



Back Barrier Erosion Monitoring at Cumberland Island National Seashore

2019 Survey Report

Natural Resource Report NPS/SECN/NRR—2020/2180



ON THE COVER

Island margin looking south at Raccoon Key on Cumberland Island National Seashore. Photograph by J. M. Bateman McDonald, 2017.

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Jacob M. Bateman McDonald^{1,2}

¹University of North Georgia
Lewis F. Rogers Institute for Environmental and Spatial Analysis
Watkins Building, Room 176
3820 Mundy Mill Road
Oakwood, GA 30566

²National Park Service
Southeast Coast Inventory and Monitoring Network
135 Phoenix Road
Athens, GA 30605

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Summary and Key Findings

This report provides the results of a technical assistance project implemented at Cumberland Island National Seashore (CUIS) to monitor island margin retreat in selected areas on the back barrier (west) side of the island. On May 22 and 23, 2019, the Southeast Coast Network (SECN) conducted an island margin survey of five sites; Cumberland Wharf (CW), Brickhill Bluff (BB), Plum Orchard (PO), Dungeness Wharf (DW), and Raccoon Key (RK). These five sites had previously been monitored by the USGS from December 2011 to February 2013 to determine the average rate of island margin retreat at these pre-identified erosional hotspots (Calhoun and Riley 2016). These sites were resurveyed in 2017 and 2018 to determine if the rates of island margin retreat from 2013 to 2017 and 2017 to 2018 (which include the effects of Hurricane Matthew [Oct. 7–8, 2016] and Hurricane Irma [Sept. 10–12, 2017]) were consistent with the rates observed from 2011 to 2013 (McDonald and Gregory 2019). McDonald and Gregory (2019) found a similar pattern of gradual erosion at Raccoon Key and larger areas of change at the other sites with little change between. In addition to the areas of gradual change at Raccoon Key, large areas of change were also identified, suggesting punctuated erosion events are also influencing areas of the island with similar margin morphology.

The purpose of the 2019 resurvey was to determine the rate(s) at which the island margin retreats during a non-hurricane year. It was hypothesized that the amount and rate of change at the sites would be more similar to the results of Calhoun and Riley (2016) than to the results of McDonald and Gregory (2019). The 2019 resurvey found that the percent of retreat at all sites was much lower than during all previous years. The amount of island margin change was most similar to the change detected between 2011 and 2013 by Calhoun and Riley (2016). The relatively high percent of the bank that did not change coupled with the fact that no major hurricane affected the island between the 2018 and 2019 surveys suggests that the large areas of change (observed during previous surveys) may be extreme event driven. If no major hurricanes affect the island during the 2019 hurricane season, an additional survey would help determine average non-hurricane year rate(s) of change.

Similar processes of margin toe erosion, undercutting, and eventual bank failure are affecting all of the sites. As

the island margin becomes undercut, a threshold will be reached and an overhang or block of bank will detach from the margin, causing the island margin to retreat. The main difference between the study sites (which creates the differences in the rate[s] of retreat) are the height and steepness of their banks, bank sediment composition, and type and density of vegetation cover. The main report provides some background on each of the study sites, a general overview of the methods used to collect and process the data, and a discussion of the results and processes causing these changes.

The following is a brief summary of the results for each site:

Cumberland Wharf

- The survey was 153 meters (502 feet [ft]) in length along the top of the bluff.
- 55% of the island margin retreated and 20% advanced from its 2018 position.
- The percent of retreat is less than previous years; though there was a greater percent retreat than the rest of the sites (except for Raccoon Key).
- The maximum retreat was 1.41 meters (4.63 ft) with an average of 0.25 meters (0.82 ft).
- The maximum and average retreat is similar to Calhoun and Riley (2016).

Brickhill Bluff

- The survey was 233 meters (764 ft) in length along the top of the island margin.
- 43% of the island margin retreated and 33% advanced from its 2018 position.
- The percent retreat is less than previous years; and second least among sites
- The maximum retreat was 0.92 meters (3.02 ft) with an average of 0.22 meters (0.72 ft).
- Had the least amount of retreat measured by all surveys; the average retreat was most similar to the 2017 resurvey (2013–2017 annual rate).

Plum Orchard

- The survey was 249 meters (816.9 ft) in length along the top of the island margin.
- 49% of the island margin retreated and 6% advanced from its 2018 position.
- The percent retreat is less than previous years; highest percent of area with no change in position.
- The maximum retreat was 2.06 meters (6.76 ft) with an average of 0.29 meters (0.95 ft).
- The maximum and average retreat is similar to Calhoun and Riley (2016).

Dungeness Wharf

- The survey was 172 meters (564.3 ft) in length.
- 28% of the island margin retreated and 58% advanced from its 2018 position.
- Least amount of retreat
- The maximum retreat was 1.83 meters (6 ft) with an average of 0.33 meters (1.08 ft).
- Maximum retreat similar to 2018 survey and average change most similar to Calhoun and Riley (2016).

Raccoon Key

- The survey was 400 meters (1,312 ft) in length.
- 82% of the island margin retreated and 6% advanced from its 2018 position.
- Slightly less percent retreat than previous surveys; most change amongst the sites.
- The maximum retreat was 5.41 meters (17.75 ft) with an average of 0.69 meters (2.26 ft).
- Maximum similar to 2017 and 2018 and average is nearly half as much as 2018.

Introduction

On May 22 and 23, the Southeast Coast Network (SECN) conducted a survey of five sites—Cumberland Wharf (CW), Brickhill Bluff (BB), Plum Orchard (PO), Dungeness Wharf (DW), and Raccoon Key (RK)—on the back barrier side of Cumberland Island National Seashore (Figure 1). The island margin at these sites ranges in morphology from high bluff in the north (Cumberland Wharf) to low marsh in the south (Raccoon Key). Brickhill Bluff and Plum Orchard are located on meander bends of the Brickhill River and Dungeness Wharf is located on Cumberland Sound near the confluence of the Crooked and St. Marys Rivers. All of the sites are affected by fluvial and tidal processes (Calhoun and Riley 2016; McDonald and Gregory 2019).

The five sites were first surveyed by the USGS from December 2011 to February 2013 to determine the average rate of island margin retreat at these pre-identified erosional hotspots (Calhoun and Riley 2016). Calhoun and Riley (2016) observed steady low magnitude retreat along Raccoon Key, related to tidal influences. At the other sites (which are set further back from the high tide line), the major driving factor behind island margin retreat is punctuated erosions events caused by combining above average tide conditions with high winds which causes increased wave energy, and exacerbated tidal height. These erosional events slowly erode the toe of the bank, causing the banks to become undercut and unstable (Calhoun and Riley 2016). Eventually, a threshold is reached and the undercut and overhanging banks will fail causing the island to retreat behind this failed section of the bank.

The five sites were resurveyed in 2017 and 2018 to determine if the rates of island margin retreat from 2013 to 2017 and 2017 to 2018 (which include the effects of Hurricane Matthew [Oct. 7–8, 2016] and Hurricane Irma [Sept. 10–12, 2017]) were consistent with the rates observed from 2011 to 2013 (McDonald and Gregory 2019). McDonald and Gregory (2019) found a pattern of erosion similar to Calhoun and Riley (2016) with high-frequency, low-magnitude erosion at Raccoon Key and low-frequency, high-magnitude areas of change at the other sites, with little change between these large areas of change. In addition to the areas of low-magnitude change at Raccoon Key, a few high-magnitude areas of change were also identified, suggesting punctuated erosional events may also be influencing areas of the island with similar margin morphology (areas of low marsh).

This report provides the results of a technical assistance project implemented at Cumberland Island National Seashore (CUIS) to monitor island margin retreat on the back barrier (west) side of the island. The following sections provide an introduction to the island and the sites that were surveyed, provides a description of the methods that were used to conduct the survey and process the collected data, and presents and discusses the results of the 2019 surveys within the context of previous investigations. The results of the SECN surveys (2017–2019) are compared to the 2011–2013 USGS surveys and an aerial photograph analysis conducted by Jackson (2006), for 1983–2002, to provide context for the island margin retreat captured by the most recent surveys.

Cumberland Island National Seashore - Back-Barrier Island Margin Monitoring

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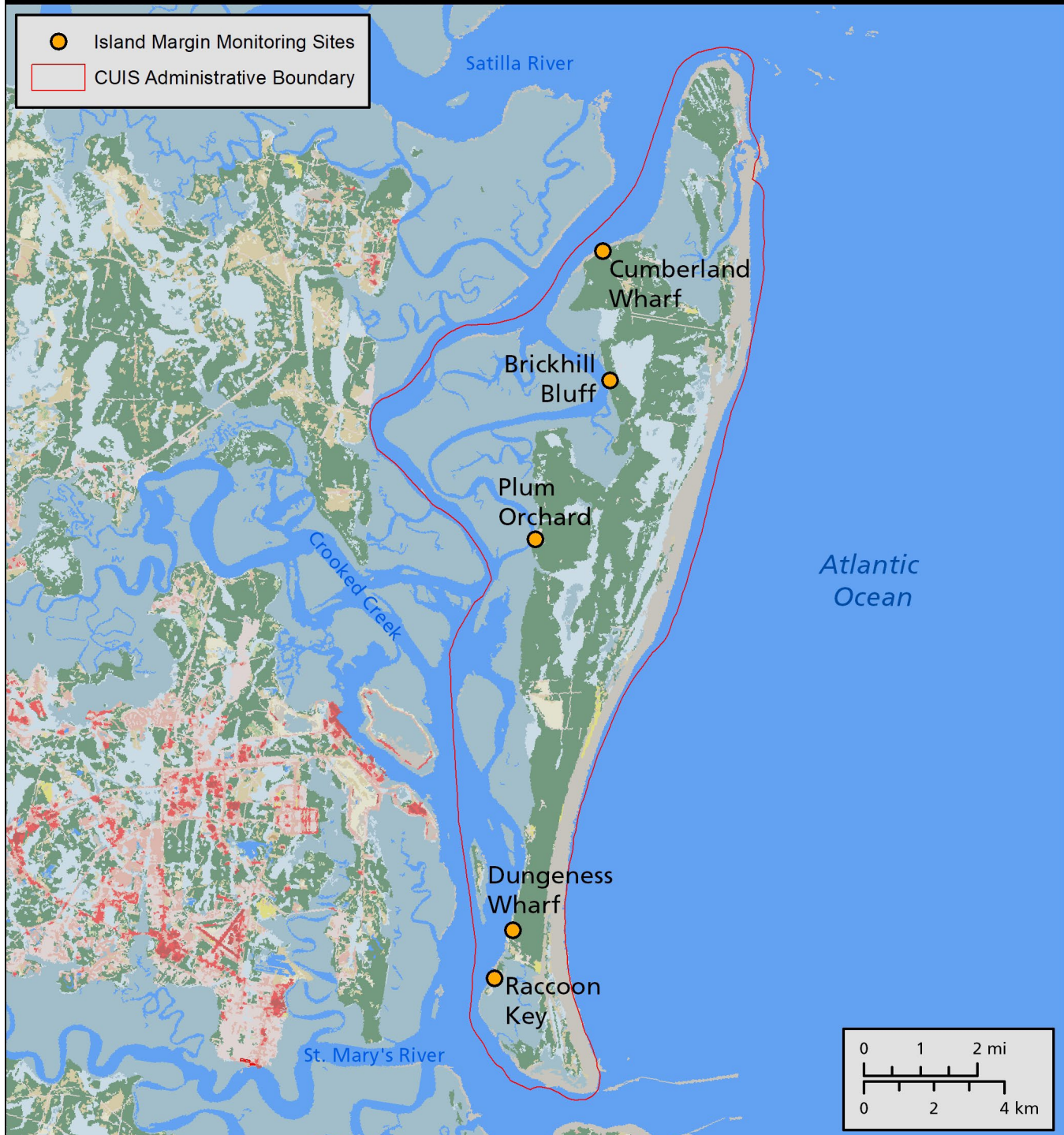


Figure 1. Overview map of Cumberland Island National Shoreline (CUIS) with the locations of the island margin monitoring sites.

Study Area

Cumberland Island is Georgia's southernmost barrier island and is located near the Georgia/Florida border in Camden County, Georgia. The island is influenced by the Satilla River in the north, the St Mary's River in the south, and the Crooked River/Cumberland River in between (Figure 1). Cumberland Island is composed of a central 'core' of Pleistocene barrier island sediments with a narrow, seaward veneer of Holocene sands (Griffin 1982). The ocean-to-estuary profile of Cumberland Island is typical of large barrier islands. The ocean (east) side of the island is characterized by wide sandy beaches beyond which (to the west) are primary and secondary dunes with lower interdunal areas (Alber et al. 2005). The back-barrier (west) side of the island is characterized by salt marsh and tidal creeks in the south and higher bluffs in the north. In some areas, the island margin is being actively eroded by wave action coupled with fluvial processes from the tidal creeks and rivers that flow through and past (Calhoun and Riley 2016). The five sites that were surveyed for this project are influenced by St. Andrew's Sound (Cumberland Wharf), Brickhill River (Brickhill Bluff and Plum Orchard), and Crooked Creek, St. Mary's River, and Cumberland Sound (Dungeness Wharf and Raccoon Key). The five survey locations were initially chosen to be representative of pre-identified erosional hotspots (Jackson 2006; Calhoun and Riley 2016). The following sections describe the five survey locations in more detail.

Cumberland Wharf

The island margin at Cumberland Wharf (CW) is a bluff located on the north end of the park (Figure 1). The bluff is high (greater than 5 meters [16.4 ft]), sandy, and in many spots deeply undercut (approximately 1 meter [3.3 ft]). Large rotational slumps and undercut failures were observed by Calhoun and Riley (2016) as well as during the SECN resurveys (McDonald and Gregory 2019). The bluff face is exposed fine to medium sands with little organic material; while the top of the bluff is heavily vegetated with shrubs and intermittent large trees (Calhoun and Riley 2016). The base of the bluff is protected from erosion by an apron of eroded bluff sediments and slump blocks that are being actively eroded by wave action and fluvial processes.

Brickhill Bluff

Brickhill Bluff is located near the north end of the park on the cutbank side of a meander bend of Brickhill River (Figure 1). The island margin is an approximately 1.5 meters (4.9 ft) tall near vertical bank composed of very fine sand with a thin layer of coarser sediments and shell fragments near the surface (Calhoun and Riley 2016). A designated group campsite occupies this portion of the island and

visitor use is contributing to island margin erosion and bank instability. Canopy cover is thick along the island margin but the understory is relatively open. In a number of places, large trees have been undercut and toppled onto the beach and are now providing some temporary bank protection (Calhoun and Riley 2016).

Plum Orchard

Plum Orchard is located near the center of the island on the cutbank side of a meander bend of Brickhill River (Figure 1). The island margin is 1.1 meters (3.6 ft) tall and composed of consolidated sands with high clay and organic content that is topped with a layer of coarser sediments and shell fragments (Calhoun and Riley 2016). A dock and boat launch are located near the middle of this site. There are also several historical structures near the island margin, one of which is protected by a wooden seawall. Canopy cover is high at the northern and southern ends of the site, while the understory is a well-manicured lawn. Significant undercutting of the banks just north of the boat launch were observed by McDonald and Gregory (2019).

Dungeness Wharf

Dungeness Wharf is located near the south end of the island on Cumberland Sound and is one of the primary points of drop off and embarkation for visitors (Figure 1). The island margin at this site is an approximately 2.8 meters (9.2 ft) tall near vertical bank composed of fine to medium sand overlain by coarser sediments and shell fragments (Calhoun and Riley 2016). This site is located just north of a concrete seawall. This site was initially chosen because Jackson (2006) identified a significant amount of island margin retreat to the north and south of the Dungeness Wharf seawall. The island margin is heavily vegetated in some areas and, similar to Brickhill Bluff, has large toppled trees from past erosion events that may be providing some degree of temporary protection to the island margin (Calhoun and Riley 2016).

Raccoon Key

Raccoon Key is located near on the south end of the island and is bordered by Cumberland Sound to the west (Figure 1). The island margin is a 0.6 meters (2 ft) tall near vertical bank. The bank is composed of highly bioturbated marsh-like sediment with high clay and organic content (Calhoun and Riley 2016). The upper portion of the bank has high root density and the bank tends to break off in smaller clumps when the lower unrooted portion is eroded away (see cover photo). One large dredge spoil mound occupies the northern portion of this site. A small tidal channel bisects the island margin where the surveys were conducted.

Methods

The methods used to survey the island margin monitoring sites were the same as those used by Calhoun and Riley (2016) and McDonald and Gregory (2019). A combination of real-time kinematic (RTK) GPS (global positioning system) and total station surveys were used to delineate the island margin at each site. The island margin was defined as the westernmost extent of the island and/or the near-vertical soil profile at the land-water interface that is susceptible to erosive forces (Calhoun and Riley 2016). At each site, a Trimble R10 GPS receiver was set up on the permanent benchmark that was used for the Calhoun and Riley (2016) surveys. The RTK signal from the base station was boosted using a Trimble TDL 450H UHF (ultra-high frequency) data radio to extend the RTK signal up to 5 kilometers (3.1 miles [mi]) from the base station. A second R10 GPS receiver was mounted on a survey pole in 'rover' mode and RTK points were taken where satellite coverage was sufficient. RTK surveys work well in open areas and under light canopy and was used where position solutions with horizontal error ranges less than 0.02 meters (0.07 ft) could be obtained. For the purposes of this survey, there was no vertical error cutoff because the purpose of the survey was to monitor horizontal (not vertical) island margin retreat.

To monitor the areas that did not have sufficient satellite coverage to obtain a RTK solution, a total station (TS) was integrated into the RTK survey through re-sectioning (Figure 2). Re-sectioning is done by obtaining a position solution on two points (using either RTK or TS) and then surveying those same points with a total station (TS is set up to make a triangle with the previously surveyed points) to back calculate the TS location. Some of the sites required multiple TS setups due to tidal incursion of the beach front during the survey and/or due to the presence of large tree falls or thick understory.

Once the surveys were complete, the data were downloaded and the Analyzing Moving Boundaries in R (AMBUR) package (Jackson 2010) for the statistical program R (R Core Team 2018) was used to determine the amount of retreat that occurred at each island margin site. The island margin position points were connected to create a line representing the island margin position during the survey. From these island margin lines, transects were cast (1 meter [3.3 ft] apart) perpendicular to the island margins and change between subsequent years was calculated by determining the length of the transects between the island margin lines.

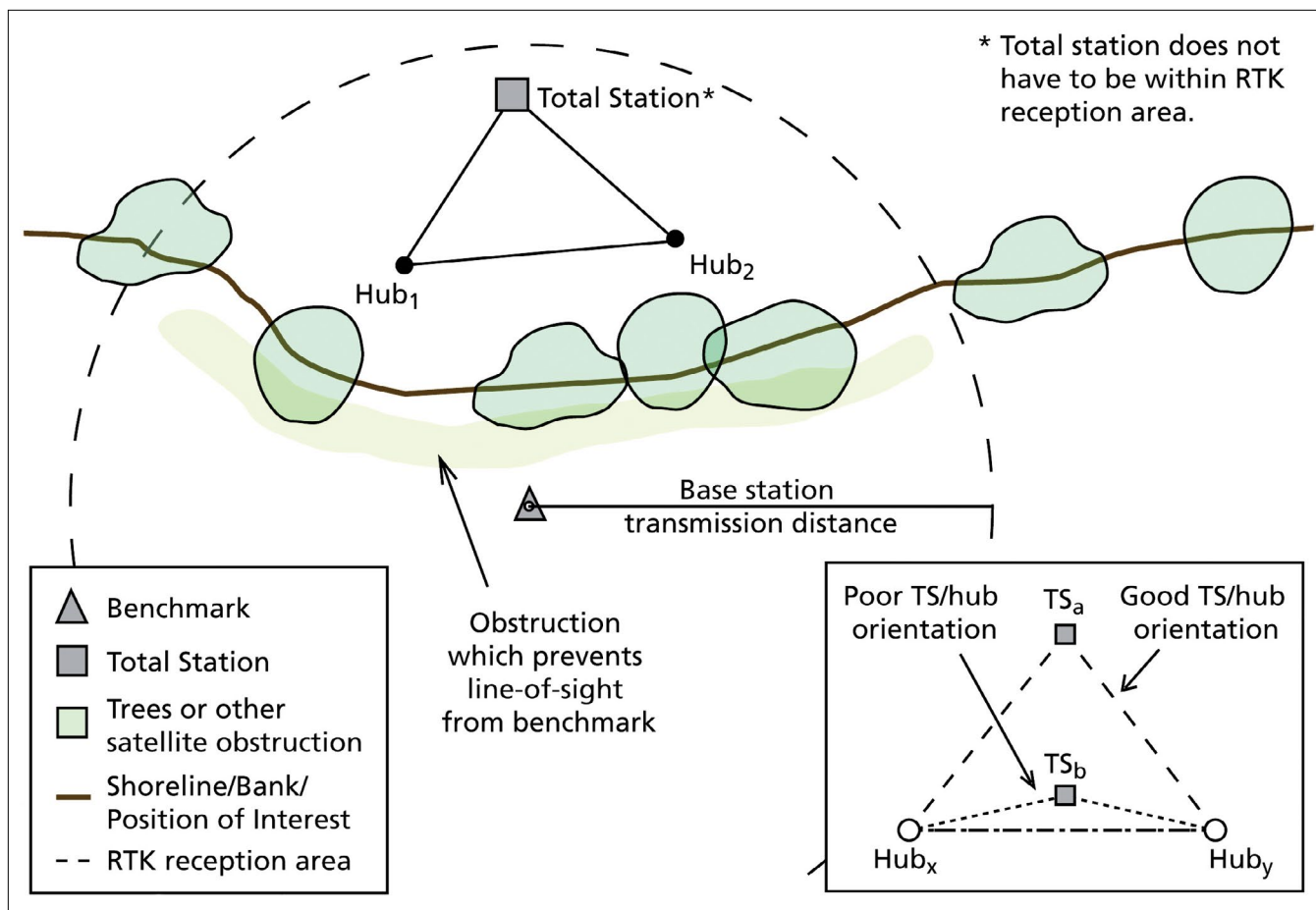


Figure 2. Example setup for an integrated survey using the resection method to setup the total station. Inset shows the difference between poor and good total station/hub orientations.

Results and Discussion

The following section describes and discusses the results of the surveys that were conducted by SECN in 2019 at each of the five island margin monitoring sites. The results of the 2019 surveys are compared to the 2017 and 2018 surveys

(conducted by the SECN), the results of the USGS 2011–2013 survey, and the aerial photograph analysis conducted by Jackson (2006) for 1983–2002 (Table 1).

Table 1. Summary of change in position of island margin (horizontal). Survey results from 2019 are compared to data extracted from Jackson (2006) for 1983–2002, Calhoun and Riley (2016) for 2011–2013, and McDonald and Gregory (2019) for 2013–2017 and 2017–2018.

Parameter	Cumberland Wharf (CW)	Brickhill Bluff (BB)	Plum Orchard (PO)	Dungeness Wharf (DW)	Raccoon Key (RK)
Survey Length (meters)	153	233	249	172	400
2017 Retreat (% of points indicating island margin retreat)	84	88	72	100	100
2018 Retreat (%)	100	97	73	95	90
2019 Retreat (%)	55	43	49	28	82
2019 Advance (% of points indicating island margin advance)	20	33	6	53	6
2019 No Change (%)	25	24	44	19	12
2011–2013 Maximum Retreat (meters)	1.41	1.99	1.94	2.40	2.34
2013–2017 Maximum Retreat (meters)	5.74	3.64	3.21	5.79	7.86
2018 Maximum Retreat (meters)	2.37	2.53	2.67	1.89	6.72
2019 Maximum Retreat (meters)	1.41	0.92	2.06	1.83	5.41
2019 Maximum Advance (meters)	0.49	2.38	0.96	0.51	1.52
2017 Average Retreat (meters)	1.82	1.19	0.82	2.06	2.82
2018 Average Retreat (meters)	0.98	1.05	0.47	0.74	1.16
2019 Average Retreat (meters)	0.25	0.22	0.29	0.33	0.69
2019 Average Advance (meters)	0.19	0.40	0.46	0.18	0.36
1983–2002 Annual Rate Retreat (meters/year)	1.87	0.50	0.65	1.90	1.90
2012–2013 Annual Rate Retreat (meters/year)	0.25	0.47	0.26	0.37	0.77
2013–2017 Annual Rate Retreat (meters/year)	0.43	0.28	0.19	0.47	0.64
2017 Standard Deviation Retreat (meters)	1.10	0.82	0.73	1.02	1.15
2018 Standard Deviation Retreat (meters)	0.57	0.54	0.47	0.36	1.26
2019 Standard Deviation Retreat (meters)	0.23	0.17	0.41	0.40	0.74
2019 Standard Deviation Advance (meters)	0.11	0.45	0.24	0.09	0.34

Cumberland Wharf (CW)

The 2019 survey of Cumberland Wharf took place on May 22. Though the bluff top is within range of the base station, canopy cover prevented RTK from being reliable (Figure 3). High tides can have a small influence on the base of the island margin at this site. The survey was done during a falling tide, so that enough of the beach would be exposed, to allow the total station to be placed far enough back, to make the whole island margin visible with one setup. At high tide the beach is too small to provide adequate total station setup locations. Portions of the bluff are deeply undercut and require a spotter (i.e., total station operator) to judge the safety of the survey as it progresses.

Approximately 55% of the island margin (approximately 84 meters; 276 ft) retreated and 20% of the island margin (30 meters; 98 ft) advanced from its 2018 position (Table 1). The maximum amount of retreat was detected in the western portion of the surveyed area where a small arcuate portion of the island margin retreated 1.41 meters (4.63

ft; Figure 3A-1). The maximum amount of retreat during the 2019 survey was equal to the maximum amount of retreat observed by Calhoun and Riley (2016) and 0.6 to 2.5 times smaller than the 2018 and 2017 surveys, respectively (McDonald and Gregory 2019). The maximum amount of advance was also detected in the western portion of the study area (edges of outcrop, Figure 3A-2). Most of the areas of advance are small enough that they are likely related to differences in how the island margin was defined. Other areas of advance (e.g., Figure 3A-3), appear as though the edge of the bank is leaning forward. The surveyed margin had on average 0.25 meters (0.82 ft) of retreat and 0.19 meters (0.62 ft) of advance. The average amount of retreat is equal to the annual rate of retreat observed by Calhoun and Riley (2016) and more than seven times less than the annual rate interpreted by Jackson (2006).

Island margin retreat along this stretch of the back barrier is interpreted as being driven by gradual erosion of the toe of the bluff, followed by undercut development, and

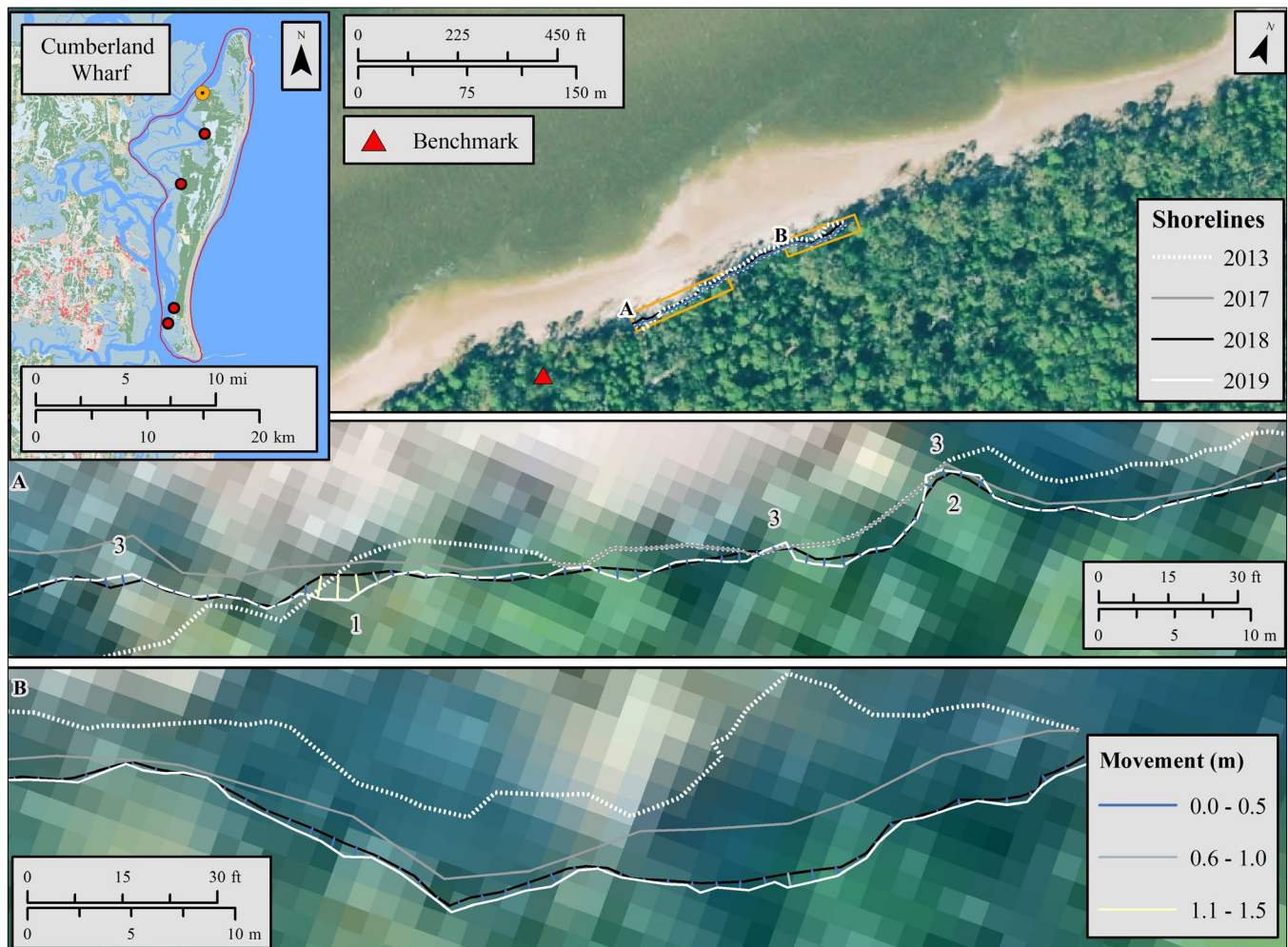


Figure 3. Island margin retreat at Cumberland Wharf.

eventual overhang failure (Figure 4). As the toe is eroded, the overhang will progressively get larger until it begins to lean forward (Figure 3A-3), a threshold is reached, an area of overhang breaks off, and the island margin retreats (e.g., Figures 3A-1, 3B [semi-continuous area of retreat], and 4D).

The large areas that were lost between 2013 and 2017 are likely due to areas where trees (and their relatively large root wads) were part of the overhang (see Figure 9 in Calhoun and Riley 2016).

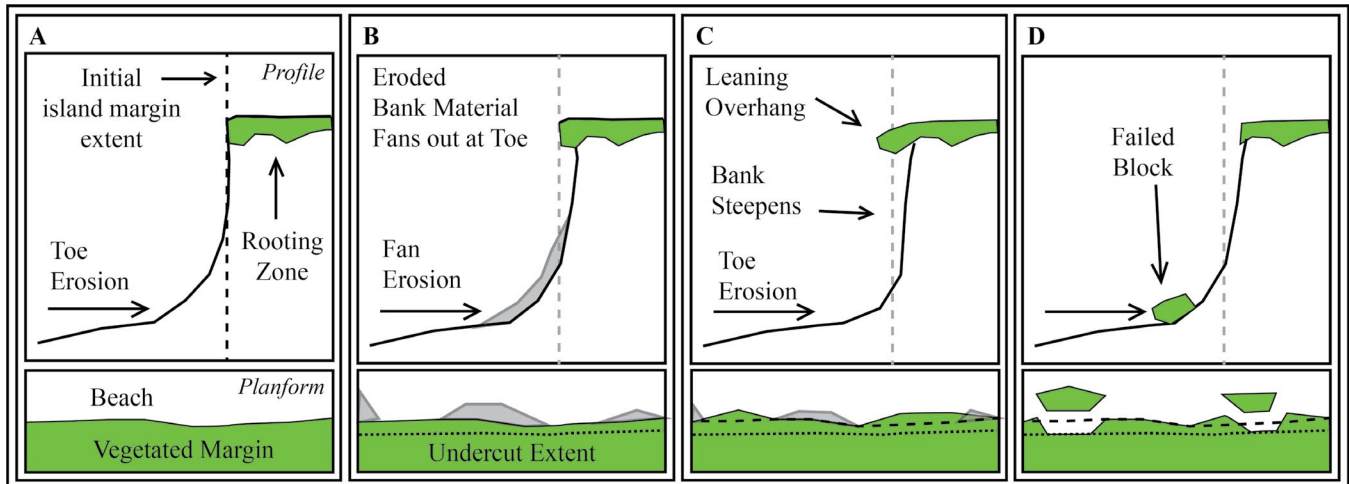


Figure 4. Schematic depiction of the process by which undercuts develop, overhangs begin to lean, overhangs fail, and the island margin retreats.

Brickhill Bluff (BB)

Brickhill Bluff is located near the north end of the park on the cutbank side of a meander bend of the Brickhill River (Figure 1). Due to growth of the tree canopy over the survey benchmark, RTK GPS nor an integrated survey could be used. To initially setup the survey, the total station was setup on the benchmark and an electronic compass was used to estimate the azimuth to a temporary backsight point. The relative orientation of the survey results were corrected in the office using data from previous surveys. Five total station setups were needed because of downed trees on the beach preventing line-of-sight to island margin. High tides can have a small influence on the base of the island margin at this site.. Additionally, at high tide, the beach is too small and the large woody debris on the beach is too dense to survey large portions of the shoreline and a prohibitive number of total station setups are needed to complete the survey.

Approximately 43% of the island margin (102 meters [335 ft]) retreated and 33% (77 meters [253 ft]) advanced from its 2018 position (Table 1). The maximum amount of retreat was detected in the middle portion of the surveyed area where a small arcuate portion of the island margin retreated 0.92 meters (3.02 ft; Figure 5B-1). The maximum amount of retreat during the 2019 survey was the least amount measured between all of the surveys. The maximum amount of advance was located in the southern portion of the survey

where the bank advanced 2.38 meters (7.81 ft; Figure 5C-2). The surveyed margin had on average 0.22 meters (0.72 ft) of retreat and 0.40 meters (1.31 ft) of advance. The average amount of retreat was up to five times less than previously detected (Table 1). Additionally, the average amount of retreat was nearly equal to the annual amount of rate interpreted from the 2013–2017 survey (McDonald and Gregory 2018).

It appears that many of the same processes that are affecting Cumberland Wharf are also affecting Brickhill Bluff, though the bank heights are much lower. Similar to the Cumberland Wharf survey, most of the areas of advance are small enough that they are likely related to differences in how the island margin was defined (Figure 5A). Brickhill Bluff also appears to have areas with leaning banks (Figure 5B-3 and 5C-3) and areas where the overhang broke away from the island margin (Figures 5B-4 and 5C-4). The large areas of advance in the southern portion of the survey (Figure 5C-2), are due to better island margin survey coverage during 2019. The island margin had better survey coverage because a total station was setup in near proximity to this portion of the margin. This area was surveyed with less accuracy during the 2018 survey due to dense vegetation cover.

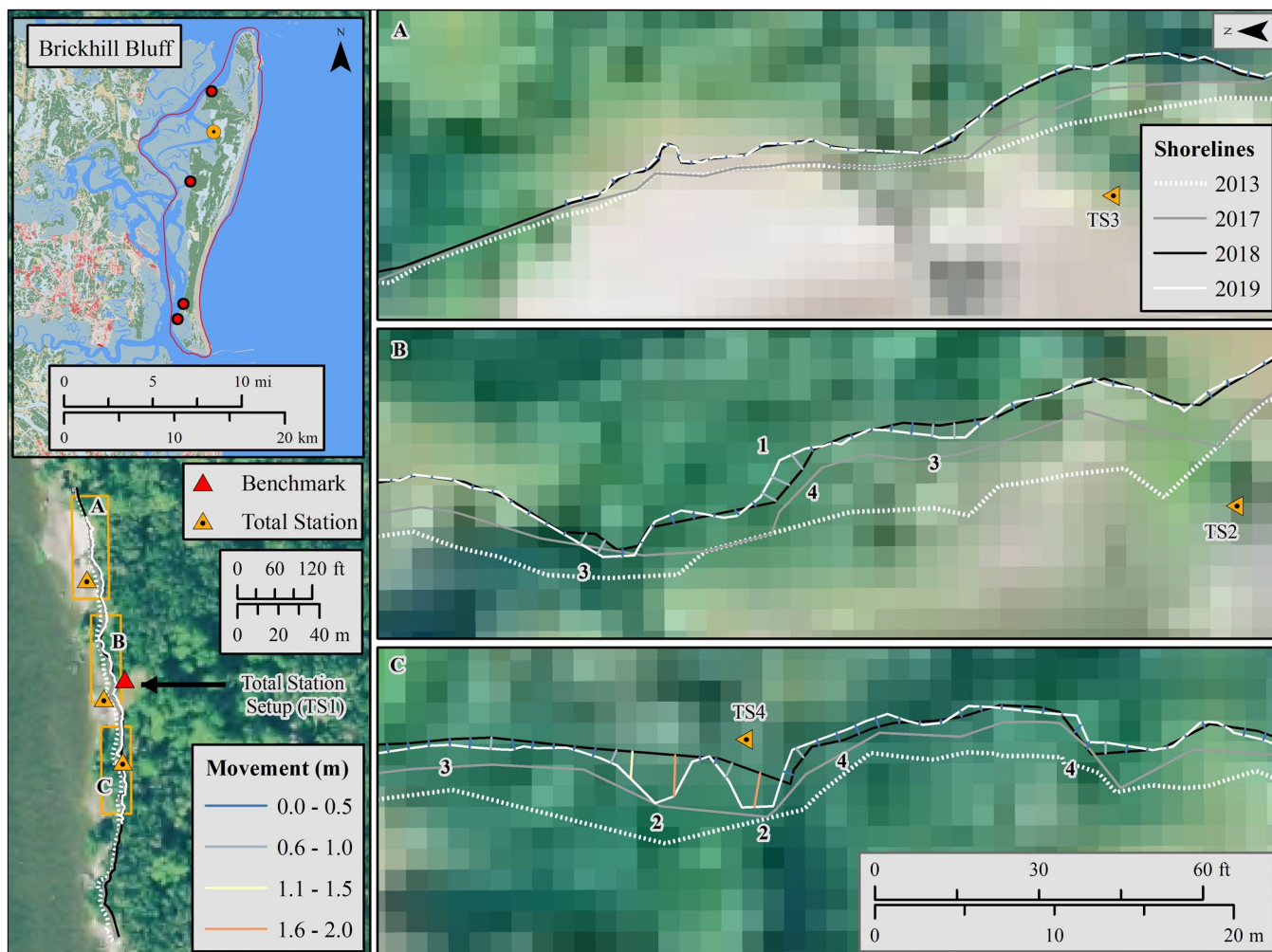


Figure 5. Shoreline retreat at Brickhill Bluff.

Plum Orchard (PB)

Plum Orchard is located near the center of the island on the cutbank side of a meander bend of Brickhill River (Figure 1). The majority of the survey was done using RTK GPS. One total station setup was sufficient to survey the points that RTK could not be used to survey (due to poor satellite coverage). While the high tide line is close to and can sometimes reach the base of the island margin, tides were not taken into account when surveying this site because the understory is managed (by mowing) and the TS was setup on the inland side of the margin. There is a dock and boat launch along this stretch of island margin (Figure 6C-1), a seawall protecting the margin between Figure 6A and 6B, and a historical structure on the edge of the island margin (Figure 6A-2).

Approximately 49% of the island margin (122 meters; 400 ft) retreated and 6% (15 meters; 49 ft) advanced from its 2018 position (Table 1). The maximum amount of retreat was detected in the northern portion of the surveyed area where the island margin retreated 2.06 meters (6.76 ft; Figure 6A-3). The maximum amount of retreat during the 2019 survey was similar to the maximum amount of retreat observed by Calhoun and Riley (2016) and 0.6 meters (1.97 ft) to 1.2 meters (3.94 ft) less than the 2017 and 2018 surveys, respectively (Table 1). The maximum amount of advance was located in the middle portion of the survey, near the seawall, where the bank advanced 0.96 meters (3.15 ft; Figure 6B-4). The surveyed margin had on average 0.29 meters (0.95 ft) of retreat and 0.46 meters (1.51 ft) of advance. The average amount of retreat in 2019 was less than observed between

2017 and 2018 (Table 1). The average amount of retreat was similar to the annual amount of retreat observed by Calhoun and Riley and slightly less than the 2013–2017 annual amount of retreat (McDonald and Gregory 2018).

Plum Orchard had the largest area with little to no change (Table 1). Additionally, the majority of the ‘change’ that was observed at Plum Orchard is likely due to differences in how the island margin was defined coupled with differences in survey point density. The large area of advance (Figure 6B-4) is an artifact of the poor satellite coverage during the survey and the inability to conduct a more representative survey. It is unlikely that the seawall advanced toward the river. Similarly, the largest area of retreat (Figure 6A-3) might be due to the dense vegetation in the area and the inability to accurately survey this portion of the island margin using this methodology. Alternatively, this area of retreat is consistent with the progressive retreat captured by the previous surveys and more than likely represents actual change to the island margin. If this area of retreat is of management concern, any additional resurveys should be sure to survey this portion of the island margin with high survey point density to increase accuracy of the change estimates. Though the majority of the island margin did not change, there were areas that do appear to have retreated significantly (i.e., Figure 6B-4). These areas appear similar to the areas at Cumberland Wharf and Brickhill Bluff that developed through the process of bank undercutting (Figure 4).

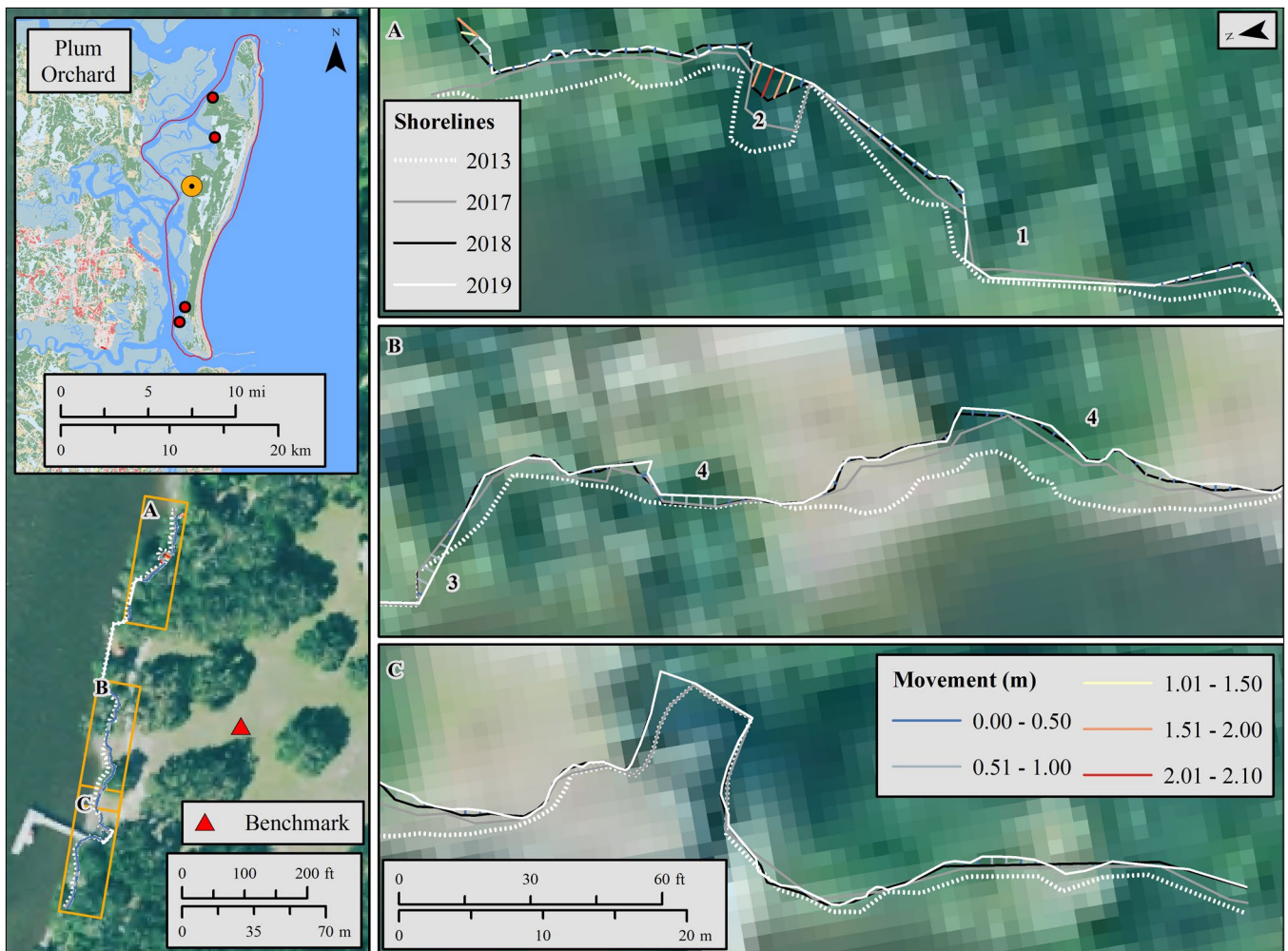


Figure 6. Shoreline retreat at Plum Orchard.

Dungeness Wharf (DW)

Dungeness Wharf is located near the south end of the island on Cumberland Sound (Figure 1). While some of the island margin was measured with RTK, an integrated survey was required to survey the entire margin. One total station setup was sufficient to survey the areas that RTK could not capture. High tides can have a small influence on the base of the island margin at this site. Additionally, at high tide the beach is too small and the large woody debris on the beach is too dense to complete the survey with a total station. There is a seawall at the southern end of the island margin.

Approximately 28% of the island margin (48 meters [157 ft]) retreated and 53% (100 meters [328 ft]) advanced from its 2018 position (Table 1). The maximum amount of retreat was detected in the middle portion of the surveyed area where the island margin retreated 1.83 meters (6 ft; Figure 7B-1). The maximum amount of retreat during the 2019 survey was similar to the maximum amount of retreat in 2018 (Table 1). The maximum amount of advance was located in the northern portion of the survey where the bank advanced

0.51 meters (1.67 ft; Figure 7A-2). The surveyed margin had on average 0.33 meters (1.08 ft) of retreat and 0.18 meters (0.59 ft) of advance. The average amount of retreat in 2019 was two to nearly seven times less than observed in 2018 and 2017, respectively (Table 1). The average amount of retreat was similar to the annual amount of retreat observed by Calhoun and Riley (2018) and slightly less than the 2013–2017 annual amount of retreat (McDonald and Gregory 2018).

Dungeness Wharf had the smallest percent of island margin retreat and the highest percent of island margin advance (Table 1). The areas with substantial retreat (e.g., Figure 7B-1 and 7B-3) appear to be similar to the arcuate area of retreat at Cumberland Wharf (Figure 3A-1). A similar process of development (Figure 4) is interpreted for this area of retreat at Dungeness Wharf. While some of the areas of advance might be due to bank lean (i.e., Figure 7A-2), the rest of the area that has ‘advanced’ is likely due to small differences in where the island margin was surveyed and the density of the survey points.

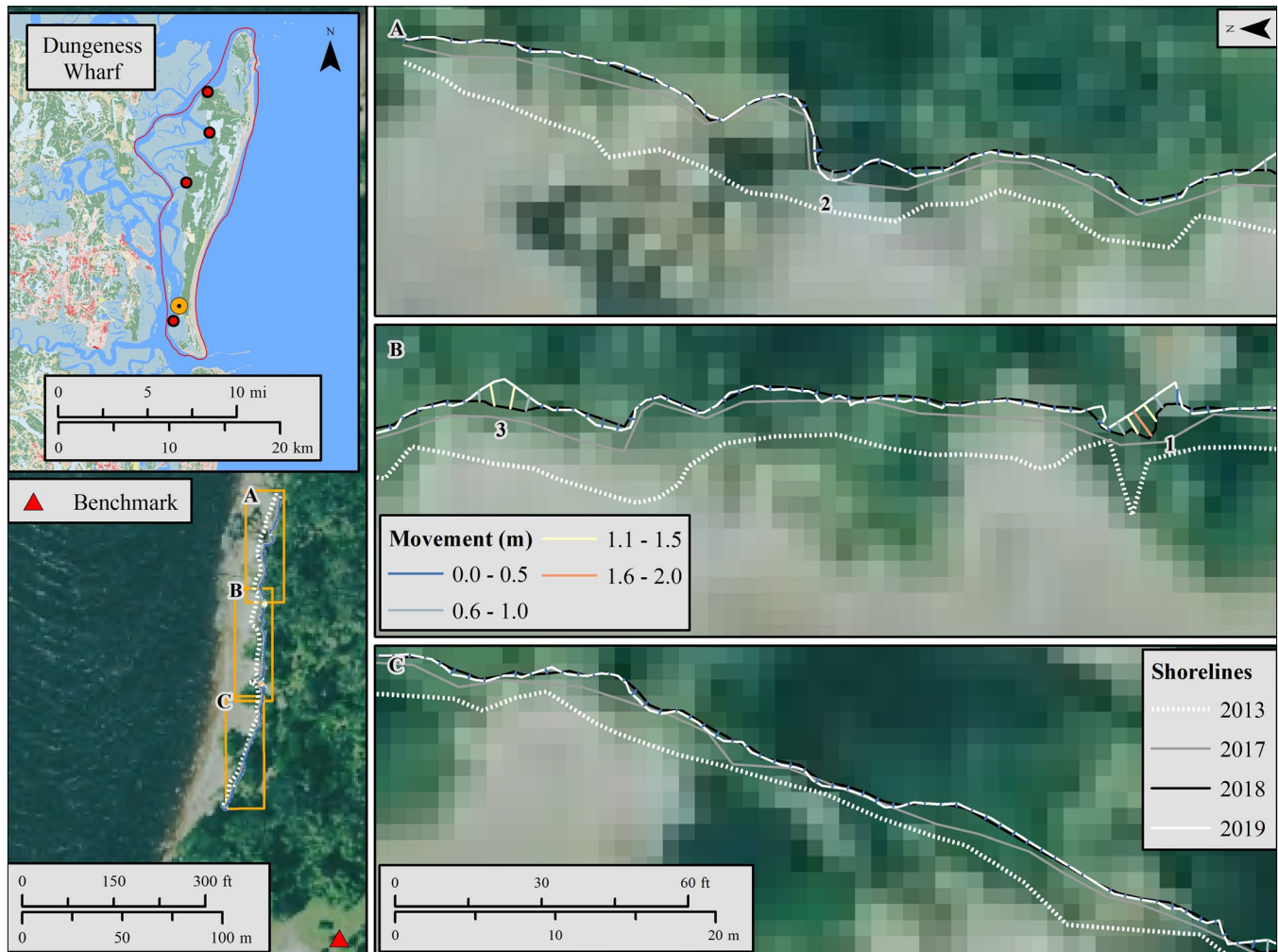


Figure 7. Shoreline retreat at Dungeness Wharf.

Raccoon Key (RK)

Raccoon Key is located near on the south end of the island near the confluence of Beach Creek and the St. Mary's River (Figure 1). RTK was used to survey the entire site due to the open canopy of low marsh grasses. Tides have a large influence on this site. At high tide, waves often break on the island margin. Additionally, at high tide, the island margin cannot be accessed because of the deep tidal creek that lies between the site and the benchmark. The survey runs from a tidal creek in the south to halfway past a large spoil pile (just south of the second benchmark, Figure 8). Another (smaller) tidal creek runs through the middle of the surveyed margin.

Approximately 82% of the island margin (328 meters [1076 ft]) retreated and 6% (24 meters [79 ft]) advanced from its 2018 position (Table 1). The maximum amount of retreat was

observed in the southern portion of the surveyed area where the island margin retreated 5.41 meters (17.75 ft; Figure 8C-1). The maximum amount of retreat during the 2019 survey was less than measured during the 2017 and 2018 surveys (Table 1). The maximum amount of advance was located in the middle portion of the survey where the bank advanced 1.52 meters (4.99 ft; Figure 8B-2). The surveyed margin had on average 0.69 meters (2.26 ft) of retreat and 0.36 meters (1.18 ft) of advance. The average amount of retreat in 2019 was similar to the annual rate of retreat observed by McDonald and Gregory (2019) and slightly less than the rate observed by Calhoun and Riley (2016).

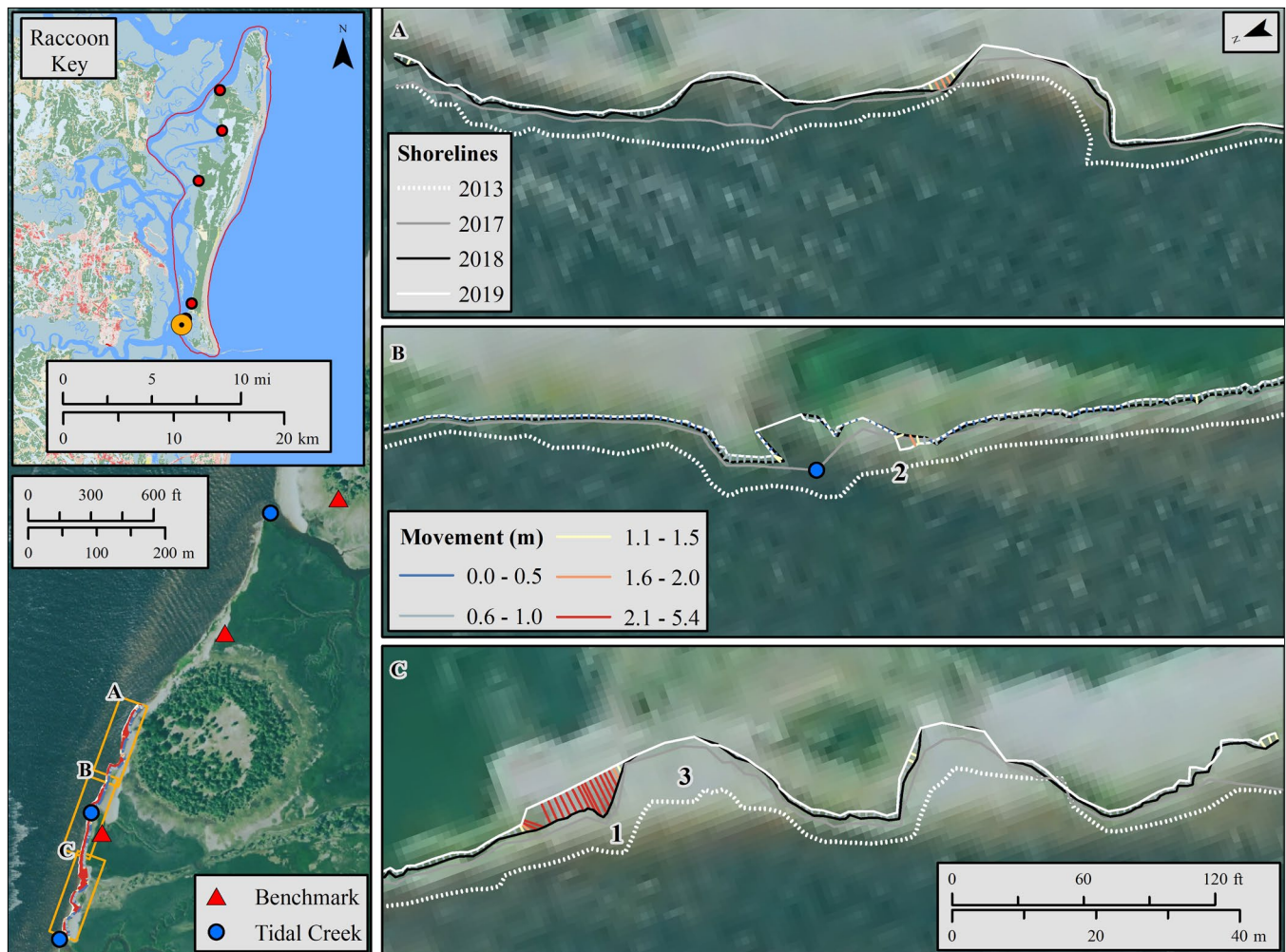


Figure 8. Shoreline retreat at Raccoon Key.

Raccoon Key had by far the highest percent of island margin retreat (Table 1). It appears two distinct processes are contributing to the erosion at Raccoon Key (Figure 9). The first process, also identified by Calhoun and Riley (2016), is the progressive retreat of the island margin through small block failures (Figure 9B–C). This process is facilitated by the diurnal effects of high tide waves breaking on or near the island margin which progressively weakens the bank through toe erosion and the addition of water to the bank through wave spray. As the wave spray drains from the bank face, areas of weakness (macropores) develop (Figure 9B) along which the block failures will occur (Figure 9C). This process is proposed as contributing to the persistent relatively uniform rates of erosion along this section of the

back barrier. The second process is proposed to be related to storm wash (Figure 9D–F). Similar to the process by which the bank failures form, storm wash draining out of the island margin will preferentially flow along natural zones of weakness and toward topographic lows (Figure 9D). In some areas, the rooting zone (Rz) will become detached from the underlying peat and a large section of vegetation will fail (Figure 9E). This failure will expose the less erosion-resistant peat to wave and storm action (Figure 9F). Once the peat has been eroded, the areas surrounding this arcuate loss of island margin will be subjected to increased stress and erosion rates will increase relative to undisturbed portions of the island margin.

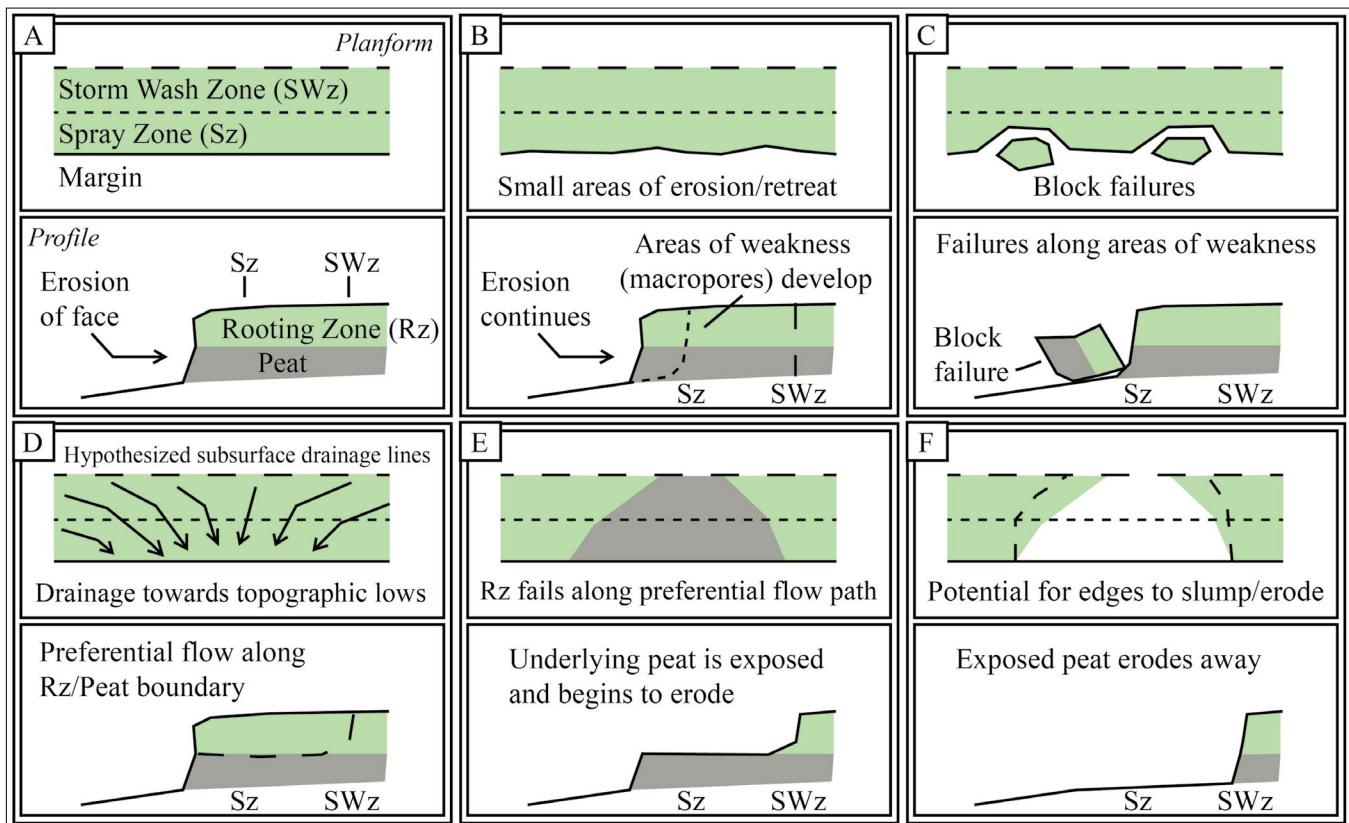


Figure 9. Schematic depiction of the process by (B–C) smaller block failures develop and (D–F) large arcuate sections of underlying peat become exposed and are then eroded (causing the margin to retreat).

Conclusion

The percent of retreat observed at all sites was lower than during all previous years. Dungeness Wharf had the lowest percent of island retreat (28%) and Raccoon Key had the highest percent of island margin of retreat (82%). The maximum amount of retreat was seen at Raccoon Key (5.41 meters [17.75 ft]) and the lowest average amount of retreat was observed at Brickhill Bluff (0.22 meters [0.72 ft]). The amount of island margin retreat was most similar to the change detected by Calhoun and Riley (2016) between 2011 and 2013. Raccoon Key is retreating at the fastest rate (0.69 meters [2.26 ft]). This result is not surprising due to the influence tides have on the low marsh site. High-magnitude areas of retreat were also identified at Raccoon Key (between 2013 and 2017 as well as between 2017 and 2018), the process by which these arcuate areas of vegetation stripping and underlying sediment erosion need to be further investigated though a process was proposed in Figure 9D–F.

The relatively high percent of the bank that did not change (compared to previous surveys) coupled with the fact that no major hurricane affected the island between the 2018 and 2019 surveys suggests that the significant areas of change are largely extreme event driven. If no major hurricanes affect the island during the 2019 hurricane season, an additional survey should be completed to determine an average non-hurricane rate of change. Additionally, to further determine the impact of hurricanes on island margin retreat, other potentially erosive events (e.g., storms with strong westerly winds during high tide) should be identified to determine whether the period between the 2018 and 2019 surveys was uncommonly quiescent, and would explain the relatively small amount of retreat that was detected.

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1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525