Quantifying the Threat to Archaeological, Historic and Cultural Resources from Shoreline Change: The Georgia Coast Example

Claudia Venherm[1], Clark Alexander[1], Michael Robinson[1], Christopher McCabe[2], Chester Jackson[3], Naomy Perez-Sanchez[1], David Crass[2]

1-Skidaway Institute of Oceanography, Savannah, Georgia 2-Georgia Department of Natural Resources, Atlanta, Georgia

3-Department of Geology and Geography, Georgia Southern University, Statesboro, Georgia

Introduction

Coastal Georgia is a dynamic environment. The natural forces of wind and water have formed and changed the shape of our coastline over the centuries, and continue to erode coastal landforms depositing the material elsewhere, sometimes dramatically. Frequently, shoreline erosion along coastlines and bluffs of tidal streams impacts important archaeological sites by exposing, removing and destroying burials, features, and artifacts that could have provided important information for interpreting and managing the sites, and for enhancing our understanding of settlement and use of coastal Georgia. Archaeological sites are non-renewable resources; once a site has been lost, it cannot be replaced, and the information it contained is lost forever.

In this three year study, we use field GPS investigations and GIS analysis to generate new shoreline change data to identify sites that are threatened and/or are being damaged by coastal erosion, evaluate their site condition and National Register of Historic Places (NHRP) status, prioritize immediacy of the erosive threat, and make management recommendations. This study includes 60 important archaeological sites located on barrier and back barrier islands along the Georgia coast. The sites were categorized based on the shoreline change character of each site and ranked by time before site loss. This information is critical for resource managers and coastal planners who need to consider cultural resources in their decisions. In addition, identification of rapidly eroding sections of shoreline can assist permitting agencies in establishing effective buffers around developments for cultural resource protection and hazard mitigation.

Methods

Coastal sites in the Georgia Archaeological Site File (GASF) database were plotted in ArcGIS 9.3 to determine their potential threat from erosion. All sites that were within a 30 m radius of a waterway or marsh (equal to 50 years of erosion at average back-barrier rates of 0.6 m/y) were compiled into a list and submitted to the Office of the State Archaeologist at the Georgia Department of Natural Resources – Historic Preservation Division (DNR-HPD). After evaluating each of the potentially threatened sites for archaeological significance and NHRP status, the DNR-HPD provided us with a 60 site subset for site-specific documentation in this study.

Archaeological Study Sites

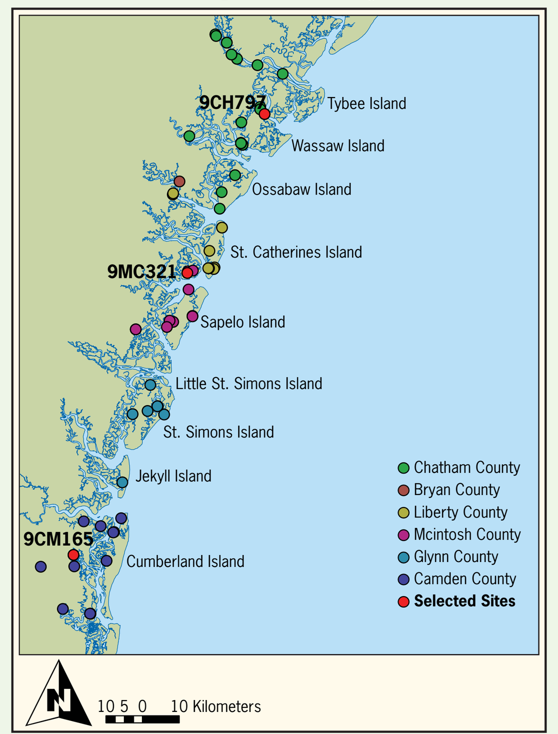

Figure 1. Study sites.

Figure 2. Site 9CH797, a stable site.

Figure 3. Site 9MC321, an accretionary site.

For each of the identified sites, individual GIS projects, which included archival historic maps (1850-1933) and aerial photography (1942-2004) for each site were generated in ArcGIS 9.3. Historical images were georectified using a 2002/2003 orthophoto data set, with 4 to 25 ground control points (GCPs) for each image. Root-mean-square (RMS) values were calculated for inclusion in the shoreline change analysis. During the process of digitizing shorelines from historical imagery, the highwater line (HWL) or swash terminus, bluff toe, or marsh edge were selected as the primary indicators of shoreline position.

The AMBUR program (Analyzing Moving Boundaries Using "R"; Jackson, 2010) was employed to calculate shoreline changes and produce a variety of statistical data. The program calculates shoreline change by measuring the time and position differences of two or more historic shorelines. These measurements were taken at transects cast perpendicular to the shore from a baseline at an interval ranging from 1 to 10 m depending on the length of the shoreline. The calculations identified segments of shoreline exhibiting erosion, accretion, or no significant change. The "endpoint rate" (EPR) shoreline change rate, which is calculated between the youngest and oldest shorelines and which is widely used by state and local agencies, was the method used to estimate both long-term and modern shoreline change rates. We also calculated the standard deviation of shoreline change rates determined between all successive paired positions of the shoreline to provide an estimate of the amount of variability in the shoreline change processes at any given site, providing an estimate of how confident we should be in projecting site-specific EPRs into the future.

Field Methods

Over the years 2007, 2009 and 2010, each site was visited by a Skidaway staff member together with a state archaeologist. The current shoreline position (eroding bluffs, marsh scarps or marsh edge) was mapped with 50 cm accuracy using a Trimble Geo-XT equipped with a high-sensitivity Hurricane antenna. In order to capture shoreline change characteristics representative of the whole local shoreline, data was collected along much greater portions of the shorelines than just adjacent to the archaeological site itself. In the AMBUR program we then analyzed the entire shoreline in addition to transects nearest to the site to provide the most site-specific data. Archaeological artifacts at the sites were documented, photographed and site dimensions recorded. In addition to field observations, we used site dimensions, contained within the site report forms, to calculate the life span of each site.

Example of Sites

Figure 4. Site 9CM165 at about transect 60. This site is eroding.

Site 9CM165 contains an abundance of archaeological artifacts ranging from arrow heads to tabby brick, evidencing several periods of human occupation. Artifacts are eroding out of the escarpment and are littered on the fronting beach. The shoreline is an actively eroding bluff. The process variability is high, especially in the southeastern part of the shoreline. Increased boat traffic due to a public boat ramp nearby may be responsible for rapid erosion and high variability.

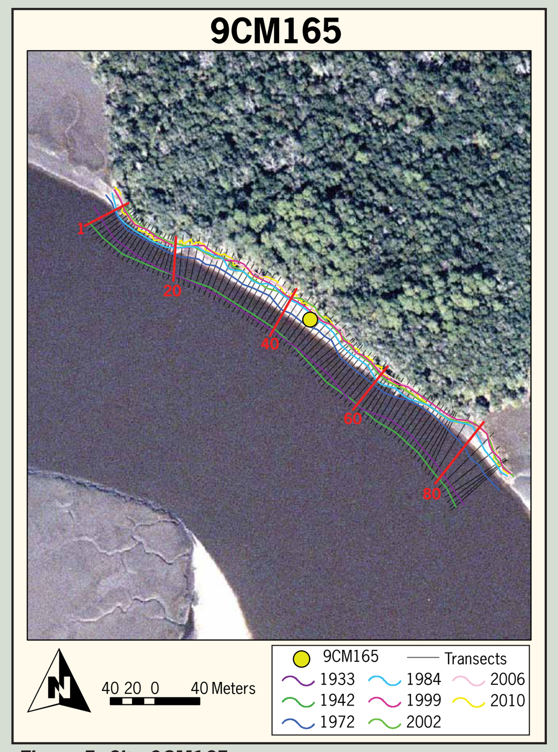

Figure 5. Site 9CM165.

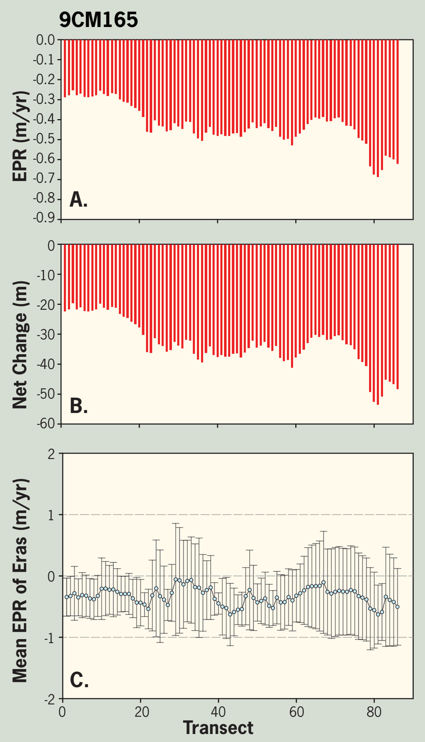

Figure 6. A) EPR, B) Net Change for Site and C) process variability at Site 9CM165. Transect spacing is 5 m.

Results

Site-specific shoreline change rates for sixty archaeological sites have been used to evaluate each shoreline trend. The data identify erosional, stable and accretionary shorelines, although erosional conditions are most common at the 60 sites. Table 1 gives an overview of all sites investigated. Sites are listed from North to South along the Georgia coast.

Of the shorelines at the sixty sites, 45 were eroding (Figure 4), 10 were stable (Figure 2) and 5 were accretionary (Figure 3). At the time of our study, nine of the erosional sites had already completely eroded away, four of the erosional sites were partially submerged in the intertidal zone.

EPR Rates at Archaeological Sites

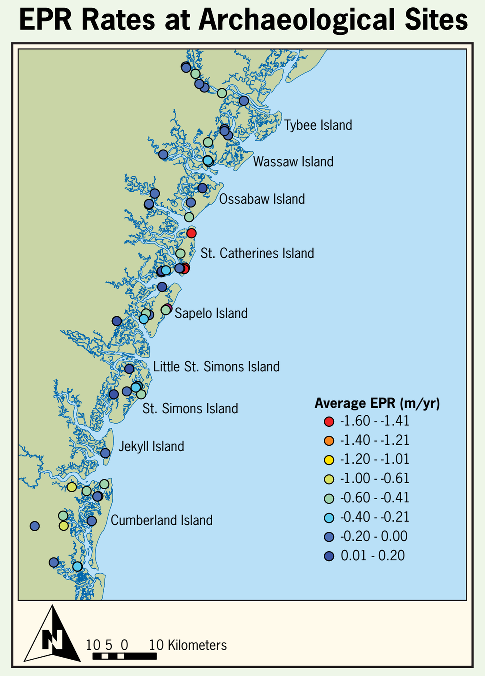

Figure 7. Average EPR rates for study sites.

The 45 erosional sites were then ranked based on which was in most danger of being lost to erosion. The projected life of each site was calculated as the number of years until erosion, at the EPR calculated for that site, would erode the entire distance to the back of the site boundary. Within the group of erosional sites that are not already lost, 21 are "actively eroding", meaning that the eroding shoreline is already within the boundaries of the site location and archaeological information is actively being lost. From this table we generated a prioritized list of sites based on their yearly percentage of site loss and shortest projected lifetime for collecting archaeological data (Table 2).

It is important to note that although several of the sites have a long projected life span, they are still actively undergoing erosion, and critical archaeological information is constantly being lost at these sites.

Fastest EPR erosion rates were found at three sites located on the open coast, as would be expected because of the high energy available to erode the unconsolidated shoreline at the open-ocean shoreface (Figure 7). However, shoreline change rates do not consistently decrease with distance from the ocean beaches, and there is no consistent pattern to the distribution of shoreline change rates at the selected sites, indicating that local factors, such as creek size and volume, geology (*e.g.*, upland lithology, substrate resistance to meandering), and physical forcing (*e.g.*, current velocities, fetch and orientation to wave attack) dominate the change signal in these settings.

Site	Average EPR (m/yr)	Average EPR Near Site (m/yr)	Estimated Shoreline Position Error (m/yr)	Shoreline Trend	Approximate Site Depth as of 2011 (m)	Site Actively Eroding (y/n)	% Site Loss per year	Projected Life of Site (yrs)
9CH817	-0.18	-0.22	0.05	Erosion	1	y	3.1	4.8
9CH820	-0.17	-0.03	0.06	Erosion	sub/intertidal	n	--	sub/intertidal
9CH685 (Argyle Island)	-0.39	-0.35	0.06	Erosion	74	y	0.4	211.6
9CH685 (Hog Island)	-0.47	-0.71	0.07	Erosion	0	y	Eroded	lost
9CH807	-0.10	-0.07	0.07	Erosion	0	y	Eroded	lost
9CH687	-0.12	-0.13	0.07	Erosion	sub/intertidal	y	--	sub/intertidal
9CH700	-0.47	-0.69	0.06	Erosion	N/A	N/A	N/A	N/A
9CH953	-0.20	-0.22	0.13	Erosion	89	y	0.2	403.6
9CH126	-0.10	-0.11	0.07	Erosion	208	y	0.1	1893.1
9CH127 (E)	-0.19	-0.09	0.07	Erosion	64	n	--	706.2
9CH127 (S)	-0.19	-0.34	0.07	Erosion	100	n	--	292.8
9CH797	-0.03	0.01	0.04	Stable	140	n	--	stable shoreline
9CH788	-0.56	-0.58	0.07	Erosion	130	n	--	223.4
9CH1103	-0.15	-0.15	0.07	Erosion	39	y	0.4	260.7
9CH614	-0.32	-0.23	0.05	Erosion	23	n	--	98.4
9CH615	-0.32	-0.33	0.05	Erosion	99	n	--	301.3
9CH619	-0.32	-0.35	0.05	Erosion	0	y	Eroded	lost
9CH612	-0.32	-0.35	0.05	Erosion	24	n	--	68.0
9CH592+9CH586	-0.32	-0.40	0.05	Erosion	N/A	N/A	N/A	N/A
9CH168	0.04	0.09	0.08	Accretion	N/A	n	--	accretion
9BN26	-0.13	-0.20	0.07	Erosion	19	y	1.0	95.0
9CH203	-0.17	-0.16	0.12	Erosion	24	y	0.5	153.0
9LI1909	-0.14	-0.03	0.05	Erosion	sub/intertidal	y	--	sub/intertidal
9LI1908	-0.14	-0.17	0.05	Erosion	sub/intertidal	y	--	sub/intertidal
9CH155	-0.60	-0.57	0.06	Erosion	336	y	0.1	590.0
9LI22	-1.43	-1.34	0.06	Erosion	0	y	Eroded	lost
9LI8	-0.54	-0.57	0.12	Erosion	38	y	1.0	67.0
9LI84	-1.60	-1.40	0.06	Erosion	170.2 ± 5	n	--	126.0
9LI105	-0.04	-0.01	0.12	Stable	N/A	n	--	stable shoreline
9LI101	-0.04	-0.07	0.12	Stable	N/A	n	--	stable shoreline
9LI87	-1.60	-1.68	0.06	Erosion	170.2 ± 5	n	--	104.0
9MC323	-0.27	-0.24	0.05	Erosion	0	y	Eroded	lost
9MC322	0.17	-0.05	0.05	Accretion	40	n	--	accretion
9MC321	0.07	0.05	0.03	Accretion	30	n	--	accretion
9MC66	0.09	0.08	0.12	Stable	N/A	n	--	stable shoreline
9MC272	-0.46	-0.36	0.12	Erosion	0	y	Eroded	lost
9MC273	-0.46	-0.40	0.12	Erosion	0	y	Eroded	lost
9MC350	-0.42	-0.39	0.05	Erosion	189	y	0.2	484.8
9MC90	-0.18	-0.22	0.12	Erosion	19	y	1.0	88.0
9MC352	-0.24	-0.33	0.05	Erosion	99	y	0.3	299.0
9MC401 distillery	0.02	-0.05	0.05	Stable	15	n	--	stable shoreline
9MC401 slave quarters	0.08	0.05	0.05	Accretion	119	n	--	accretion
9GN52	0.06	0.04	0.12	Stable	N/A	n	--	stable shoreline
9GN142	-0.47	-0.48	0.02	Erosion	1	y	16.0	2.3
9GN66	-0.26	-0.23	0.03	Erosion	4	y	4.6	17.7
9GN36	0.00	0.02	0.12	Stable	N/A	n	--	stable shoreline
9GN241	0.15	0.17	0.12	Accretion	N/A	n	--	accretion
9GN139	-0.47	-0.44	0.07	Erosion	N/A	N/A	--	N/A
9GN49	-0.06	-0.08	0.07	Stable	N/A	n	--	stable shoreline
9CM52	-0.52	-0.57	0.07	Erosion	8	y	6.0	15.0
9CM24 (E)	-0.43	-0.56	0.04	Erosion	147	y	0.4	262.9/114.0
9CM24 (W)	-0.75	-0.70	0.07	Erosion	147	y	0.5	209/114.0
9CM347	-0.43	-0.47	0.07	Erosion	798	y	0.1	1697.1
9CM6	-0.06	-0.16	0.07	Stable	N/A	n	--	stable shoreline
9CM239	-0.06	0.01	0.07	Stable	N/A	n	--	stable shoreline
9CM165	-0.43	-0.46	0.07	Erosion	29	y	1.3	63.1
9CM80	-0.19	-0.24	0.07	Erosion	19 ± 10	n	--	122.0
9CM23	-0.82	-0.83	0.03	Erosion	0	y	Eroded	lost
9CM360	-0.19	-0.28	0.07	Erosion	0	y	Eroded	lost
9CM365	-0.13	-0.14	0.03	Erosion	99	y	0.1	709.3
9CM250	-0.22	-0.39	0.07	Erosion	397	y	0.1	1017.6
9CM242	-0.22	-0.39	0.07	Erosion	177	y	0.2	453.5

Table 1. Shoreline Change Trends for All Sites Surveyed. Negative values represent erosion and positive values represent accretion. Values within the error of the estimated shoreline position are classified as stable. Sites 9CH685 and 9MC401 have two features within one site therefore two shoreline analysis were performed. 9CH127 and 9CM24 have two separated shorelines. 9CH592 and 9CH586 fall into the same location.

Site	% Site Loss per year	Projected Life of Site (yrs)
9GN142	16.0	2.3
9CH817	3.1	4.8
9CM52	6.0	15
9GN66	4.6	18
9CM165	1.3	63
9LI8	1.0	67
9MC90	1.0	88
9BN26	1.0	95
9CM24	0.5	114
9CH203	0.5	153
9CH685 (Argyle Island)	0.4	212
9CH1103	0.4	261
9MC352	0.3	299
9CH953	0.2	404
9CM242	0.2	454
9MC350	0.2	485
9CH155	0.1	590
9CM365	0.1	709
9CM250	0.1	1018
9CM347	0.1	1697
9CH126	0.1	1893

Table 2. Prioritized list of erosional sites in order of projected years until total site loss.

Conclusion

Coastal Georgia is a dynamic environment where natural forces continue to erode coastal landforms. Frequently, important archaeological features are impacted and information regarding human colonization and use of coastal Georgia is being threatened or lost to erosion. Prior to this project, there has been no published study that looked at regional-level data using GIS and historical documents along the Georgia coast. For this study we visited 60 archaeological sites covering several time periods in Georgia's history of human occupation. Archaeological sites included Native American shell mittens, American colonial forts, civil war forts and early 20th century settlements. Nine percent of all sites were already lost. Of the 60 archaeological sites studied, 75% are being actively eroded, among them antebellum burial grounds and civil war living quarters. Only a few sites (17%) were stable and even fewer (8%) exhibited accretionary shoreline settings.

It is not possible to protect every single archaeological site in coastal Georgia. Like nearly all state divisions, the Georgia Historic Preservation Division is faced with decreasing budgets. Using historical maps, aerial imagery, GPS field survey methods in a GIS and the new, moving-boundary GIS analysis tool AMBUR, we provided a list of prioritized sites for detailed documentation. With the ranked order of most vulnerable archaeological sites, we are able to provide a relatively low cost way to identify the most endangered places. As archaeology continues to extend our knowledge into the past, we hope that this work shows that researchers of different disciplines should continue to work together to ensure the preservation, protection and support of our historic legacy.

References

Jackson, C. J., C. Alexander and D. Bush. 2011. Spatio-temporal analysis of shoreline change: The 'ambur' package for *R. Journal of Computer and Geosciences*. In review.

Robinson, M. H., Alexander, C. R., Jackson, C. J., McCabe, C. P., Crass, D., 2010. Threatened archaeological, historic, and cultural resources of the Georgia Coast: Identification, prioritization and management using GIS technology. *Geoarchaeology: An International Journal*. Vol. 25, No. 3, 312-326.