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Gulf Coastal Science Consortium
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A Consensus Statement

<u>Sea-Level Rise and Subsidence</u>

The Issue

The historical acceleration of sea-level rise is real (Rahmstorf, 2007; Nicholls and Cazenave, 2010). The most recent scientific results indicate that the rate of sea level rise in the northern Gulf of Mexico has increased from the long-term pre-historic rate of less than 0.6 mm/yr (the rate for the past ~3000 years, Milliken et al., 2008) to the current rate of nearly 3.0 mm/yr. The increased rate of rise is attributed to expansion of the oceans as they are heated and from water released to the oceans by glaciers and ice sheets. Both effects on sea-level are now well documented (Rahmstorf, 2007; Vermeer and Rahmstorf, 2009). Scientists predict that the rate of rise will likely at least double by the end of this century (Bindoff et al., 2007). Vermeer and Rahmstorf (2009) predict that sea-level rise will be a meter or more by 2100. This does not account for potential contributions to sea-level rise from accelerated retreat of the Greenland and West Antarctic ice sheets (Zwally et al, 2005), which are currently exhibiting signs of instability.

What the Science Says

Tide gauge records from around the Gulf of Mexico show different rates of relative sea-level rise over historical time. The geographic variation in the rate of rise is due to subsidence as a result of compaction and consolidation of younger, organic-rich sediments, downward movement associated with faults, and to human impacts, in particular groundwater and oil and gas extraction (Morton et al., 2006; Törnqvist et al., 2008). All of these factors vary along the coast, resulting in geographic variability in subsidence.

The highest rates of subsidence are in coastal Louisiana. There, estimated rates have been as high as 23 mm/yr (Shinkle and Dokka, 2004). Differences in the magnitude of the rates are, in part, real and reflect regional variability due to those factors mentioned above. The Mississippi Delta shows a large discrepancy between the historic rates of subsidence from benchmark leveling work (Shinkle and Dokka, 2004) and those for the past ~1.5 ka (Törnqvist et al., 2008). Therefore, there is consensus that the current rate of subsidence in some areas must be unprecedented, implying human influence.

Our Analysis

We performed a survey of the latest research on climate change. Like the vast majority of scientists, we accept that climate change is a reality and that mitigating its effects requires a swift and effective response.

Implications

Sea-level rise will pose serious challenges to the Gulf Coast in terms of maintaining flood control and navigation systems. Increasing water levels will make these systems more vulnerable to flood damage. Increasing sea level will also threaten valuable natural systems such as wetlands and barrier islands. These are immensely valuable ecosystems from both ecological and economic perspectives.

Given these factors, it may be impossible to protect all residents of the Gulf Coast from the impacts of sea-level rise; the problem is especially chronic in south Louisiana. The loss of wetlands due to rising water levels may also make employment based on wetland estuaries less sustainable. This information should be clearly and honestly presented to coastal residents and others so that fully informed decisions can be made.

There is a need for clear policies to address these issues. Society has to look carefully at these problems and search for realistic solutions. Attempts to deny the problem will only make the solution more difficult down the road.

Sediment Supply and Management

The Issue

Prediction of coastal response to sea-level rise requires information about both the rate of sea-level rise and sediment supply. Constraints on sediment supply and dispersal mechanisms are necessary for predicting coastal change and analyzing possible ways to combat change. Many areas of the Gulf Coast are faced with insufficient sediment supply to keep pace with the acceleration of sea-level rise that is already occurring.

What the Science Says

By far the most serious case of coastal response to decreased sediment supply is that of south Louisiana. Diversion of river sediment away from the Mississippi Delta plain and into the Gulf of Mexico has resulted in dramatic loss of wetlands and, according to some scientists, may be unrecoverable (Blum and Roberts, 2009). However, it could be possible to divert sediment from the Mississippi River in order to build back eroding land (Kim et al., 2009; Nittrouer et al., 2012). Elsewhere, rivers that supply sediment to bayhead deltas have been dammed. These include the Trinity and San Jacinto rivers (Galveston Bay), Sabine and Neches rivers (Sabine Lake), Alabama River (Mobile Bay), and Appalachicola River (Appalachicola Bay). The long-term impacts of these dams have not been properly assessed, but it is known that the Sabine and Trinity bayhead deltas have experienced significant loss of their delta plains over the past few decades (Milliken et al., 2008; Anderson et al., 2008).

Natural salt marsh shorelines of estuaries are being replaced with bulkheads and riprap. These modifications can provide property some protection from flooding, but at the price of long-term sustainability. Most tidal inlets and deltas, which represent unique habitats where estuarine and Gulf of Mexico waters are mixed on a daily basis, have been altered by dredging and jetty construction. The likely impacts of these changes to tidal deltas involve significant reductions in sediment supply and retention, which has resulted in a reduction in their size and the salinity structure of adjacent bays and estuaries.

Our Analysis
Sediment supply varies naturally in response to climate, sea-level rise and fall, and storminess. However, the natural delivery has been reduced by damming that traps the coarser sediment at the upstream ends of reservoirs, changes in land-use practices, and construction of levees separating sediment-charged channel flow from adjoining wetlands. Aside from the Mississippi Delta, sediment supply in most places has naturally been low over recent geologic time.

Implications
Sediment supply and management is a serious issue for coastal communities around the Gulf of Mexico. Many shorelines around the Gulf of Mexico are rapidly eroding, with much of this due to a combination of low sediment supply and/or a mismanagement of the available sediment supply. In areas where sediment supply is naturally low (i.e. Texas, Mississippi, and Alabama), it is especially critical to manage sediment resources wisely. Along the Mississippi Delta, sediment diversion projects could aide in the reestablishment of wetlands.

Hurricanes

The Issue
The impact of hurricanes on the Gulf of Mexico coast is perhaps the most dramatic of the aforementioned issues. History has shown us that no area is safe, and hurricanes Katrina (2005), Ike (2008), and Isaac (2012) exemplify their devastating effects. Further, there is now compelling evidence that suggests that the frequency and magnitude of hurricanes could be changing into the future.

What the Science Says

There is now compelling evidence that the frequency of strong hurricanes will increase in the 21st century (Knutson et al., 2010). Emanuel (2005) showed that Atlantic sea surface temperatures in the tropics increased roughly 1^{o}C over the past half century. During this time interval, the total hurricane intensity increased by about 80 percent. Over the past several decades, the frequency of category 4 and 5 storms has increased (Webster et al., 2005). Based on an analysis of factors contributing to hurricane intensity, it appears as though the increased frequency of category 4 and 5 storms between 1970 and 2004 was directly linked to increased sea surface temperatures (Hoyos et al., 2006). Some have argued, however, that these increases are not linked to climate change but to decadal cycles in tropical storm activity (Goldenberg, 2001). Whether the recent intensification of hurricanes is due to climate change or is part of a multi-decadal cycle, it appears likely that the future will bring stronger hurricanes.

Our Analysis
We support the consensus within the hurricane research community that Atlantic hurricane strengths will likely increase, while the overall frequency of storms will likely decrease (Knutson et al., 2010). These changes are associated with human-induced greenhouse warming.

Implications
This increased frequency of intense storms will likely increase the likelihood of associated natural disasters along Gulf of Mexico coastlines. Management plans for coastal communities should emphasize development that is both sustainable and resilient to these stronger storms.

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