



Shoreline Change at Fort Matanzas National Monument

2020–2021 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2022/1343



ON THE COVER

Photo taken of the beach at Fort Matanzas National Monument displaying the high tide line that was mapped during the spring 2021 data collection. The photo is facing north. NPS photo / SECN staff.

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Summary and Key Findings

In 2020 and 2021 the Southeast Coast Network (SECN) collected shoreline data at Fort Matanzas National Monument as a part of the NPS Vital Signs Monitoring Program. Monitoring was conducted following methods developed by the National Park Service Northeast Barrier Coast Network and consisted of mapping the high tide swash line using a global positioning system (GPS) unit in the spring of each year (Psuty et al. 2010). Shoreline change was calculated using the Digital Shoreline Analysis System (DSAS) developed by USGS (Theiler et al. 2008).

Key findings from this effort:

- A mean of 2,255.23 meters (7,399 feet [ft]) of shoreline were mapped from 2020 to 2021 with a mean horizontal precision of 10.73 centimeters (4.2 inches [in]) at Fort Matanzas National Monument from 2020 to 2021.
- In the annual shoreline change analysis, the mean shoreline distance change from spring 2020 to spring 2021 was -7.40 meters (-24.3 ft) with a standard deviation of 20.24 meters (66.40 ft). The shoreline change distance ranged from -124.73 to 35.59 meters (-409.1 to 116.7 ft). Two erosion areas and one accretion area were identified in the study area beyond the uncertainty of the data (± 10 meters [32.8 ft]).
- The annual shoreline change from 2020 to 2021 showed erosion on the east and west sides of A1A where the Matanzas Inlet is located.
- Overall, the most dynamic area of shoreline change within Fort Matanzas National Monument appeared to be on the east and west side of A1A, along the Matanzas River inlet.

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 geoindicator 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. Geomorphologic change is a basic concern because it also influences change in other natural resource areas of interest within the National Park Service such as estuarine and subsurface water quality, species and habitats of concern, recreational visitor use, and even resource extraction. 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 level, and (3) it will eventually result in the loss of static resources. The establishment of local long-term monitoring programs will enhance understanding of these effects.

To effectively monitor 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 GPS equipment. The

data collected is post-processed to attain higher accuracy data and analyzed using the Digital Shoreline Analysis System (DSAS) created by USGS (Theiler et al. 2008). This approach is modeled after the *Northeast Coastal Barrier Network Geomorphological Protocol: Part 1—Ocean Shoreline Position* (Psuty et al. 2010).

The monitoring objectives for which data are collected and analyzed as part of this effort are (Baron 2018a):

1. Determine inter-annual changes in mean high-water shoreline position (average and standard deviation of change in position at fixed transects, and cumulatively within management units).
2. Determine the magnitude, direction, and spatial distribution of observed shoreline change including the identification of areas of highly dynamic shorelines, and areas of accretion versus erosion.

This report provides a summary of shoreline monitoring data collected by the network to address these objectives at Fort Matanzas National Monument (FOMA) from 2020 through 2021 (Figure 1). Data used in this report are available at <https://irma.nps.gov/DataStore/Reference/Profile/2267045>.

Fort Matanzas National Monument Shoreline Study Area

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

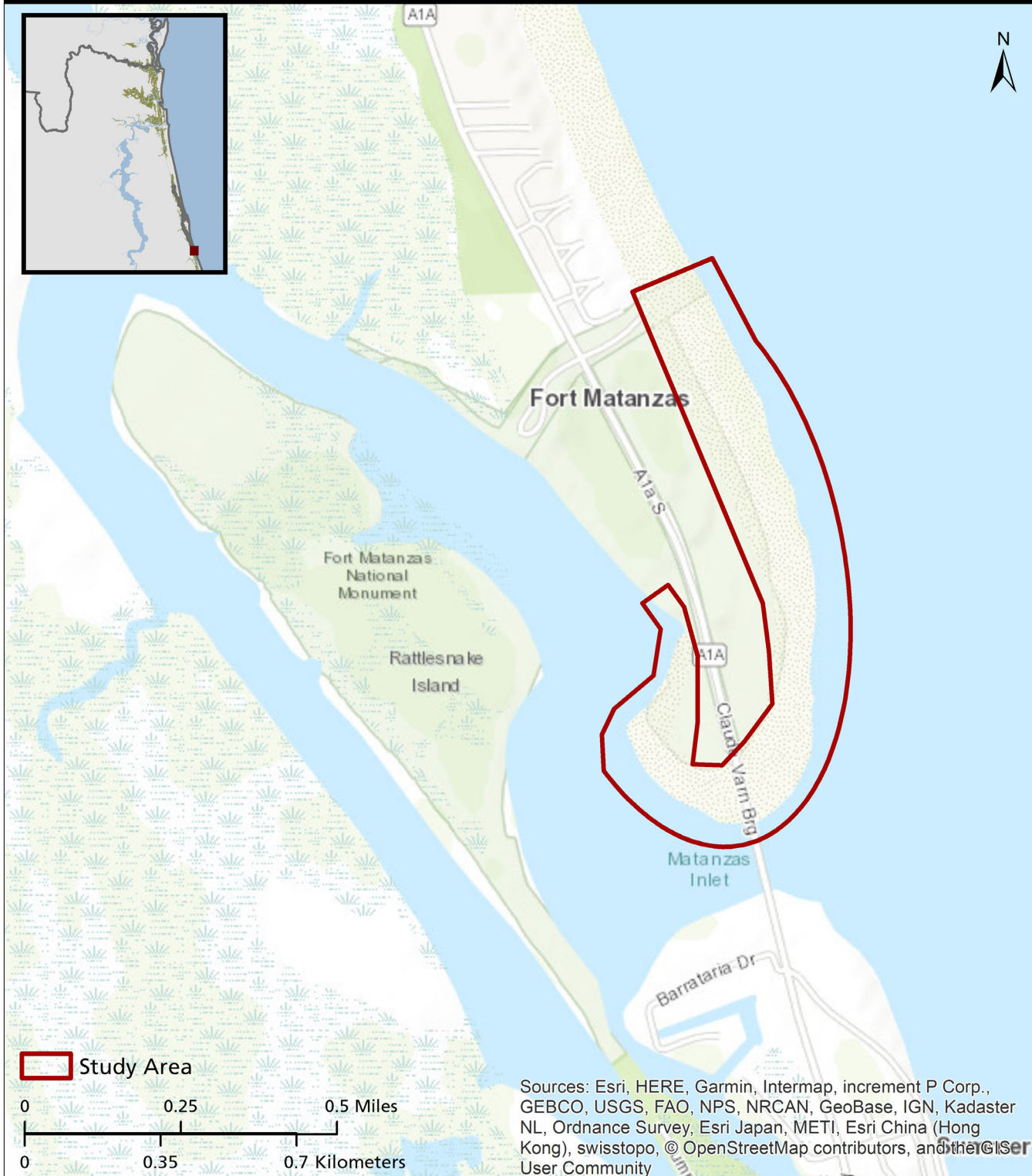


Figure 1. Map showing the location where long-term shoreline monitoring data is collected at Fort Matanzas National Monument, highlighted by the red polygon (study area). The area monitored includes the entire ocean shoreline of the monument and a portion of the shoreline along the Matanzas River.

Study Area

Fort Matanzas National Monument is located 22 kilometers (14 miles [mi]) south of St. Augustine on the northeast Atlantic coast of Florida, embedded within the boundaries of the Guana Tolomato Matanzas National Estuarine Reserve (GTMNERR). It encompasses a total of 298 acres (120.6 hectares [ha]) divided between the southern tip of Anastasia Island and the northern end of Rattlesnake Island. Both are barrier islands separated from the Florida mainland by the Matanzas River and the Intracoastal Waterway (DeVivo et. al. 2015).

The site's namesake, Fort Matanzas, is a historic structure, prominent to this area as it was integral in protecting the southern waterway access to St. Augustine during the colonial wars. The sediment along the banks of the historic Fort is continually changing based on the dynamics of shifting sediment along the ocean shoreline as well as the Matanzas Inlet spit. Also, the area is an important stopover spot for migratory and nesting birds as well as nesting sea

turtles. Mapping efforts have been focused on the ocean shoreline of the monument, which is a 1.3-kilometer (0.8-mi) long stretch of beach beginning at the northern boundary line and ending at Matanzas Inlet. The section of back barrier beach stretching from Matanzas Inlet to the pedestrian walkway along the Matanzas River was added to the study area at the request of the park. Documenting long-term trends in shoreline change will greatly benefit future wildlife and cultural management decisions for this site.

The purpose of this report is to deliver the most recently collected data from within the park as part of an ongoing long-term shoreline-change monitoring program.

Methods

Standard Operating Procedure

Table 1 lists the standard operating procedures (SOPs) utilized in the long-term 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 both 2020 and 2021 data sets.

The shoreline was mapped along the oceanfront sandy shoreline of Fort Matanzas National Monument following the methods developed by the National Park Service Northeast Coast Barrier Network (Psuty et al. 2010). The Digital Shoreline Analysis System (DSAS; Theiler et al. 2008) was used to analyze the shoreline change. Annual shoreline change distances were calculated by determining the distance between two shorelines. Two shoreline surveys are included in this report, including spring 2020 and spring 2021.

As stated in SOP 2.3.11 *Coastal Shoreline Monitoring Annual Change Analysis*—Version 1.0 (Baron 2021b), the uncertainty of the individual shoreline survey is ± 5 meters (16.4 ft). 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 an uncertainty of ± 10 meters (32.8 ft; 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 1.1 (Baron 2021c).

The high tide swash line is mapped using a Trimble® GPS unit. The data collected is post-processed according to SOP 2.3.10 *Post Survey GPS Data Processing*—Version 1.1 (Baron 2021d) using Pathfinder Office software to obtain higher accuracy data. 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.

Shoreline Change Analysis

The two shoreline surveys collected during the 2020–2021 time period were analyzed using DSAS. The annual shoreline change was performed by analyzing the spring 2020 and spring 2021 shoreline data.. The spring 2020 shoreline data was collected on March 19, 2020 and the spring 2021 shoreline data was collected on March 4, 2021. An annual analysis was performed using these two data sets. The analysis was performed by calculating the distance the high tide line moved between the two shorelines analyzed, along cross-shore transects spaced 10 meters (32.8 ft) apart. This analysis is termed "net shoreline movement" in DSAS.

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

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

SOP number	SOP title	SOP version
1.3.21	Survey timing and GPS mission planning	2.0
1.3.22	Conducting the GPS shoreline survey	1.1
2.3.10	Post survey GPS data processing	1.1
2.3.11	Coastal shoreline monitoring annual change analysis	1.0
2.3.09	Coastal shoreline monitoring annual reporting	1.1

Water Levels

The two shoreline surveys of the high tide swash line included in this report were conducted during neap tide windows. The survey window was chosen based on the predicted tides using the closest NOAA tide gage with predicted tides (Mayport Bar Pilot Dock, FL—Station ID: 8720218; NOAA 2021). The actual tide heights that occurred before the surveys included in this annual report are listed in Table 2. The high tides prior to the shoreline surveys conducted have similar water levels.

Protocol Changes

No changes have occurred to the protocol. The data collected for this report was collected using SOP 1.3.22 *Conducting the Shoreline Survey*—Version 1.1 (Baron 2021c).

Table 2. High tide levels surveyed during the spring FOMA shoreline monitoring (m—meters).

Season	Survey collection date	Previous high tide height* (m)	Previous high tide time
Spring 2020	3/19/2020	1.55	06:12
Spring 2021	3/4/2021	1.56	12:54

* Tide heights are relative to Mean Lower Low Water, Mayport Bar Pilot Dock, FL - Station ID: 8720218

Results

Shoreline Data

Two shoreline surveys were collected in in the 2020 and 2021 time period. On average, 2,255.23 meters (7,399 ft) of shoreline were mapped during the time period analyzed with a mean horizontal error of 10.73 centimeters (4.2 in; Table 3).

Annual Shoreline Change Analysis

Figure 2 displays a map of the shorelines collected in 2020 and 2021 and the annual shoreline change that occurred from spring 2020 to spring 2021. The annual shoreline change distance is displayed by the transects between the two shorelines, which are clipped to the extent of shoreline change and colored according to the shoreline change distance. The lowest shoreline change distance was -124.73 meters (-409.1 ft) and the highest shoreline change distance was 35.59 meters (116.7 ft; Appendix A). The mean shoreline distance change for the area mapped was -7.40 meters (-24.3 ft) with a standard deviation of 20.24 meters (66.40 ft).

One erosion area was present in the study area, represented as red, orange, and yellow transects in Figure 2. Erosion was identified for 27.45% of the transects (56 of 204) in the analysis (Figure 3). Because the transects are located every 10 meters (32.8 ft) along the baseline, it can be inferred that erosion occurred along a cumulative 560 meters (1,837.3 ft) of the study area surveyed.

One accretion area was present in the spring 2020 to spring 2021 shoreline survey analysis and is represented as green and blue transects in Figure 2. Accretion was identified for 5.39% of the transects (11 of 204) in the analysis (Figure 3). Because transects are located every 10 meters (32.8 ft) along the baseline, it can be inferred that accretion occurred along a cumulative 110 meters (360.9 ft) of the study area surveyed.

Data used in this report are available at <https://irma.nps.gov/DataStore/Reference/Profile/2267045>.

Table 3. Table listing the length and positional error of the shorelines collected during 2020 and 2021 with the mean length and horizontal precision calculated by averaging across the entire shoreline feature [cm—centimeters; m—meters].

Collection Date	Mean Horizontal Accuracy (cm)	Length (m)
3/19/2020	10.56	2,347.00
3/4/2021	10.90	2,163.47



Shoreline Data

Spring 2020 to Spring 2021

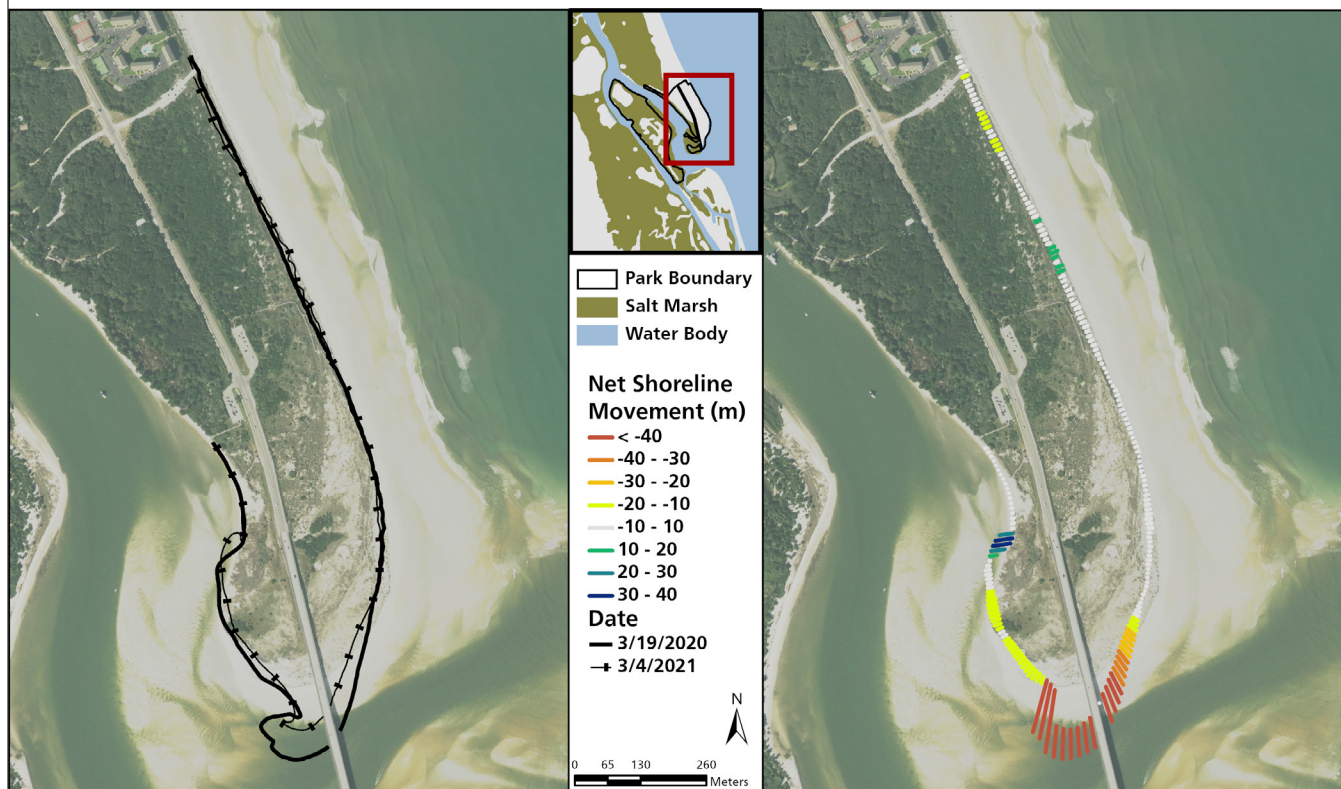


Figure 2. Map of the shoreline surveys collected from 2020 to 2021 and the spring 2020 to spring 2021 shoreline change at Fort Matanzas National Monument. The shoreline survey collected in spring 2020 is shown as a solid black line and the shoreline survey collected in spring 2021 is shown as a hatched line. The more negative shoreline change denotes more erosion and are shown in warmer colors (yellow, orange, and red). The positive shoreline change or accretion are displayed as cooler colors (greens and blues). The grey transects denote shoreline change distance within the uncertainty range of the data (± 10 meters [32.8 ft]).

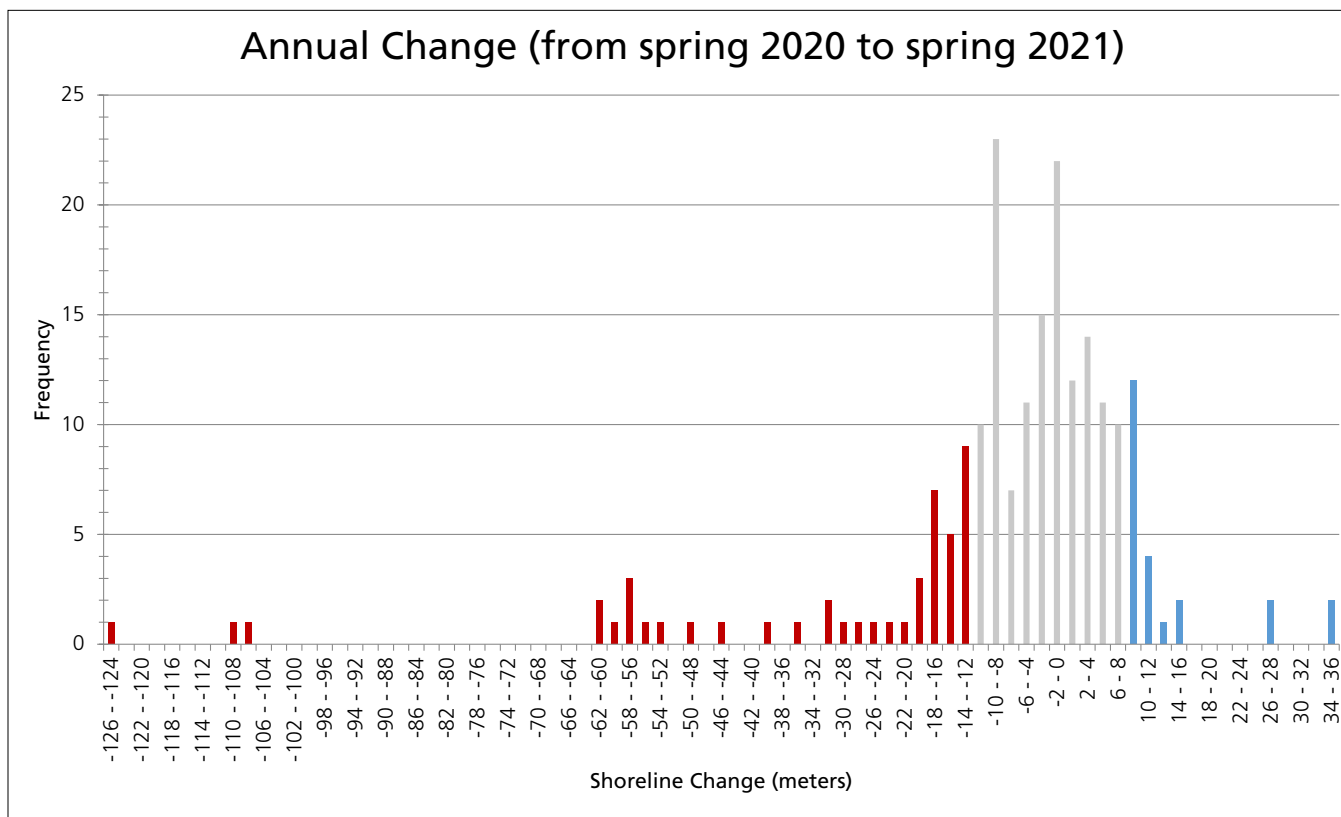


Figure 3. Histogram of transect shoreline change distance for spring 2020 to spring 2021. The shoreline change distance is binned by 2-meter (6.56 ft) increments. The value of the x-axis represents the bin range. The value on the y-axis represents the frequency. The accretion transects are shown in blue and the erosion transects are shown in red. The transects within the uncertainty range (± 10 meters [32.8 ft]) are displayed as grey.

Summary

The annual shoreline change from 2020 to 2021 determined erosion occurred on the east and west sides of A1A, along the Matanzas Inlet. Some accretion occurred on the west side of A1A along the Matanzas River, just north of where the erosion occurred. The shoreline change along the oceanfront beach within the park, east of A1A, was mostly within the uncertainty range of the data, with some occurrences of erosion and accretion.

The most dynamic area of shoreline change is evident in the annual analysis, which appears to be on the east and west side of A1A, along the Matanzas River Inlet.



Photo taken of the beach at Fort Matanzas National Monument displaying the high tide line that was mapped during the spring 2021 data collection. The photo is facing south. NPS photo / SECN staff.

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Appendix A. Transect End Point Rates

Table A-1. Table of the shoreline change distances (net shoreline movement), in meters, for the study area analyzed. Negative net shoreline movement denotes erosion and positive net shoreline movement denotes accretion.

Transect ID	Spring 2020 to Spring 2021	Transect ID	Spring 2020 to Spring 2021
9	-6.64	51	11.92
10	-5.30	52	15.21
11	-7.32	53	10.16
12	0.00	54	7.43
13	-12.27	55	12.28
14	-8.43	56	11.80
15	-8.01	57	7.58
16	-8.14	58	5.43
17	-8.38	59	4.61
18	-7.96	60	8.59
19	-8.98	61	8.18
20	-9.67	62	4.46
21	-10.56	63	9.31
22	-11.51	64	8.96
23	-12.05	65	7.59
24	-10.53	66	8.02
25	-8.78	67	8.71
26	-9.50	68	8.74
27	-11.02	69	6.25
28	-10.98	70	5.96
29	-10.10	71	6.43
30	-8.01	72	6.17
31	-6.37	73	4.64
32	-3.40	74	5.65
33	-1.51	75	3.15
34	-2.74	76	2.49
35	-1.35	77	0.81
36	0.08	78	1.62
37	1.32	79	0.58
38	2.48	80	0.30
39	3.44	81	0.67
40	3.32	82	3.91
41	6.16	83	4.21
42	8.95	84	2.97
43	8.16	85	4.62
44	9.21	86	5.70
45	10.51	87	3.76
46	7.84	88	3.17
47	8.54	89	3.76
48	9.14	90	3.82
49	6.46	91	3.12
50	7.72	92	1.44

Transect ID	Spring 2020 to Spring 2021
93	3.69
94	4.85
95	4.30
96	0.27
97	-1.44
98	-2.46
99	-2.29
100	-4.13
101	-3.43
102	-3.64
103	-2.26
104	-6.03
105	-8.08
106	-7.85
107	-8.38
108	-9.35
109	-9.39
110	-9.02
111	-8.41
112	-5.01
113	-4.88
114	-3.47
115	-4.63
116	-3.19
117	-3.49
118	-5.71
119	-4.28
120	-1.00
121	-1.02
122	-0.14
123	0.92
124	2.96
125	0.04
126	-2.28
127	-0.75
128	-2.50
129	-5.12
130	-7.56
131	-9.64
132	-13.31
133	-15.56
134	-18.81
135	-20.47
136	-23.19
137	-24.95
138	-27.03
139	-28.68

Transect ID	Spring 2020 to Spring 2021
140	-30.18
141	-31.43
142	-35.26
143	-39.63
144	-45.59
145	-49.57
146	-52.06
147	-57.90
148	0.00
150	-59.72
151	-57.21
152	-55.25
153	-57.37
154	-60.66
155	-61.37
156	-124.73
157	-109.49
158	-106.29
159	-13.99
160	-16.77
161	-18.80
162	-19.33
163	-16.98
164	-16.12
165	-15.39
166	-14.95
167	-14.96
168	-13.78
169	-13.69
170	-13.37
171	-10.91
172	-8.88
173	-8.10
174	-10.62
175	-12.70
176	-15.64
177	-17.30
178	-17.10
179	-17.26
180	-17.21
181	-11.25
182	-13.11
183	-10.52
184	-8.76
185	-8.31
186	-9.44
187	-9.95

Transect ID	Spring 2020 to Spring 2021
188	-9.03
189	-5.54
190	1.94
191	14.36
192	27.95
193	35.59
194	34.13
195	26.52
196	-3.09
197	-4.79
198	-4.55
199	-2.77
200	-2.77
201	-1.72
202	-1.24
203	-1.11
204	-0.77
205	-0.75
206	-0.71
207	-0.52
208	-0.47
209	-0.21
210	-0.31
211	-0.92
212	-1.21
213	-1.32

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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