SEDIMENTOLOGICAL EQUILIBRIUM OF MARSHES AND MUDFLATS AT CUMBERLAND ISLAND NATIONAL SEASHORE, GEORGIA

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REFERENCE: Proceedings of the 1993 Georgia Water Resources Conference, held April 20 and 21, 1993, at The University of Georgia, Kathryn J. Hatcher, Editor, Institute of Natural Resources, The University of Georgia, Athens, Georgia.

INTRODUCTION

Coastal wetland loss has become nationally recognized as a significant habitat destruction and degradation process (Frayer et al., 1983 and Park et al., 1989). The causes of land loss in wetlands are complex, however, linkages to natural processes and cultural factors are poorly understood in most cases. Efforts to establish causal relationships have led a number of researchers to develop techniques for assessing changes in marsh environments. Until recently these techniques have been limited to measurements of planimetric change or land loss.

Changes in rates of sedimentation, nutrient supply, and inundation may cause physiological stress to marsh vegetation. The ultimate result is plant death, disintegration of the root mat, and land loss. Few efforts have been directed toward measuring the early process-setting changes. The rate of change in marsh surface elevation -- if it could be measured reliably -- might serve as a diagnostic predictor of these more subtle effects of microtopographical change. Such knowledge could serve as the basis of a very focused countermeasure program to reduce or stop land loss.

Project Purpose. This project was designed to determine whether backbarrier dredging for the King's Bay Naval Base is affecting marsh habitat sustainability on Cumberland Island National Seashore. If this operation is indeed exerting an influence on Cumberland Island, it would most likely be first perceived in the effect it has on the rates of supply and delivery of sediments to the marshes and mudflats.

STUDY AREA

Cumberland Island is the southern terminus and the largest of Georgia's "Sea Isles" barrier island system. It is backed by Cumberland Sound, which receives limited freshwater input from Crooked River and the St. Marys River basin. The sound is connected to the Atlantic Ocean via the St. Marys River Entrance, an artificially stabilized inlet at the southern end of Cumberland Island. Littoral drift on the oceanside at Cumberland Island is toward the south (St. Marys River Entrance). This drift has created a wide sandy beach that fronts relict dunes and modern foredune deposits. The sound is in a mesotidal setting characterized by semi-diurnal tides, with a mean tidal range of 1.9 m and a spring range of 2.6 m.

Three study sites were selected on the southern half of Cumberland Island. The sites consisted of marsh, mudflat, and tidal creek systems that were comparable in morphology but exhibited a spectrum of different exposures to Cumberland Sound and the St. Marys Entrance (Figure 1).

Site 1 - Beach Creek is the southernmost site, located 3 km northwest of St. Marys Entrance inlet. Wave energy, tidal currents and exposure to both inlet and tidal creek processes are greater here than at the other two sites. This location was chosen to provide an indication of the upper limits of sediment erosion and deposition dynamics.

Site 2 - This site is located about 6 km north of Site 1 and immediately across the sound from Kings Bay Naval Base. This location was selected to provide a benchmark for normal backbarrier marsh sedimentation rates away from the influence of the inlet, but near the Kings Bay Naval facility.

Site 3 - This is the northernmost station, located 1.5 km north of Site 2 in the lee of Stafford Island. This location was chosen as the control site to provide an indication of the lower limits of sediment erosion and deposition dynamics.

METHODS

Seven separate field techniques were employed to monitor the horizontal and vertical extent of erosion and accretion at the selected sites. These techniques included: (#1, 2, 3) repeated point measures using field surveys, sedimentation pins, sedimentation table; (#4, 5) marker layer measures using, clay-marker horizons, stable r-are-earth tracers; (6) dating using Cesium (^{137}Cs); and (7) process measurements using sediment flumes.

The areas sampled for each method were nested in close proximity to one another in order to provide a good basis for comparison. Wooden walkways were constructed

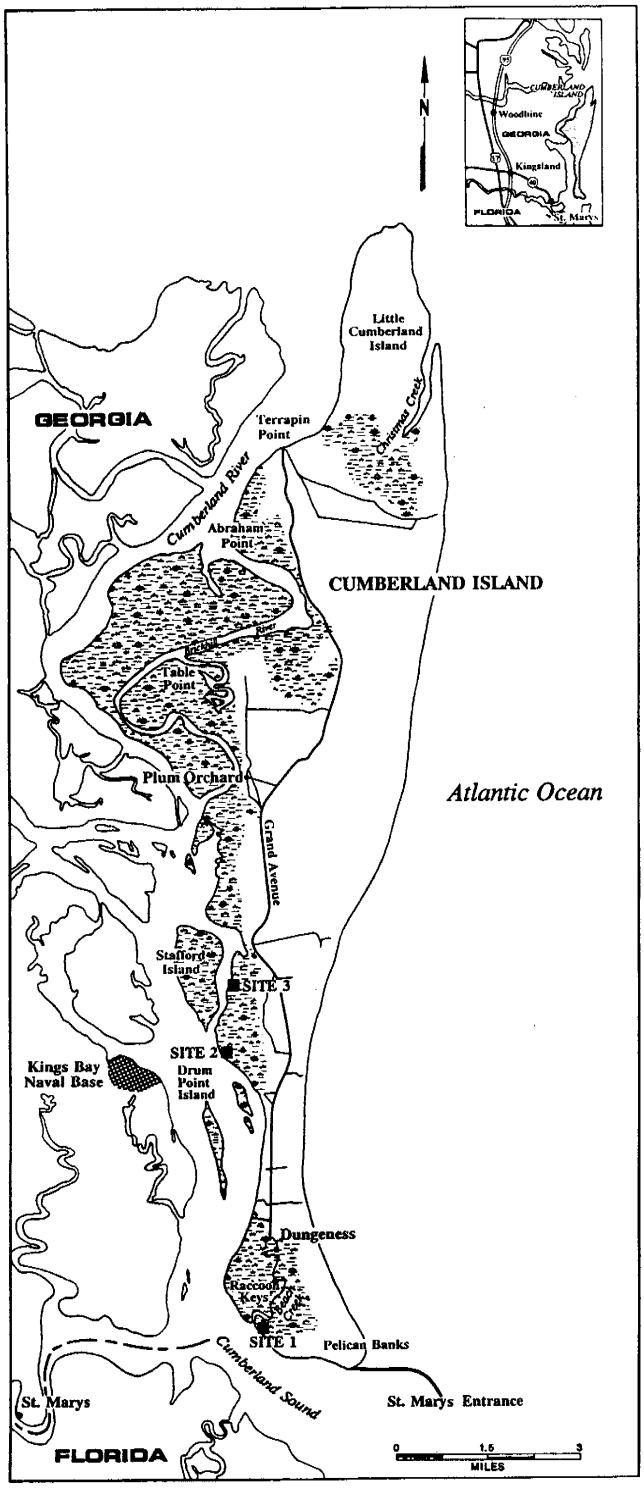


Figure 1. Cumberland Island Location Map

to provide undisturbed access to the sampling areas. Locations of the measurements recorded in this study are shown in Figure 2.

RESULTS

Seven different methods for measuring sedimentation and erosion rates on marsh and mudflat surfaces were being applied for comparison at three backbarrier study sites on Cumberland Island in an effort to determine whether channel dredging is affecting marsh/mudflat habitat sustainability. The data provided here date from December 1989 through August 1991, with final study results to be given in late 1993.

Initial Results (1989-1990). In the first year, the study team compared six of seven different methods (field surveys, sedimentation pins, sedimentation table, Cesium activity, stable rare-earth tracers, and clay-marker layers) for monitoring sedimentation.

An initial evaluation was made of the relative strengths and weaknesses of these various methods. The two marker layer methods were found to be seriously deficient in that they did not have the capability to record erosion. The standard survey approach was too imprecise. The sedimentation pins provided useful results, although they were subject to disturbance from flotsam/jetsam and accidental contact. The sedimentation table was found to have the most advantages in that it: could be referenced to a datum, could monitor erosion, was not susceptible to data loss from physical damage, and provided a high level of accuracy.

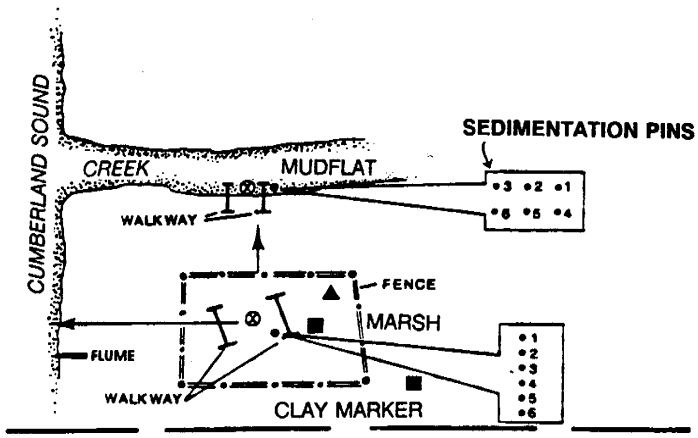


Figure 2. Plan View of Marsh/Mudflat Sampling Locations.

Overall Results (1989-1991). The database collected thus far allows an evaluation of the following: (A) the differences in marsh surface elevations between sites, and (B) the magnitude of short-term vertical changes.

Differences In Marsh Surface Elevations Between Sites

The interior marsh surface exhibits an apparently regional trend of increasing elevation from south to north, with a range of 40 cm between Sites 1 and 3. The marsh surface also varies considerably within individual sites. Topographic surveys established that the surface typically slopes at a slight angle towards the sound and creeks. The other methods show that elevation is also affected by elements of microtopography, which range from high-tide debris deposits to footprints and fiddler crab burrows.

Over a distance of tens of meters, the average vegetated marsh and mudflat surface elevation at any one site at any single time varies within a range of 4 to 17 cm. Over smaller distances of a single meter or less (based on results obtained from the other methods), the marsh and mud surfaces exhibit a range in elevation or roughness of 1 to 6 cm.

The data collected thus far indicate that sedimentation at the marsh/sound/creek interface at Site 1 is the most dynamic. Sediments are both accreting and eroding in this environment. Deposition is occurring low on the profile, near the marsh/water interface and farther inland on the upper marsh surface. An intermediate point that delimits the marsh vegetation line at the sound displays net retreat.

The spatial variability (between Sites 1 and 3) of dissolved nutrients was greater than the temporal variability. The flume data also indicate that sediment mobility is away from the marsh under normal astronomic tide and storm conditions.

Magnitude Of Short-term Vertical Changes

Accretion and erosion of the marsh surface are assumed to be manifested in apparent changes in the elevation of this surface relative to a benchmark or subdatum. Vertical accretion of the Cumberland Island marshes is approximately 0.50 cm yr^{-1}, based on the long-term ^{137}Cs results. A summary of the short-term record of accretion and erosion for the sedimentation pins and table at each site is shown in Figure 3. Accretion or erosion is signified by a plus (+) or minus (-) value, in millimeters.

SUMMARY

Results are presented from one-half of a four-year program designed to determine the effects of the Kings Bay Naval Base dredge channel on the marshes and mudflats of Cumberland Island National Seashore.

Three marsh/mudflat sites, with varying degrees of exposure to the effects from the dredge channel, were selected for detailed, long-term sedimentation and process measurements.

CONCLUSIONS

For measuring minute changes (to the nearest mm) in marsh surfaces, repeated point measures (sedimentation table and sedimentation pins) are favored over marker layer methods (clay-markers and stable rare-earth tracers).

Marsh elevations increase from south to north, with a range of 40 cm between Sites 1 and 3. The marsh surface also varies considerably within individual sites, with the elevation affected by small-scale perturbations, which range from high-tide debris deposits to fiddler crab burrows.

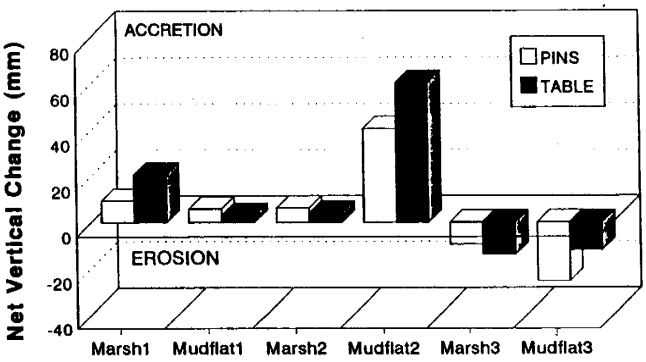
Marshes have accreted approximately 0.50 cm per year based on $^{137}Cesium$ dating.

The flumes established that the spatial variability (between Sites 1 and 3) of dissolved nutrients was greater than the temporal variability. Sediment mobility is away from the marsh under normal astronomic tide and storm conditions.

Sedimentation at the marsh/sound/creek interface at Site 1 is the most dynamic. Sediments are being redistributed on the marsh profile, and areas of erosion and accretion have changed with migration of the marsh vegetation line.

RECOMMENDATIONS

For the three Cumberland Island sites, additional measurements are required and the results could be directed toward the following:



	Marsh1	Mudflat1	Marsh2	Mudflat2	Marsh3	Mudflat3
PINS	9.5	5.9	6.3	40.86	-9.5	-25.6
TABLE	20.7	3	4	60.6	-14	-12

Figure 3: Sedimentation Pin and Table Net Change

1) Evaluating accretion/erosion patterns to identify seasonal trends for each marsh/mudflat environment.
2) Statistical analysis (analysis of variance) to quantify the differences in marsh response attributable to the measurement methods, location (spatial component) and time.
3) Modeling of the effects of the dredge channel on the Cumberland Island National Seashore marsh/mudflat system.

LITERATURE CITED

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