



Shoreline Change at Fort Matanzas National Monument

2018–2019 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2019/1240



ON THE COVER

Picture taken of the Fort Matanzas beach displaying the high tide line that was mapped during the spring 2019 data collection. The picture is facing south. NPS photo / SECN.

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Natural Resource Data Series NPS/SECN/NRDS—2019/1240

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October 2019

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

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Please cite this publication as:

Baron, L. C. 2019. Shoreline change at Fort Matanzas National Monument: 2018–2019 data summary. Natural Resource Data Series NPS/SECN/NRDS—2019/1240. National Park Service, Fort Collins, Colorado.

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Acknowledgments

This report was completed with the assistance of Kelsey Mack (SECN Coastal Monitoring Intern) and previous work performed by Jason Gardner (previous Coastal Monitoring Technician). Thank you for your assistance and efforts that facilitated the creation of this report.

Summary and Key Findings

In 2018 and 2019 the Southeast Coast Network 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 are as follows

- A mean of 2,226.23 meters (m; 1.38 miles [mi]) of shoreline were mapped from 2018 to 2019 with a mean horizontal precision of 10.63 centimeters (4.19 inches [in]).
- The mean shoreline distance change from 2018 to 2019 was -0.94 meters (-3.08 feet [ft]) with a standard deviation of 21.95 meters (72.01 ft). The shoreline change distance ranged from -51.29 meters to 67.53 meters (-168.28 to 221.56 ft).
- Three high erosion areas were identified in the study area. 21% of the transects were located in areas of erosion beyond the uncertainty range of the data (± 10 meters [32.81 ft]), which equates to 430 meters (1,410.76 ft) of the surveyed shoreline distance.
- Three accretion areas were present in the 2018 to 2019 shoreline survey analysis beyond the uncertainty range of the data (± 10 meters [32.81 ft]).

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 2018 through 2019 (Figure 1). Data used in this report are available at <https://irma.nps.gov/DataStore/Reference/Profile/2267045>.



Photo taken during the 2018 spring shoreline data collection at the beginning of the survey. You can see the beach access ramp and the sign which are also shown on the cover picture. Notice how much higher the tide was in 2019 compared to 2018.

NPS photo / SECN

Fort Matanzas National Monument Shoreline Study Area

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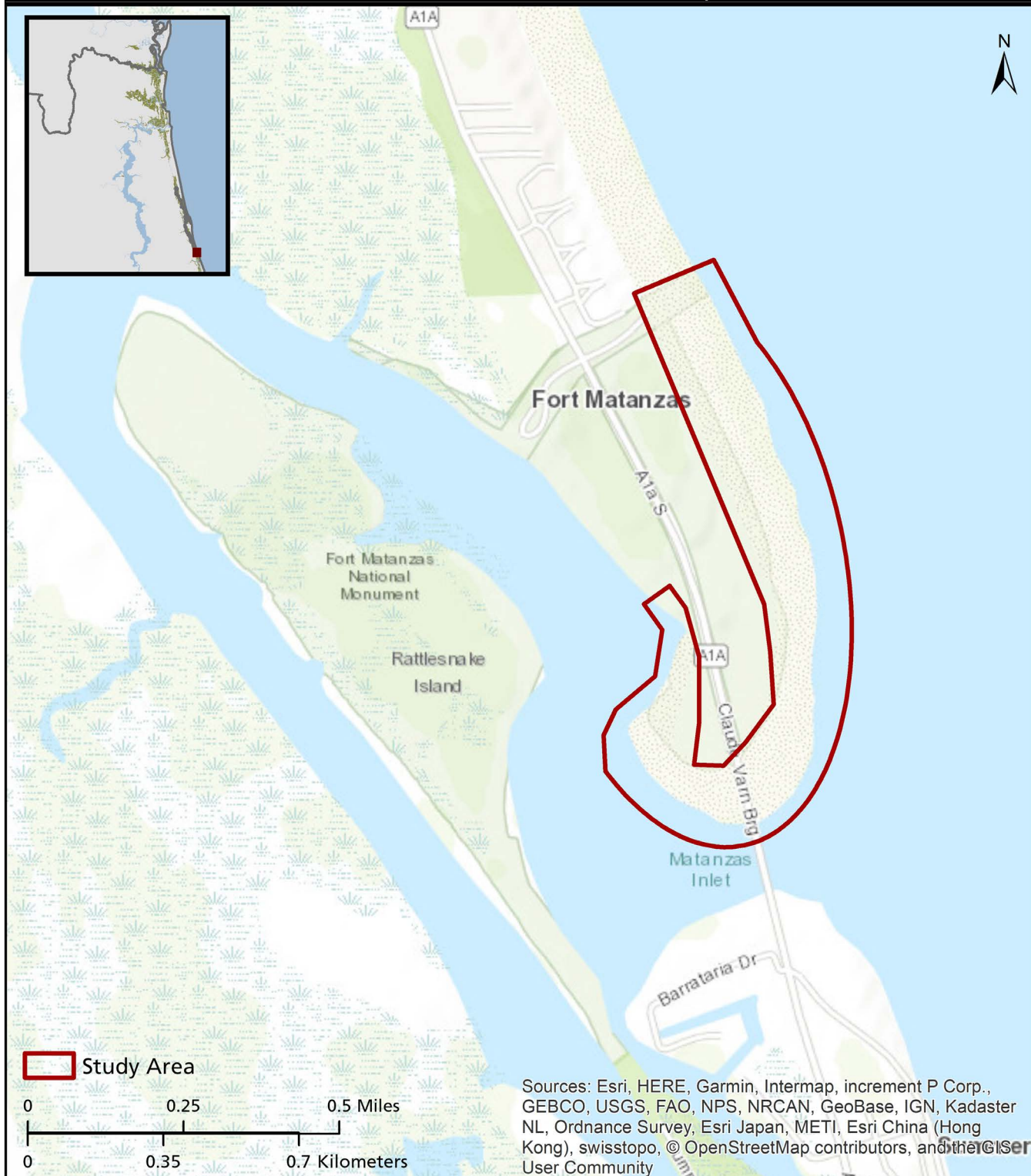


Figure 1. Map showing the location where long-term shoreline monitoring data is collected at Fort Matanzas NM, highlighted by the red polygon (study area). The area monitored includes the entire ocean shoreline of the monument and a portion of the shoreline along the Matanzas River.

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 an 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.



Photo at the end of the 2018 spring shoreline data collection, on the Matanzas River, facing south. NPS photo / SECN.

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 2018 and 2019 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. Shoreline surveys were collected in 2018 and 2019; therefore, the shoreline change that occurred between those two time periods is analyzed in this report (Figure 2).

As stated in SOP 2.3.11 *Coastal shoreline monitoring annual change analysis—Version 1.0* (Baron 2018b), 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 1.0* (Baron 2018c). 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 1.0* (Baron 2018d) 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 shorelines were analyzed using DSAS. The annual shoreline change was performed by analyzing the 2018 and 2019 shoreline data collected. The 2018 shoreline was collected on 25 March 2018 and the 2019 shoreline was collected on 8 April 2019. The two shorelines were analyzed by calculating the distance the high tide line has moved from 2018 to 2019, along cross-shore transects spaced 10 meters (32.8 ft) apart. This analysis is termed "net shoreline movement" in DSAS.

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

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	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

Water Levels

Two shoreline surveys of the high tide swash line included in this report were conducted during neap tides. The survey window was chosen based on the predicted tides using the closest NOAA tide gage with predicted tides (Trident Pier,

Florida—Station ID 8721604; NOAA 2018). The actual tide heights that occurred before the surveys included in this annual report are listed in Table 2. The two previous high tides prior to the shoreline surveys conducted have similar water levels.

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 2018	3/25/2018	1.22	0242
Spring 2019	4/8/2019	1.11	1113

* Tide heights are relative to Mean Lower Low Water, Trident Pier, FL - Station ID: 8721604

Fort Matanzas National Monument Long-Term Shoreline Monitoring

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Figure 2. Map of the shoreline surveys collected from 2018 to 2019 at Fort Matanzas NM. The shoreline survey collected in 2018 is shown as a solid black line and the shoreline survey collected in 2019 is shown as a dotted black line (base layer from NAIP 2015).

Results

Shoreline Data

On average, 2,226.23 meters (1.38 mi) of shoreline were mapped during the time period analyzed with a mean horizontal error of 10.63 centimeters (4.19 in; Table 3).

Annual Shoreline Change Analysis

Figure 3 displays a map of the spring shorelines collected in 2018 and 2019. 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. A negative shoreline change distance denotes erosion, shown in warmer colors. Positive shoreline change distances are depicting accretion, and are shown in cooler colors (if present). The most negative (indicating shoreline retreat) shoreline change distance was -51.29 meters (-168.27 ft) and the most positive (indicating shoreline advance or accretion) shoreline change

distance was 67.53 meters (221.56 ft; Appendix A). The mean shoreline distance change for the area mapped was -0.94 meters (-3.08 ft) with a standard deviation of 21.95 meters (72.01 ft).

Three high erosion areas were present in the study area, represented as red and yellow transects in Figure 3. Erosion was identified for 21 % of the transects (43 of 204) in the analysis (Figure 4). Because the transects are located every 10 meters (32.8 ft) along the baseline, it can be inferred that high erosion occurred along a cumulative 430 meters (1,410 ft) of the study area surveyed. Two accretion areas were present in the 2018 to 2019 shoreline survey analysis.

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 2018 and 2019 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)
3/25/2018	11.26	2,305.22
4/8/2019	10.00	2,147.23

Fort Matanzas National Monument Long-Term Shoreline Monitoring

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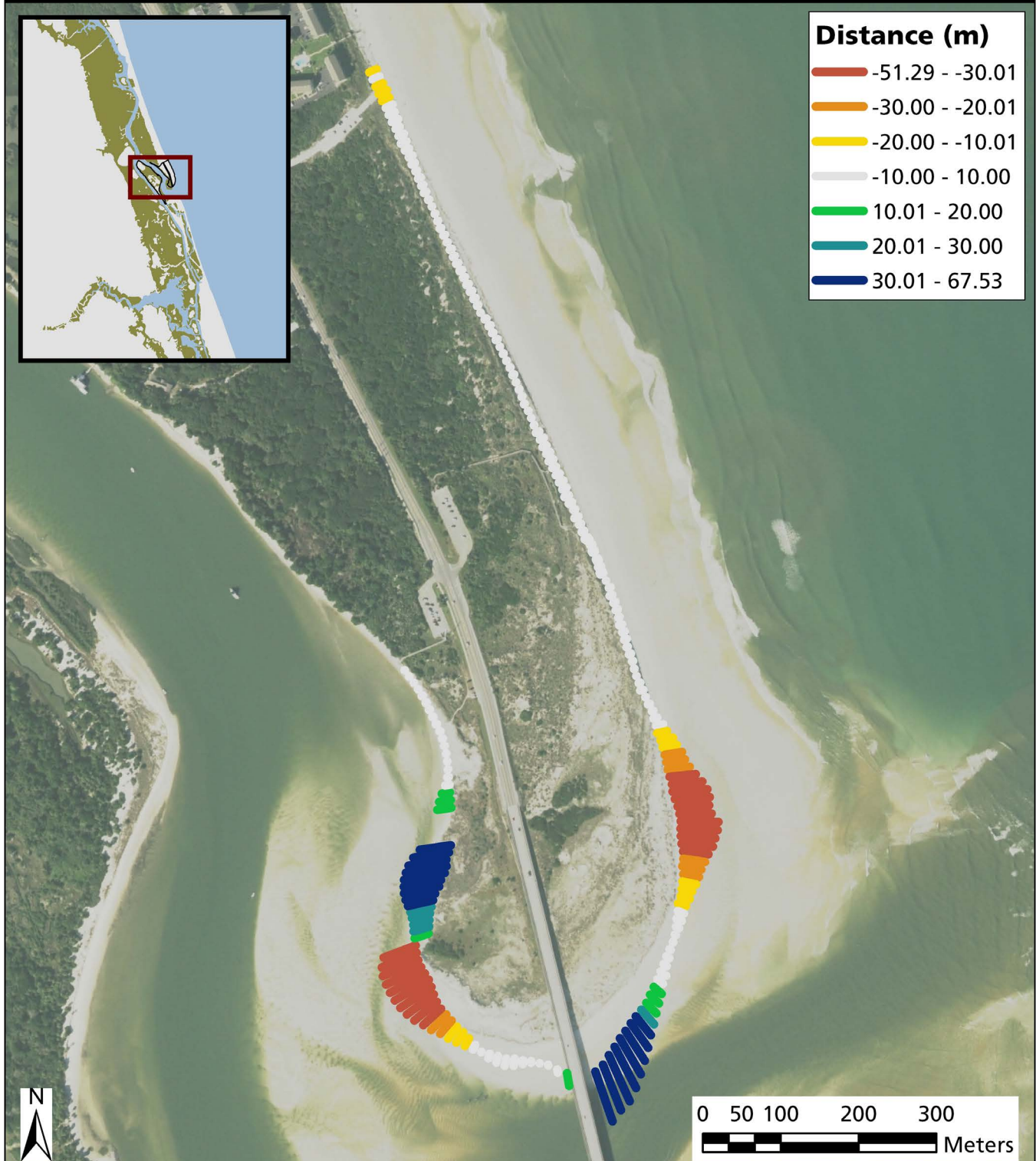


Figure 3. Map of shoreline change distance (meters) for the 2018 and 2019 surveys at Fort Matanzas NM. The more negative shoreline change denotes more erosion and is shown in warmer colors. The less negative shoreline change denote less erosion and in some cases can represent accretion (when positive) and is displayed as cooler colors. The grey transects denote shoreline change distance within the uncertainty range of the data (± 10 meters [32.8 ft]). Base layer from NAIP 2015.

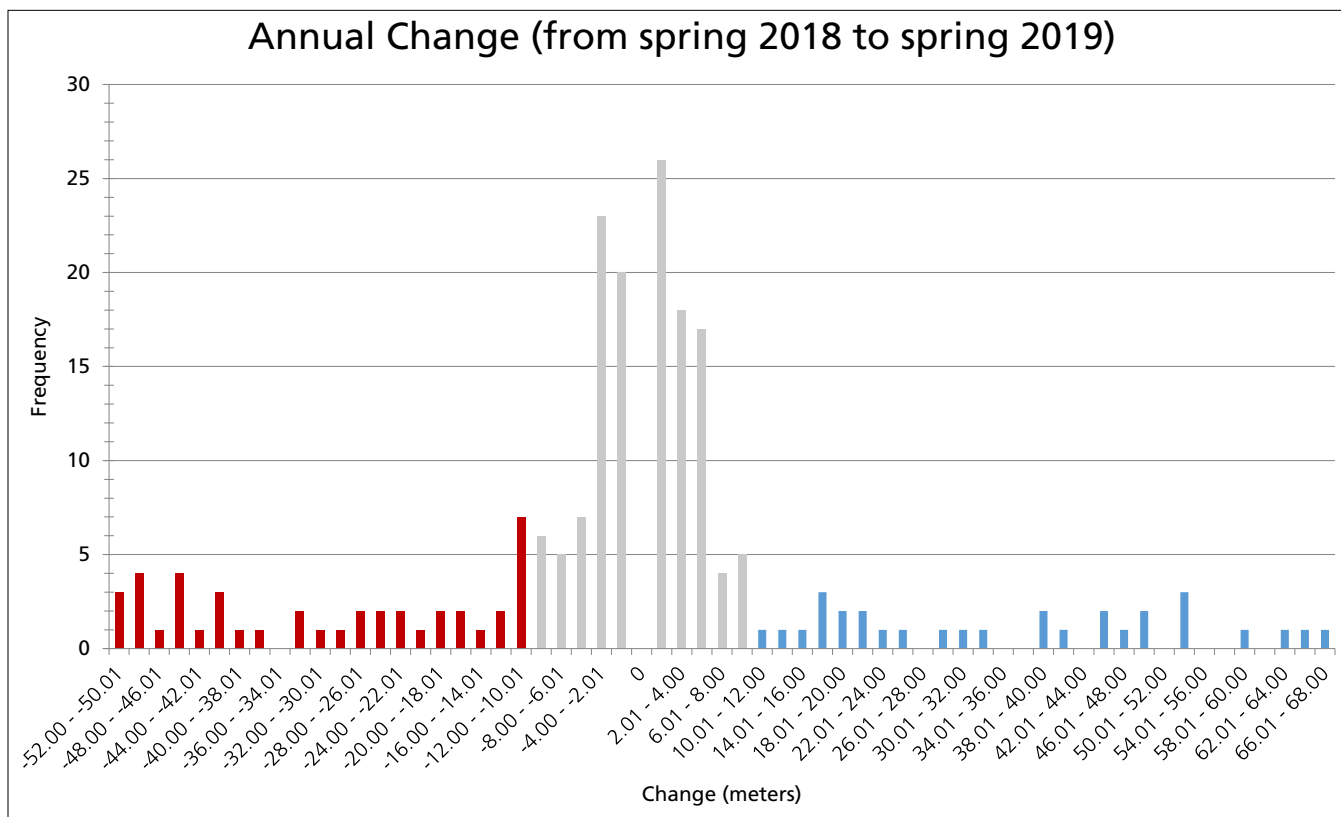


Figure 4. Histogram of transect shoreline change distances. The shoreline change distance is binned by 2-meter intervals. The bars are colored red denoting high erosion, grey for transects within the uncertainty range of ± 10 meters, and blue for transects where high accretion was calculated.

Literature Cited

- Baron, L. C. 2018a. Monitoring coastal shoreline change in Southeast Coast Network parks: Protocol implementation plan. Natural Resource Report NPS/SECN/NRR—2018/1744. National Park Service, Fort Collins, Colorado. Available at <https://irma.nps.gov/DataStore/Reference/Profile/2256509> (last accessed August 2019).
- Baron, L. C. 2018b. Coastal shoreline monitoring annual change analysis—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.3.11. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2253897> (last accessed August 2019).
- Baron, L. C. 2018c. Conducting the GPS Shoreline Survey—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—1.3.22. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2253893> (last accessed August 2019).
- Baron, L. C. 2018d. Post survey GPS data processing—Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.3.10. Southeast Coast Network, Athens, Georgia. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2253896> (last accessed September 2019).
- DeVivo, J. C., J. Asper, S. Eastman, N. M. Rankin, A. C. Curtis, C. J. Wright, E. Thompson, and M. W. Byrne. 2015. Protocol for monitoring coastal salt marsh elevation and vegetation communities in Southeast Coast Network parks. Natural Resource Report NPS/SECN/NRR—2015/985. National Park Service, Fort Collins, Colorado. Available at <https://irma.nps.gov/DataStore/Reference/Profile/2222936> (last accessed August 2019).
- National Agricultural Imagery Program (NAIP). 2015. Imagery - NAIP 2015 1 meter (USDA). Available at: <https://www.arcgis.com/home/item.html?id=843f883ed6c5453ebdb346a6bfc3a2d4> (last accessed August 2019).
- National Oceanic and Atmospheric Administration (NOAA). 2018. The Center for Operational Oceanographic Products and Services. Available at: tidesandcurrents.noaa.gov (last accessed August 2019).
- Psuty, N. P., T. M. Silveira, M. Duffy, J. P. Pace, and D. E. Skidds. 2010. Northeast Coastal and Barrier Network geomorphological monitoring protocol: Part I—ocean shoreline position. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/664308> (last accessed August 2019).
- Thieler, E. R., E. A. Himmelstoss, J. L. Zichichi, and A. Ergul. 2008. The digital shoreline analysis system (DSAS) version 4.0—an ArcGIS extension for calculating shoreline change. Open-File Report 2008-1278. U.S. Geological Survey. Available at: <https://cmgds.marine.usgs.gov/publications/DSAS/of2008-1278/> (last accessed August 2019).

Appendix A. Shoreline Change Distances

Table A-1. Table of the shoreline change distances for the study area analyzed. Only the transects that intersected both shorelines are included in the table.

Transect Number	Spring '18–Spring '19 Shoreline Change Distance (meters)	Transect Number	Spring '18–Spring '19 Shoreline Change Distance (meters)
9	-10.02	51	0.83
10	-9.45	52	2.72
11	-10.67	53	-0.44
12	-11.38	54	1.11
13	-10.08	55	0.95
14	-9.61	56	-0.92
15	-8.41	57	-0.61
16	-9.28	58	-0.52
17	-6.08	59	0.96
18	-7.94	60	4.63
19	-7.79	61	5.89
20	-5.94	62	5.50
21	-5.48	63	5.54
22	-4.59	64	6.78
23	-2.38	65	5.34
24	-3.74	66	5.34
25	-3.30	67	6.06
26	-3.33	68	5.59
27	-1.41	69	6.12
28	0.46	70	5.03
29	-0.80	71	2.48
30	-1.26	72	5.58
31	-2.14	73	3.00
32	-2.42	74	3.85
33	-1.25	75	5.19
34	-2.82	76	3.13
35	-2.67	77	3.62
36	-2.94	78	3.25
37	-3.37	79	3.79
38	-2.62	80	4.07
39	-3.29	81	0.02
40	-3.15	82	2.60
41	-3.47	83	3.40
42	-2.09	84	3.25
43	-0.23	85	3.13
44	-2.58	86	2.28
45	-2.96	87	4.15
46	1.63	88	3.22
47	-2.55	89	3.71
48	0.41	90	2.08
49	0.95	91	3.02
50	0.61	92	1.21

Transect Number	Spring '18–Spring '19 Shoreline Change Distance (meters)
93	0.70
94	-0.14
95	-2.27
96	-4.05
97	-1.00
98	-2.38
99	-1.91
100	-5.19
101	-9.10
102	-12.85
103	-16.26
104	-18.22
105	-22.24
106	-24.19
107	-28.16
108	-33.55
109	-39.01
110	-44.93
111	-44.95
112	-40.55
113	-41.38
114	-48.63
115	-47.79
116	-44.61
117	-40.46
118	-32.82
119	-27.86
120	-24.55
121	-20.37
122	-17.64
123	-13.79
124	-11.97
125	-10.70
126	-8.38
127	-7.30
128	-4.55
129	-1.61
130	-0.67
131	1.63
132	4.52
133	5.04
134	8.48
135	9.27
136	13.5
137	16.05
138	18.87

Transect Number	Spring '18–Spring '19 Shoreline Change Distance (meters)
139	24.52
140	31.01
141	38.60
142	45.76
143	53.45
144	59.78
145	64.76
146	62.85
147	67.53
150	16.40
151	4.41
152	-1.12
153	-0.30
154	2.51
155	5.11
156	9.39
157	9.51
158	8.86
159	6.63
160	-0.62
161	-6.46
162	-11.40
163	-15.82
164	-18.99
165	-22.37
166	-27.93
167	-30.99
168	-37.41
169	-43.06
170	-48.24
171	-51.12
172	-51.29
173	-50.65
174	-49.67
175	-48.52
176	-44.13
177	18.81
178	20.68
179	21.68
180	23.90
181	28.22
182	32.83
183	38.91
184	45.80
185	48.75
186	52.93

Transect Number	Spring '18–Spring '19 Shoreline Change Distance (meters)
187	52.96
188	49.11
189	46.54
190	40.02
195	17.99
196	14.99
197	10.80
198	5.77
199	1.93
200	0.34
201	-0.21
202	0.50
203	0.79
204	1.06
205	1.44
206	1.59
207	1.38
208	1.45
209	1.57
210	1.34
211	0.30
212	-0.29
213	-0.35
214	0.03
215	-4.35
216	-2.81
217	-3.70
218	-3.93

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