Assessing the Vulnerability of Coastal Marshes to Sea Level Rise

Background

Coastal marshes are threatened by factors associated with global change such as sea level rise. The objectives of my study are to examine the rates of elevation change (subsidence) of Chesapeake Bay marshes, specifically Nanticoke estuarine marshes, in response to global change, and of particular interest, sea level rise and resultant saltwater intrusion. Site specific information is necessary to the vulnerability of a marsh given that stress variables are expressed in varying degrees of magnitude, differing site by site. In situ studies in the Chesapeake Bay region, specifically comparing different marsh types (e.g. submerged upland, estuarine meander) of differing salinity regime (e.g. tidal freshwater marsh, oligohaline and mesohaline) may indicate which marshes may be the most vulnerable to global change, allowing for concentrated management efforts on those marshes at greatest risk. Not only would this be valuable for management efforts in Chesapeake Bay, but information could be added to a growing body of information used to understand how coastal marshes along the eastern coast of the United States respond to global change, especially sea level rise.

Phase I, Work Completed: Surface Elevation and Accretion Trends of Estuarine Salinity Gradient

My project has been conducted in two phases. The first phase was conducted to determine rates of surface elevation change and accretion/erosion in marsh environs. This phase was funded through a grant awarded to Dr. Andrew Baldwin from the National Institute for Climate Change Research (NICCR), data were collected with intriguing/novel results. Rates of accretion and elevation change were collected utilizing the Surface Elevation Table (SET)-Feldspar Marker Horizon (MH) methodology beginning in October 2007 (baseline) until present. The primary objective, of this phase of the study, was to understand surface elevation change of Chesapeake Bay coastal marshes in response to factors associated with sea level rise, and to determine factors contributing to subsidence trends along the estuarine salinity gradient of the Nanticoke estuary. Initial data reflect a trend in rates of elevation change and accretion significantly differing between marshes of differing salinity regimes. Results suggest that mesohaline marshes at the mouth of the estuary are more resilient, and tidal freshwater marshes are subsiding but at a very low rate. The most intriguing and novel finding so far, however, is that mid-estuary, oligohaline marshes of the Nanticoke estuary are experiencing the highest rates of subsidence. Previous studies observed the greatest loss in lower-estuary, submerged upland marshes (Kearney et al. 1988); however, preliminary data indicate that oligohaline marshes may be more highly impacted and may exhibit greater amounts of loss or drowning. This is one aspect we hope to understand better in the second phase of the project.

Another important aspect of understanding coastal marsh response to the effects of sea level rise is to examine resultant salt water intrusion. To do this, an in situ experiment was designed to examine the effects on vegetation and surface elevation of sea salt addition. It is hypothesized that tidal freshwater marshes will exhibit high rates of subsidence (a decrease in the rate of elevation change) in the presence of sea salts. Sulfate reduction is a more efficient decomposition pathway compared to methanogenesis (the dominant form of decomposition in tidal freshwater marshes)(Howarth 1984). Sulfates are present in sea water and may expedite decomposition, causing rapid subsidence. SETs were installed in a tidal
freshwater marsh in MD (Jug Bay) and wells were then installed in ½ of the plots. Instant Ocean, a synthetic combination of sea salts will be applied to the top 30 cm (the root zone) of SET plots via PVC wells. The experiment has been installed and 1 summer of treatments were applied; however, rates of elevation change require more years of data to be meaningful and only one set of data points have been collected. Treatments will resume in March 2011 and continue throughout the growing season.

Phase II, Work yet to be Completed: Soil Cores, *In situ* field experiment

Upon completion of my Master’s degree, I began work on my PhD in the summer of 2009, continuing without project funding, to monitor rates of elevation change and accretion. In addition to the ongoing monitoring of these sites, project objectives and hypotheses were formed based on preliminary (Master’s work) data. After observing significantly higher rates of subsidence in oligohaline marshes, new research questions were determined to explore the trend. In identifying possible underlying factors, it was noted that the depth to underlying sand (a possible indicator of age or formative process, i.e. submerged upland vs. estuarine meander marsh) was significantly deeper in oligohaline marshes, potentially indicating a contributing factor in the greater rates of subsidence. Greater depth may coincide with a greater mass of organic matter within the soil profile. In marshes with a greater mass of organic matter, compaction and decomposition may exert a greater influence and contribute to higher rates of subsidence. To examine the potential differences in organic matter mass and depth of profile, cores will be taken with a MaCaulay sampler to underlying sand at 5 sites (3 cores/site) along the Nanticoke estuary, at the same sites elevation change has been measured. Cores will be taken in 25 cm sections and analyzed for organic matter content, salinity, and bulk density. Basal peat samples will be Carbon 14 dated in order to determine the age of the marsh (time of formation). One project goal would be to identify whether some estuarine marshes are more vulnerable to the effects of sea level rise and global change (i.e. having greater masses of organic matter that can be compressed or decomposed, indicated by age of the marsh) in order to direct management techniques. An index of vulnerability for estuarine marshes could be useful in targeting management efforts at those marshes most likely to subside. At this time, there are no other studies examining the effect of underlying substrate on marsh subsidence and the work that is proposed in this project would be a useful addition to the body of knowledge on understanding the responses of coastal marshes to sea level rise and global change. Cores have been collected at 2/5 sites, and few samples have been analyzed. The remainder of the cores will be taken and analyzed in the summer of 2011. At this time, due to lack of funding, basal peat samples have not been dated.

Hydrologic Reconnaissance Study

Local hydrologic conditions can significantly affect marsh elevation. Large amounts of groundwater can cause the highly organic marsh profile to swell, increasing elevation. Drought and watertable lowering can shrink marsh profiles, reflected in a decreased surface elevation (Whelan et al 1994). In order to determine the magnitude of hydrologic effect on surface elevation and rates of elevation change, I plan to monitor SETs each hour throughout a tidal cycle. The main objective for this is not only determining hydrologic effect, but also ensuring that elevation change trends are resultant of subsidence and not hydrologic condition.
Conclusion

Coastal marsh loss has been significant in Louisiana and areas of Chesapeake Bay due to global changes including sea level rise, groundwater withdrawal and nutrient pollution. After observing rates of subsidence in the Nanticoke estuary, potential contributing factors have been identified that could be used to develop an index of vulnerability based on marsh age and salinity regime. This would be useful for management efforts in order to address the most threatened marshes. Upon completion, this project will give us one of the clearest pictures of marsh health above and below ground, across a 6 year time horizon, across a 50 mile transect in the Chesapeake Bay. The scale alone has is significant, resulting in new techniques and processes for assessing marsh health. The results will be used to develop a clearer picture of the factors that contribute to marsh health, and to update models of marsh loss.

Usage of Funds

Funds provided by the scholarship would be utilized for Carbon 14 basal peat samples, renting a GPS unit that measures actual elevation of marshes relative to sea level, Instant Ocean for treatment application, project supplies (e.g. gasoline for boat, sample bags) and labor (student assistance in soil sample processing, field help), and if allowable, travel costs for field sampling.

Summary:

Overall project objective:

To understand the responses of coastal marshes to global change, specifically, sea level rise

Objective 1: To understand observed elevation change and accretion trends along an estuarine salinity gradient, specifically to determine possible causes for high rates of subsidence in mid-estuary sites

Methods: SET-MH, Sediment cores and Carbon 14 analysis

Objective 2: To determine effects of sea salt addition on surface elevation of a tidal freshwater marsh

Methods: In situ Instant Ocean addition field experiment, SET-MH

Goal: To further understanding of responses of coastal marshes to global change, and to possibly create an index of vulnerability of coastal marsh types

References

