SEA LEVEL CHANGE

GLOBAL CLIMATE CHANGE IMPACT ON THE UPPER TEXAS COAST

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ENVIRONMENTAL ISSUES

VERY FEW SCIENTISTS STILL QUESTION GLOBAL WARMING and the role humans have had in the process, while outside the science community it is largely viewed as a prediction. The reality is that climate change and associated accelerated sea-level rise are not predictions. Tide gauge records are supported by satellite data telling us that the rate of rise has significantly increased within the past two centuries. These combined results indicate that the rate of global sea-level rise averages ~3.0 mm/yr, although the actual rate varies regionally (Rahmstorf et al., 2007; Church et al., 2011; Carlson, 2011). However, within the northwestern Gulf of Mexico, subsidence contributes to relative sea-level rise with rates in east Texas as high as 6.0 mm/yr (Paine, 1993). Regardless of the actual value, this is a multifold increase over the long-term rate of the past few thousand years of ~0.40 to 0.60 mm/yr (Milliken et al., 2008). The only mechanisms that can cause such a rapid increase in the rate of sea-level rise are heating and expansion of the oceans and melting of glaciers and ice sheets; both are known to be occurring at unprecedented rates. The main uncertainty in predicting the actual magnitude of sea-level rise is the contribution from the Greenland and Antarctic ice sheets, but both ice sheets are exhibiting signs of instability.

It is generally accepted that the rate of sea-level rise will continue to increase during the 21st century given rates of heat uptake by the oceans, the fact that the vast majority of glaciers have shifted to a negative mass balance and recent observations indicating a negative mass balance for large portions of the Greenland and West Antarctic ice sheets (Rignot et al., 2011).

While an increase of only a few millimeters per year may seem insignificant, numerical models indicate that an increase of just 1 mm/yr in the rate of rise can result in an increase in the rate of shoreline retreat of several meters per year. It has been more than 7,000 years since sea level was rising as fast as the current rate. At that time the upper Texas coast experienced episodes of retreat as high as 60 m/yr (Figure 1, Rodriguez et al., 2004). Indeed, most modern barrier islands and modern bays did not form until after the rate of sea-level rise had slowed to less than 1 mm/yr (Anderson, 2007), (Figure 2). Add to the equation the impacts of human alteration to sediment delivery to the coast, such as construction of dams that prevent sediment being carried to our bays and coastal lands, and it is easy to understand why our coast is experiencing such dramatic change.

Current rates of shoreline erosion along the upper Texas coast range from 0 to 4 m/yr. The variability in erosion rates is largely due to differences in the rate of sand supply to the coast, differences in rates of subsidence and human alteration of the shoreline.

One of the more problematic impacts of global climate change is increased frequency and magnitude of severe storms (Elsner et al. 2008; Emanuel, 2005; Webster et al., 2005). While the scientific community is still divided on this issue, studies of the geological record of severe storm impacts indicate no notable variation in storm impacts across the northwestern Gulf of Mexico coast during the past few thousand years (Wallace and Anderson, 2010). In addition, there have been no significant differences in the

FIG. 1

GALVESTON TIPPING POINTS

SEA-LEVEL CURVE FOR THE NORTHWESTERN GULF OF MEXICO SHOWING THE LONG-TERM DECLINE IN THE RATE OF RISE OVER THE PAST SEVERAL THOUSAND YEARS. THE BLUE BOX SHOWS THE HISTORICAL (RED) AND PROJECTED (YELLOW) RATE OF RISE. NOTE THAT MODERN BARRIERS OF THE UPPER TEXAS COAST FORMED AFTER THE RATE OF RISE HAD DECREASED TO LESS THAN ABOUT 3 MM/YR, WHICH IS THE CURRENT RATE OF RISE (FROM ANDERSON ET AL., 2010).

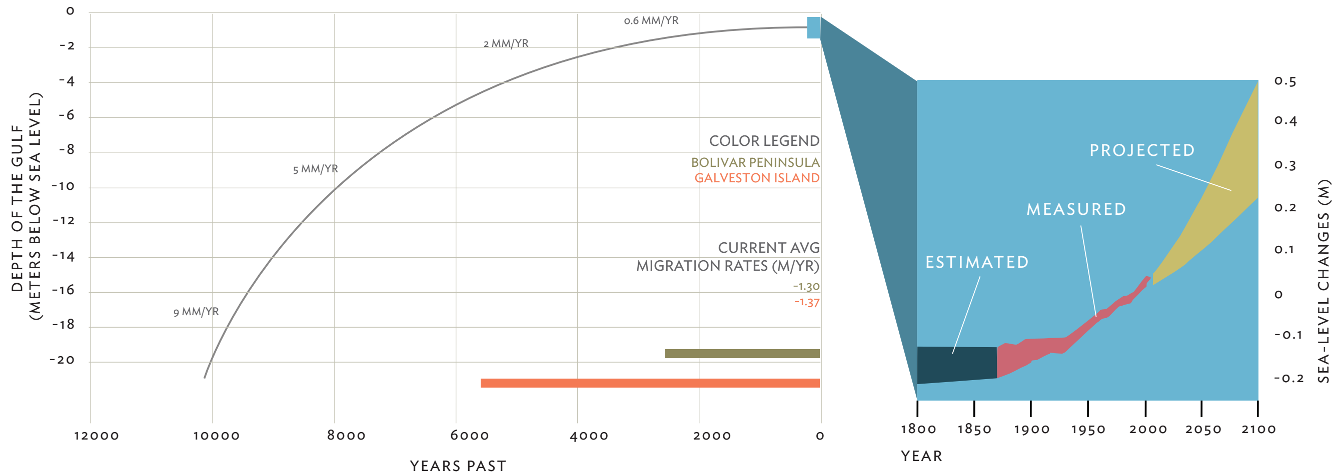

FIG. 2

PALEOLITHIC SHORELINE

CHANGES IN THE UPPER TEXAS SHORELINE DURING THE PAST 7,700 YEARS. THIS MAP IS BASED ON YEARS OF MARINE GEOLOGICAL RESEARCH AIMED AT IDENTIFYING PAST SHORELINE POSITIONS. (MODIFIED FROM RODRIGUEZ ET AL., 2004).

landfall probabilities between the eastern and western Gulf of Mexico, suggesting that storm steering mechanisms have not varied during this time.

Texas is currently experiencing extended droughts, which severely impacts our water supplies, landscape, and economy. Here again, there are lessons to be learned from geological history. Paleoclimate records from around the state reveal a history of climate variability between warm/dry and cool/wet cycles that reflect natural climate variability over millennial time scales. There is a dire need for additional research to understand the natural climate variability along the upper Texas coast to test numerical models for predicting climate change in the region.

The acceleration of sea-level rise, coupled with minimal sediment supply to the coast, has resulted in increased rates of coastal erosion, both along the Gulf Coast and within bays, and loss of wetlands (Morton et al., 2006; Paine et al., 2012). Thus, the first line of defense against storm surge in more inland areas is being removed. At the same time, the population of the greater Houston area continues to push south and into areas that are highly vulnerable to storm surge. The highly vulnerable Port of Houston and petrochemical industry at the head of Galveston Bay continues to expand. The City of Galveston refuses to adopt a setback policy for new construction along the Gulf shoreline. We are truly living in a "state of denial."

One of the greatest obstacles facing the scientific community is communicating knowledge about global climate change and its impacts to policy makers. In Louisiana, where the problems are more chronic, there is far greater awareness of the issue. As a result, that state has already developed a comprehensive coastal management plan, which is a requirement for future federal funding related to the BP settlement. The Texas General Land Office has just begun working on a comprehensive coastal management plan, but to date that process has resulted in little more than a color brochure and a long shopping list of projects that require attention. We are far behind in our ability to predict coastal response to global climate change, and this is an essential requirement for a comprehensive coastal management plan. Without a comprehensive plan, there will be less money for research and without research there can be no real comprehensive plan. We must break this cycle.

In the past few years there has been an increased effort on the part of the science community to become better organized, share information about the potential impacts of global climate change on coastal environments, and convey scientific knowledge to policy makers (Anderson, 2013). For the most part, these efforts have failed at the city to the state level. Texas has an outstanding academic knowledge base to provide scientific input to the development of a comprehensive coastal management plan. The most widely published academic coastal scientists have joined together in the "Gulf Coastal Science Consortium" intended to provide scientific information and advise on coastal issues (https://shellcenter.rice.edu/Content.aspx?id=2147483966). To date, there has been minimal effort on the part of the General Land Office of Texas to seek input from its leading coastal scientists in preparing a comprehensive coastal management plan. We need to continue to explore ways to inform policy makers about the realities of global climate change, its ongoing impact on our coast, and potential environmental and socio-economic impacts of continued denial of these issues. We owe it to future generations. C

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