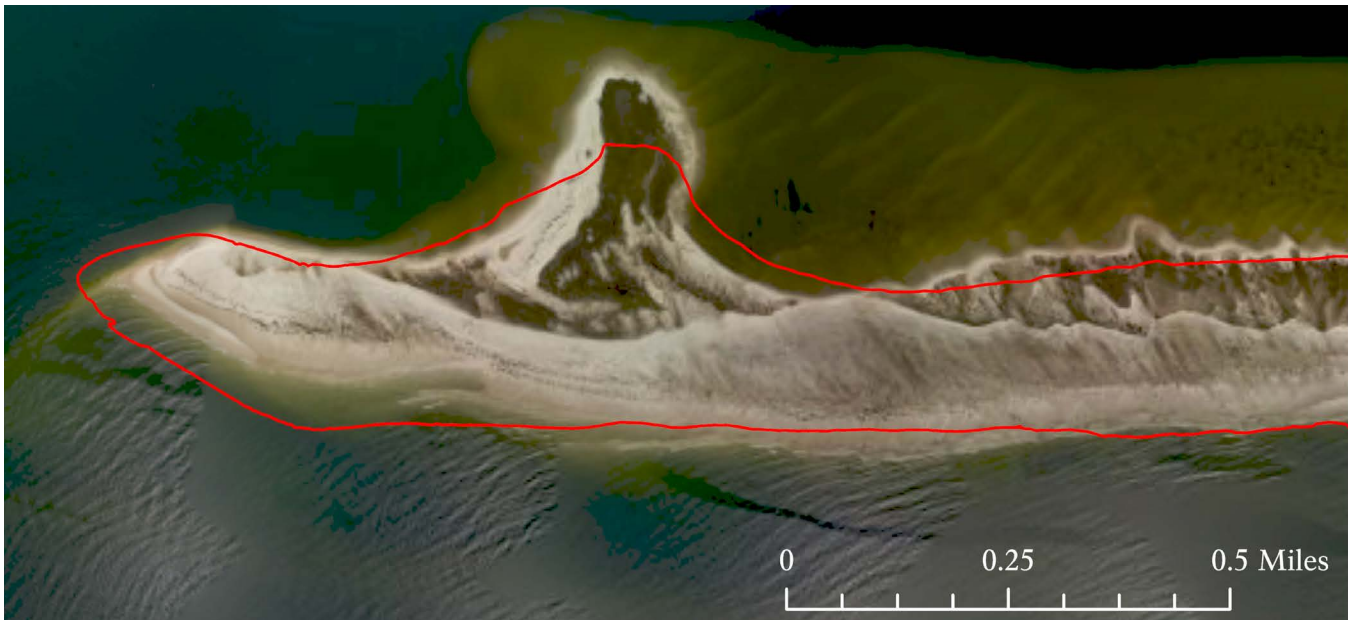

Figure 11. This image is provided by NOAA Remote Sensing Division and was taken October 10, 2017 after Hurricane Nate. This scene shows storm overwash at the west end of Horn Island, Miss. Red line represents the shoreline position in spring 2021.

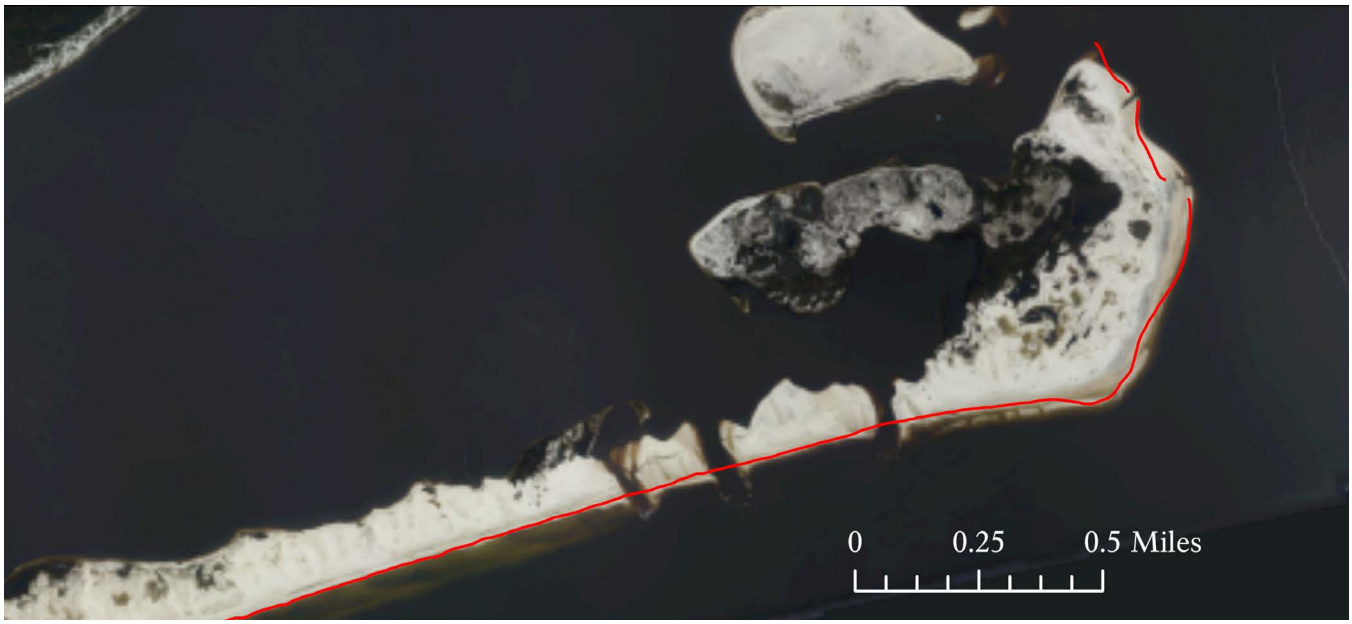

Figure 12. This image is provided by NOAA Remote Sensing Division and was taken September 18, 2021 after Hurricane Sally. This scene shows breeching at the east end of Perdido Key, near Pensacola Pass, Fla. Red line represents the shoreline position in spring 2021.

Results

Shoreline Position Data Quality

Shoreline position was recorded in the spring of 2018 and 2021. There was an approximate 2.5-kilometer (1.6 miles) gap in data coverage on the western Gulf shoreline of Horn Island due to equipment operator error. There was also a gap in coverage on the east end of Perdido Key at Pensacola Pass due to heavy visitation including boats moored along the shore (Figure 13). The average post-processed horizontal precision remained near or below 10 centimeters (3.9 inches; Table 4).

Figure 13. Crowded shoreline at the east end of Perdido Key.

Table 4. Summary of GNSS accuracy during the shoreline position surveys.

Area	Year	Horizontal Accuracy (meters)
Florida	2018	0.015
Mississippi	2018	0.042
Florida	2021	0.048
Mississippi	2021	0.130

Tables 5 and 6 present grouped summary statistics for the 2018 to 2021 shoreline position change rates and includes: transect count, minimum, maximum, average, and standard deviation. All groups showed overall landward retreat or island narrowing. End point and island width rate histograms, grouped by unit, are presented in Appendix A and related change rate maps are presented in Appendix B.

Table 5. Summary of End Point Rate (EPR) for the Florida Units. Distances are reported in meters per year. Positive numbers indicate an advance seaward and negative numbers indicate landward retreat.

Group	Transect Count	Minimum	Maximum	Average	Standard Deviation
Fort Pickens	582	-19.01	26.46	-6.02	5.28
Perdido Key	539	-23.11	12.71	-8.28	4.41

Table 6. Summary of Island Width Rate (IWR) for the Mississippi Units. Change is width is reported in meters per year. The negative numbers indicate island narrowing, while positive numbers indicate island widening over the three-year interval.

Group	Transect Count	Minimum	Maximum	Average	Standard Deviation
Petit Bois Island	484	-28.46	22.55	-7.70	9.16
West Petit Bois Island	73	-69.00	61.62	-18.90	23.67
Horn Island	826	-44.90	34.45	-8.00	12.38

Annual Shoreline Change Analysis

Table 5 reports EPR for Fort Pickens and Perdido Key. The average rates of retreat are much higher than the short-term losses (1978 to 2018) reported in Kratzmann et. al (2021), where Perdido Key retreated 2.14 meters/year (7.0 ft/year) and Fort Pickens retreated 0.93 meters/year (3.1 ft/year) with a standard deviation of 1.03 meters (3.4 ft) and 1.55 meters (5.1 ft) respectively. Results of EPR used in Florida are not directly comparable to Island Width Rates used in Misssippi because EPR only accounts for change on one shoreline. Even so, the changes reported for the Mississippi islands in Table 6 likely parallel the pattern of increased rates of retreat shown in Florida. Himmelstoss et al. (2017), which does not include West Petit Bois Island, reports rates of -2.88 meters/year (-9.4 ft/year) at Petit Bois Island and -1.69 meters/year (-5.5 ft/year) at Horn Island from 1966 to 2001 with a standard deviation of 5.32 meters (17.5 ft) and 6.63 meters (21.8 ft) respectively.

Areas of Special Interest

During scoping meetings for this project, GUIS Resource Management staff expressed targeted interest in the areas adjacent to Pensacola Pass. The most western 1-kilometer (.62 miles) stretch of Fort Pickens retreated 0.55 meter/year (1.8 ft/year) while the most eastern 1-kilometer (.62 miles) stretch of Perdido Key lost 7.0 meters/year (23.0 ft/year).

Problems and Concerns

When interpreting change in shoreline position, it is important to consider the influence of beach slope on horizontal displacement of shoreline position. Even slight changes in water level will expose or inundate large areas where the slope is shallow. A technical report summarizing the influence of slope and tidal variation can be found in Appendix B of Bracewell (2019). It is important to keep in mind that what may seem like a dramatic change in shoreline position could be attributed to a slight beach slope and tidal variation between surveys. It is anticipated that linear regression models used in trend analyses will lessen the impact from tidal variation.

Tropical storm Alberto formed in late May 2018 and caused the park to close on May 26, forcing postponement of the GULN's survey work. Although the storm veered east and had virtually no impact on the Mississippi barrier islands, it served as a reminder that early season tropical systems may challenge completion of surveys within the April/May survey window.

Protocol Changes

No major changes occurred to the GULN PIP (Bracewell 2017) between its initial publication in 2017 and composition of this report.

Additional Information

For data and information related to this report please visit the Gulf Coast Network Shoreline Monitoring Project. For information about the GULN's complementary coastal dynamics project on topographic change, see the Gulf Coast Network Coastal Topography Monitoring Project.

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Appendix A. End Point and Island Width Rate Histograms

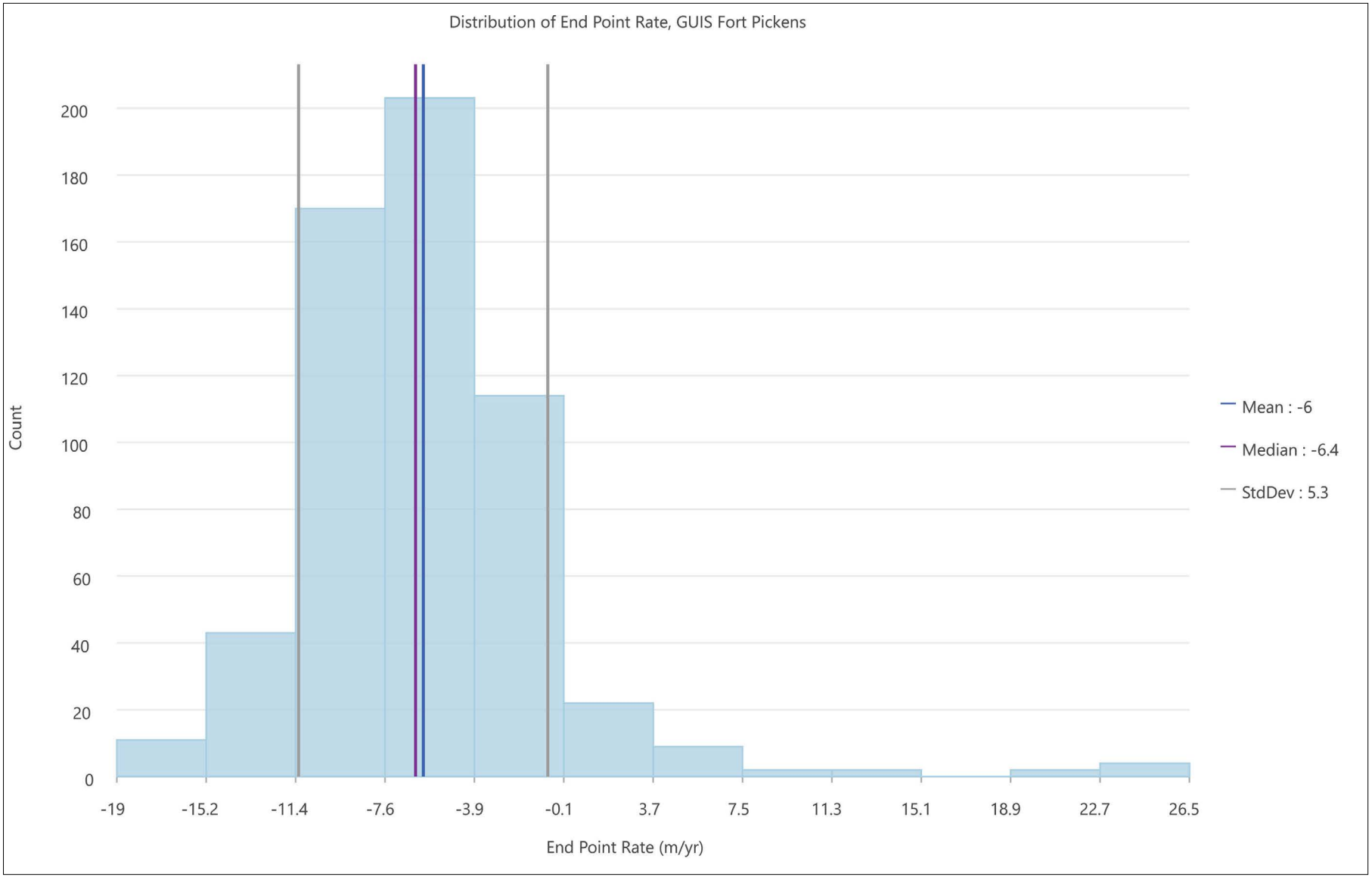

Figure A-1. Distribution of the End Point Rates calculated for transects at Fort Pickens.

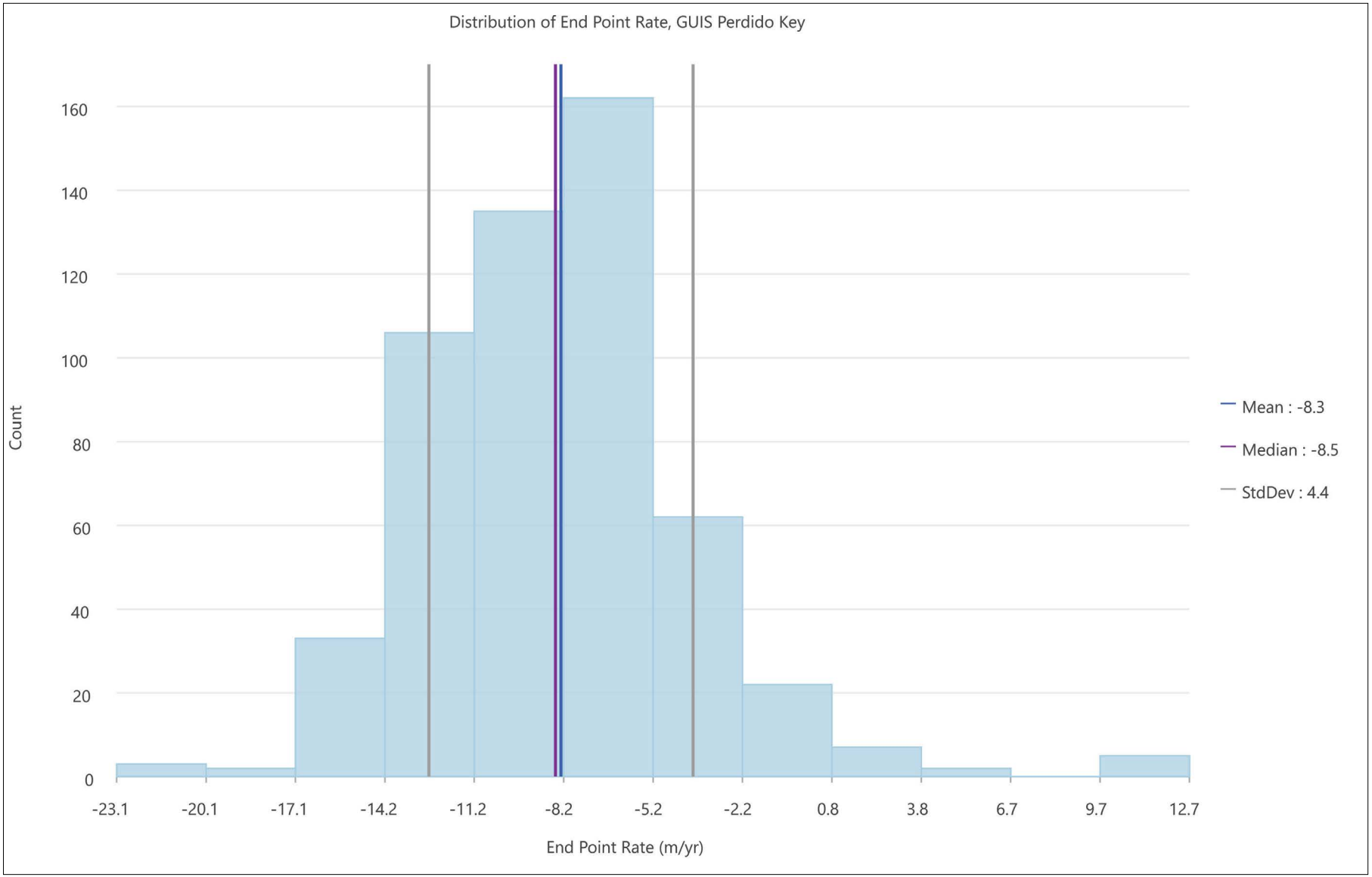

Figure A-2. Distribution of the End Point Rates calculated for transects at Perdido Key.

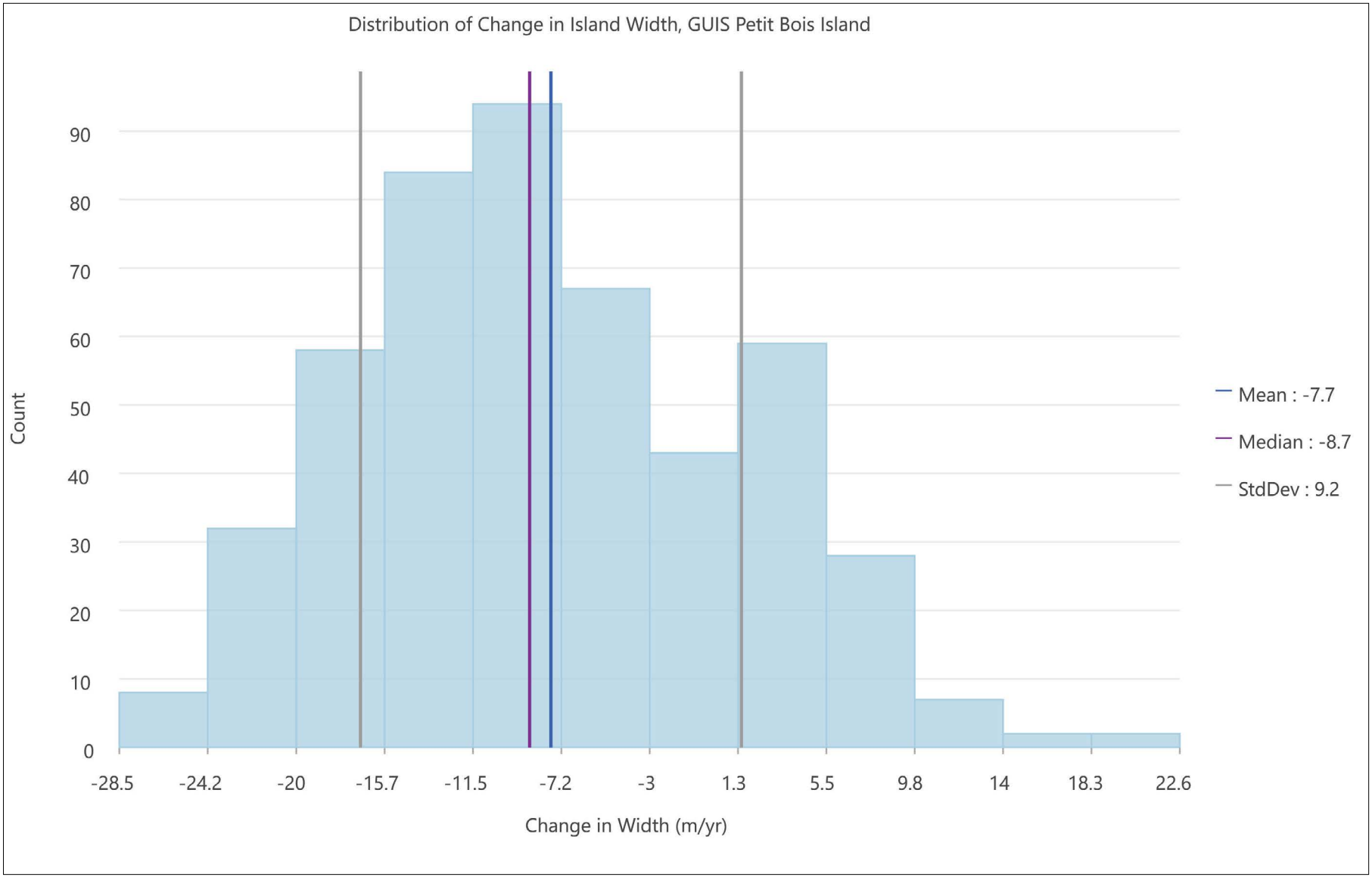

Figure A-3. Distribution of the End Point Rates calculated for transects at Petit Bois Island.

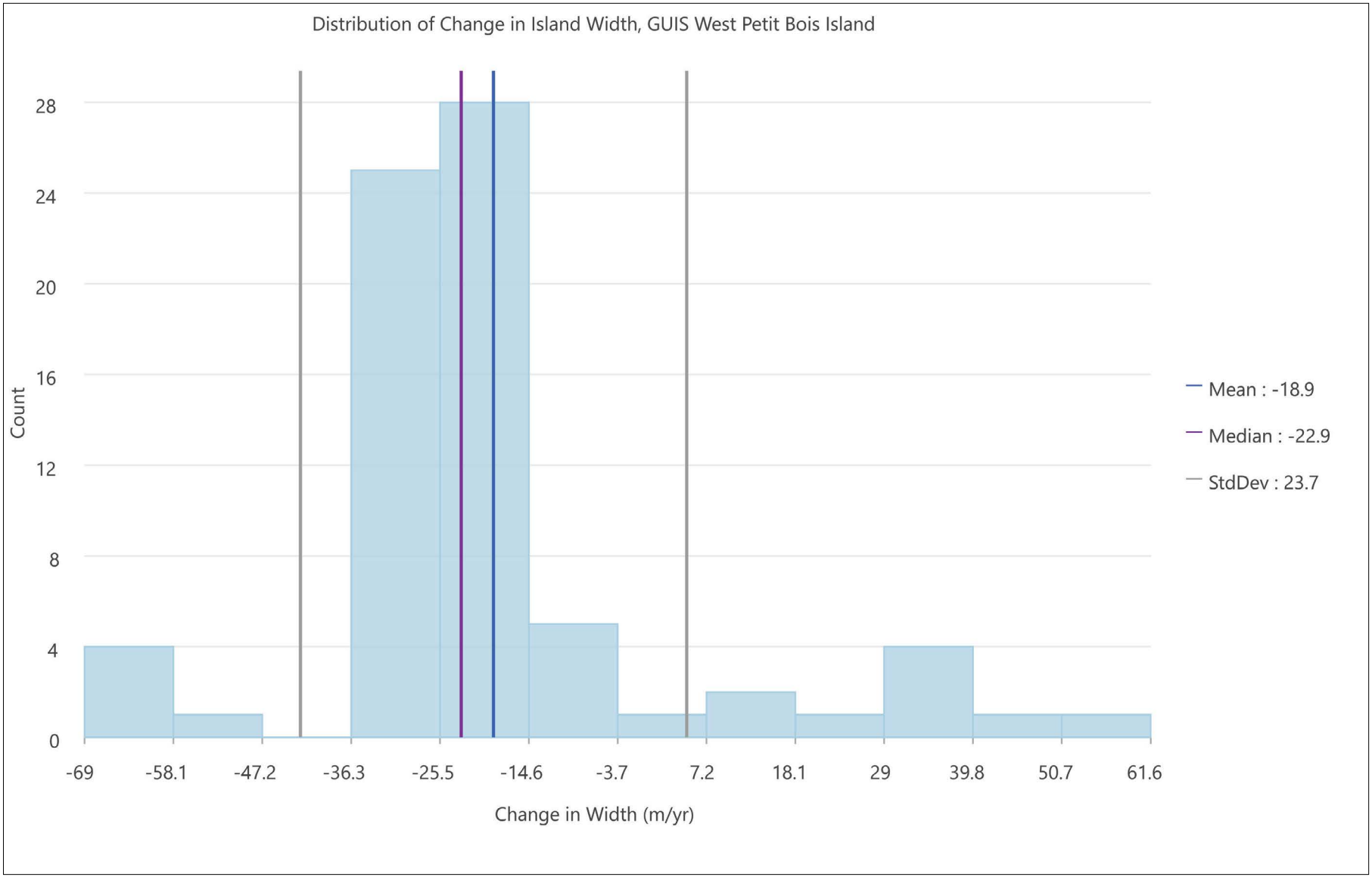

Figure A-4. Distribution of the End Point Rates calculated for transects at West Petit Bois Island.

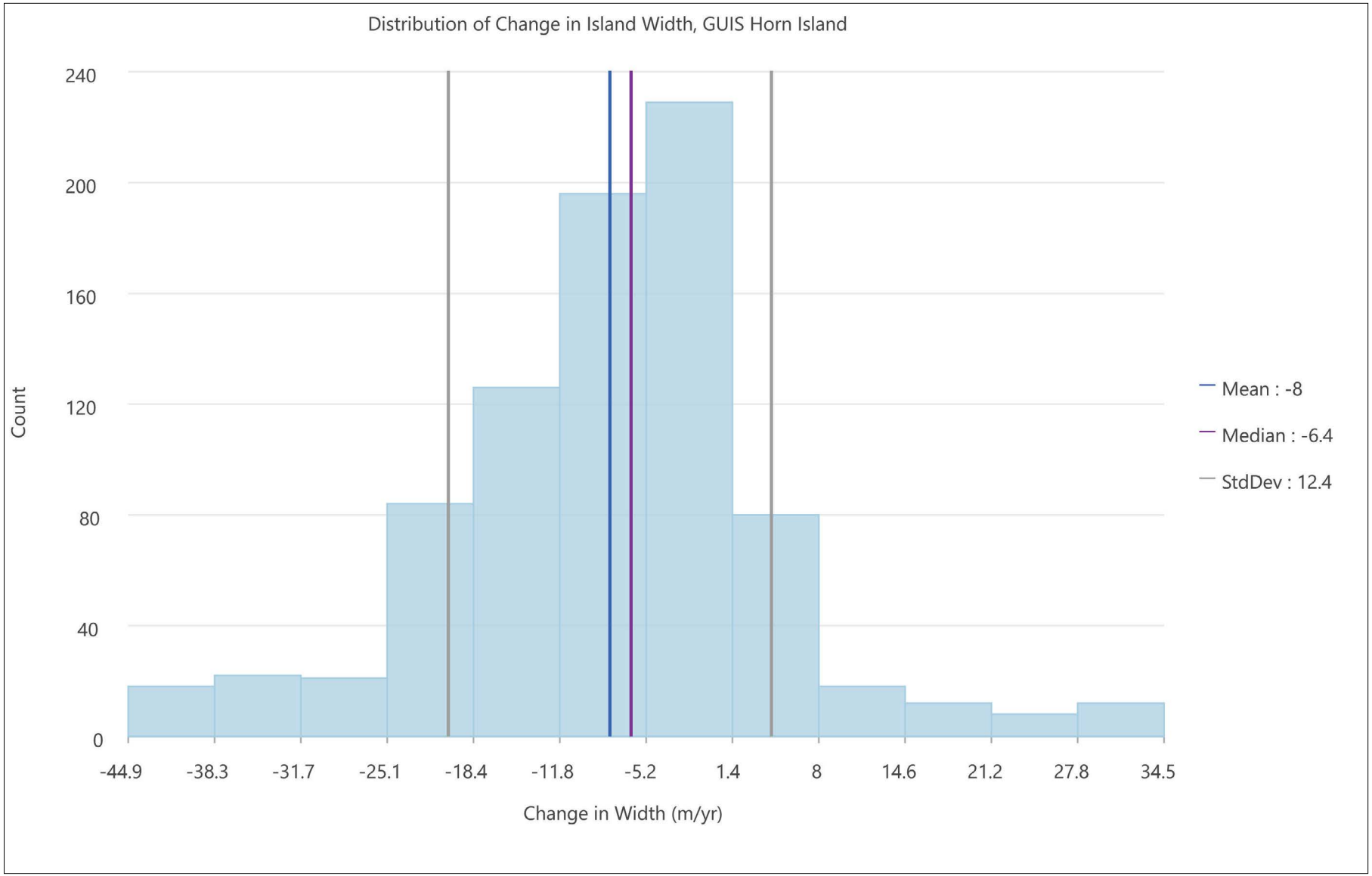

Figure A-5. Distribution of the End Point Rates calculated for transects at Horn Island.

Appendix B. Change Rate Maps

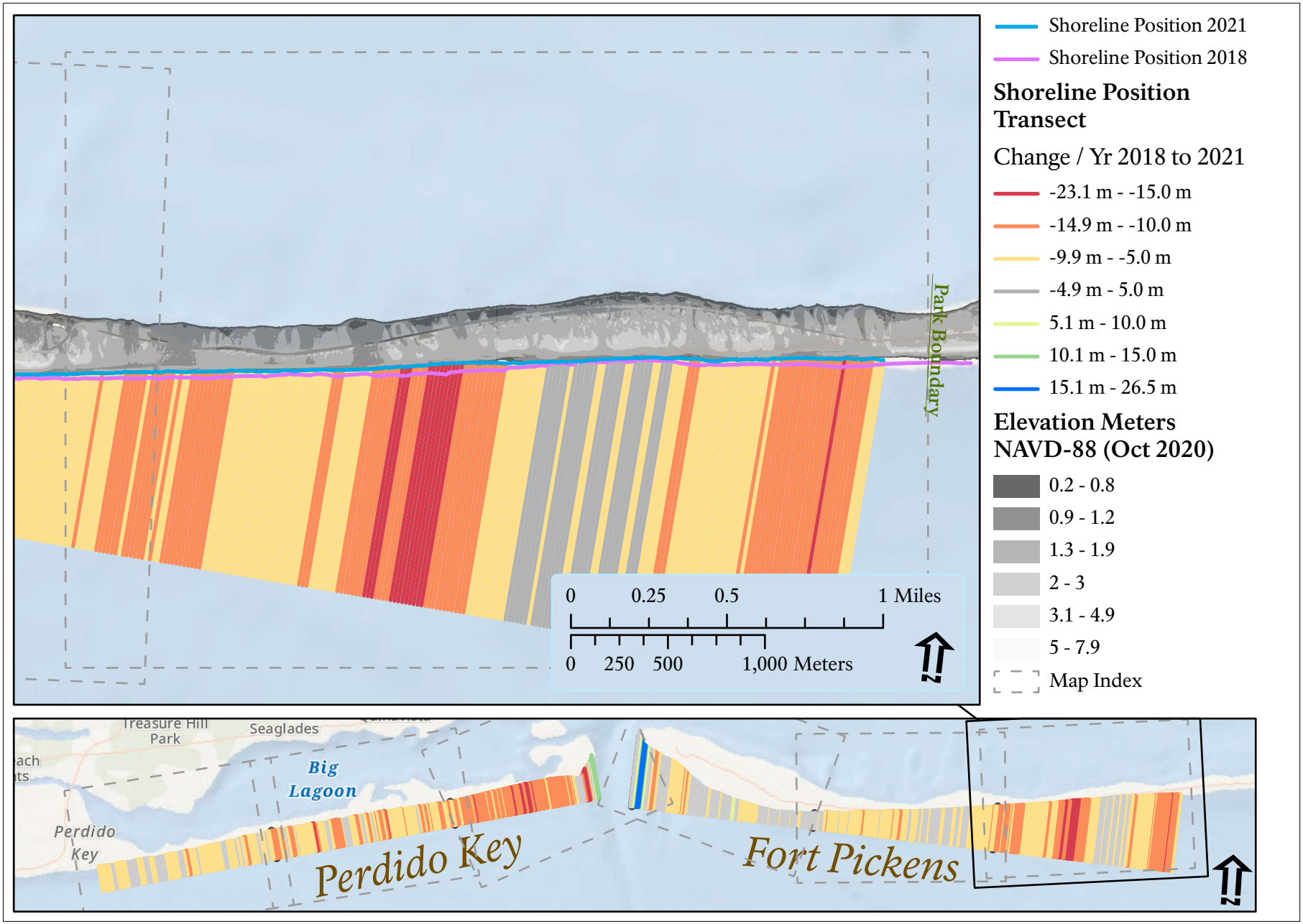

Figure B-1. End Point Rate for Fort Pickens and Perido Key 1 of 6.

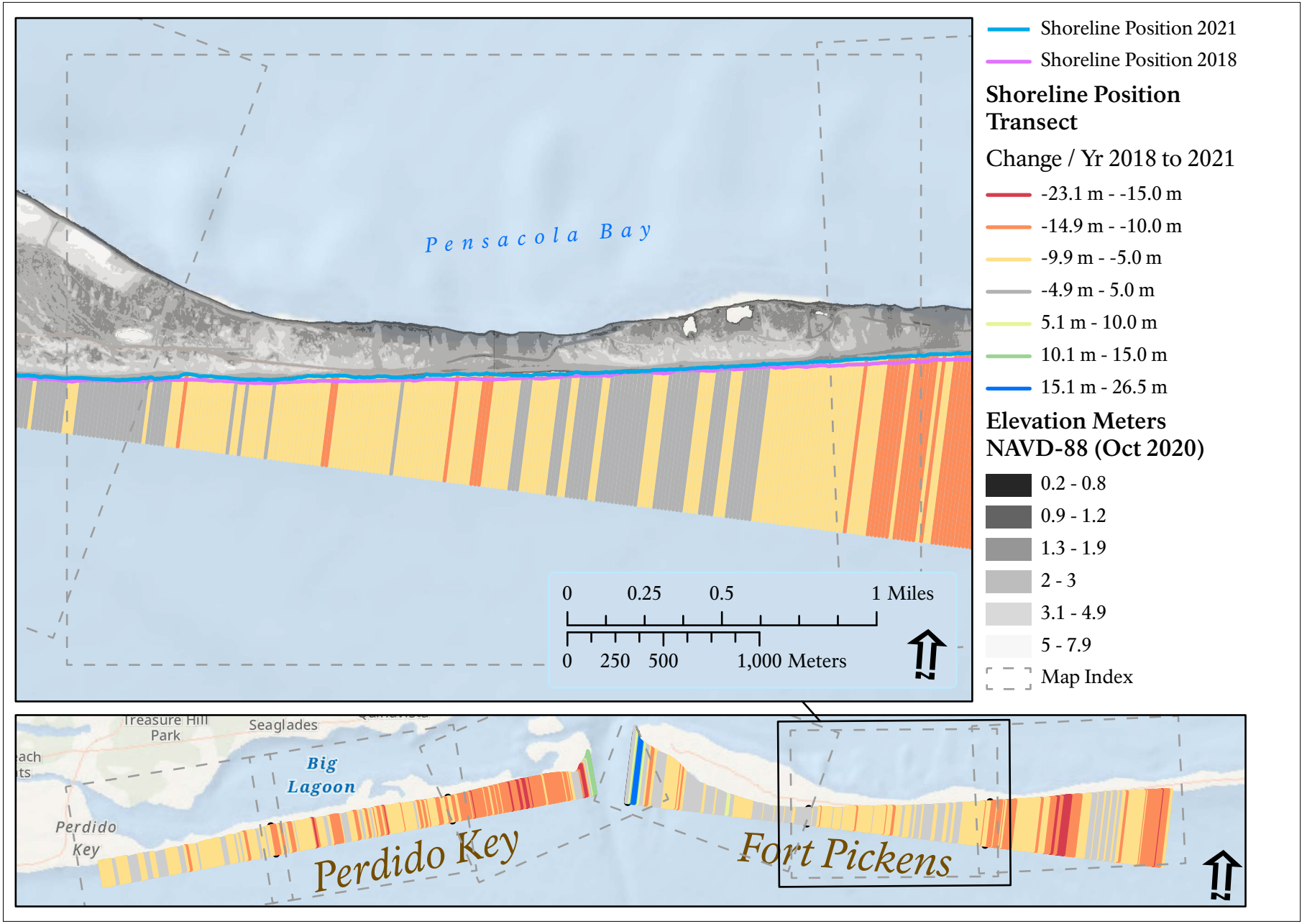

Figure B-2. End Point Rate for Fort Pickens and Perido Key 2 of 6.

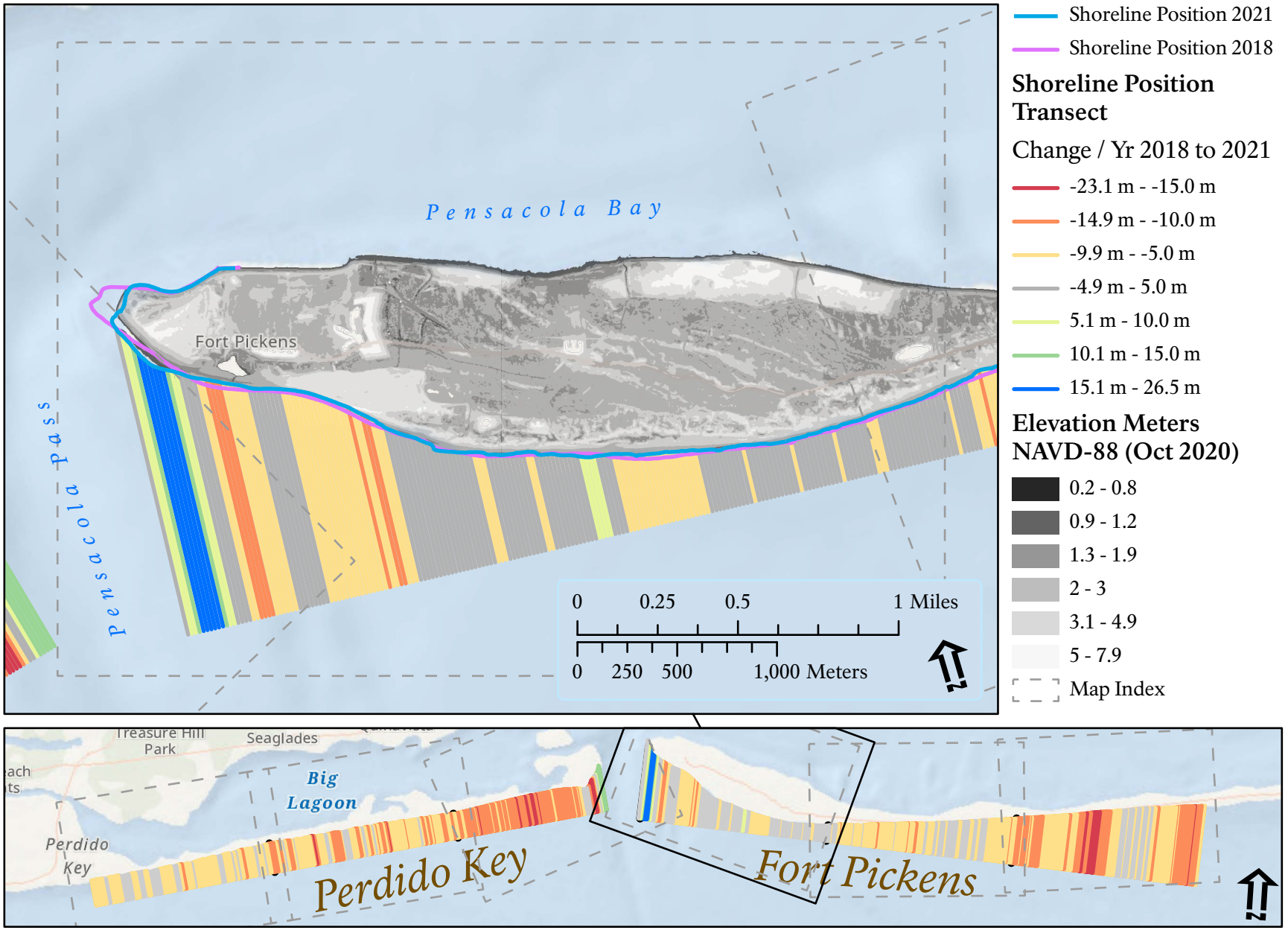

Figure B-3. End Point Rate for Fort Pickens and Perido Key 3 of 6.

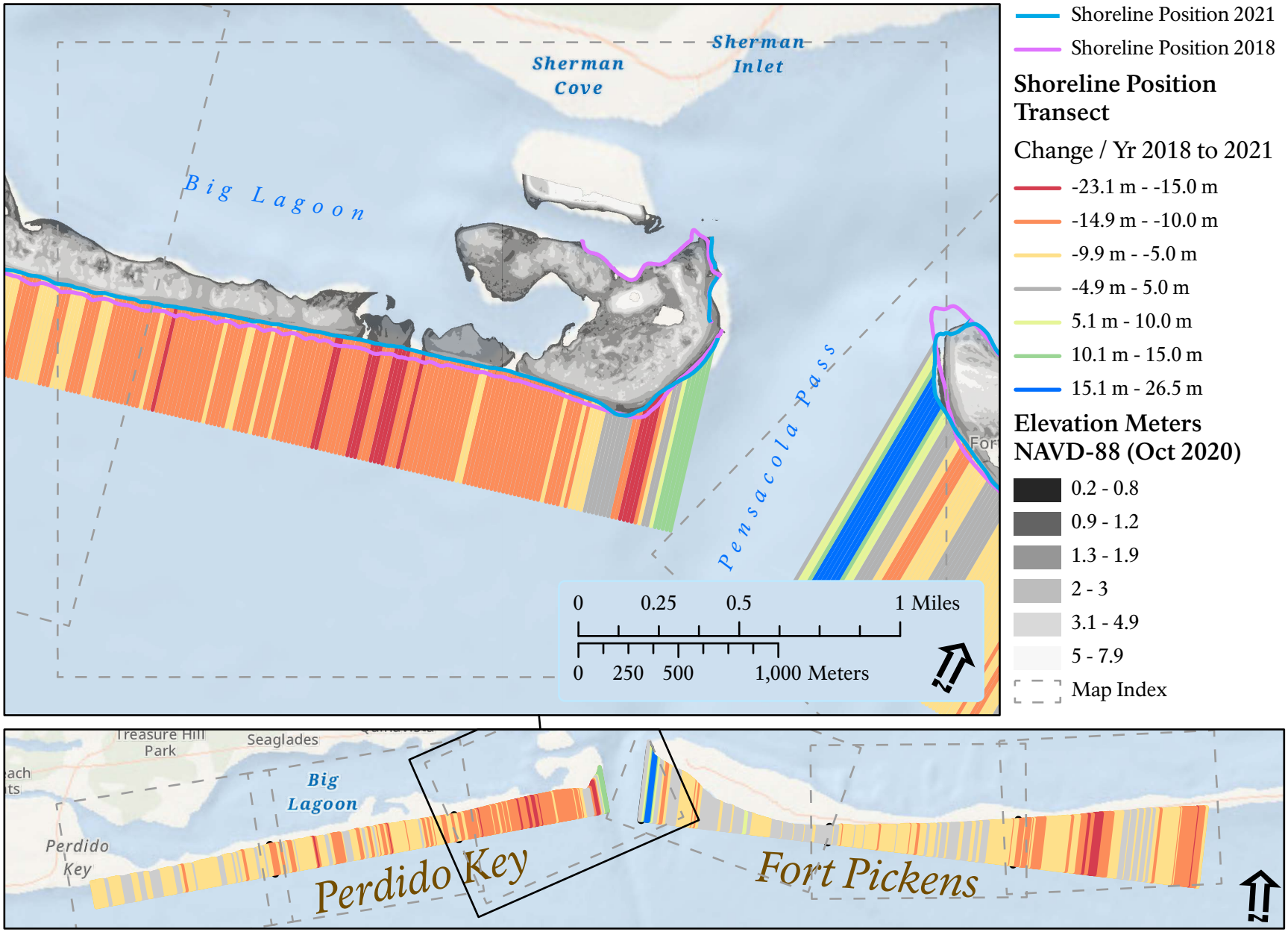

Figure B-4. End Point Rate for Fort Pickens and Perido Key 4 of 6.

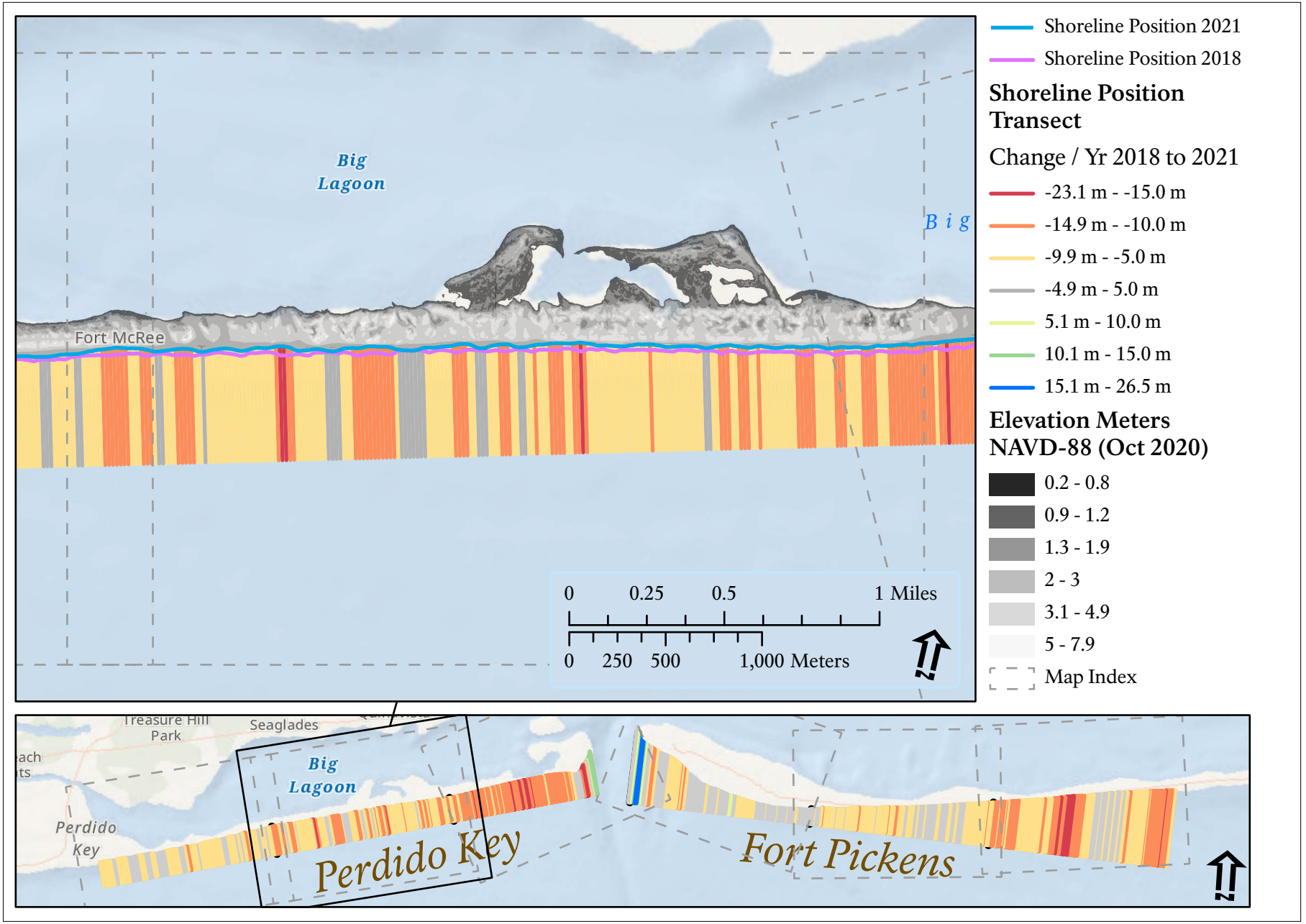

Figure B-5. End Point Rate for Fort Pickens and Perido Key 5 of 6.

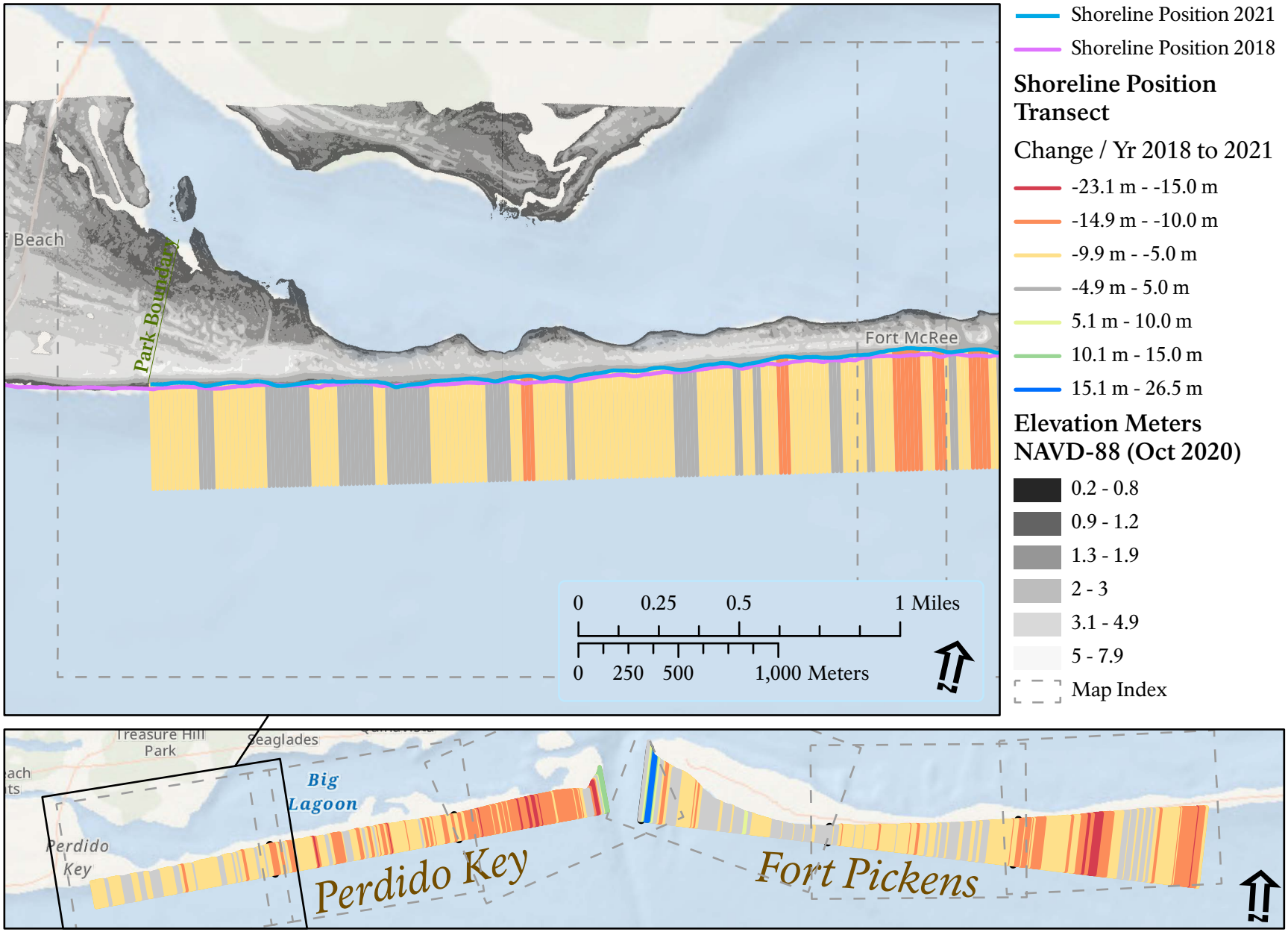

Figure B-6. End Point Rate for Fort Pickens and Perido Key 6 of 6.

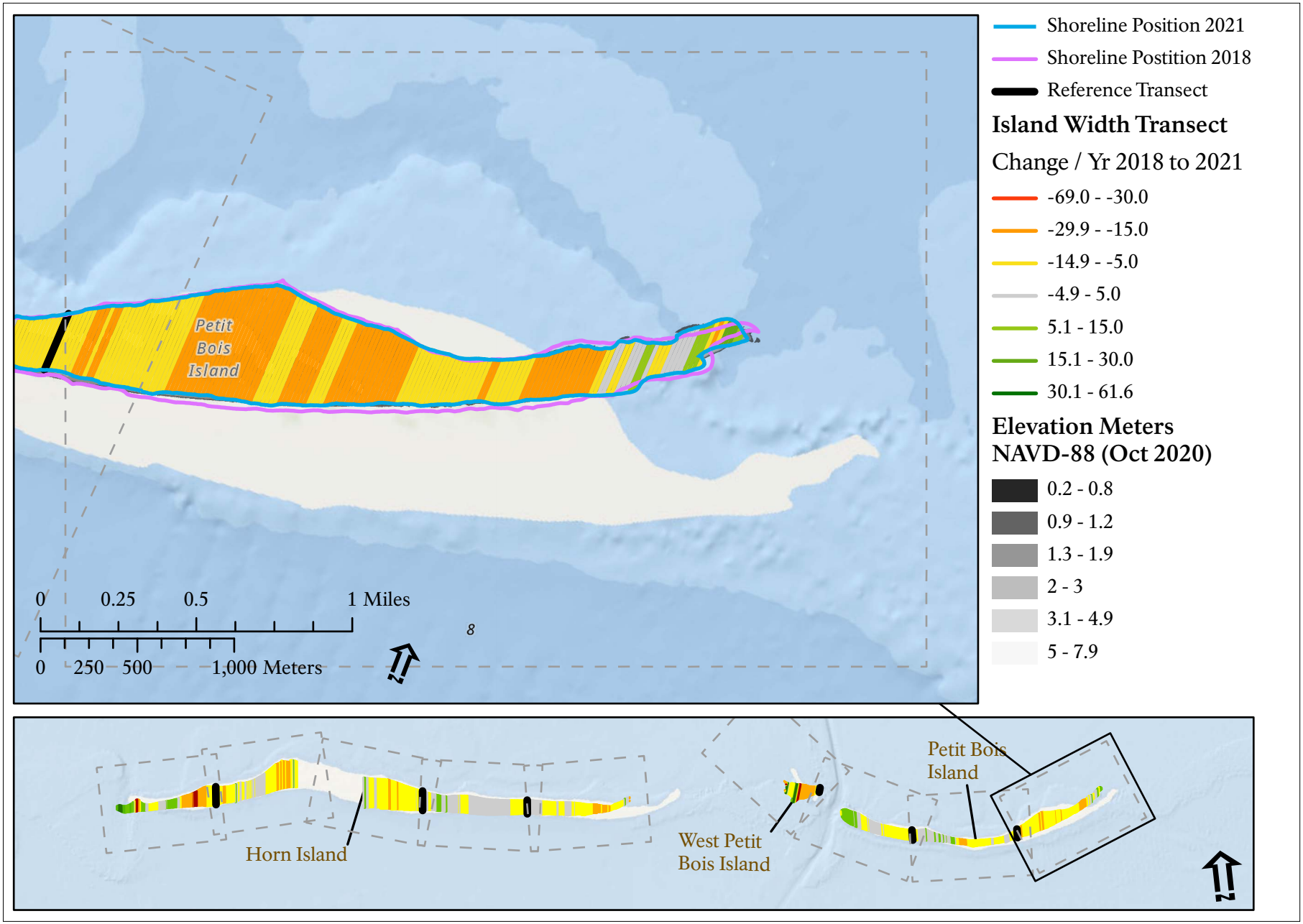

Figure B-7. Island Width Rate for Petit Bois, West Petit Bois and Horn Islands 1 of 9.

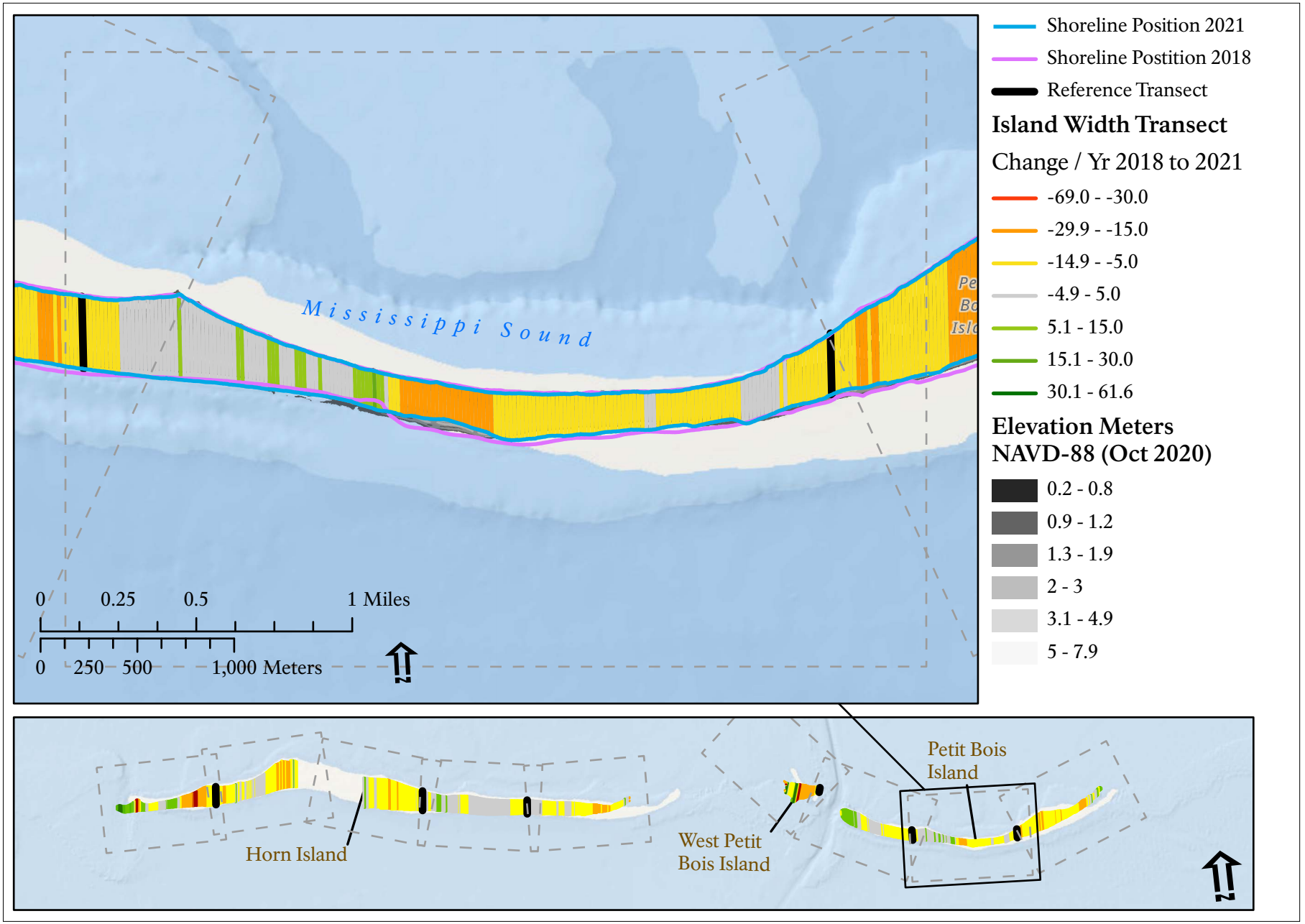

Figure B-8. Island Width Rate for Petit Bois, West Petit Bois and Horn Islands 2 of 9.

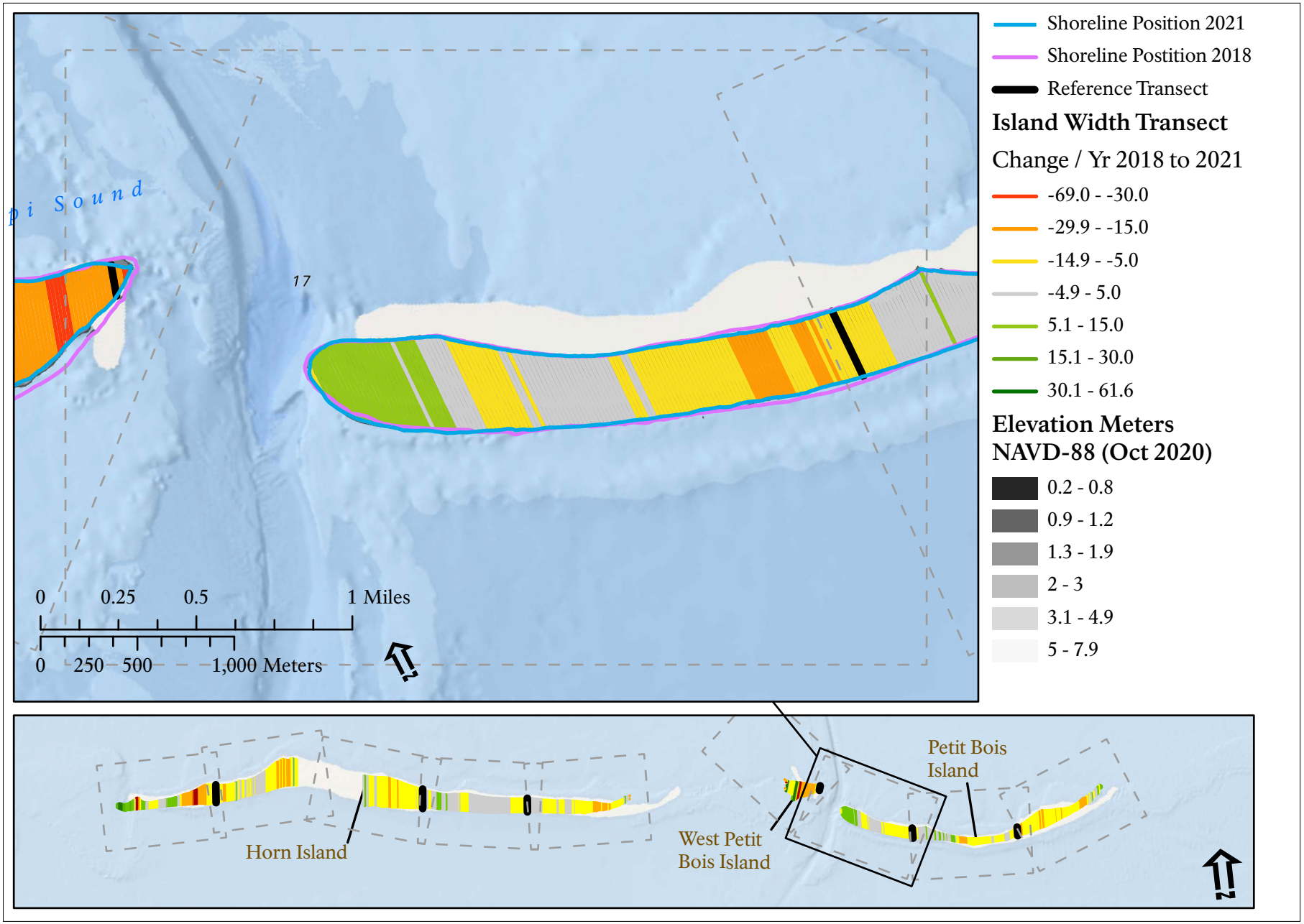

Figure B-9. Island Width Rate for Petit Bois, West Petit Bois and Horn Islands 3 of 9.

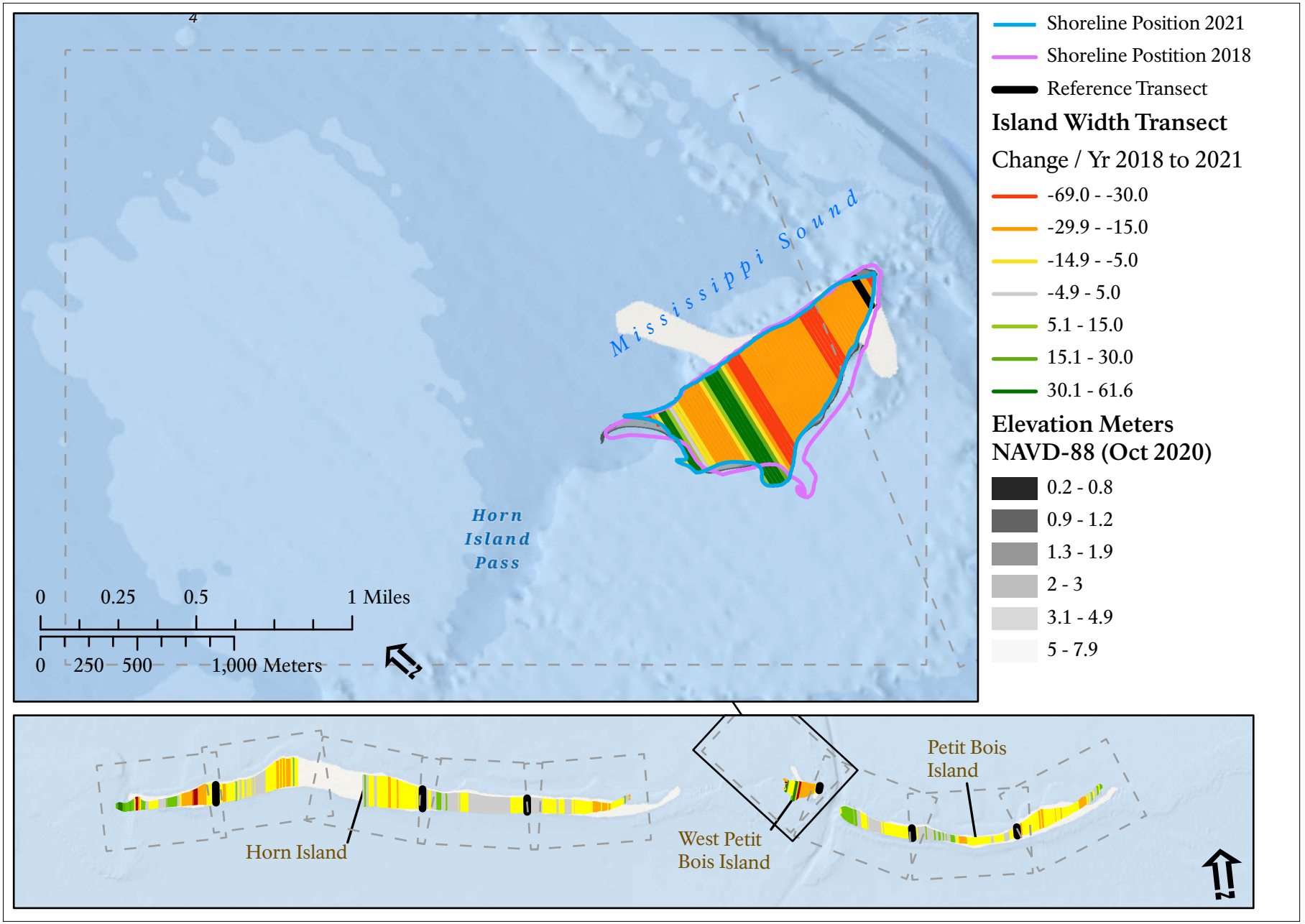

Figure B-10. Island Width Rate for Petit Bois, West Petit Bois and Horn Islands 4 of 9.

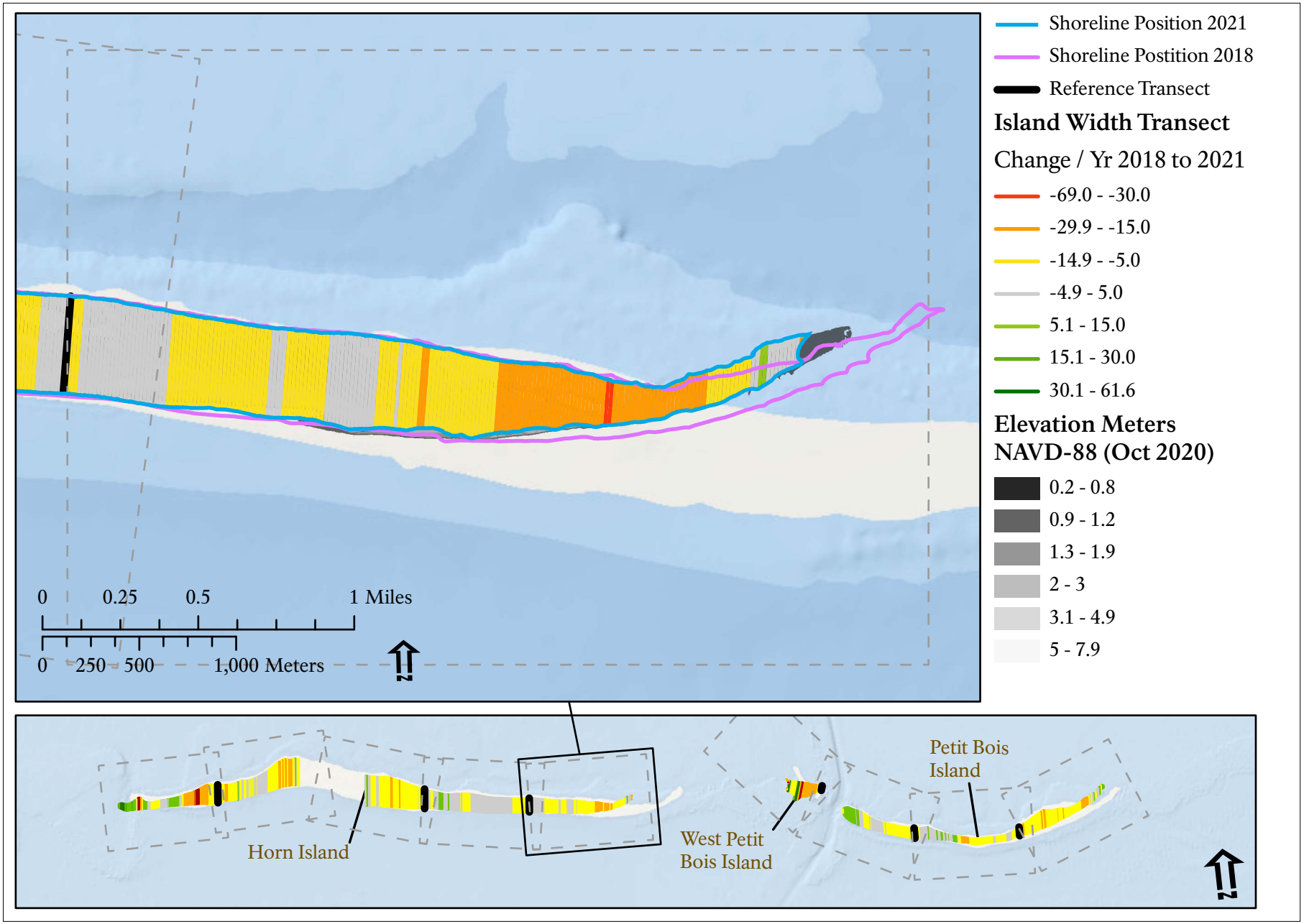

Figure B-11. Island Width Rate for Petit Bois, West Petit Bois and Horn Islands 5 of 9.

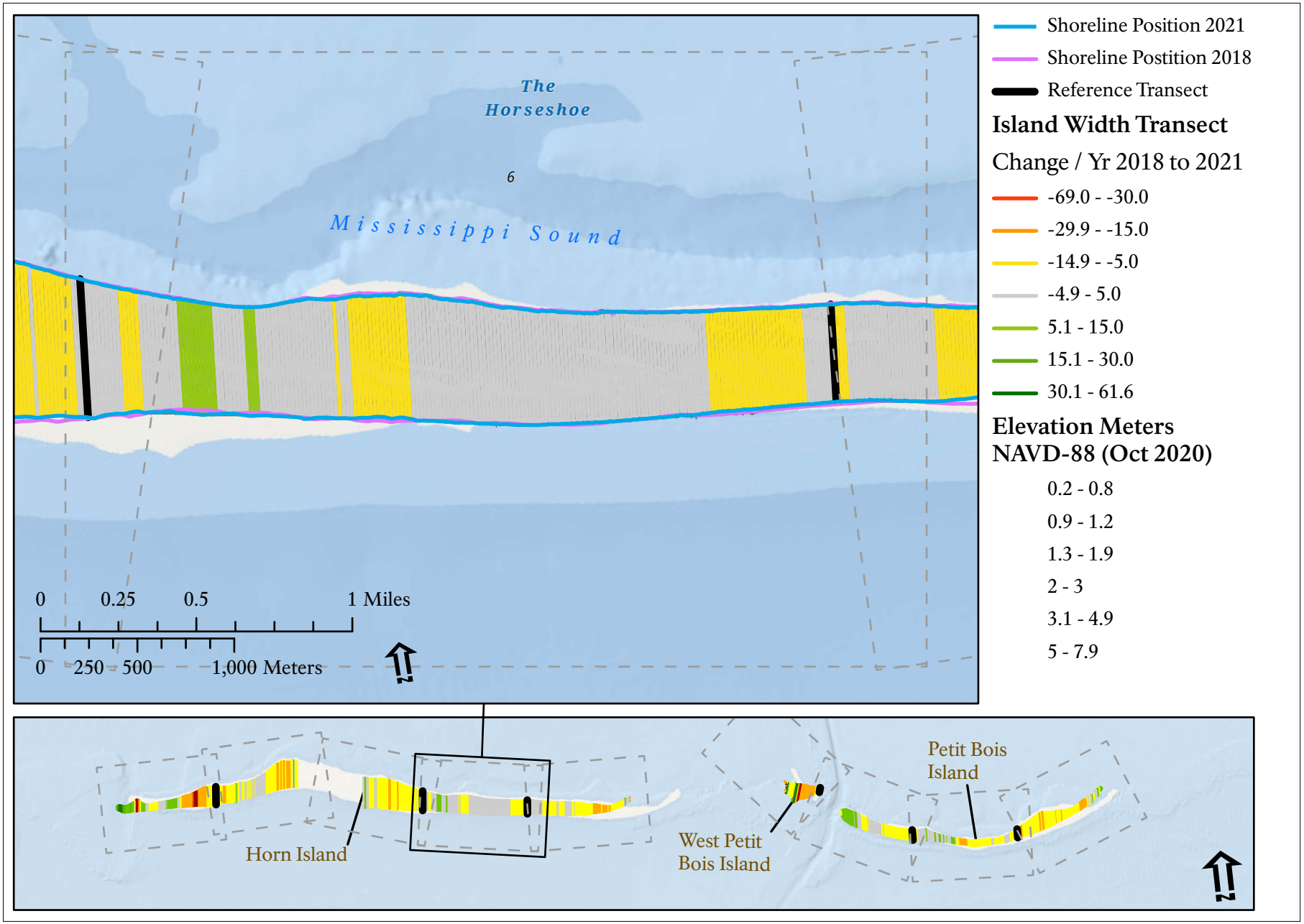

Figure B-12. Island Width Rate for Petit Bois, West Petit Bois and Horn Islands 6 of 9.

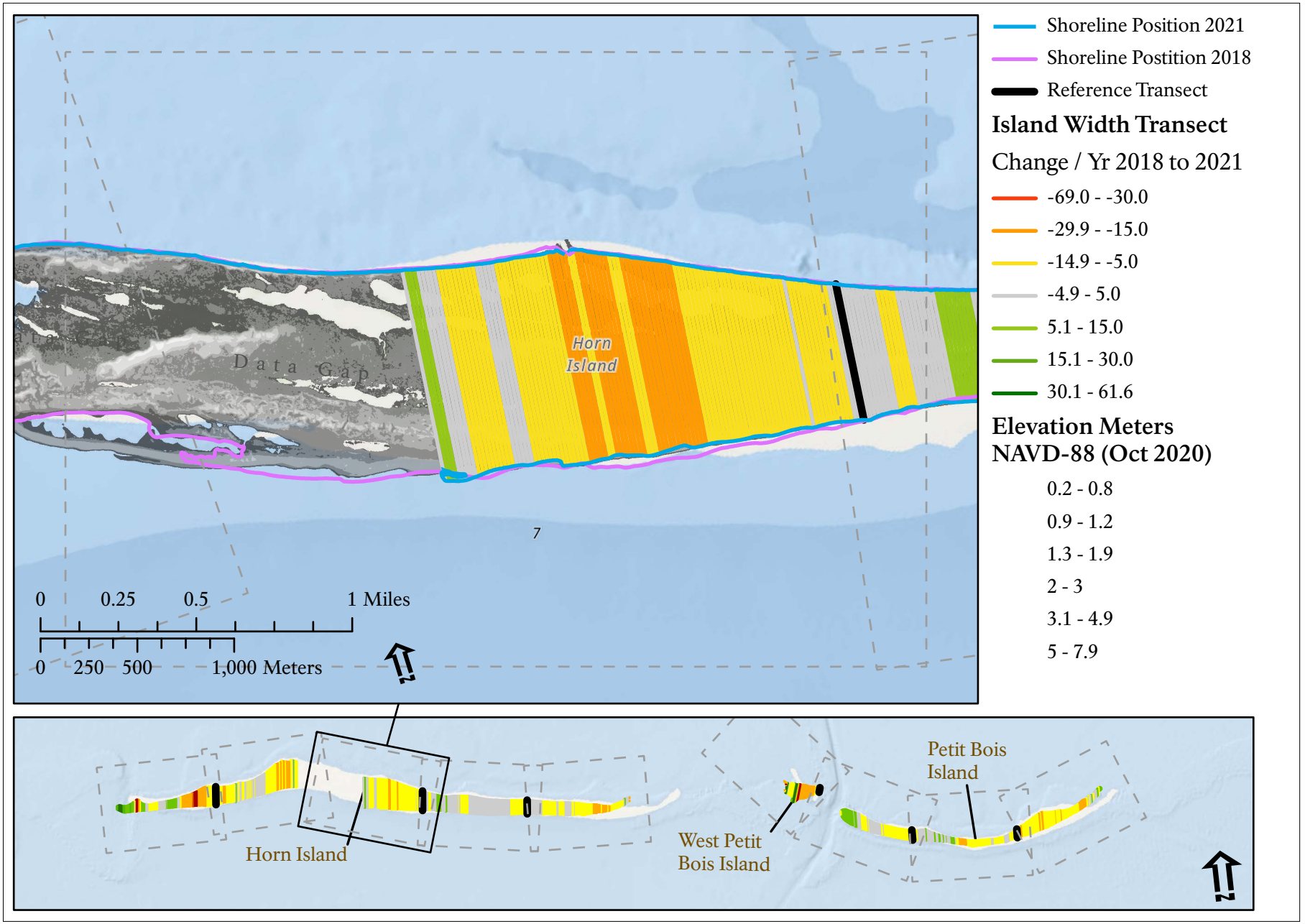

Figure B-13. Island Width Rate for Petit Bois, West Petit Bois and Horn Islands 7 of 9.

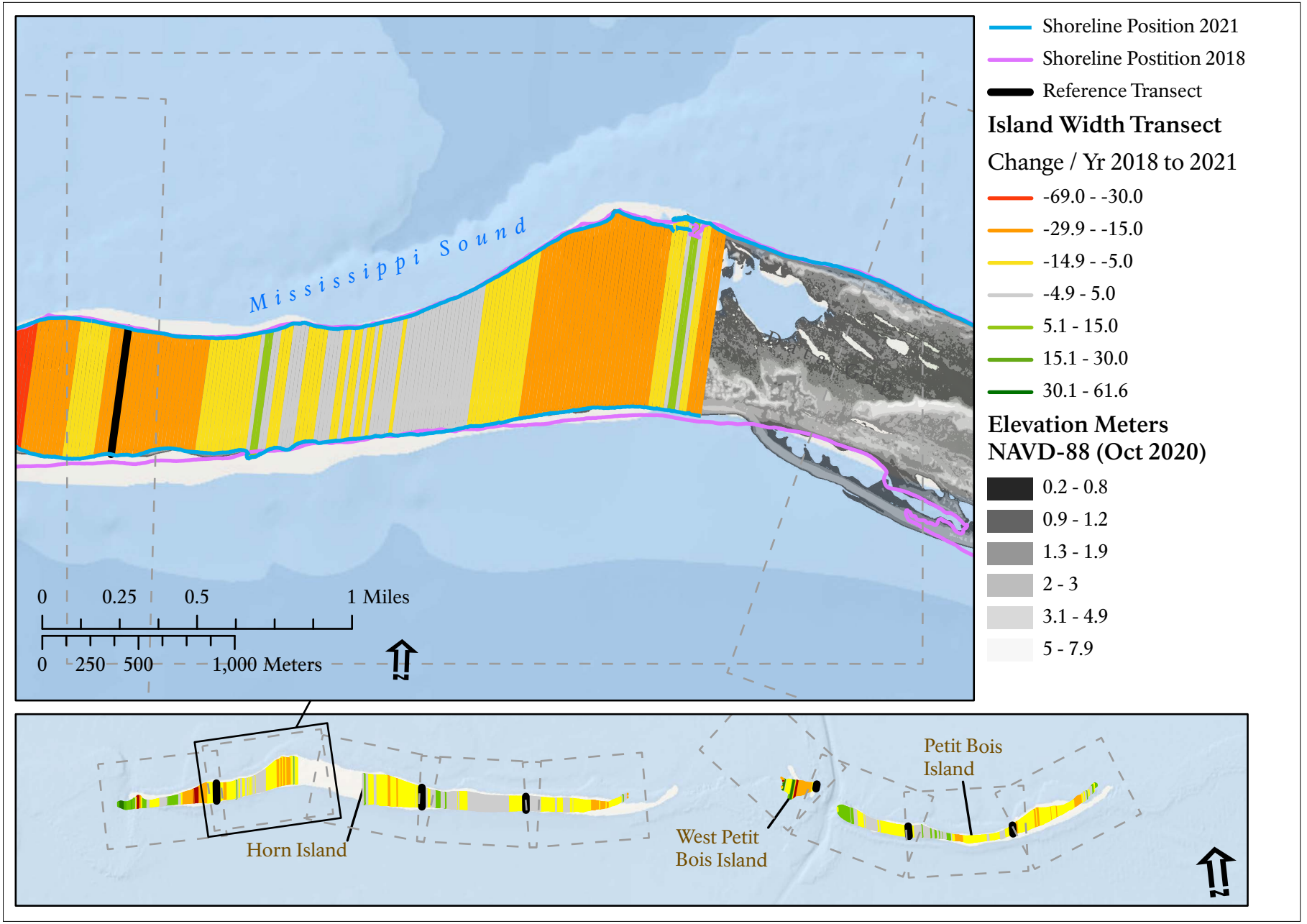

Figure B-14. Island Width Rate for Petit Bois, West Petit Bois and Horn Islands 8 of 9.

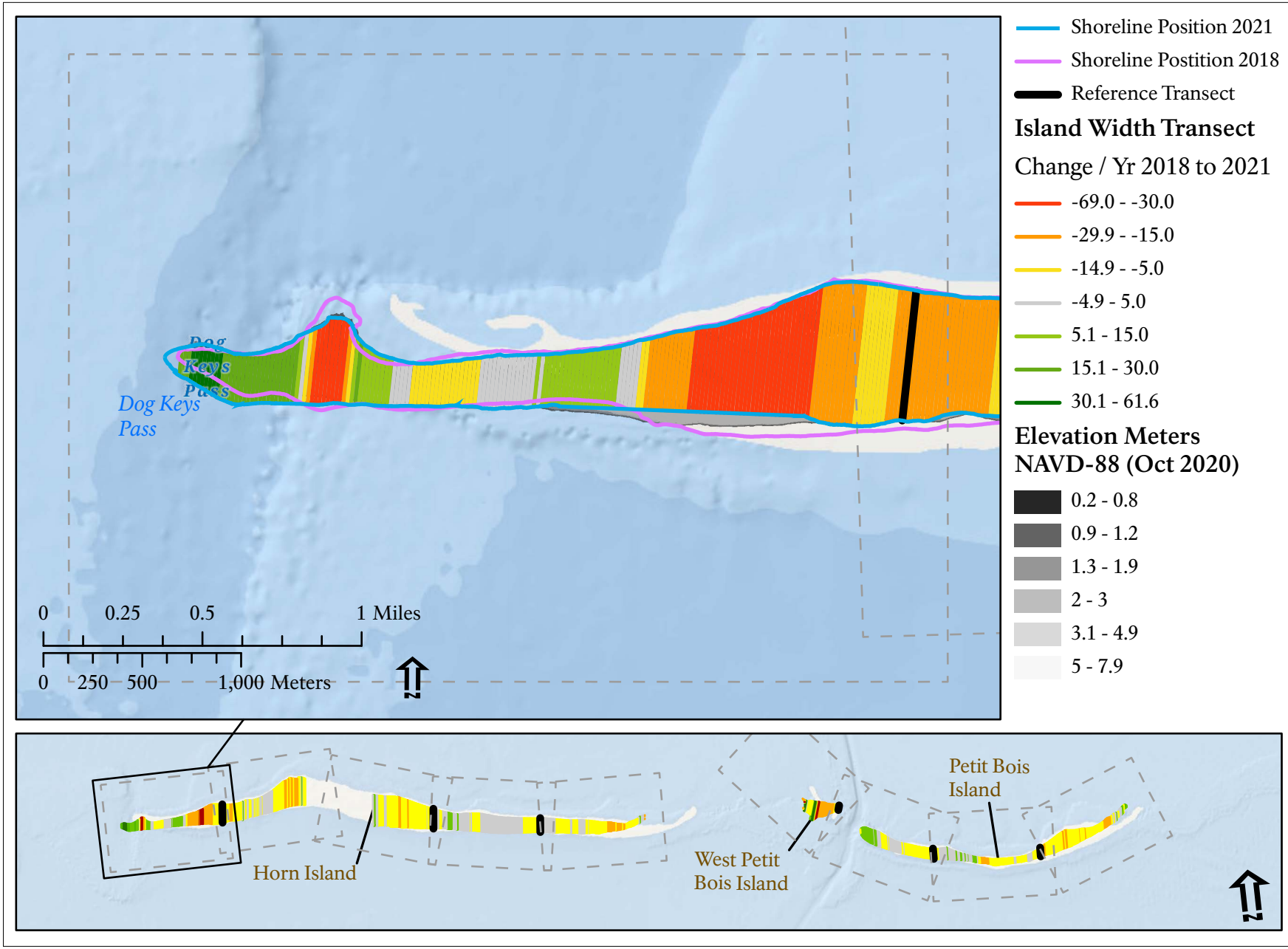

Figure B-15. Island Width Rate for Petit Bois, West Petit Bois and Horn Islands 9 of 9.

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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National Park Service
U.S. Department of the Interior

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