

Final Report to Alabama Center for Estuarine Studies

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Title: Changes in water conditions and sedimentation rates associated with construction of the Mobile Bay Causeway

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Introduction

The Mobile Bay Causeway (Highway 90/98 from its emergence from the Bankhead Tunnel to the high ground in Baldwin County) is a 11.2 km (7 mile) roadway, built in the 1920s to provide a transportation route between Mobile and Baldwin Counties. Although the causeway has bridges to span the Tensaw, Apalachee, and Blakeley Rivers, a built-up roadway traverses the marshlands and acts like a dam across the tidal wetlands. This low barrier impedes the flow of fresh water from the rivers into the bay as well as the movement of saline water from the bay up into the delta. Construction of the causeway reduced the distance available for free exchange of riverine and bay water from approximately 6.9 km (4.3 miles) to 1.2 km (0.75 miles) (Fig. 1). Water exchange occurs through openings representing less than 20% of the original cross section. Riverine and tidal waters flow faster through the narrow channels, and water depths are deeper in those areas. Concurrently, Polecat and Chocalata (Chacaloochee) Bays have become isolated from Mobile Bay.



Figure 1. Portion of Mobile Bay, Alabama Survey of the Coast of the U.S. Published in 1856, Navigation aids corrected to 1881 (on left) compared to same portion of Mobile Bay Nautical Chart published in 1998.

Recently, this blockage of normal flow at the head of Mobile Bay by the Mobile Bay Causeway has become a highly publicized controversial issue. Some environmentalists believe that restoration of pre-causeway hydrology is so important to the overall health of Mobile Bay that they advocate removing almost all of the blockages and building a new elevated roadway. Others believe that stable ecosystems have evolved to fit the current situation, therefore, any changes may cause more harm than good. The actual impact that the causeway has had on the lower delta is difficult to quantify because there is a paucity of data on the ecological conditions before the causeway's construction in the 1920s.

Research objectives

This research focused on Chocalata Bay and used paleoecological and sedimentological methods for demonstrating the effect causeway construction actually had on this relatively small ecosystem. Chocalata Bay is a floodbasin that once received water from overflow events associated with high river levels and from tidal currents (Smith, 1988). Now, the causeway protects the bay from all but the most extreme salt water events coming from Mobile Bay. Our study used (1) diatom analysis as an indicator of water conditions; (2) pollen and phytoliths as indicators of vegetation change; (3) grain size analysis as an indicator of energy conditions; and (4) Cesium-137 (Cs-137) and Lead-210 (Pb-210) to provide dating control for critical horizons in the cores. Carbon-14 (C-14) analysis was dropped from the study because our focus was on the last 200 years and organic material in an estuarine environment is often brought in by currents rather than generated in situ.

In addition to providing information concerning the ecological impact of causeway construction, this work provided research experience for one graduate student from marine sciences and six undergraduate students (1 from physics, 2 from biology, 3 from geography, and 1 from geology). Students worked on various aspects of sample processing and data presentation. Two posters with student co-authorship resulted from their efforts. One of the students had the opportunity to present at a national meeting.

Methods

Fieldwork was accomplished during the summer of 2002. At least three sediment cores were taken at each of four sites in Chocalata Bay using a piston corer. The longest core (Core 1, 190 cm) was retrieved from the northernmost site. Cores in Chocalata Bay north of the Causeway are at least 1 meter long, those south of the Causeway are slightly shorter. Figure 2 shows the location of the coring sites that yielded the best cores for analyses. Cores were kept in cold storage until they were sub-sampled for the various analytical procedures.

Cores from Sites 1, 3, and 4 were sub-sampled at 1 cm intervals for loss on ignition, grain-size analysis, and microfossil analysis. Cesium analysis was done on separate but parallel cores from the same sites also at 1 cm intervals. Dried samples for Cesium-137 analysis were placed in an N-type high-purity germanium (HPGe) gamma-ray detector. The detector operates at low temperatures, provided by liquid nitrogen, has a very high energy resolution, and has a relatively high sensitivity to low-energy gamma rays such as those from Pb-210. We performed Cesium-137 counts down to the level of no further detection. Loss on ignition followed the procedure set forth by Dean in 1974 and was done every 1 cm. Also at 1 cm intervals, we employed the pipette and sieve method of grain size analysis according to methods

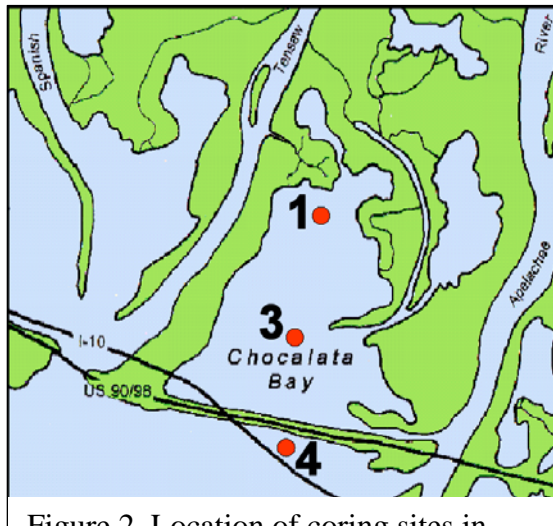


Figure 2. Location of coring sites in Chocalata Bay

outlined in Coventry and Fett (1979). Five to 20g sediment fractions were dried, weighed, disaggregated and transferred into hydrometer jars with 1000 ml of distilled water. Following agitation, 10 ml aliquots were extracted at a specific depth at timed intervals according to Stoke's Law (corrected for temperature; Haywick, 1996). Percent silt and percent clay were determined by weighing the sediment content of these aliquots as collected on pre-weighed filter papers.

Processing for pollen followed standard pollen extraction techniques (Faegri et al. 1989) with the addition of exotic *Lycopodium* markers for concentration calculations. The procedure includes hydrochloric acid to remove carbonates, potassium hydroxide to break organic bonds and remove humic acids, hydrofluoric acid to remove clays, decantation to separate sand from the sample, acetolysis to remove cellulose, tertiary butyl alcohol for dehydration, safranin stain, and silicone oil as a mounting medium. Initial pollen sample processing was at every 2 cm. Counting was at every 4 cm. Processing and counting for biogenic silica (diatoms and phytoliths) was done at the same intervals used for pollen counting. Processing included oxidation with Chlorox to destroy organic material and deflocculation of clays with sodium pyrophosphate. The desired sand and silt sized particles were separated from clays by gravity settling. Biogenic silica was extracted by heavy liquid flotation in zinc bromide (specific gravity 2.3).

Results and Discussion

Cesium-137 is present only in the top 20 cm of cores inside Chocalata Bay while analysis of the core south of the Causeway has Cesium-137 down to 50 cm. Other cores from sub-estuaries around Mobile Bay have Cesium-137 down to 50 to 100 cm (Fig.3). This suggests that the sedimentation rate in Chocalata Bay is low because it is currently isolated from Mobile Bay, its primary sediment source. Claims that the Causeway made Chocalata Bay fill up faster with sediment are not supported by our data. If we extrapolate the rate back in time, the sediments corresponding to Causeway construction should be about 40 cm downcore.

Grain size analyses of the sediment cores indicate that Chocalata Bay was changing from an estuarine to a deltaic environment before Causeway construction. Mobile Bay/delta regional processes controlled the depositional

environment. After construction, more specific local influences dominated (Fig. 4).

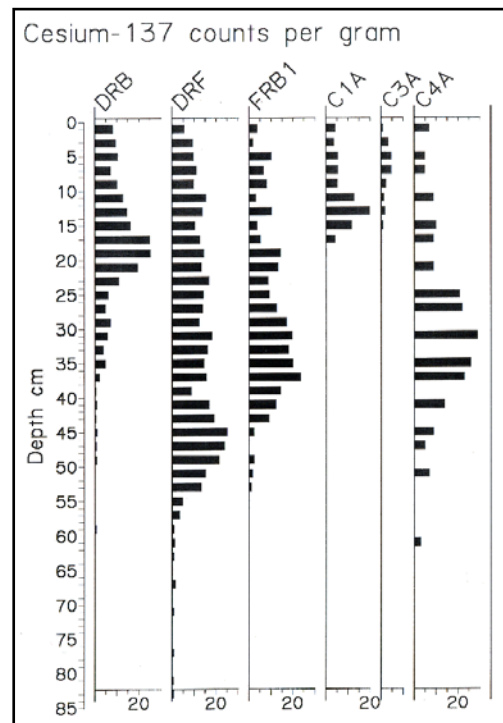


Figure 3. Cesium profiles for the Causeway cores (C1A, C3A, C4A) as compared to profiles from other sites around Mobile Bay

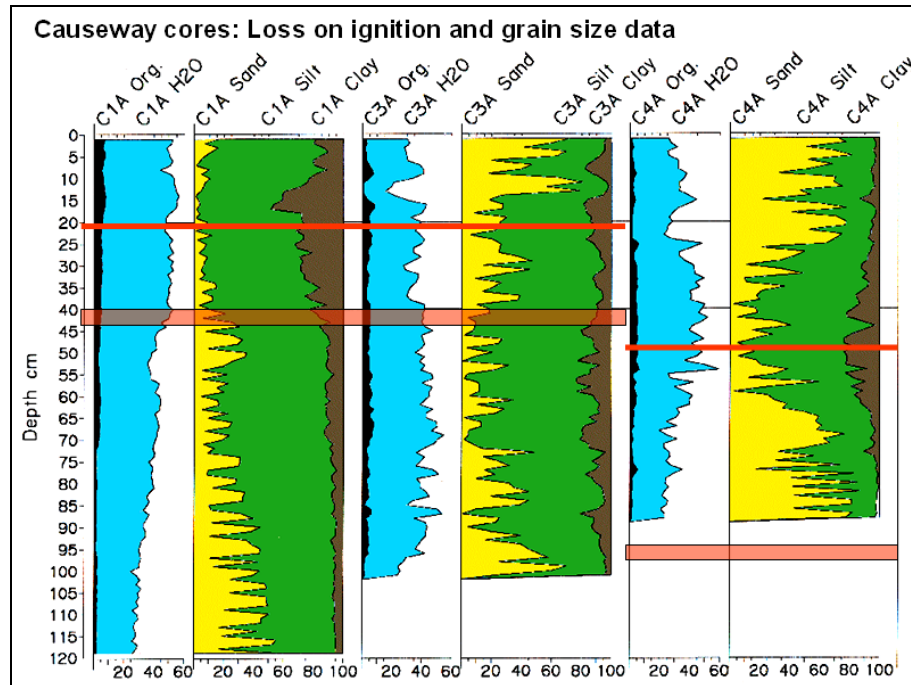


Figure 4. Organic and water percentages, sand, silt and clay percentages for Sites 1, 3, and 4. Top red line indicates Cesium level and bottom red screen indicates estimated causeway construction level.

Pollen analysis of Core 1 (and others) shows that pine (*Pinus*), bald cypress (*Taxodium*), and oak (*Quercus*) have always been the dominant pollen contributing taxa, however, at about 40 cm in Chocalata Bay cores, disturbance indicators become evident (Fig. 5). This coincides well with our extrapolation from the Cesium-137 data that this level marks Causeway construction. Interestingly, water milfoil (*Myriophyllum*) pollen is not apparent until about 30 cm downcore, some 15-20 years after the Causeway was built. Although some Mobilians blame the Causeway for the proliferation of this invasive aquatic species, our data does not confirm the relationship. Pollen concentrations decrease after Chocalata Bay became isolated from Mobile Bay. Apparently, much of the pollen as well as sediment came from Mobile Bay itself as waterborne pollen.

We grouped diatoms into both morphology and salinity classes. In general, biraphid diatoms are mobile while all others attach to plants or sediment. Biraphid diatoms are more common in lower energy environments. They dominate the upper 40 cm of Core 1 inside Chocalata Bay. The upper 40 cm also has slightly higher percentages of freshwater diatom taxa. This supports our grain-size data that suggest lower energy in Chocalata Bay after 1927.

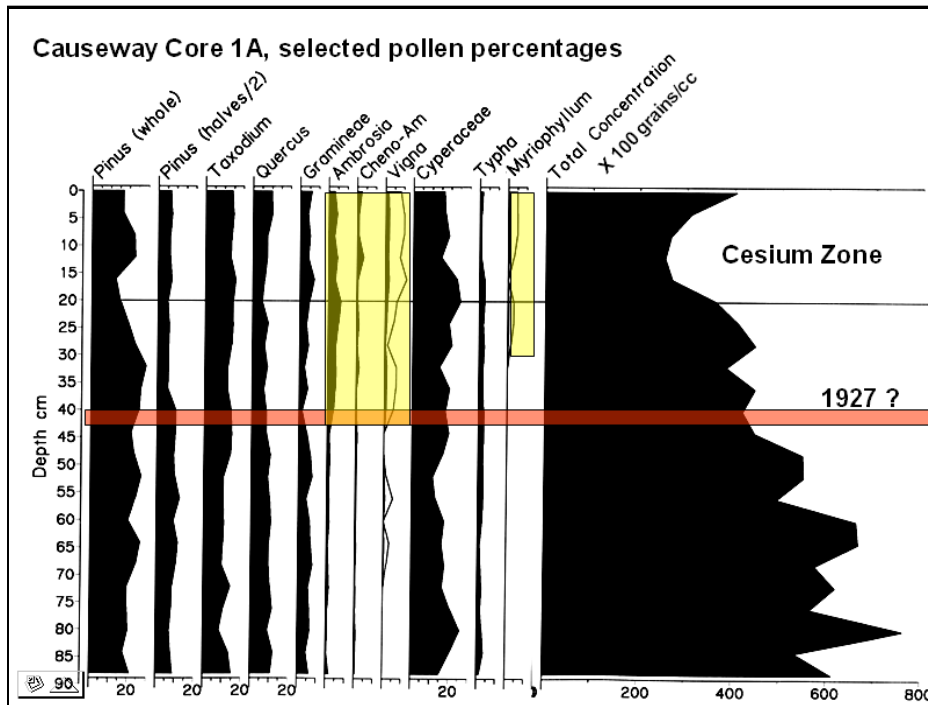


Figure 5. Selected pollen percentages for Core 1. *Ambrosia* (ragweed), *Cheno-Am*, and *Vigna* are disturbance indicators. *Myriophyllum* (water milfoil) appears well after Causeway construction.

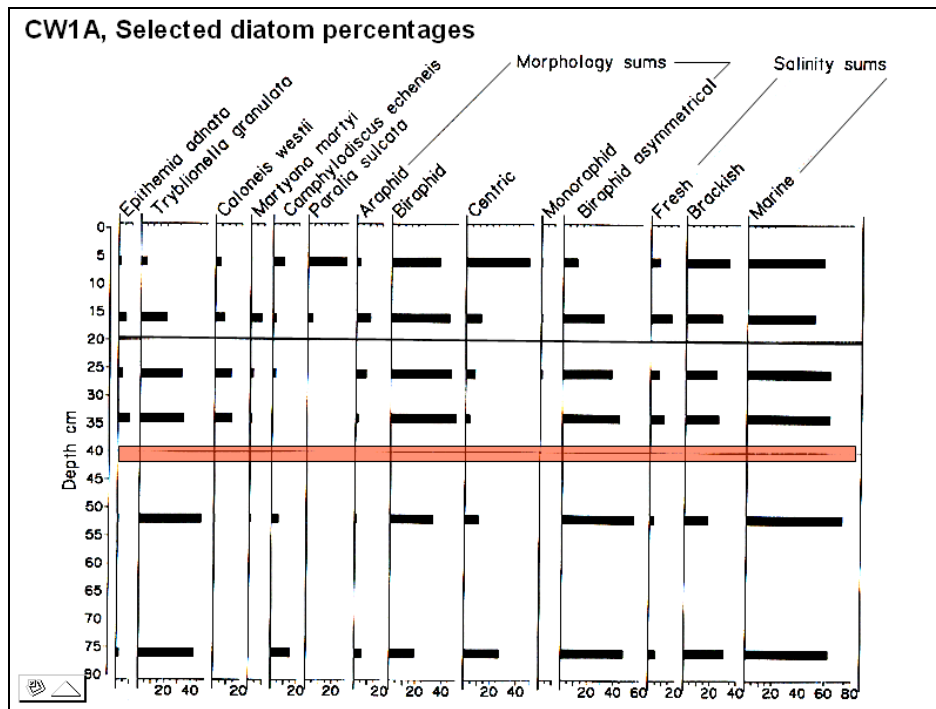


Figure 6. Preliminary diatom data for Core 1. Biraphid diatoms show a distinct increase after Causeway construction. Fresh water taxa also increase.

Conclusions

These data all confirm that about 40 cm of sediment has accumulated in Chocalata Bay since the mid-1920s. It became calmer and slightly fresher after the Causeway was built. With isolation from Mobile Bay, sedimentation decreased. Although the Causeway obviously had an effect on Chocalata Bay, no dramatic recent changes are evident in the sedimentary record. Efforts to remove parts of the Causeway will disturb the habitat that now exists and may not lead to desired “restoration” of the original conditions. Any openings created should be done on a limited basis with careful assessment and monitoring of pre and post conditions.

Publications/Presentations

- Fearn, M. and McCullough, C. 2004. Ecological impacts of causeway construction. In: 2004 Abstract Volume, The Association of American Geographers 100th Annual Meeting, Philadelphia, Pennsylvania, CD-ROM.
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- McCullough, C., Ellison, P. and Fearn, M. 2004. Did Causeway Construction Change Conditions in Chocalata Bay? University of South Alabama Research Forum.
- Haywick, D.W., Fearn, M.L. and Sanders, J.M.. 2003. Sedimentation rates in marginal marine environments in southern Alabama, In: 2003 Abstracts with Programs, Geological Society of America, 2003 Annual Meeting, November 2-5, Seattle, WA. Geological Society of America.

Future Activities

Some data processing remains on this project; however, no expenses are associated with the future work. The supplemental final technical report will be submitted within six months.

Supplemental keywords

estuary, ecosystem, indicators, decision making, Alabama, EPA Region 4.

Relevant web sites <http://www.usouthal.edu/geography/fearn/Causeway.htm>

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