

Final Report Executive Summary

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Title: An Estimate of the Upper Limit of Wave Level Tolerance for *Spartina alterniflora* in Coastal Alabama

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Institution: University of South Alabama

Research Category: ACES regular grant

Objectives of the Research Project: The restoration and creation of coastal wetlands has become a priority in many regions because of historic losses of coastal wetlands due to development pressures and the combined effects of sea level rise and subsidence. In order for a wetland community to become established, vegetation must be able to recruit and survive. Salinity, sediment type, elevation, and wave climate are some of the important factors influencing vegetation growth. Many studies have described relationships between salinity, sediment composition, oxygen, and nutrition levels with marsh vegetation; however, only a few investigators have closely examined wave climate. Those investigators (Knutson, et al. 1981 and Keddy 1982) used surrogates for wave climate such as sediment size, shoreline configuration (headland or cove), and/or fetch distance (the distance across water over which the wind blows to generate waves) to evaluate wave climate at wetland sites.

Wave climate refers to the long-term frequency of occurrence of wave characteristics such as wave height (vertical distance from crest to trough), length (horizontal distance from crest to crest), and period (amount of time required for one wave length to pass a stationary point). Wave climate is influenced by fetch, wind direction and speed, offshore and near-shore depths, near-shore bottom slope, shoreline orientation, and distance from navigation channels. Oceanographers and engineers typically forecast and hindcast waves using more comprehensive evaluations and formulations of windspeed, fetch, depth, and shoreline orientation than the above mentioned approaches for wetland wave climate evaluation. Using historic wind records in the wind-wave generation equations can provide hindcast estimates of wave height and, thus, wave climate at a site. However, these wave generation models have not been extensively explored for evaluating biological communities such as wetlands.

The primary objective of this study was to investigate the use of wind-wave hindcasts in estimating the wave climate, in terms of wave height, at sites along the bay shorelines of Alabama in hopes of finding a critical range of wave climate exposure (highest tolerable amount of wave energy) for wetland establishment and survival. A secondary objective was to quantify such a critical level of wave energy for use in the design of minimal breakwater systems in conjunction with engineered wetland creation projects in open water sites.

Summary of Findings:

The critical, upper limit of wave tolerance for a wetland species is quantified in terms of wave height apparently for the first time ever in the literature. Sites with existing *Spartina alterniflora* along the shorelines of coastal Alabama were fairly well segregated from sites without vegetation (i.e. sandy beaches) in terms of the site-specific wave climate. Sites with vegetation were found to have lower wave height levels than the nearby sites without vegetation. Other sites with eroding stands of vegetation had wave levels which were intermediate between the no-vegetation and vegetation sites.

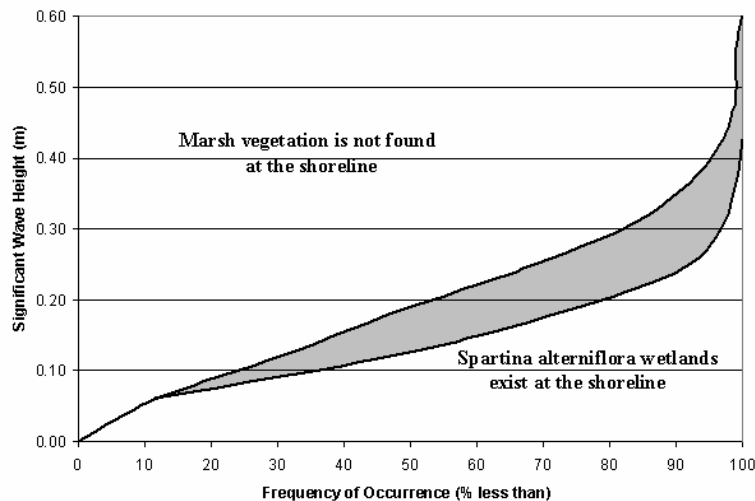


Figure. Wave levels where *Spartina alterniflora* wetlands existed at the shoreline in this study. The upper area indicates wave levels beyond the limits for wetland vegetation at the shoreline. The intermediate grey area indicates wave levels where eroding wetlands occurred.

The above figure summarizes the critical wave height frequency conditions where *S. alterniflora* was found in this study. The wave height frequencies shown in the figure were generated by hindcasting waves at each of nine specific sites in Mississippi Sound and Mobile Bay for a 14-year period using hourly wind data from the Dauphin Island Sea Lab and the wave generation methodology recommended by US Army (1984). That methodology uses Hassellmann's parametric wave generation equations modified for shallow water.

The actual critical wave height values can be found by examining any given frequency in the figure. The upper limit of wave energy for (non-eroding) salt marsh existence was found to be a median (50th percentile) significant wave height of about $H=0.13$ m and a corresponding 80% percentile (less than this level 80% of time) significant wave height of $H=0.20$ m. Sites with less wave energy had vegetation along the shoreline.

The results indicate that wave height frequency distribution based on wind-wave modeling hindcasts is an appropriate methodology for wave climate evaluation at wetland sites. Given that the critical level is now expressed in terms of wave height, the results can be used to minimize the size of breakwaters used in constructed wetlands.

The initial objectives and hypotheses for this research project included constructing and monitoring wetlands with breakwater systems. However, discussions with state-level permit agencies in 2000-2001 made it clear that no new breakwater systems were going to be permitted until the scientific community in coastal Alabama came to some consensus as to the desirability of these types of projects. Thus, research related to monitoring could not be achieved within the originally planned three-year time frame. Therefore, a decision was made to focus on the development of the analysis for quantifying an upper limit of wave tolerance as described above.

Publications/Presentations:

Roland, R.M. 2003 “Wave climate evaluation for *Spartina alterniflora* existence in coastal Alabama, master’s thesis, Department of Marine Sciences, University of South Alabama, Mobile, AL, May 2003.

Douglass, S.L., Roland, R.M. and Stout, J. 2003 “Bulkheads on Urban Estuarine Shorelines on the Gulf Coast,” oral presentation at 17th Biennial Conference of the Estuarine Research Federation, Seattle, WA.

Roland, R.M. and Douglass, S.L. 2004 “Wave tolerance of *Spartina alterniflora* in coastal Alabama,” accepted for publication in the *Journal of Coastal Research*.