



Shoreline Change at Padre Island National Seashore, Texas

2017–2021 Data Summary

Natural Resource Data Series NPS/GULN/NRDS—2021/1339



ON THE COVER

Photo of a dredge boat depositing material near Port Mansfield Channel taken on November 21, 2019. NPS photo / GULN staff.

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December 2021

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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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Please cite this publication as:

Bracewell, J. 2021. Shoreline change at Padre Island National Seashore, Texas: 2017–2021 data summary. Natural Resource Data Series NPS/GULN/NRDS—2021/1339. National Park Service, Fort Collins, Colorado. <https://doi.org/10.36967/nrr-2289824>

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Summary and Key Findings

In the spring of 2017, 2019, and 2021 the Gulf Coast Network collected shoreline position data at Padre Island National Seashore 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:

- Shoreline position was recorded for the entire Gulf-side shore, a 105-kilometer (65.2-mile [mi]) extent.
- Overall, 86.29% of transects exhibited landward retreat and only 13.71% of transects were static or advanced seaward.
- The mean shoreline change rate from 2017 to 2021 was -1.16 meters per year (-3.81 feet [ft] per year) $\pm$ 0.69 meters (2.26 ft). The shoreline change rate ranged from -5.85 meters to 43.49 meters per year (19.19 ft to 142.68 ft per year).
- Highest erosion rates occurred on the northern extent of the park at Closed Beach and North Beach.
- Recent beneficial use dredging at Mansfield Channel nourished the adjacent park beach and advanced the shoreline there up to 169 meters (554 ft).

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 (GULN) 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 Padre Island NS from May 2017 through May 2021.

Study Area

Padre Island National Seashore (PAIS) was established in 1962, and consists of approximately 130,000 acres (52,609 hectares [ha]) of land and water. At 113 kilometers (70 mi), it is the longest stretch of undeveloped barrier island in the world, and ranges in width from 0.8 to 4.8 kilometers (0.5 to 3 miles; Cooper et al. 2005). The authorized boundary of the seashore includes not only the barrier island itself, but also portions of the Gulf of Mexico and the Laguna Madre. Figure 1 shows the extent of the shoreline mapping effort at Padre Island NS from the northern Gulf-side boundary at North Beach to Port Mansfield Channel, near mile marker 60.

There are a number of aquatic and terrestrial ecosystems in Padre Island NS. Beginning on the Gulf-side and going west to the Gulf Intracoastal Waterway, the park includes the nearshore waters, the foreshore (swash zone) and backshore (from high-tide line to dunes) on the beach, foredunes, vegetated flats behind the dunes with shallow fresh- or brackish-water ponds and marshes, back-island dunes in some areas, wind-tidal flats, and shallow, hypersaline seagrass beds in the lagoon. The interplay of climate, physiography, and geomorphology results in a landscape that is largely shaped by wind (Withers et al. 2004).

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](#).

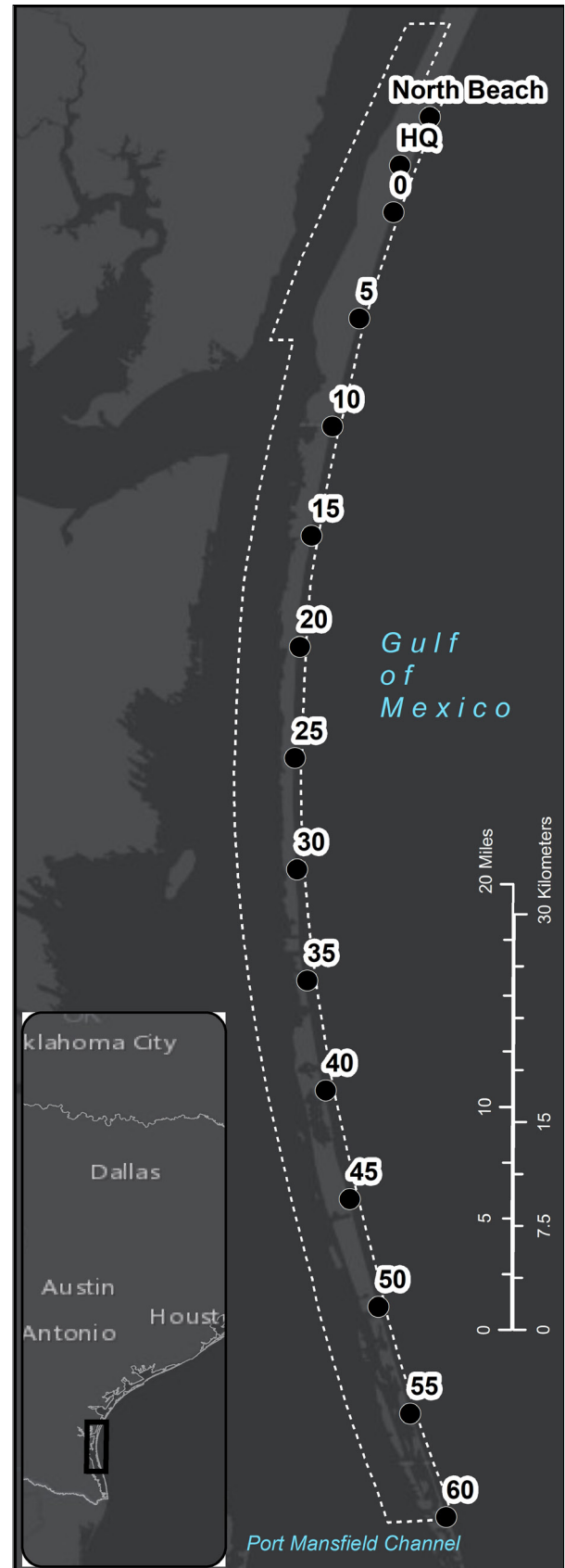


Figure 1. (Right) Extent of shoreline mapping at Padre Island NS. Dashed line indicates the park boundary and numbered black dots represent the park's mile marker system.

Methods

The position of the entire Gulf-side shoreline is mapped in the spring of every other year using methods developed by National Park Service Northeast Coastal and Barrier Network (Psuty et al. 2010) and adapted by the Gulf Coast Network (Bracewell 2017). 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 50 meters (164 ft). Annual shoreline change rates are calculated using the Linear Regression Rate (LRR) and End Point Rate (EPR) methods. EPR calculates the movement between the oldest and most recent shorelines and divides distance by the time between the surveys (Figure 2). LRR calculates shoreline movement by fitting a least squares regression line to shoreline intersection distances (Figure 3). This report addresses shoreline change between spring 2017 and spring 2021.

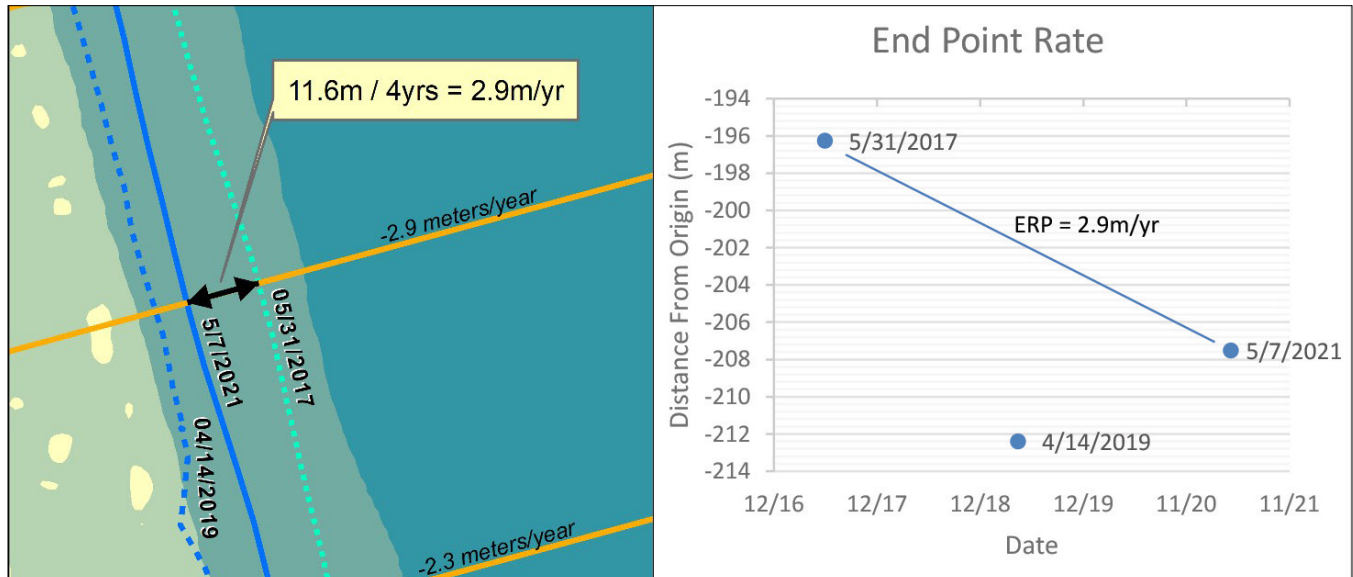


Figure 2. End Point Rate calculation for transect at Padre Island NS. In this case the shoreline retreated 16.11 meters (52.85 ft) over 683 days, or 8.6 meters (28.2 ft) of retreat per year.

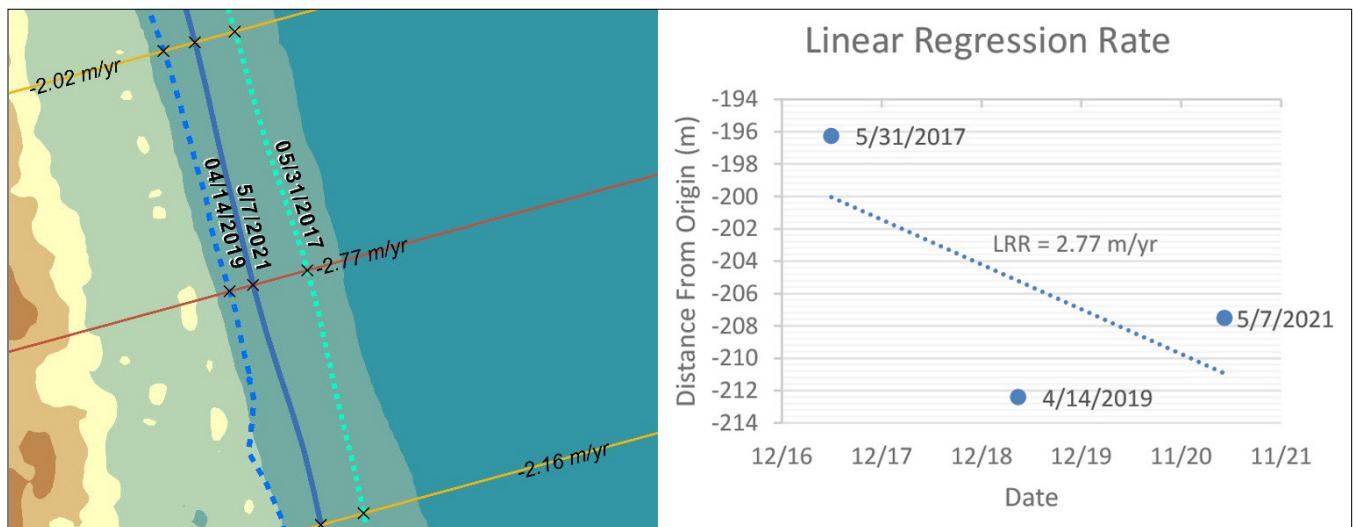


Figure 3. Linear Regression Rate (LRR) calculation for transect at Padre Island NS. Rate is defined by best-fit slope using all dates. In this case the shoreline retreated 2.77 meters per year (9.08 ft per year) from May 2017 to May 2021.

Standard Operating Procedure

Table 1 presents the Standard Operation Procedures that are considered critical to maintaining continuity between data

sets across many surveys so that the 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 of every other year. 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 station at Bob Hall Pier (NOAA 2018). The verified water levels occurring before surveys are listed in Table 2. Graphs of verified vs. predicted water levels for the survey periods and the prior week are presented in Figures 4, 5 and 6.

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	05/31/2017 15:31 to 18:36	Mansfield Channel thru Malaquite Beach	0.554	05/31/2017 10:12
Spring	06/01/2017 17:12 to 17:20	North Beach	0.495	06/01/2017 11:18
Spring	04/14/2019 14:15 to 19:15	Mansfield Channel thru North Beach	0.417	04/14/2019 13:30
Spring	04/07/2021 14:12 to 17:51	Mansfield Channel thru North Beach	0.437	05/07/2021 13:42

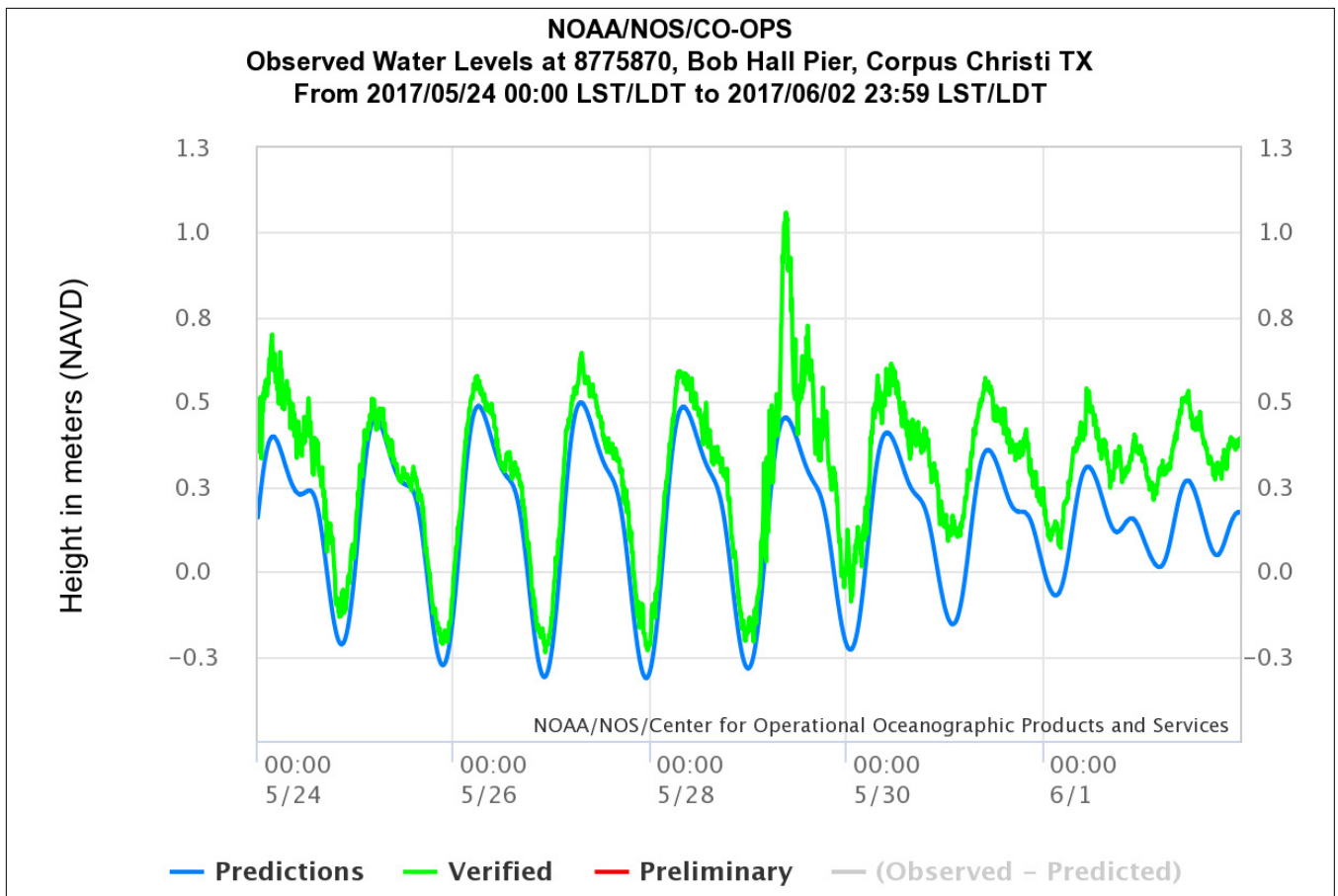


Figure 4. Water levels at Bob Hall Pier for 2017 shoreline position survey conducted on 5/31 and 6/1.

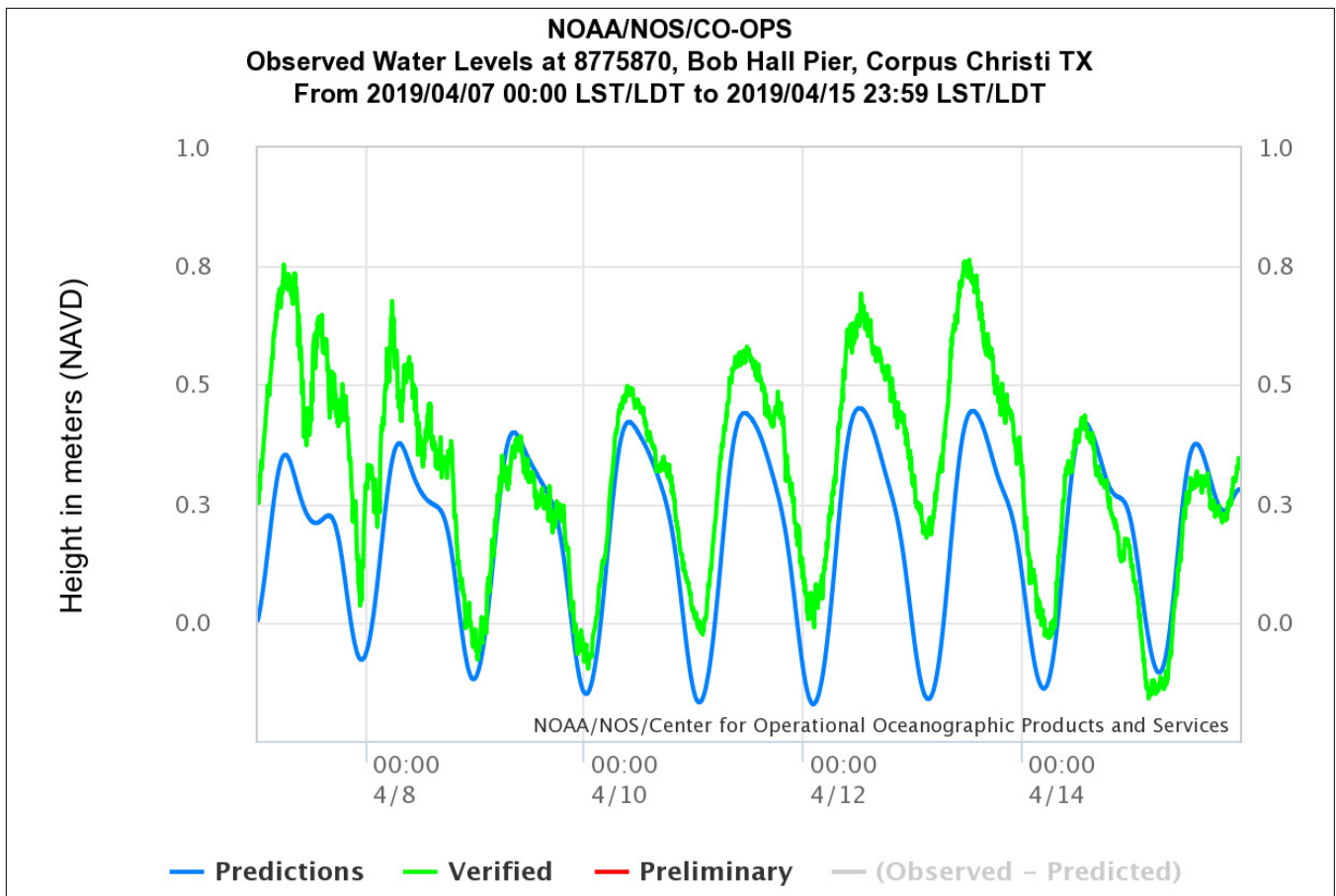


Figure 5. Water levels at Bob Hall Pier for 2019 shoreline position survey conducted on 4/14.

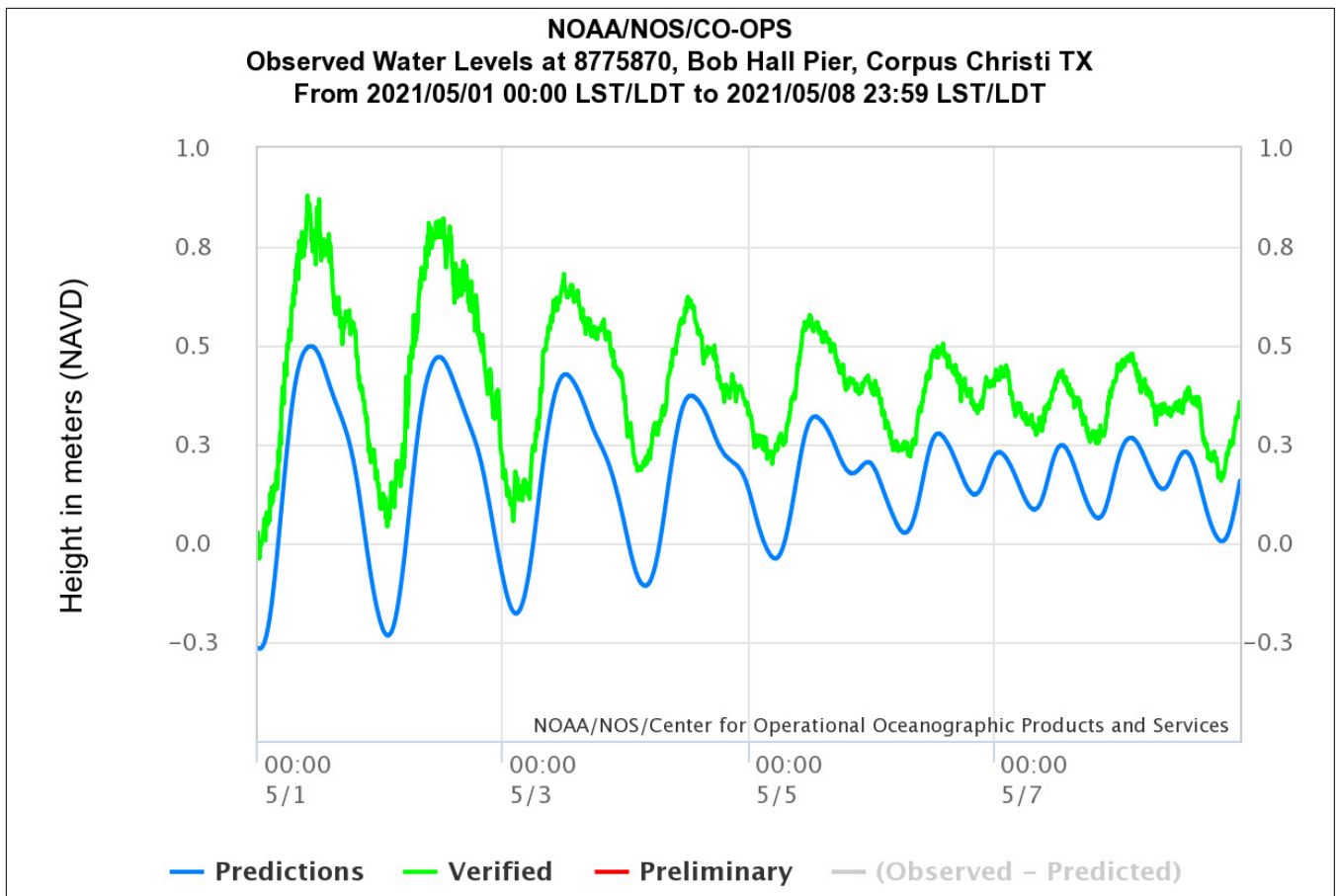


Figure 6. Water levels at Bob Hall Pier for 2021 shoreline position survey conducted on 5/7.

Natural and Anthropogenic Events Affecting Shoreline Position

There were five named storms between 2017 and 2021 that caused water levels to rise to or above 1.2 meters (3.94 ft; NAVD88) at Bob Hall Pier, including Hurricane Harvey in 2017 and Hurricanes Hanna, Laura, Beta and Delta in 2020 (Figure 7). A list of high-water level events at Padre Island National Seashore between January 2017 and the survey date of May 7, 2021 is included in Appendix A. These tidal conditions alone are enough to extend water levels to the shoreward margin of the primary dune complex, while wind and wave action can further exaggerate wave run up and degrade the beach and foredune (Figure 8). High water marks surveyed at the PAIS Visitor Center and Malaquite Campground boardwalks following Hurricane Hanna were between 2.8 meters (9.18 ft; NAVD 88) to just over 3 meters (9.84 ft; NAVD 88; Bracewell 2020).

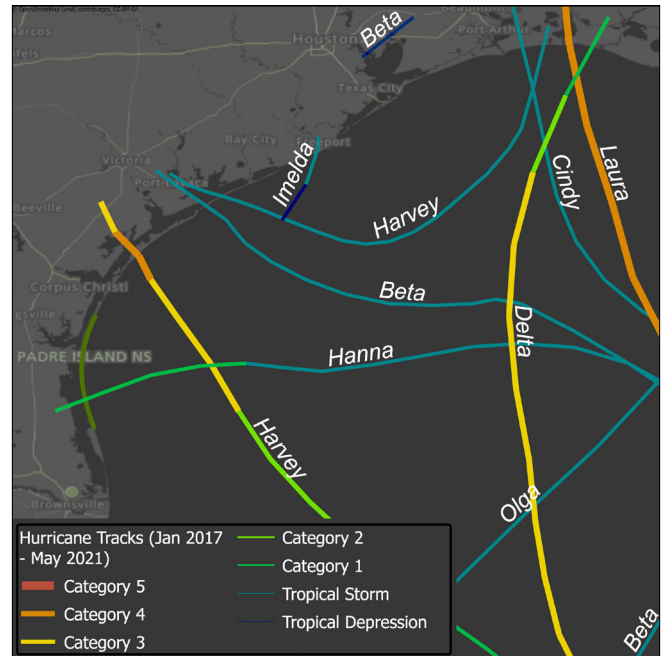


Figure 7. Named storms making landfall on the Texas and Western Louisiana coast between January 2017 and May 2021.



Figure 8. Photo taken August 28, 2017 showing eroded foredune at North Beach following Hurricane Harvey.

Results

Shoreline Position Data Quality

Shoreline position was recorded in May and June 2017, and April 2019 and May 2021. In all survey years, 105.5 kilometers (65.5 miles) of shoreline position was recorded. The average post-processed horizontal precision remained near or below 10 centimeters (3.9 inches [in]; Table 3).

Table 4 presents grouped and total summary statistics for the 2017 to 2021 shoreline position change rates and includes:

transect count, minimum, maximum, average, and standard deviation for rate of change. All groups showed overall landward retreat except those near Mansfield Channel. Retreat was generally least toward the center of the island's north/south extent, between mile markers 20 and 25 and increased toward both northern and southern reaches of the seashore. Linear Regression Rate maps are presented in Appendix B.

Table 3. Table listing the average horizontal positional precision of the shoreline features collected during 2017, 2019 and 2021 [m—meters].

Collection Date	Average Horizontal Precision (m)
05/31/2017	0.096
06/01/2017	0.037
04/14/2019	0.128
05/07/2021	0.122

Table 4. Summarization of Linear Regression (LRR) and End Point Rates (EPR) for sections of Padre Island NS in meters per year (m/yr). Negative values show shoreline retreat and positive values indicate shoreline advance [MIN—Minimum; MAX—Maximum; STD—Standard Deviation]. Final row summarizes shoreline change for the entire gulf extent of Padre Island NS.

Baseline ID	Park Section	Count	MIN_LRR m/yr	MAX_LRR m/yr	MEAN_LRR m/yr	STD_LRR m/yr	MIN_EPR m/yr	MAX_EPR m/yr	MEAN_EPR m/yr	STD_EPR m/yr
1	North Beach	36	-5.04	-2.70	-3.76	0.57	-5.03	-2.73	-3.79	0.57
2	Closed Beach	146	-4.79	-2.30	-3.52	0.46	-4.83	-2.37	-3.56	0.46
3	MM 0–5	161	-4.21	-0.88	-2.65	0.79	-4.25	-0.92	-2.69	0.79
4	MM 5–10	161	-3.78	-0.26	-1.71	0.60	-3.81	-0.32	-1.74	0.60
5	MM 10–11	160	-3.72	-0.27	-1.96	0.74	-3.71	-0.31	-1.99	0.72
6	MM 15–20	161	-4.10	0.26	-1.83	1.05	-4.18	0.22	-1.88	1.05
7	MM 20–25	160	-1.55	1.26	-0.31	0.49	-1.56	1.22	-0.34	0.49
8	MM 25–30	161	-2.76	0.90	-0.84	0.75	-2.74	0.87	-0.85	0.74
9	MM 30–35	161	-3.92	1.53	-0.92	0.93	-3.94	1.57	-0.93	0.94
10	MM 35–40	160	-5.01	2.30	-1.23	1.57	-5.04	2.28	-1.25	1.57
11	MM 40–45	161	-3.70	2.54	-0.91	1.26	-3.71	2.48	-0.94	1.25
12	MM 45–50	161	-4.76	3.28	-1.15	1.54	-4.77	3.16	-1.18	1.53
13	MM 50–55	161	-5.16	3.09	-1.05	1.70	-5.17	3.01	-1.13	1.69
14	MM 55–60	157	-5.85	43.49	3.54	12.48	-5.95	85.59	3.92	13.91
–	Seashore	2107	-5.85	43.49	-1.31	1.78	-5.95	85.59	-1.31	1.88

Annual Shoreline Change Analysis

In the initial GULN shoreline change report for Padre Island National Seashore (Bracewell 2019), End Point Rate (EPR) was used to measure change. A summary of EPR for 2017 to 2021 is in Table 4, but this and future reports will focus on Linear Regression Rate (LRR). The average LRR for the seashore between 2017 and 2021 is -1.16 meters per year (-3.81 ft per year), with a standard deviation of 3.88 meters per year (12.73 ft per year; Figure 9). The historical rate of change for North Padre Island between the 1930s and 2012 is -0.82 meters per year (2.69 ft per year), with a standard deviation of 0.98 meters per year (3.22 ft per year), which increases for the more recent period between 2000 and 2012 to -1.14 meters/ year (-3.74 ft per year) with a standard deviation of 1.19 meters (3.9 ft per year; Paine 2014).

Areas of Special Interest

During scoping meetings for this project, PAIS Resource Management staff expressed special interest in Closed Beach and the area north of Mansfield Channel (mile marker 55 to 60). Closed Beach measured a LRR retreat of -3.52 meters per year (11.55 ft per year), while Mansfield Channel witnessed a shoreline advance of 3.54 meters per year (11.61 ft per year). The advance at Mansfield corresponds with recent beneficial use dredging projects. In late 2019, a hopper dredge transported material from the channel bottom to a nearshore disposal site north of the north jetty. A larger project, started in October 2020 and completed in early 2021, placed 970,000 cubic yards of dredged material on the adjacent northern beach (Figure 10).

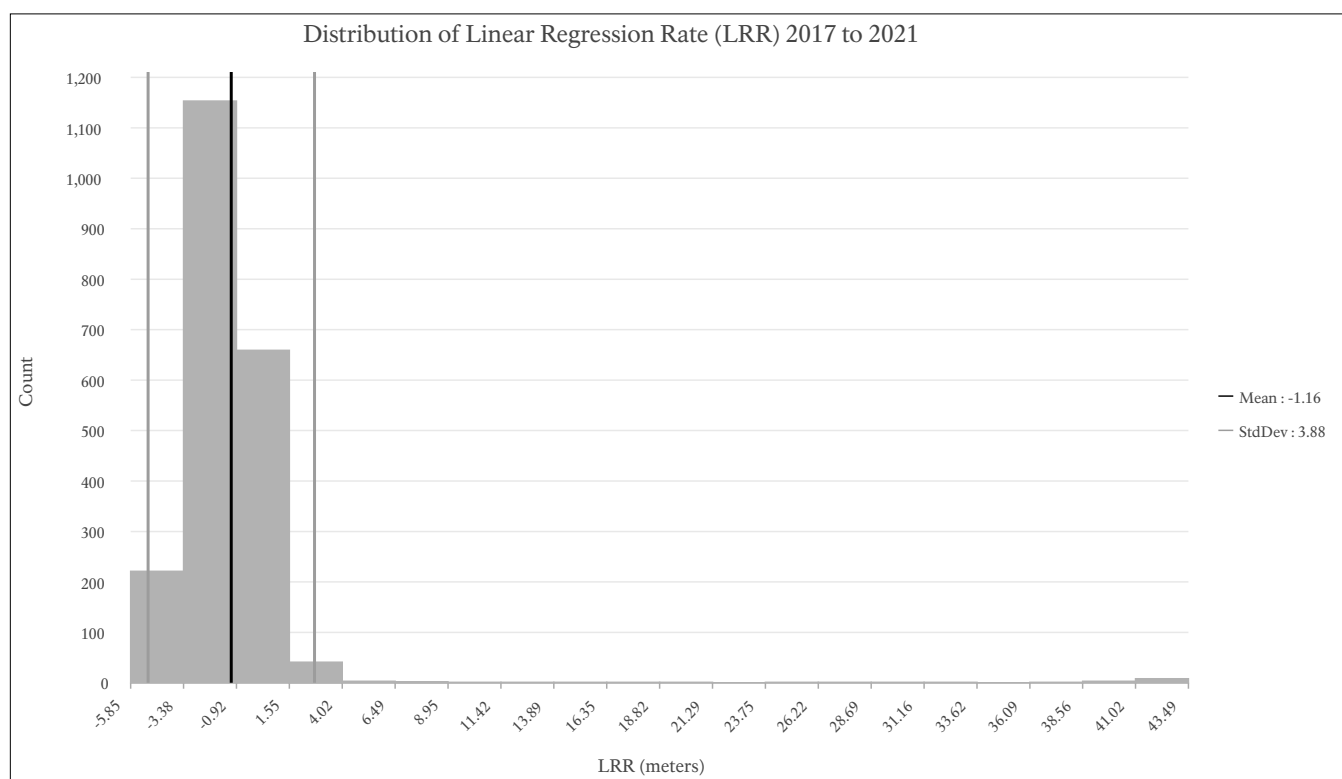


Figure 9. Histogram and of shoreline position change. Dark vertical line shows mean retreat of -1.16 meters per year (-3.81 ft per year) for the entire PAIS Gulf shoreline.



Figure 10. Photo taken May, 7, 2021 near Port Mansfield Channel, facing south. This section of the park experienced the highest shoreline advance following recent placement of dredged material. NPS photo.

Problems and Concerns

Tidal conditions were as expected, and winds were mild for the duration of the shoreline survey. As a result, water levels and the high tide swash line position were consistent with previous surveys (Table 2). Likewise, there were no unexpected circumstances that degraded the performance of surveying equipment (Table 3).

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](#).

Literature Cited

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Appendix A. High Tide Events at Bob Hall Pier

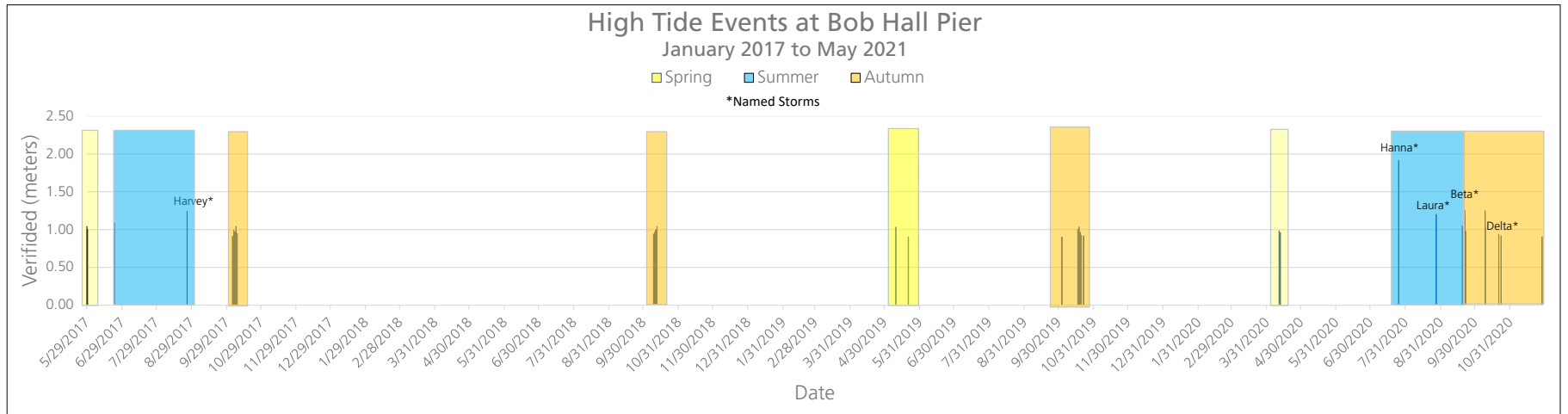


Figure A-1. High tide events measured at Bob Hall Pier from Jan 2017 to May 7, 2021. The average water level, calculated on daily high/low tides, for this entire three-year period is 0.31 meters (1.02 ft; NAVD88).

Appendix B. Shoreline Linear Regression Rate Maps

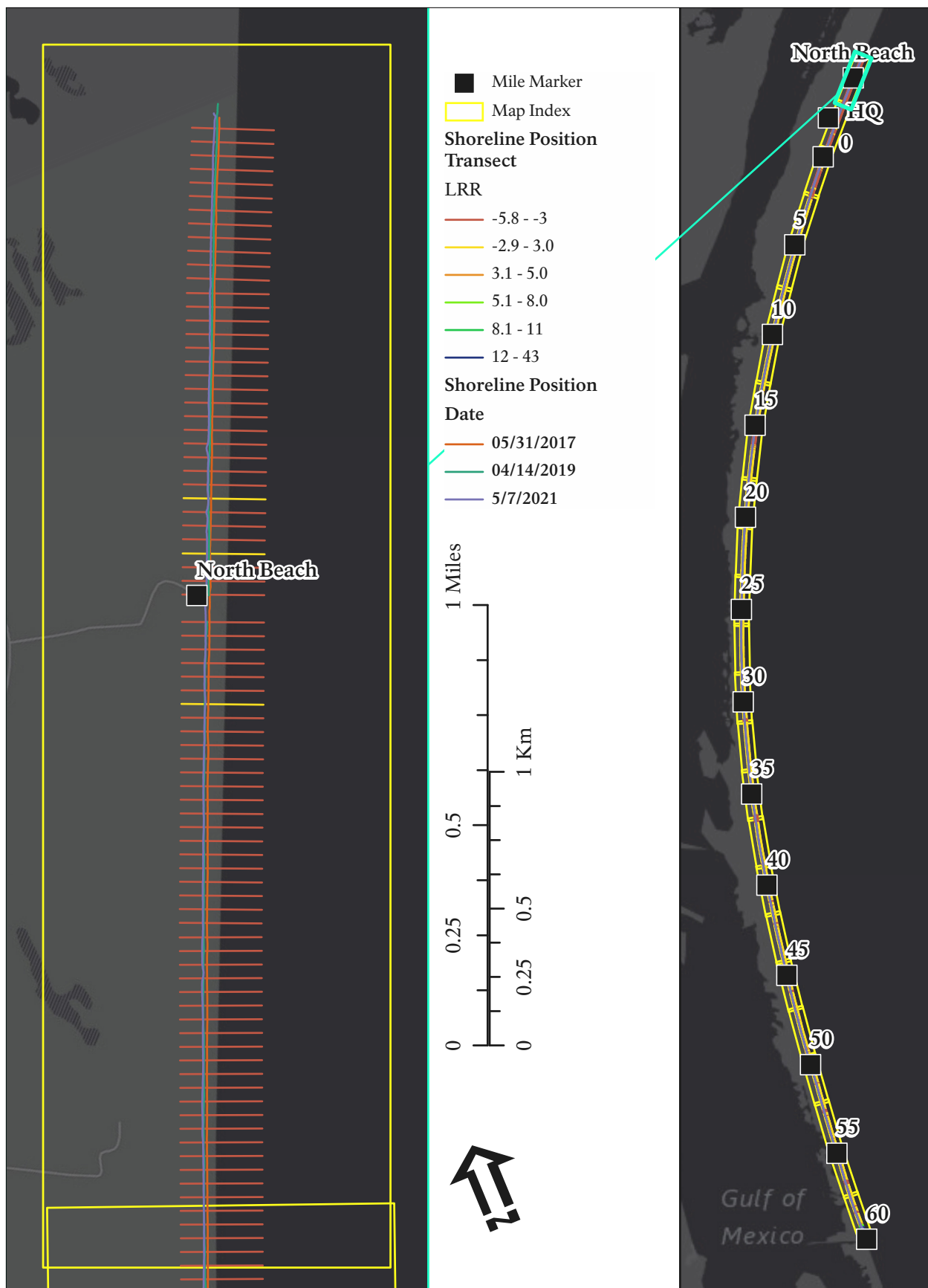


Figure B-1. Shoreline position change in meters per year. North Beach.

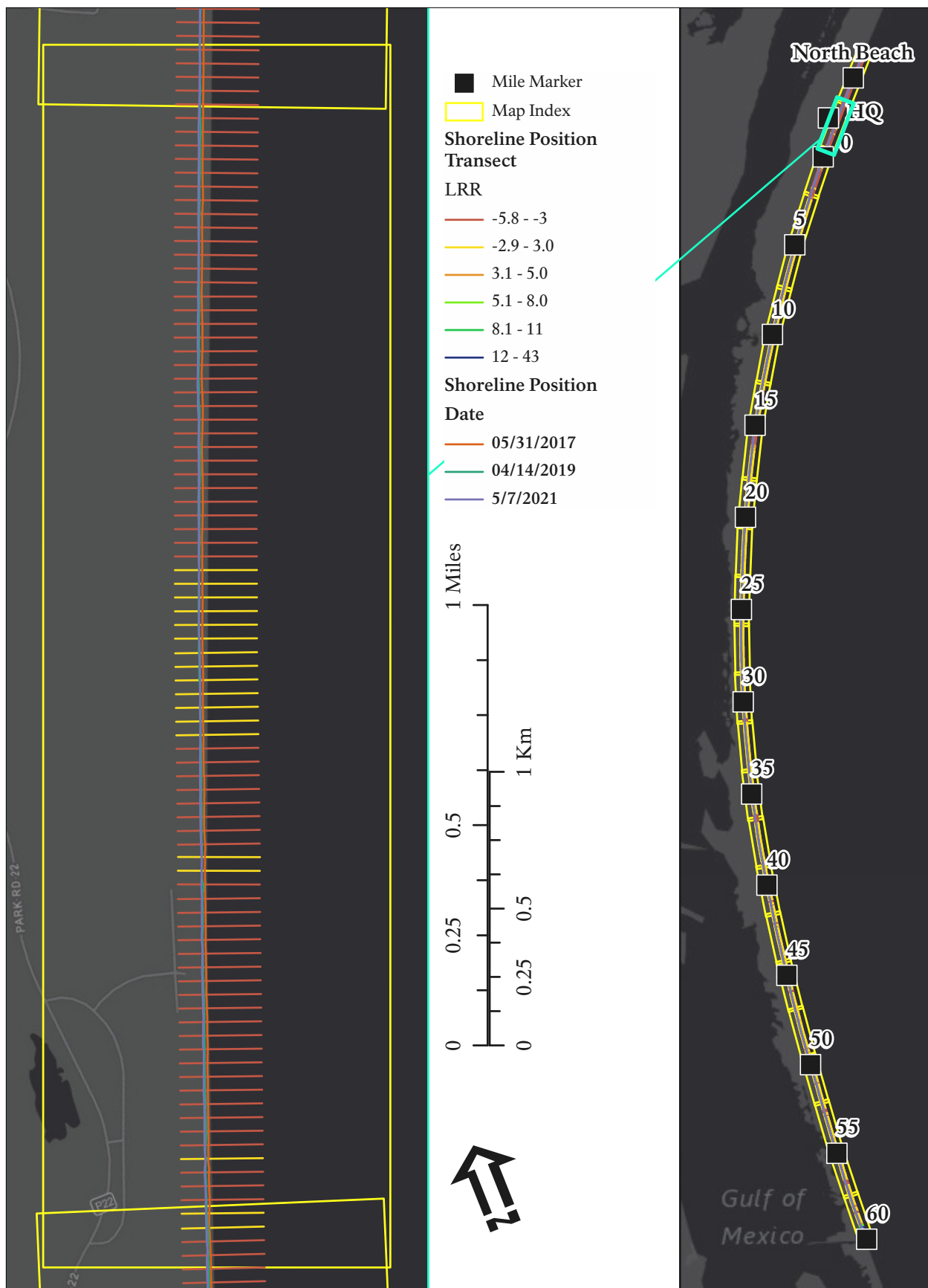


Figure B-2. Shoreline position change in meters per year. Closed Beach.

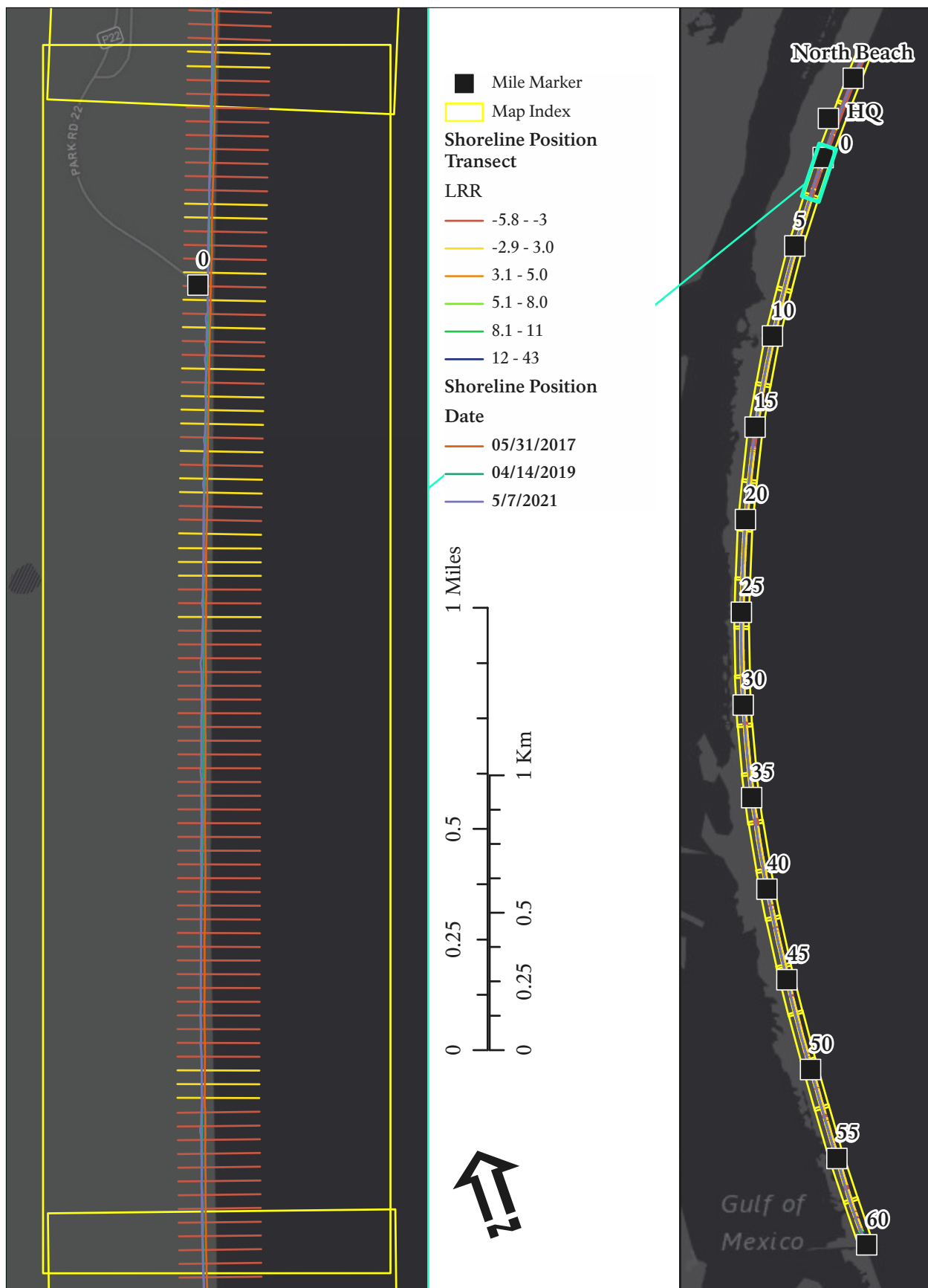


Figure B-3. Shoreline position change in meters per year. Mile Marker 0 through Mile Marker 2.

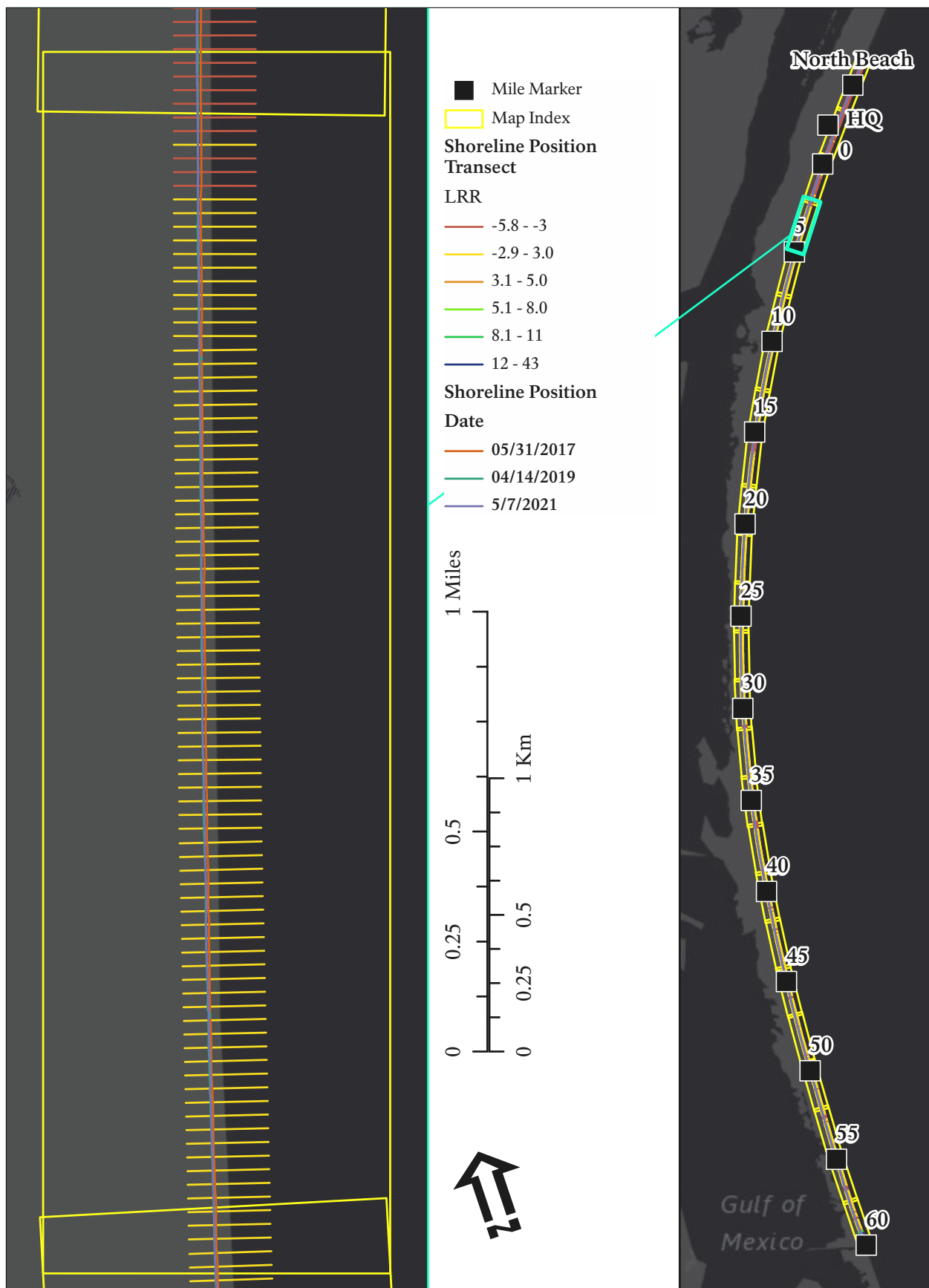


Figure B-4. Shoreline position change in meters per year. Mile Marker 2 through Mile Marker 5.

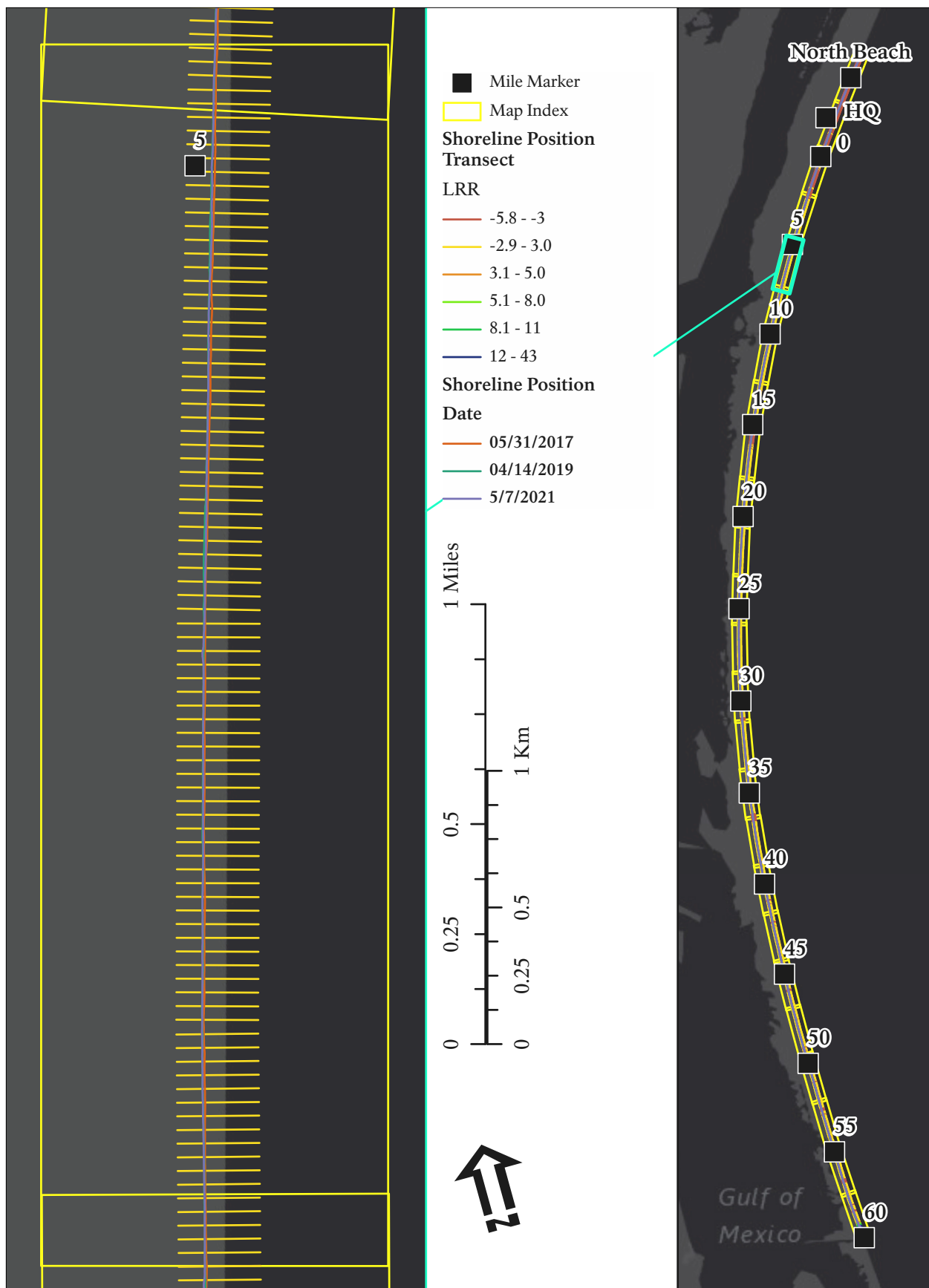


Figure B-5. Shoreline position change in meters per year. Mile Marker 5 through Mile Marker 7.

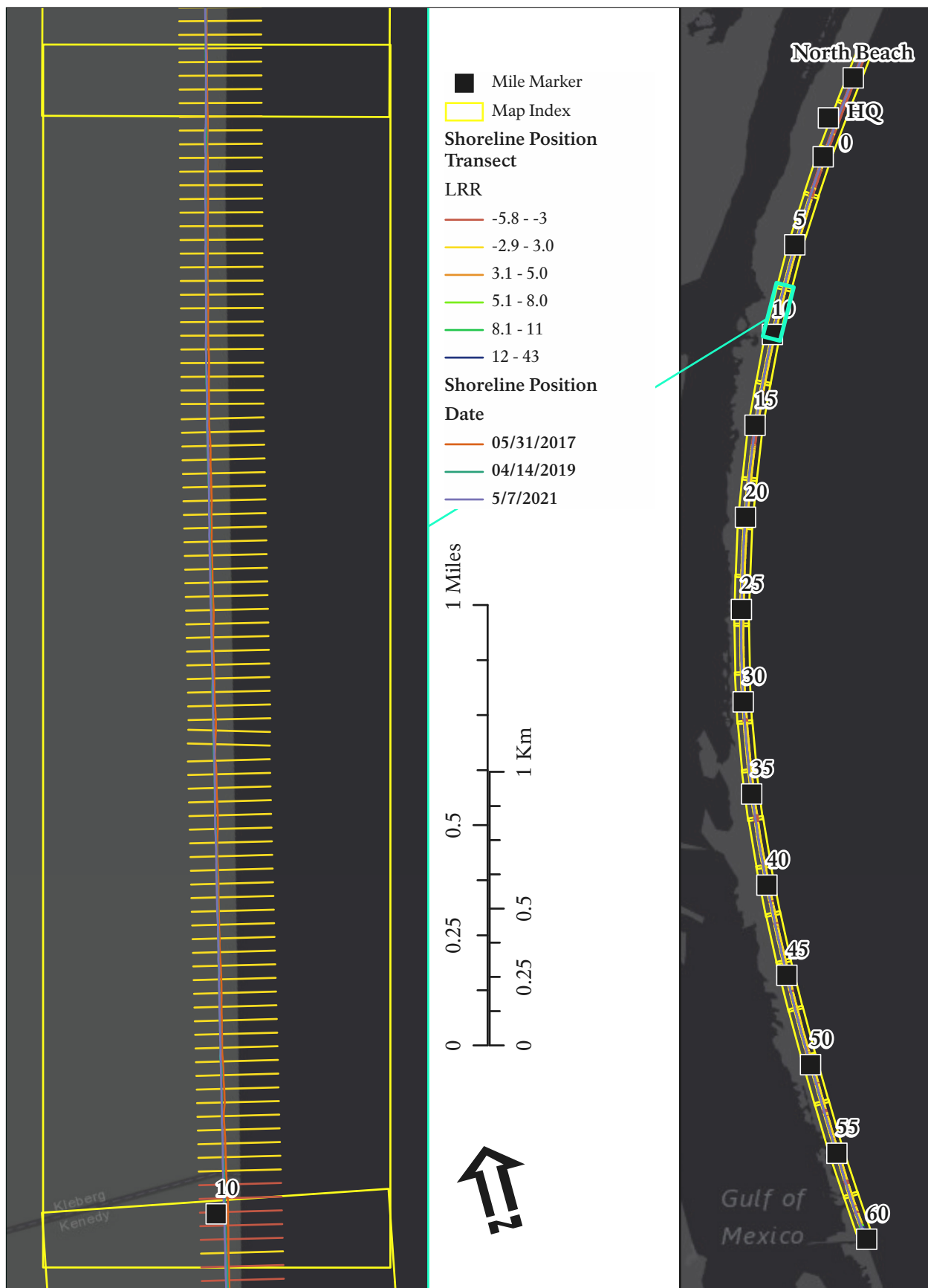


Figure B-6. Shoreline position change in meters per year. Mile Marker 7 through Mile Marker 10.

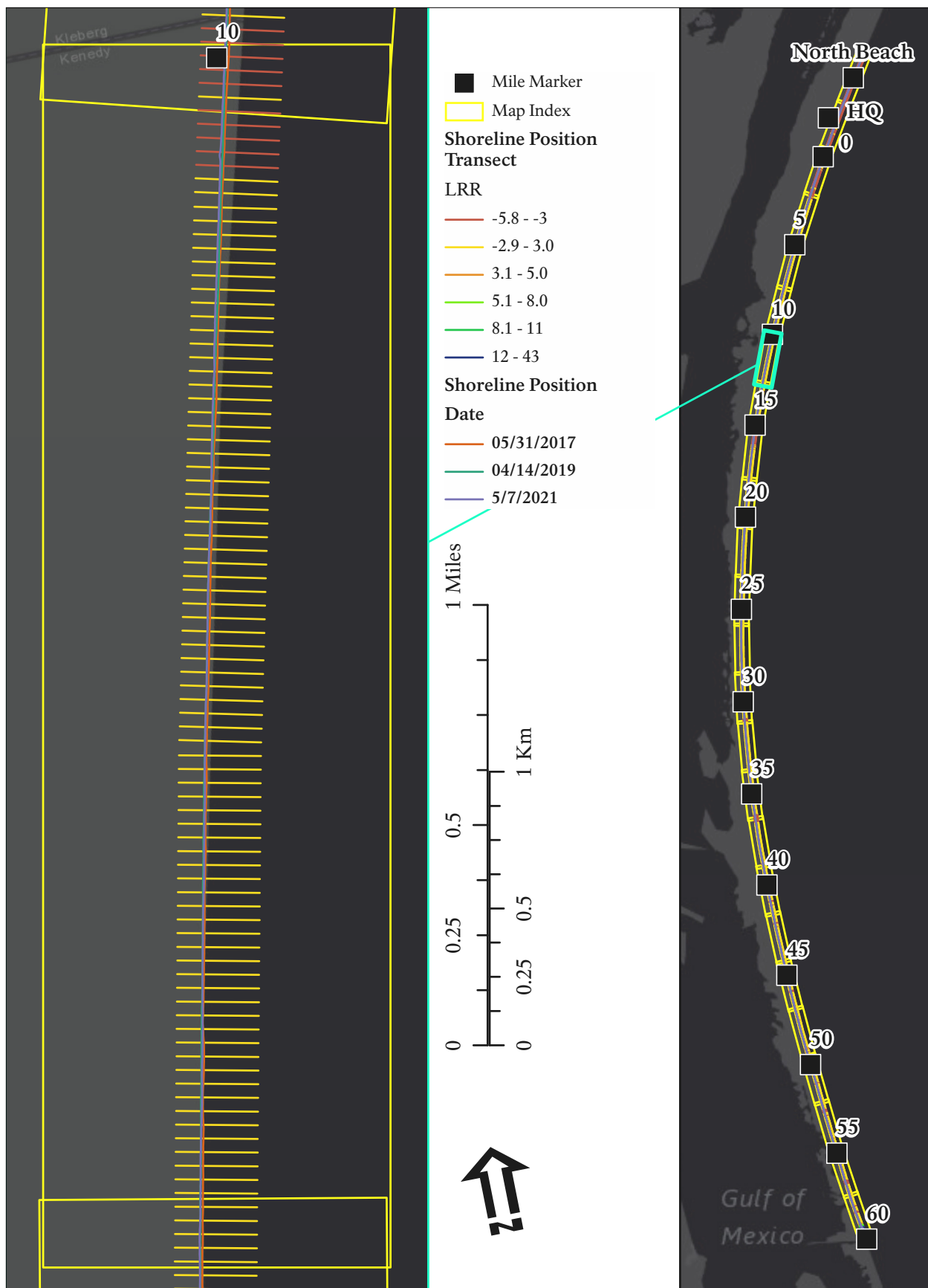


Figure B-7. Shoreline position change in meters per year. Mile Marker 10 through Mile Marker 13.

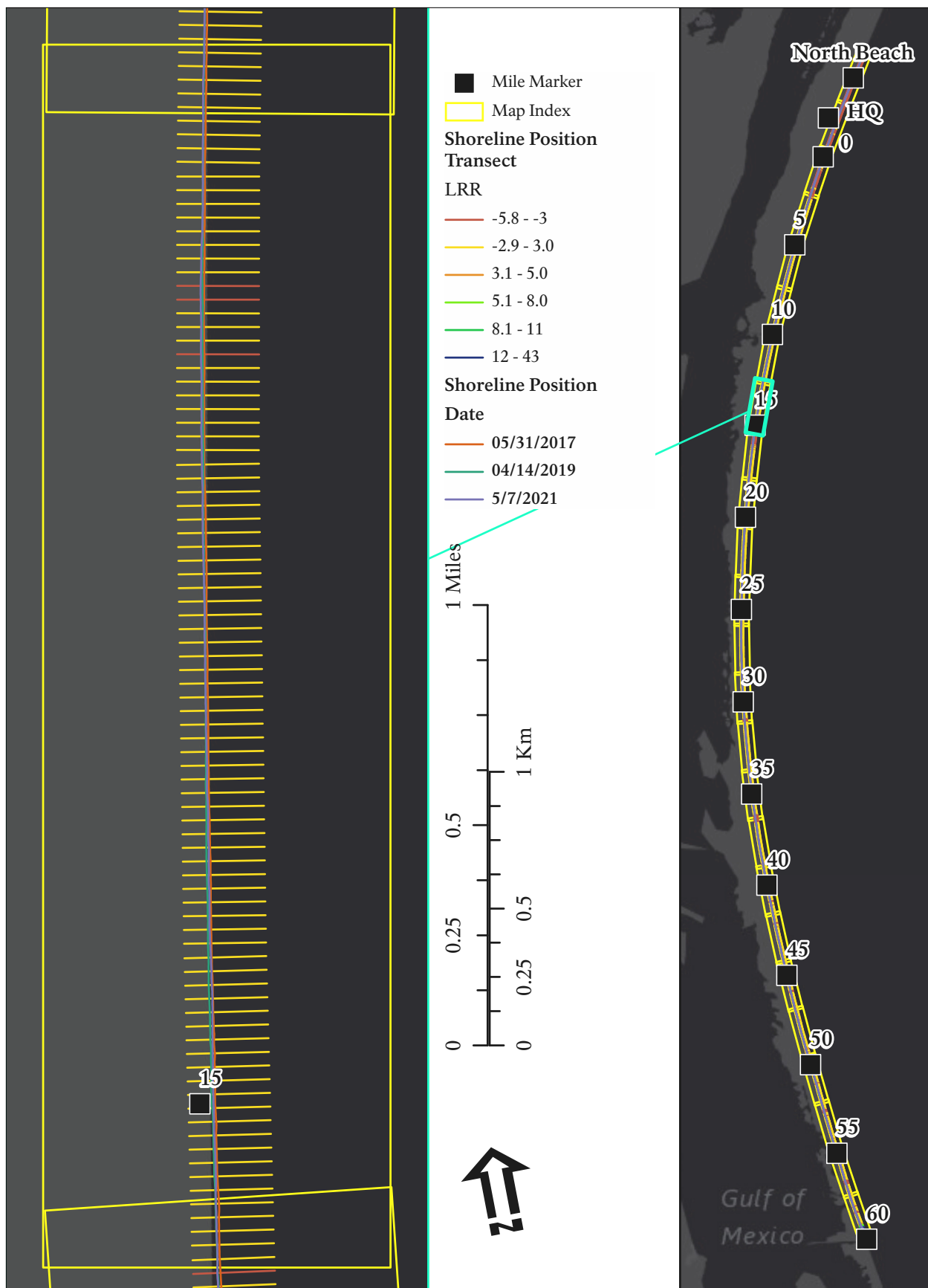


Figure B-8. Shoreline position change in meters per year. Mile Marker 13 through Mile Marker 15.

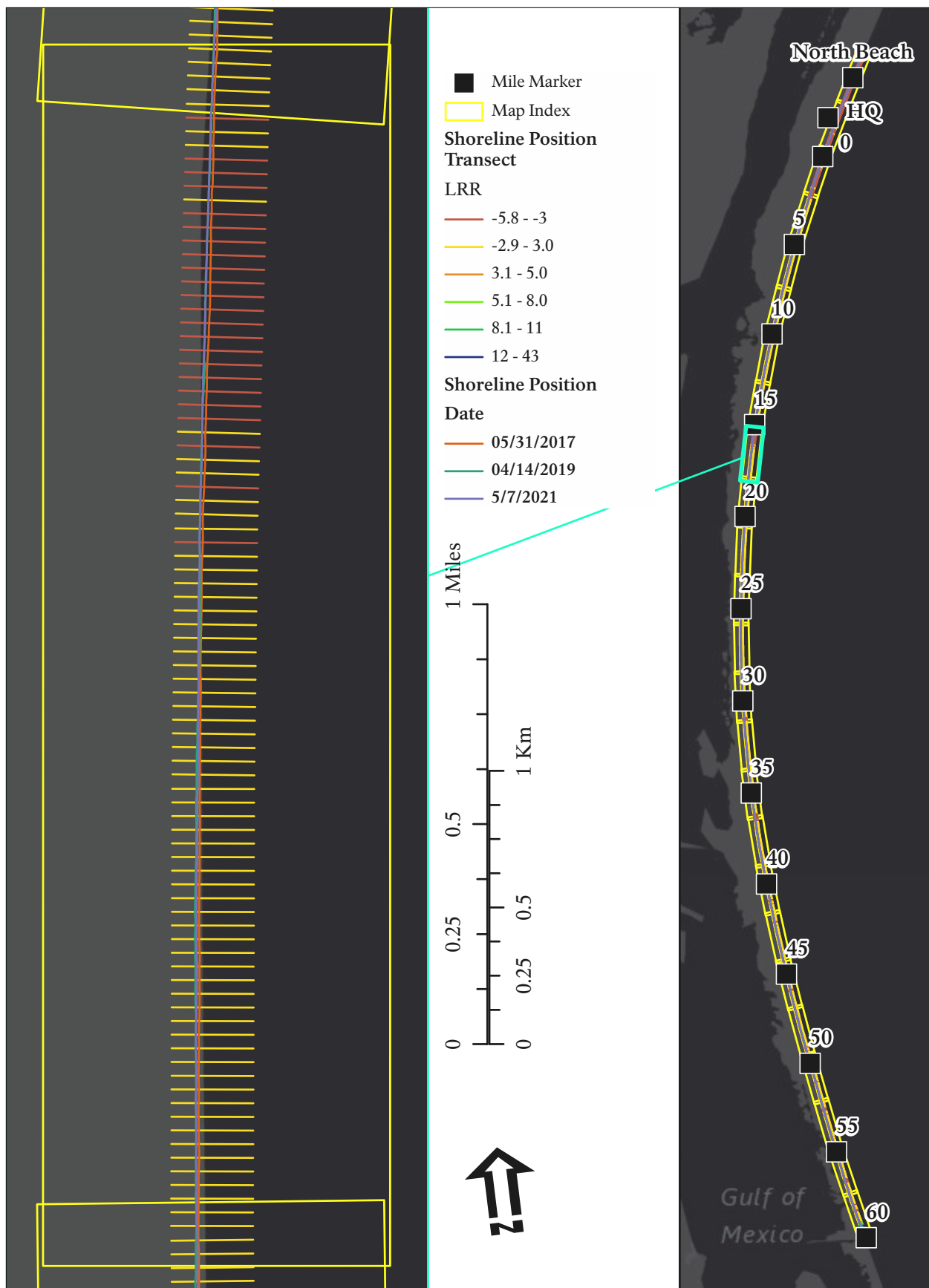


Figure B-9. Shoreline position change in meters per year. Mile Marker 15 through Mile Marker 18.

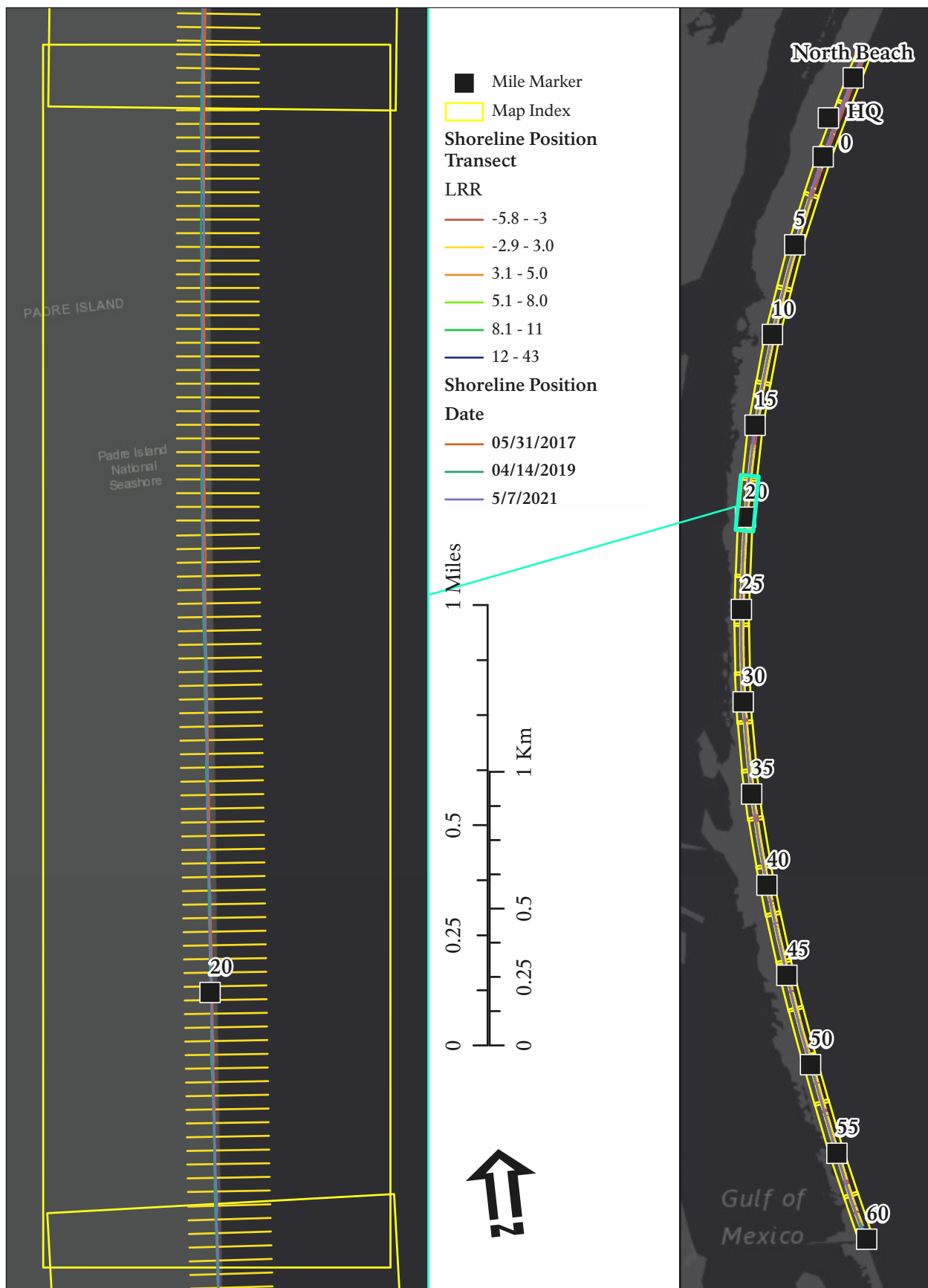


Figure B-10. Shoreline position change in meters per year. Mile Marker 18 through Mile Marker 20.

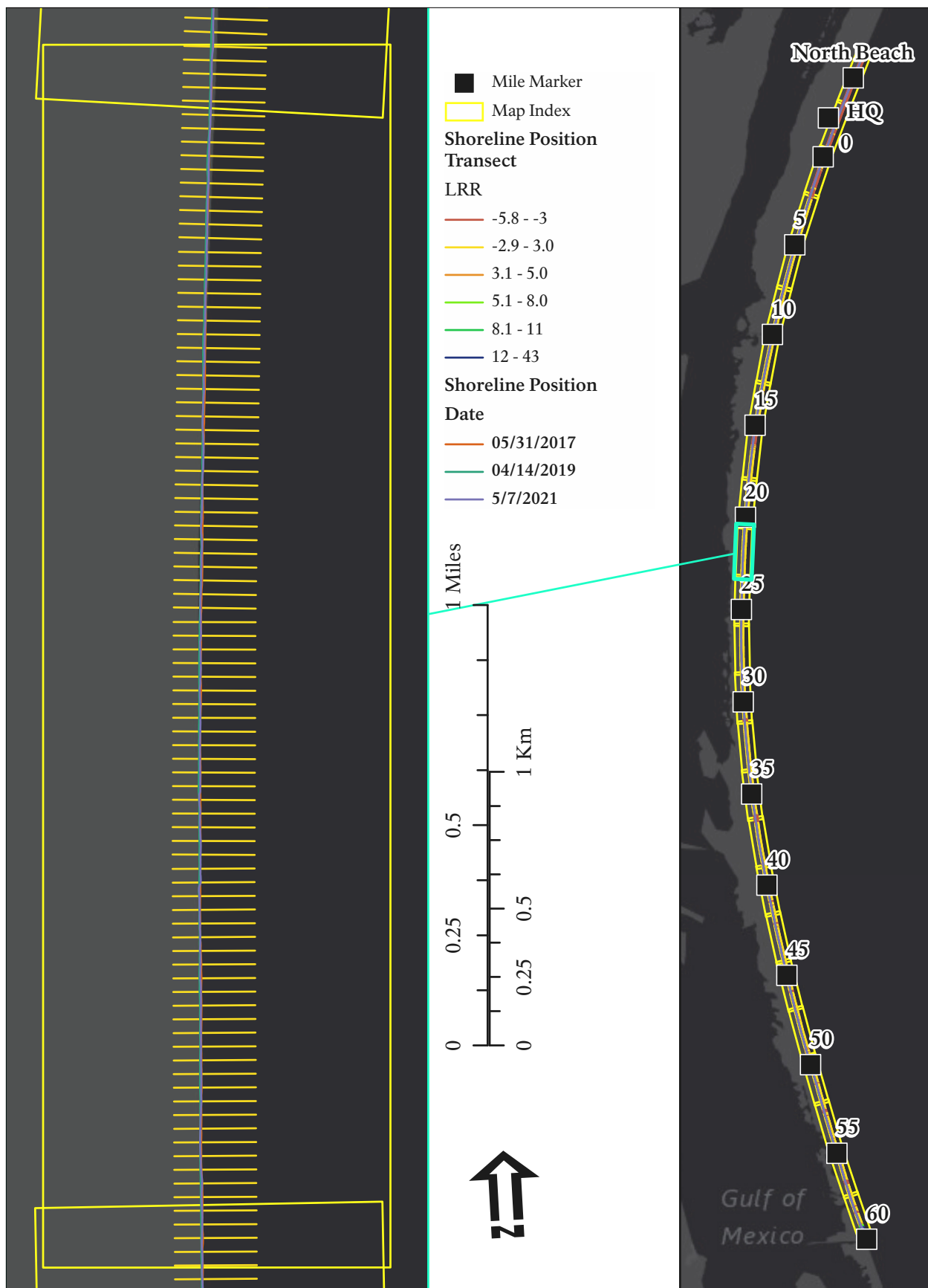


Figure B-11. Shoreline position change in meters per year. Mile Marker 20 through Mile Marker 23.

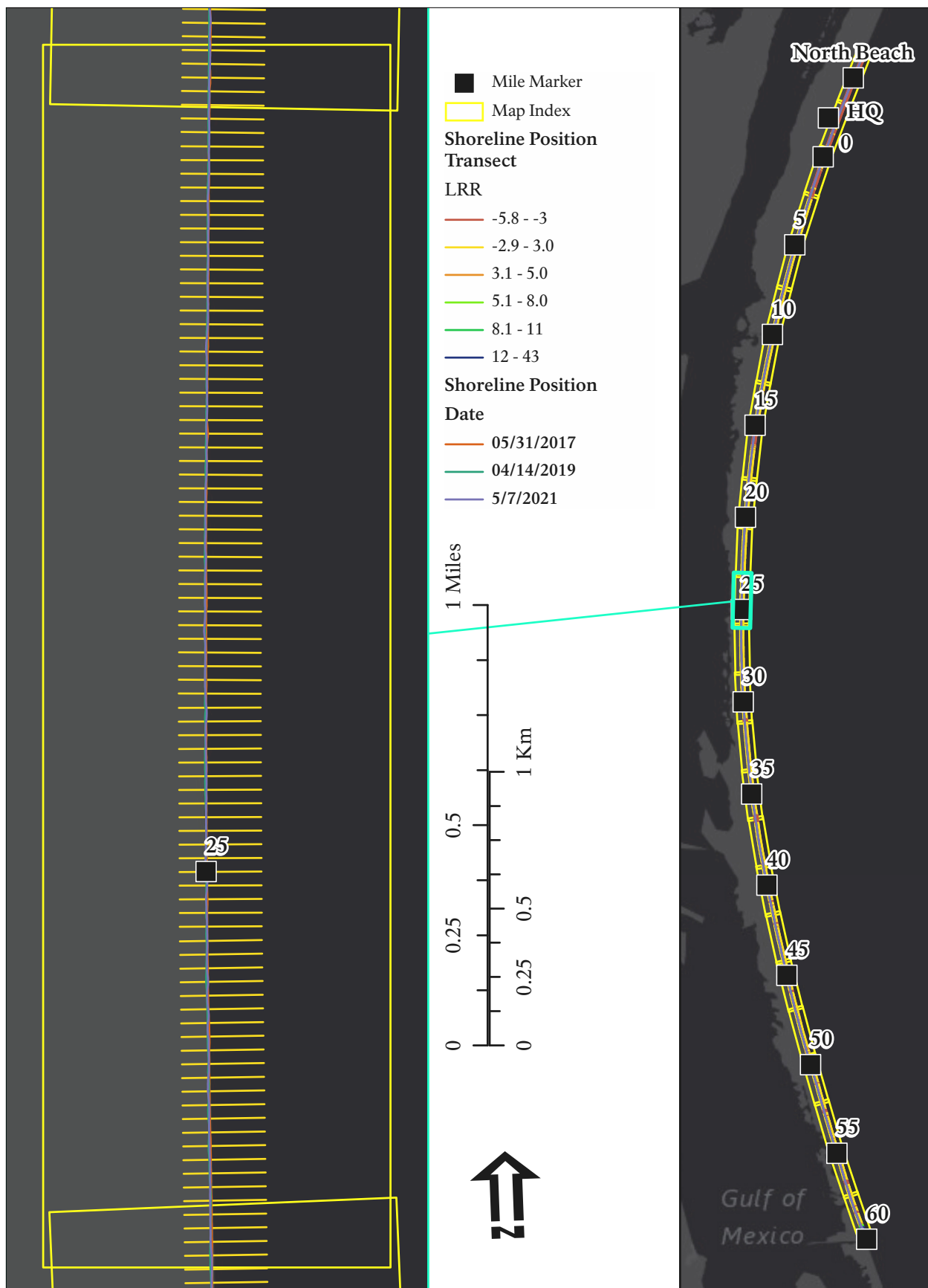


Figure B-12. Shoreline position change in meters per year. Mile Marker 23 through Mile Marker 26.

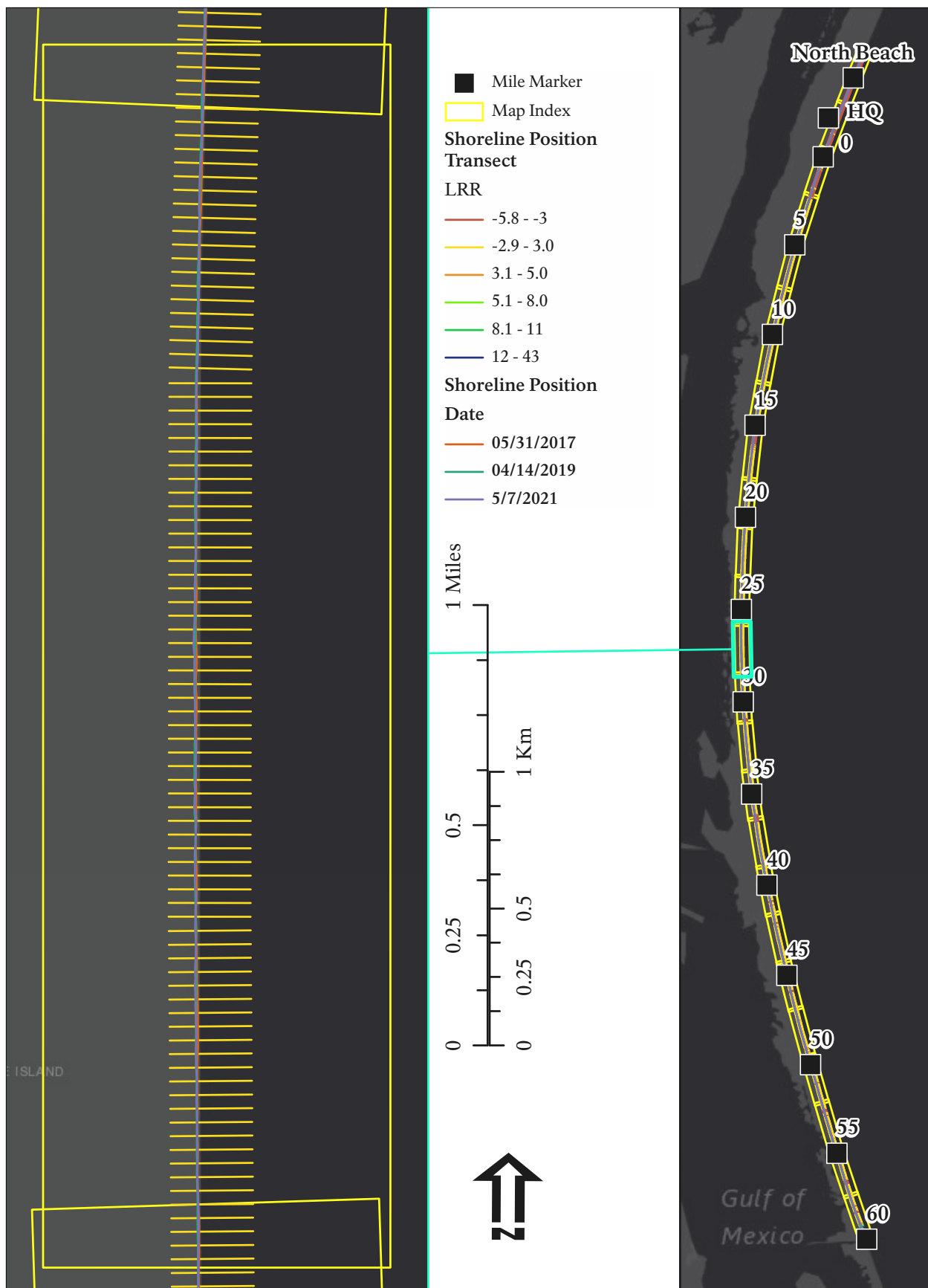


Figure B-13. Shoreline position change in meters per year. Mile Marker 26 through Mile Marker 28.

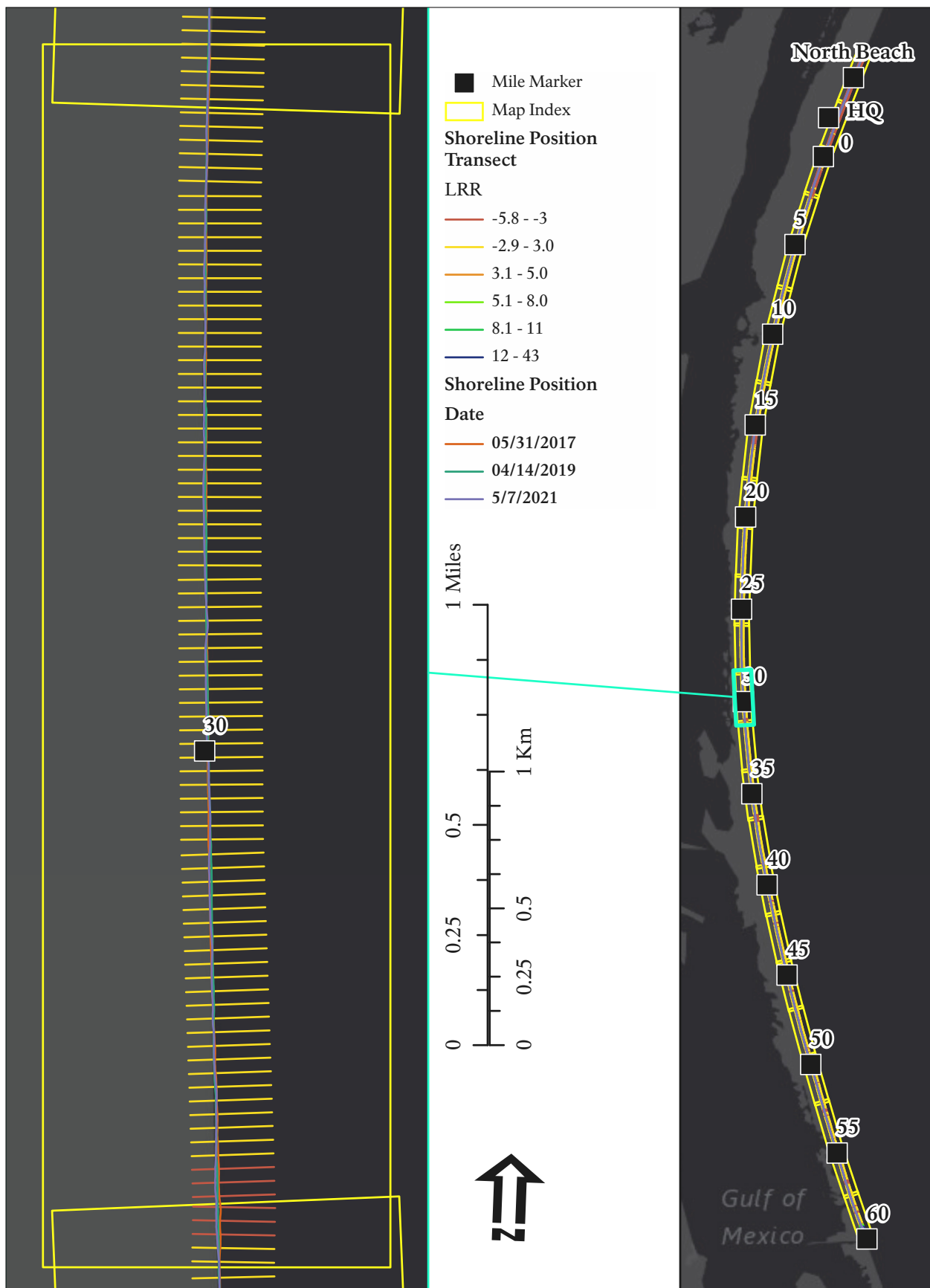


Figure B-14. Shoreline position change in meters per year. Mile Marker 28 through Mile Marker 31.

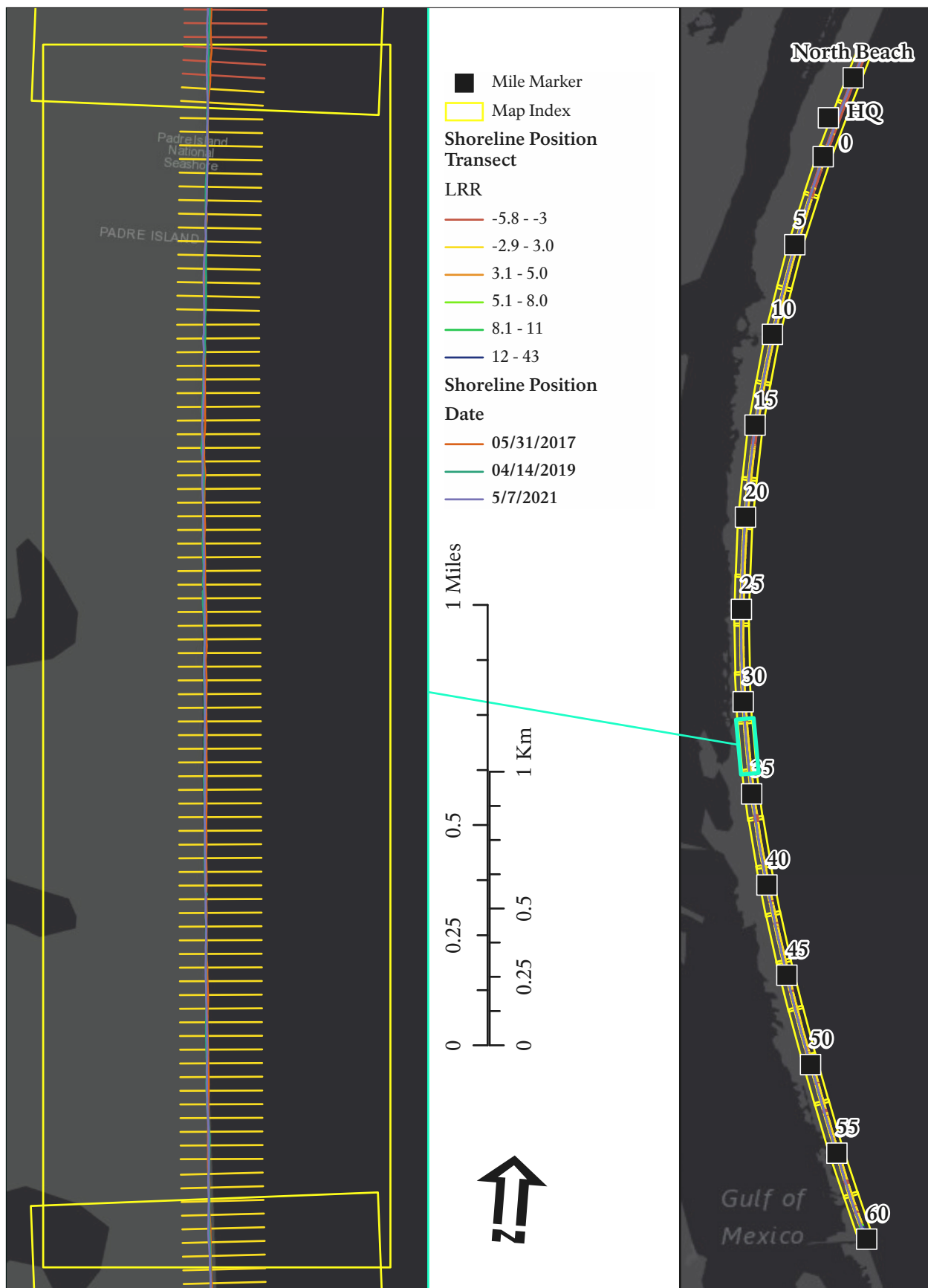


Figure B-15. Shoreline position change in meters per year. Mile Marker 31 through Mile Marker 34.

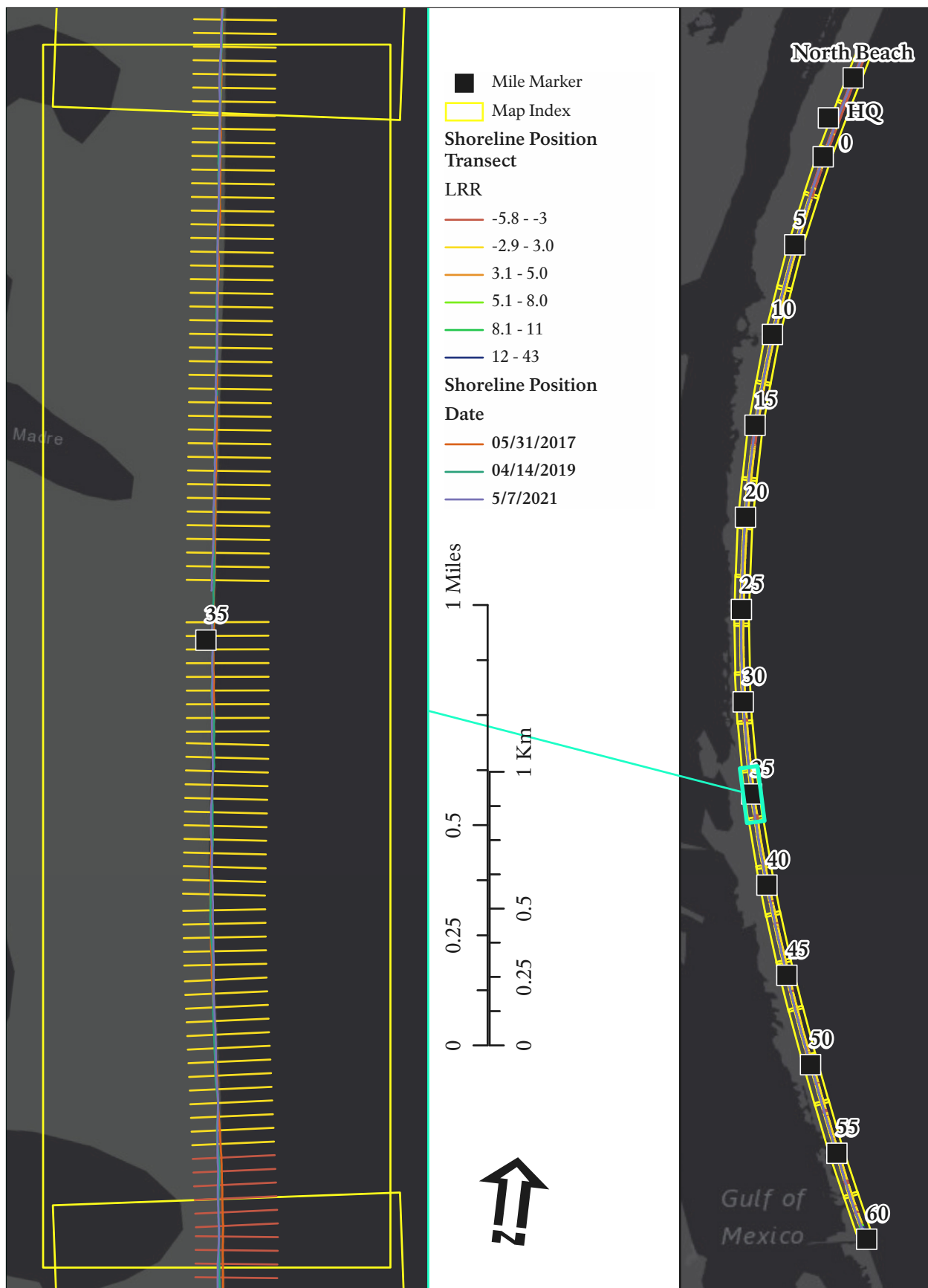


Figure B-16. Shoreline position change in meters per year. Mile Marker 34 through Mile Marker 36.

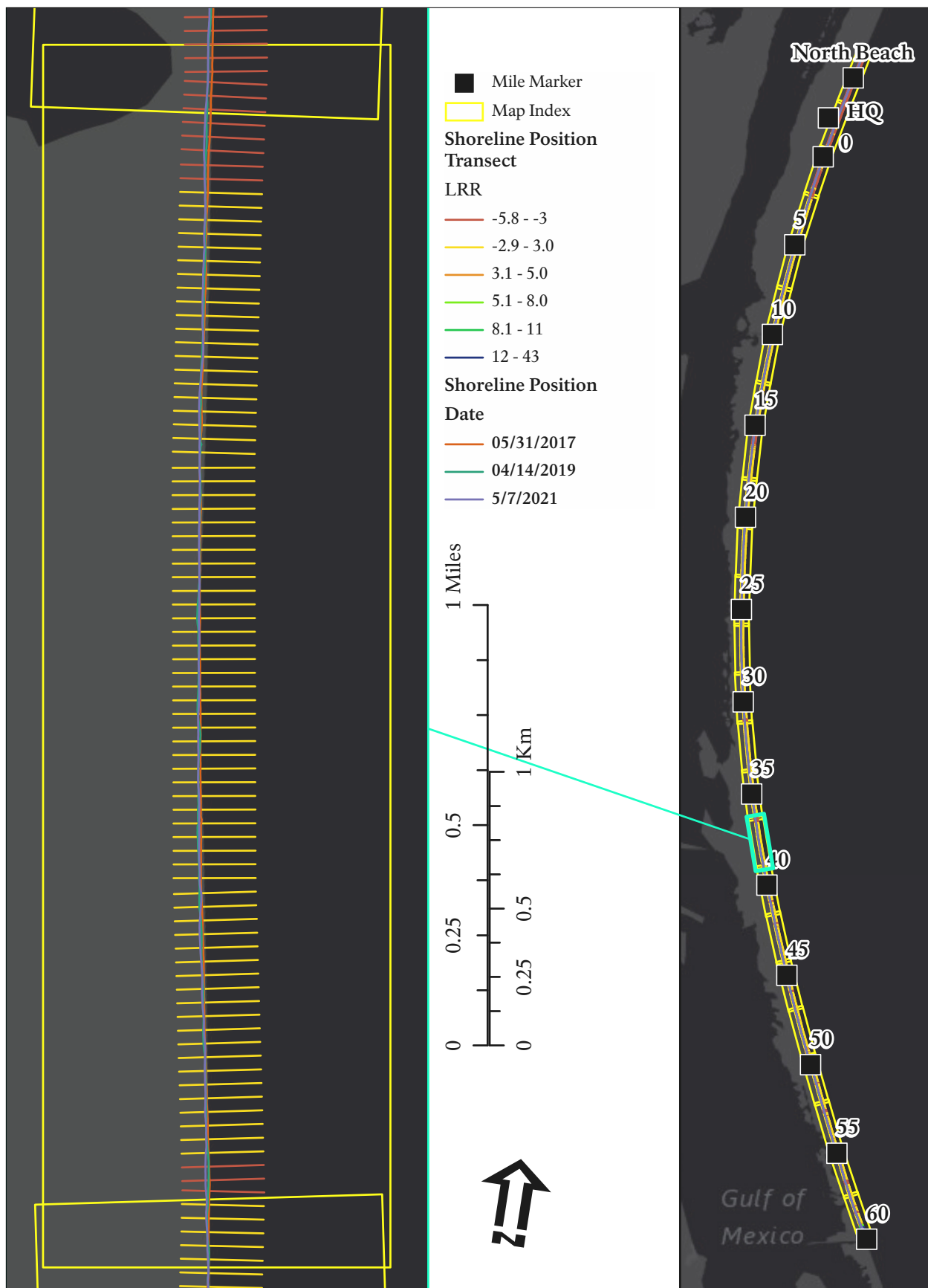


Figure B-17. Shoreline position change in meters per year. Mile Marker 36 through Mile Marker 39.

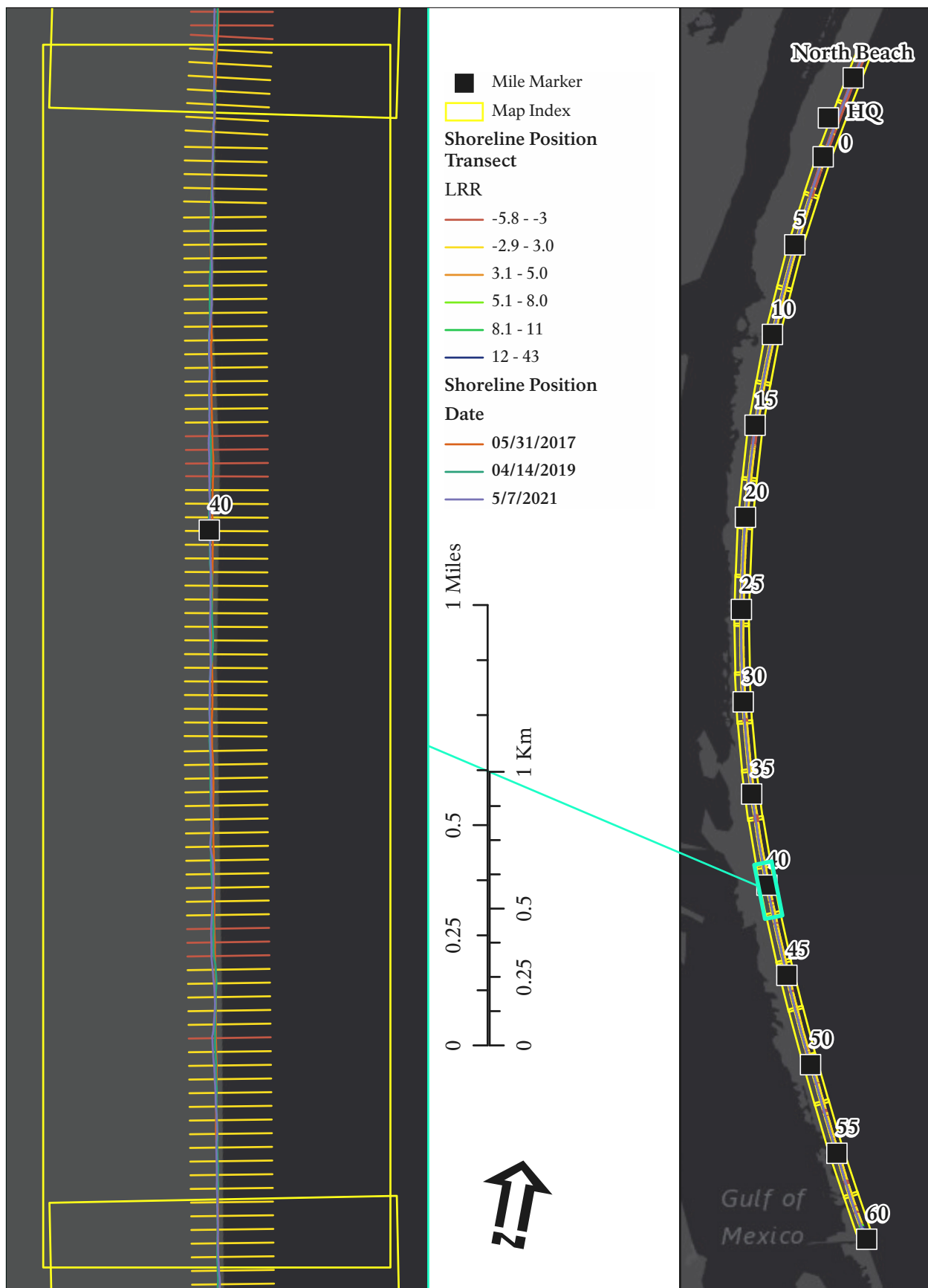


Figure B-18. Shoreline position change in meters per year. Mile Marker 39 through Mile Marker 41.

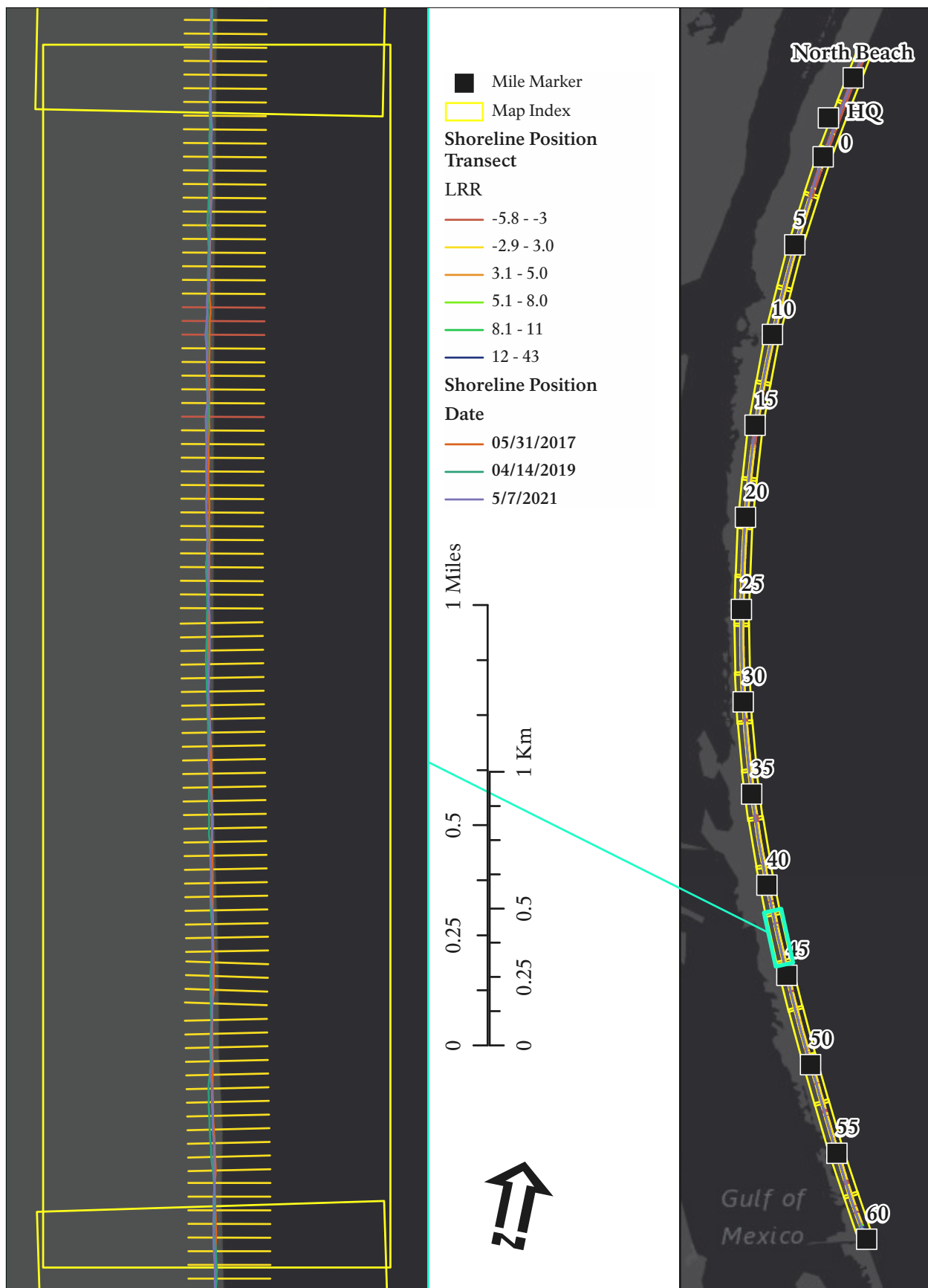


Figure B-19. Shoreline position change in meters per year. Mile Marker 41 through Mile Marker 44.

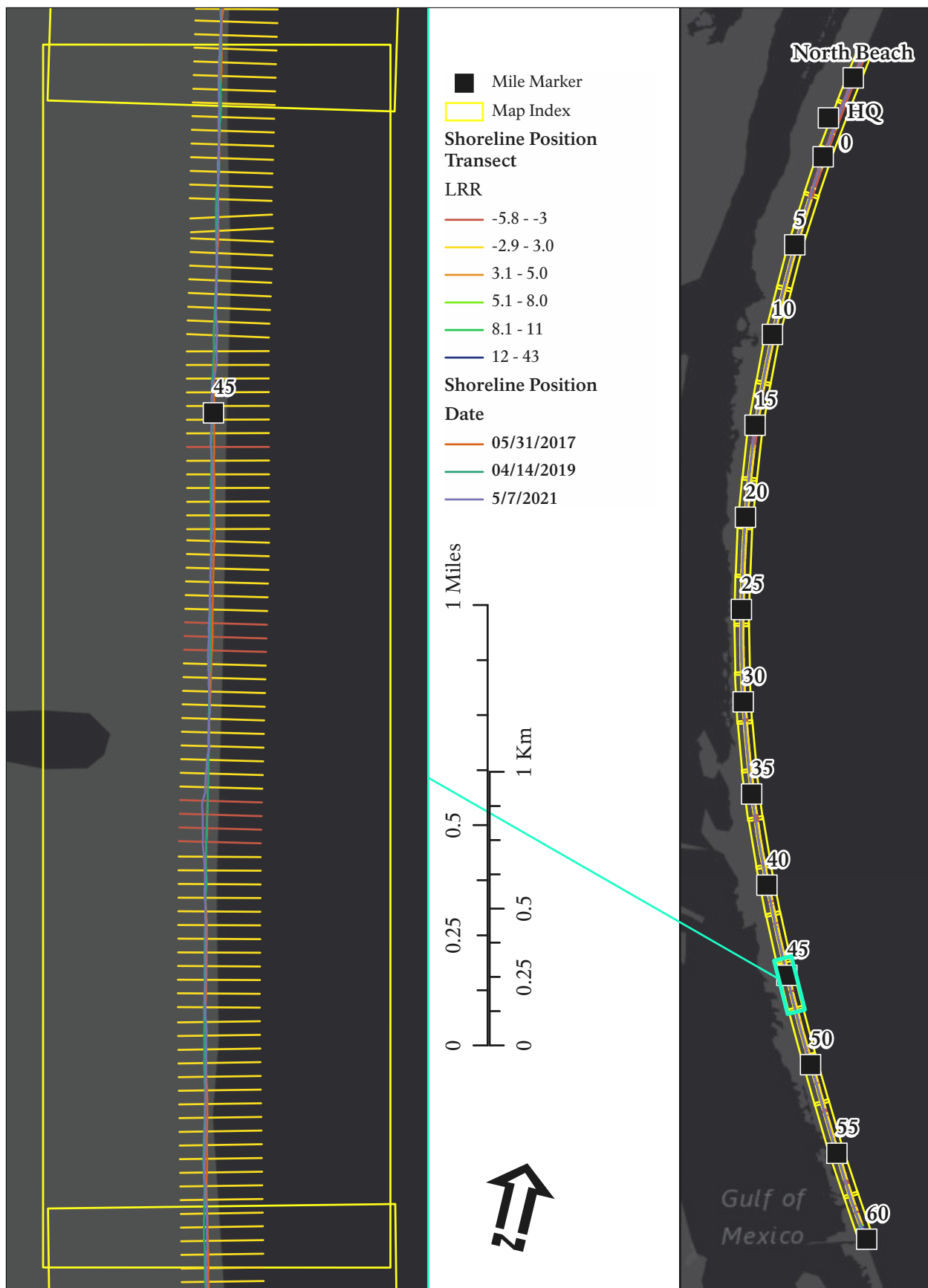


Figure B-20. Shoreline position change in meters per year. Mile Marker 44 through Mile Marker 47.

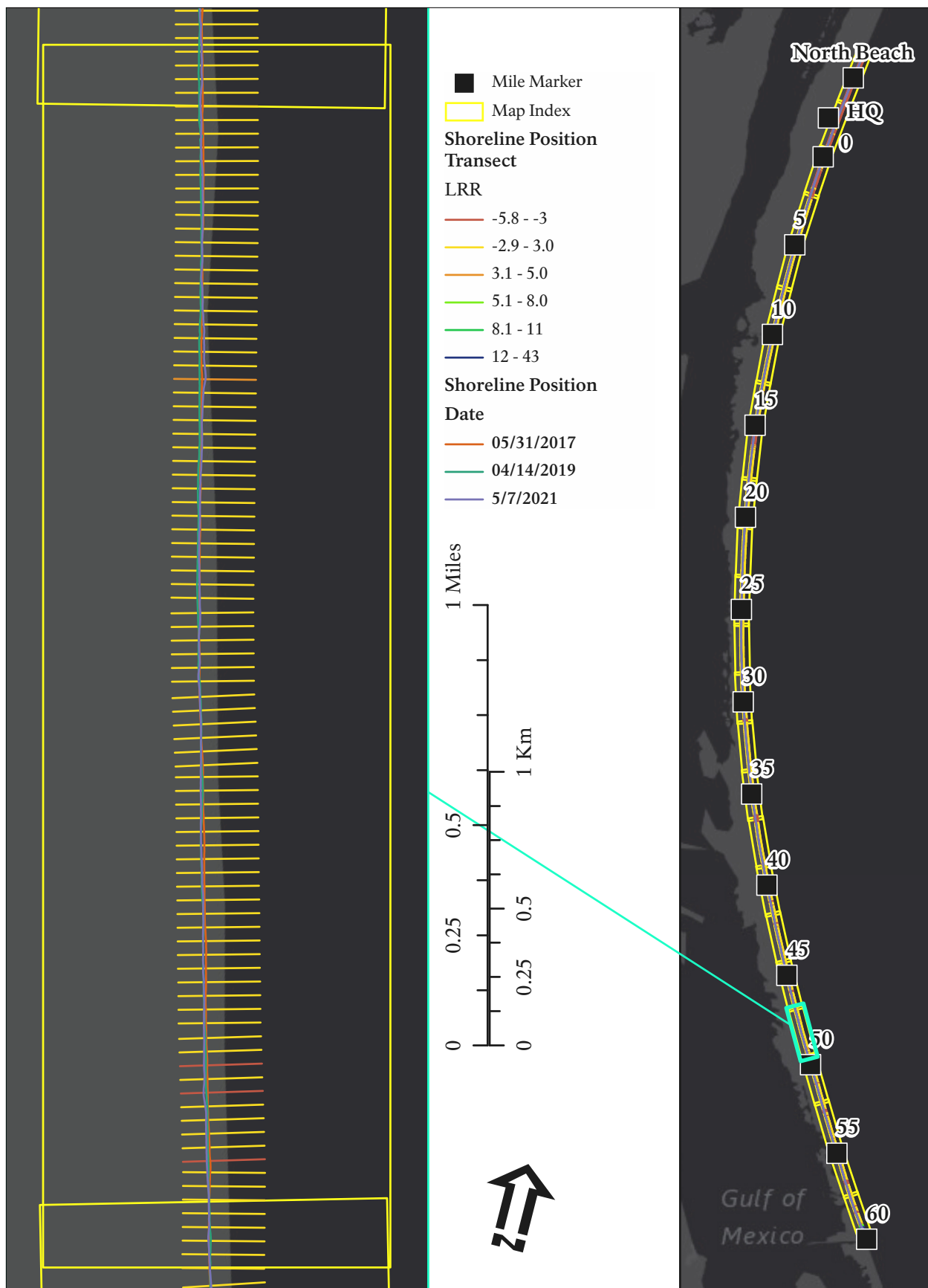


Figure B-21. Shoreline position change in meters per year. Mile Marker 47 through Mile Marker 49.

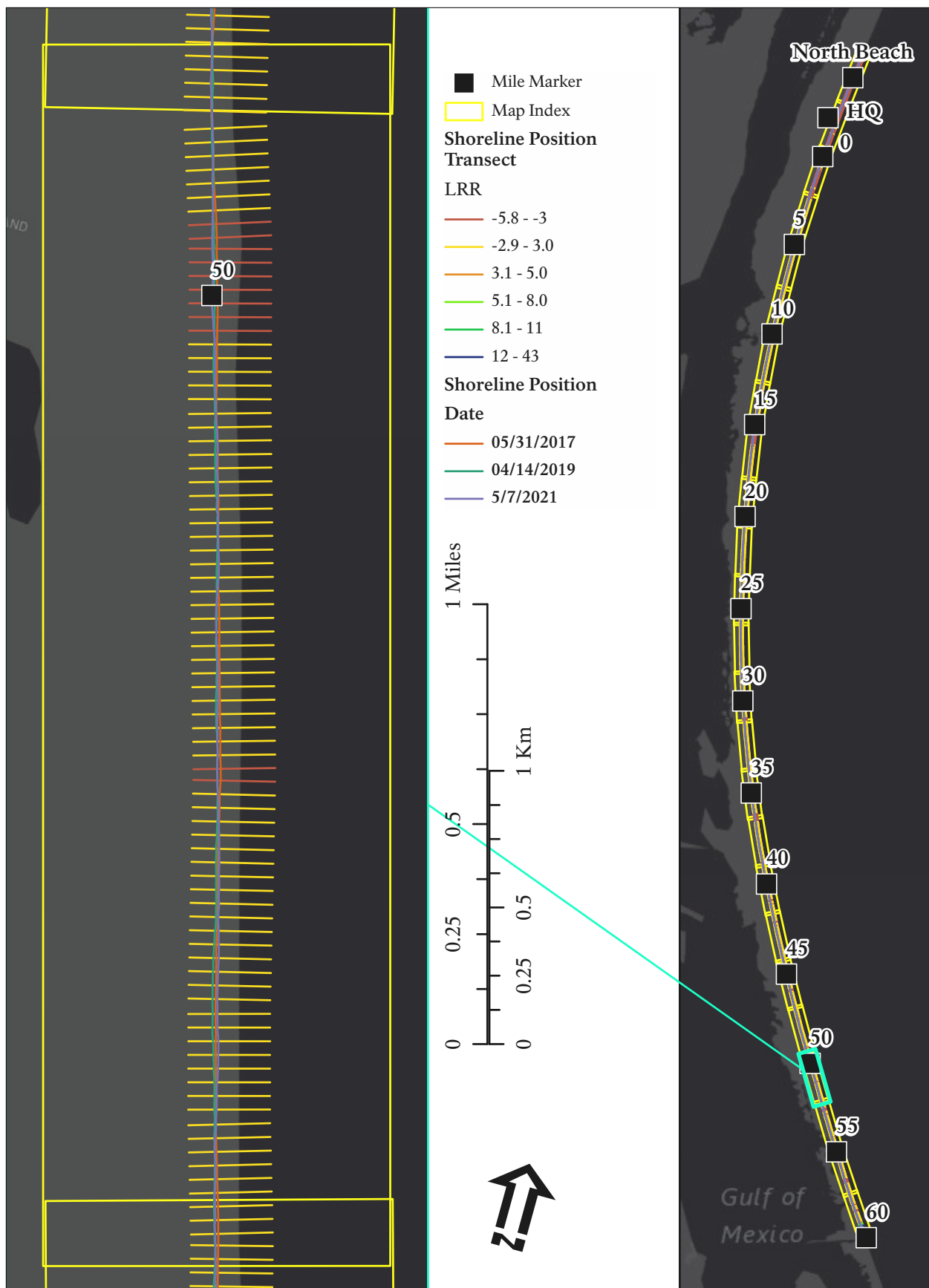


Figure B-22. Shoreline position change in meters per year. Mile Marker 49 through Mile Marker 52.

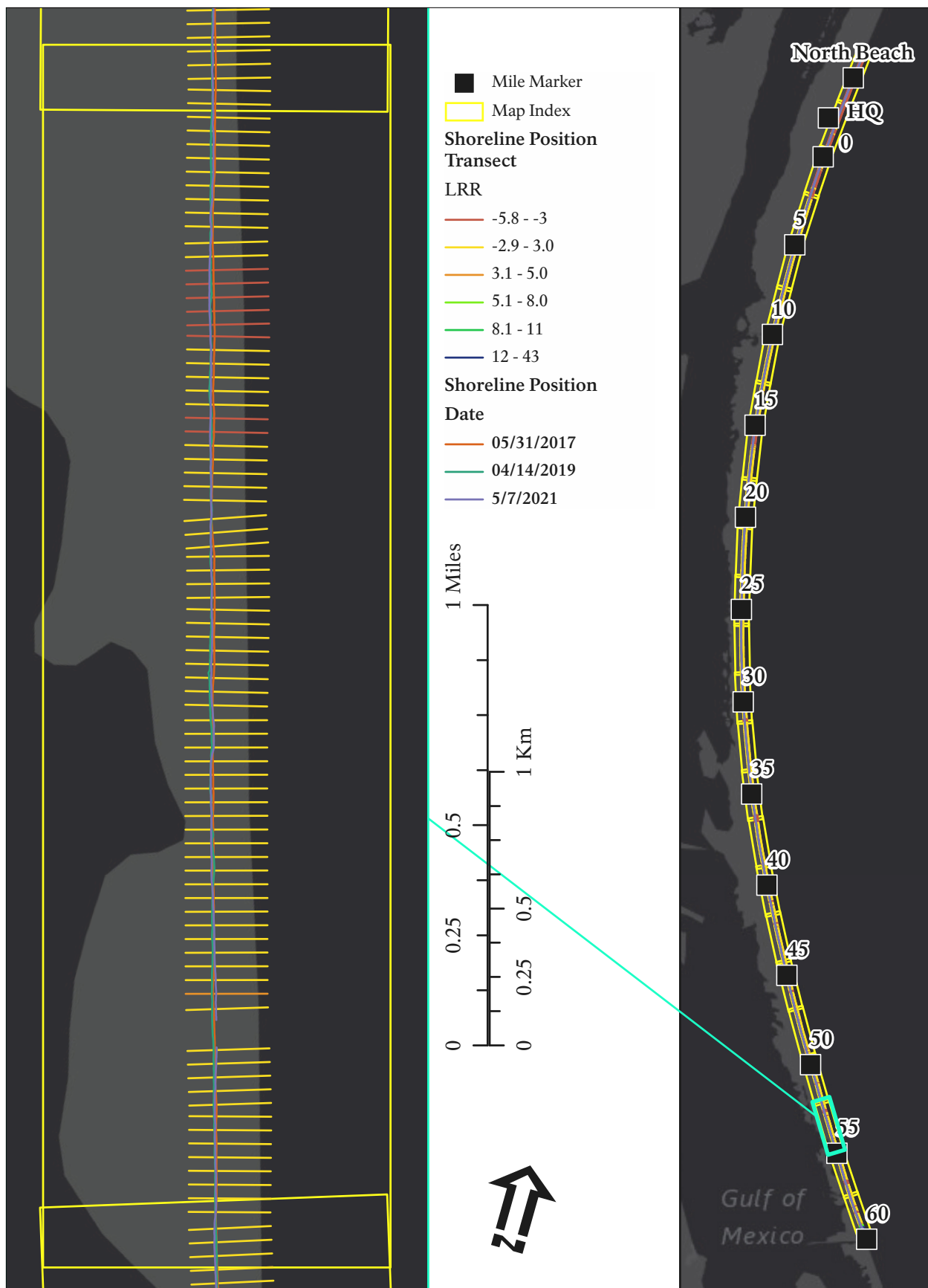


Figure B-23. Shoreline position change in meters per year. Mile Marker 52 through Mile Marker 55.

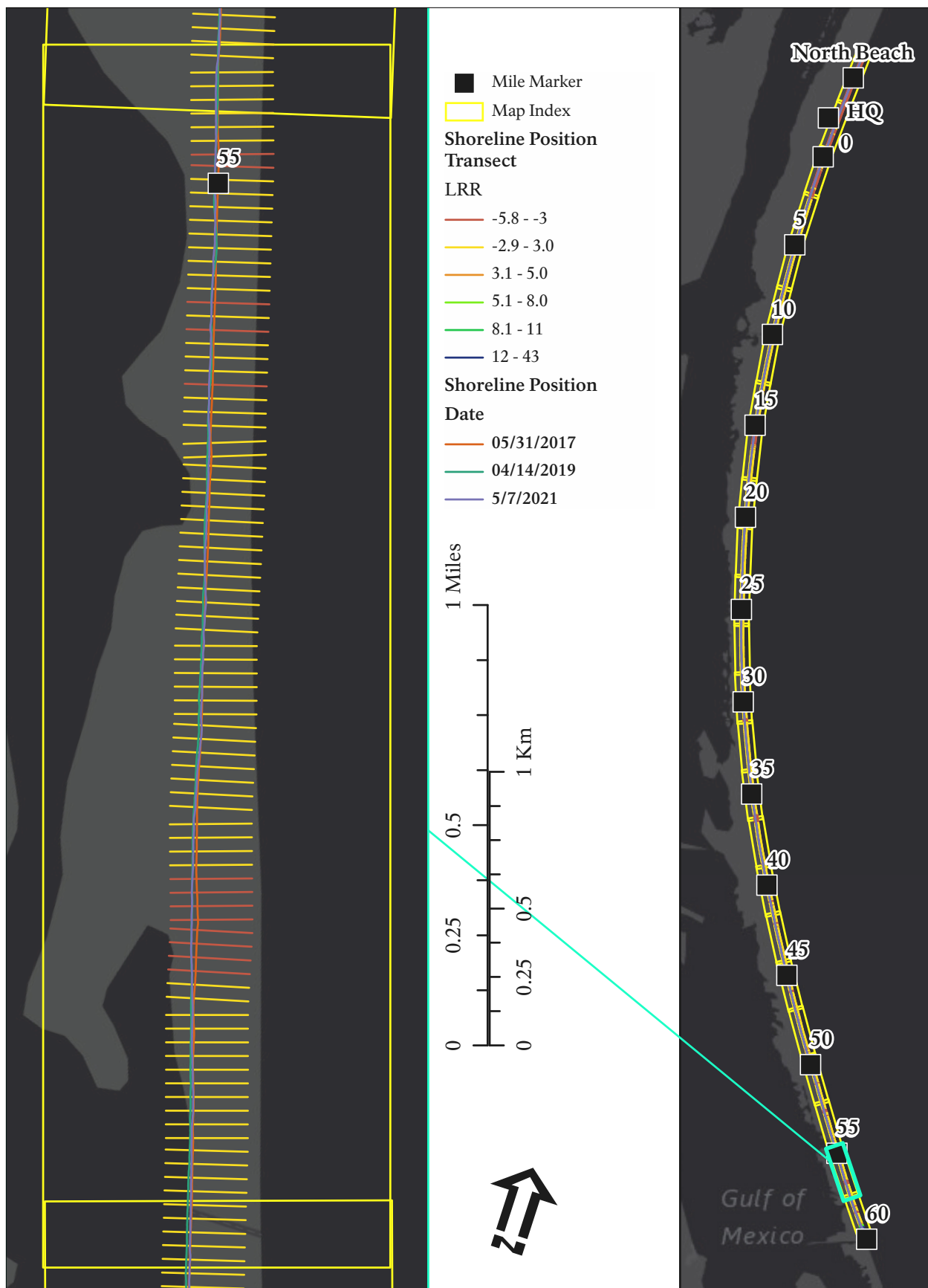


Figure B-24. Shoreline position change in meters per year. Mile Marker 55 through Mile Marker 57.

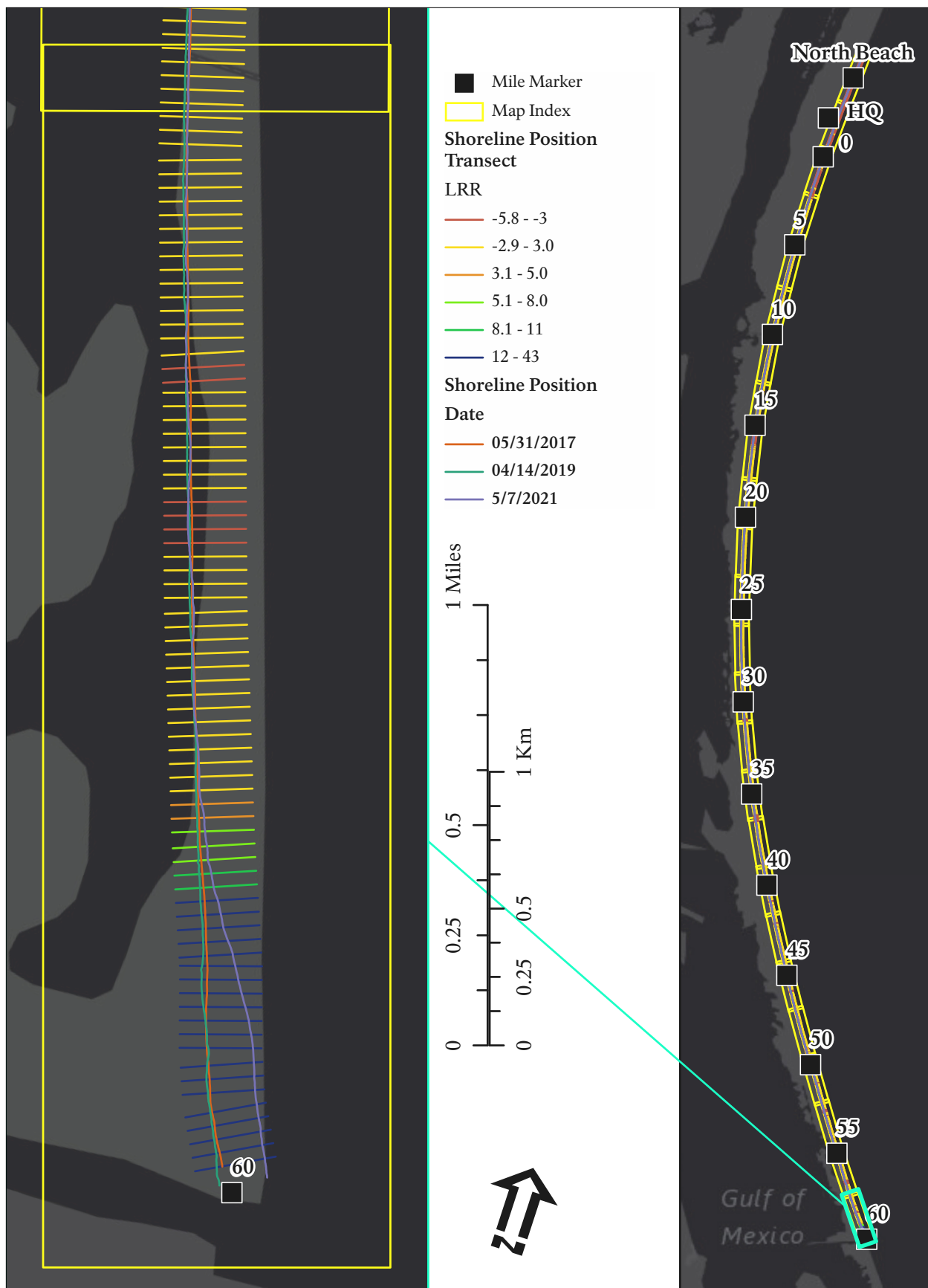


Figure B-25. Shoreline position change in meters per year. Mile Marker 57 through Mile Marker 60.

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.

National Park Service
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Natural Resource Stewardship and Science

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