Coastal Litigation in the Context of Science Literacy

Chris McLindon
New Orleans Geological Society

The various lawsuits filed by levee boards and parish governments in the coastal zone of south Louisiana since 2013 have had obvious impacts on the energy industry, and by extension on the thousands of people that worked on the drilling rigs and production platforms, as well as in the service industries, restaurants, hotels and stores across the coast. Although less obvious, the same lawsuits also pose an existential threat to the long-term sustainability of coast as a whole. Scientific understanding of the processes that controlled changes in the coastal wetlands in the past, and the processes that will affect changes in the coast going forward has been in a state of continual flux over the past few decades. New research and new technology is constantly evolving our collective understanding of how, when and where we can maintain a sustainable existence along the Louisiana coastline. The most important component of any plan to achieve coastal sustainability is a shared understanding, by the entire community of stakeholders, of the basic science that forms the foundation of the plan.

This type of community understanding and engagement in science is the centerpiece of the 2016 report from the National Academies of Sciences, Engineering and Medicine:

> ***Science Literacy – Concepts, Contexts and Consequences***
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> "The value of community participation in scientific research is widely recognized and supported by evidence. Community involvement can bring new questions to light, provide data that would otherwise be unavailable, encourage the integration of qualitative and observational data with experimental data, increase the robustness and public relevance of data collection strategies, garner political and community support for conclusions, produce new instruments and technologies, and build community awareness and knowledge."

The principal challenge to building community awareness and knowledge of new observational data and new technologies is the inherent level of science literacy in the community. In the coastal community of south Louisiana this refers to the general state of public knowledge about the loss of coastal wetlands over the past few decades and our ability to restore those wetlands to their previous states of existence. A poll of a representative portion of the residents of coastal Louisiana is likely to reveal a set of commonly held beliefs about these issues:

1. The wetlands of south Louisiana were built up in a continuous and progressive increase in land area by the deposition of sediment by the Mississippi River over the last 6,000 years.
2. Until the middle part of the 20th century these wetlands provided a protective buffer to most residents of coastal Louisiana from storm surge generated by hurricanes.
3. The loss of hundreds of thousands of acres of wetlands over the past few decades is an unprecedented event in the history of the coast.
4. Wetlands loss has primarily been caused by coastal erosion caused by saltwater intrusion carried into the wetlands by oil and gas canals.

5. Because wetlands loss was primarily caused by the action of humans, it can also be reversed by the actions of humans.

The fact that none of these beliefs is supported by any significant portion of the most current body of peer-reviewed scientific literature is a direct measure of the general state of science literacy regarding coastal issues in the local community. The fact that the coastal lawsuits are fundamentally based on and reliant on this set of beliefs is a direct indication of how the lawsuits threaten long-term coastal sustainability. Taken together this set of beliefs may be considered the "coastal litigation science model", and they are explicitly expressed in the introduction of the first coastal lawsuit:

> ***Board of Commissioners of the Southeast Louisiana Flood Protection Authority-E, et al. v. Tennessee Gas Pipeline Company, LLC, et al., No. 2013-6911, Civil District Court for the Parish of Orleans, Louisiana***
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> "Coastal lands have for centuries provided a crucial buffer zone between south Louisiana's communities and the violent wave action and storm surge that tropical storms and hurricanes transmit from the Gulf of Mexico. Coastal lands are a natural protective buffer, without which the levees that protect the cities and towns of south Louisiana are left exposed to unabated destructive forces.
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> This natural protective buffer took 6,000 years to form. Yet, as described below, it has been brought to the brink of destruction over the course of a single human lifetime. Hundreds of thousands of acres of the coastal lands that once protected south Louisiana are now gone as a result of oil and gas industry activities– all as specifically noted by the United States Geological Survey."

The challenge of building community awareness and knowledge about the current state of coastal science is a foundational component in achieving long-term sustainability. The coastal litigation science model stands in direct opposition to any effort to achieve the necessary levels of science literacy in the community. The way in which coastal litigation challenges science literacy can best be understood by examining the coastal litigation science model in comparison to other principal challenges to science literacy in modern American culture:

1. The teaching of "creation science" in public education
2. The anti-vaccination movement
3. Accuracy in media coverage of science
4. The anti-industry equals pro-environment paradigm
5. Unrealistic expectations about future outcomes in natural systems

<u>The teaching of "creation science" in public education</u>

The U.S. Supreme Court has ruled that the teaching of creationism as science in public schools is unconstitutional. The essence of the scientific problem with creationism was captured in the exchange in which Clarence Darrow examined William Jennings Bryant in the 1925 Scopes Trial. In that exchange Bryant explained how in 1650 Irish bishop James Ussher had determined that the earth was created at midday on October 23, 4004 B.C. Modern science recognizes that the earth is approximately 4.6 billion years old, and Ussher's calculation that the earth is only 6,000 years old is often attributed strictly to religious dogma. However, noted evolutionary biologist Stephen Jay Gould famously came to Ussher's defense in his 1991 essay "The Fall of the House of Ussher". Gould contended that Ussher had used “the best of scholarship in his time. He was part of a substantial research tradition, a large community of intellectuals working toward a common goal under an accepted methodology.” Ussher’s findings were likely not based solely on religious belief. Gould noted that many cultures have had creation stories that invoke a very similar timeframe. It is likely that the 6,000-year period of the creation science model is the result of a basic limitation of human beings to perceive the span of geologic time. In much the same way that humans are only capable of seeing a narrow window of the electromagnetic spectrum that we call “visible light”, it is likely that we are only inherently capable of conceiving of a narrow span of time equivalent to the 6,000 years that we commonly call “recorded human history”. Technology has allowed for us to devise ways to “see” wavelengths in the infrared and ultraviolet portions of the spectrum, and we have similarly developed analogs and metaphors that help us to understand the scope of geologic time, such as the “football field geologic time scale”. It appears likely however, that the creation science model exposes a basic human tendency to limit our perception of the world to the last 6,000 years. That is in fact the principal challenge that creationism poses to science literacy.

The first serious challenge to the creation science model came during the 18th century Scottish Enlightenment. James Hutton, often considered the father of geology, studied the rock outcrops around Edinburgh, and determined that the earth would have to be considerably older than 6,000 years to allow for all of the complexities that he was seeing in the rocks. Hutton proposed that the modern landscapes were not the result of a continuous, straight-line set of processes from creation to the present, as creationism held. He saw them as the result of innumerable cycles of building, destruction, and rebuilding. The creation science model did not allow for the many repeated cycles of change that were recorded in the rocks. The challenges to science literacy presented by the coastal litigation model are nearly identical to those presented by the creation science model. The coastal lawsuits clearly envision that the “natural protective buffer” was the result of a 6,000-year period of uninterrupted land-building. They present the recent period of land loss in stark contrast to the preceding period of land-building.

The formation of the coastal wetlands of south Louisiana did occur over the past 6,000 years. The seminal work of David Frazier “Recent Deltaic Deposits of the Mississippi River: Their Development and Chronology” published in 1967 delineated 16 historical deltas of the Mississippi River, and numbered them accordingly by age. Each one built a discernible delta ecosystem consisting of river channels, swamps and marshes. The coastal wetlands at the surface today are partial remnants of those 16 deltas. Only a small portion of the total land area built over the last 6,000 years is still at the surface today. This is because the wetlands were not built up in a straight-line, continuous process. They are the result of a cycle of building, destruction, and rebuilding, commonly called the “delta cycle”. The nature of the delta cycle is best captured by examining the profiles of sedimentary layers that Frazier constructed across the coast. One of those profiles extends from New Orleans East to Grand Isle. Where it crosses lower Barataria Basin the profile shows the arrangements of the sedimentary deposits of Frazier’s delta numbers 7, 10 and 13. Delta 7 crossed into an open Barataria Bay about 3,500 years ago. It built up a delta across Barataria Bay raising the elevation of the land by several feet. After the period of about 500 years over which Delta 7 received water and sediment from the Mississippi River Basin, the river channel switched and started flowing through a channel that is represented today by

Bayou Terre aux Boeuf in St. Bernard Parish. Delta 7 was abandoned, and began to lose elevation due to subsidence. Over the next few centuries it submerged beneath the surface, and Barataria was once again an open bay. By about 2,000 years ago the river had built the massive St. Bernard Delta (Frazier 8 & 9) to its maximum area. The delta covered well over 2,500 square miles, and supported cypress swamps, and probably the inhabitation of human beings. When the St. Bernard Delta had reached maximum area the river switched back into Barataria Bay, and began building Delta 10. Delta 10 continued building for the next 300 years, and it filled in the bay and built new emergent land across the area. About 1,800 years ago the river switched into the channel that is now represented by Bayou Sauvage, and it built up the area that is now New Orleans with Frazier Delta 11. The abandoned Delta 10 fell victim to the forces of subsidence, and it sank below the surface. Barataria Bay was once again an open body of water. About 1,000 years ago the river moved back into Barataria Bay and built up a new delta. Frazier Delta 13 extended out past the barrier islands south of Bastian Bay, and eastward across Breton Sound into St. Bernard. Delta 13 was the active delta during the time period generally associated with the inhabitation of several archeological sites in the area. The state of submergence of these archeological sites is a testament to the subsidence that has occurred since Delta 13 was abandoned about 300 years ago. This is the point at which the river switched to its current channel in Frazier Delta 16, also called the “modern birdfoot delta”.

Frazier’s profile across Barataria Bay shows that the remains of Delta 7 are now about 30 feet below the surface, having originally submerged about 2,000 years ago. The sedimentary deposits left by Delta 10 overlie those of Delta 7 and are found about 15 feet below the surface. Much of the original Delta 13 began to sink below the surface well before the first land loss figures were collected. In the past 85 years Barataria Bay area has continued to experience a measurable amount of land loss, but it is a small portion of the total loss of land area in Delta 13 that occurred prior to the first measurements. The total original land areas of Delta 7 and Delta 10 have also been “lost” due to subsidence. This same sequence happened with other historical deltas over and over across coastal Louisiana throughout the last 6,000 years. Deltas are stacked one on top of the other. In addition to Deltas 7 and 10 all of Deltas 3, 5, 8 and 9 have also completely submerged below the surface, and are overlain by the deposits of younger deltas. The great deltas that once reached out into the Gulf of Mexico and Breton Sound are now represented by submerged sand shoals that were once their delta’s edge. Trinity Shoal, Outer Shoal, Ship Shoal and St. Bernard Shoal are all vestiges of Frazier’s Deltas. The wetlands were not built up by a continuous process of land-building. Land loss is an inextricable part of the building of the wetlands. It can be reasonably estimated that 20,000 square miles of total land loss has occurred in southeast Louisiana over the past 6,000 years. The measure of land loss that has occurred in the last 85 years, since measurement began, is a very small portion of the total. The submergence of the wetlands in the areas of abandoned deltas going on today is very much a continuation of the natural processes of the delta cycle.

The characterization of the protective buffer of the wetlands being “been brought to the brink of destruction over the course of a single human lifetime” by the coastal lawsuits needs to be understood in two contexts. First, “over the course of a single human lifetime” is another way of saying “since 1932”. Nearly all land loss figures for coastal Louisiana are quoted as “since 1932”. This is for the simple reason that 1932 aerial photographic surveys are the first reliable basis from which to measure changes in land area. 1932 is otherwise a completely arbitrary point in time from which to measure land loss. The fact that the survey was taken 85 years ago, the span of a human life, is a coincidence. If it were possible to make land loss measurements "since 1902" or "since 1887", the values for total land loss would be different than those measured "since 1932". Reconstructions of the St. Bernard Delta by the U.N.O. Coastal Research Laboratory show that hundreds of thousands of acres of land area was lost during the span of a single human lifetime at around the time of the Roman Empire as the delta wetlands subsided below the surface. The second context in which to understand the reference to changes that have occurred over a single lifetime is something that may be called "the expectation of permanence". Anyone that has been to the beaches along the Gulf Coast more than a few times knows that the sand bars that are generally found just off the beach can migrate towards, and away from, and along the beach over relatively short periods of time. There is no reasonable expectation that the configuration of the sand bars is going to be the same at any one beach from summer to summer, or even from week to week. The barrier island systems that parallel the Gulf Coast also experience patterns of migration that are similar to those of sand bars, but on a much slower time scale. The difference is that sand bars migrate rapidly enough that we can perceive their movement. Changes to the shape and location of barrier islands take much longer – generally creating an expectation of permanence about barrier islands as features of the coastal landscape. In the same way, each turn of the delta cycle takes centuries to complete, and most people living in the coastal communities have an expectation of permanence about the delta wetlands. It is this unfounded expectation shared by most of the coastal community that allows for the natural submergence of the wetlands to be characterized as them having "been brought to the brink of destruction". This is one of the principal challenges to science literacy posed by the coastal litigation model.

<u>The anti-vaccination movement</u>

The U.S. Centers for Disease Control and Prevention website offers links to a set of scientific studies to support their position on a web page titled "Vaccines Do Not Cause Autism". The anti-vaccination movement grew up around the opposite position. The movement is an example of a challenge to science literacy that has its origins within the science community. In this case the origin was a peer-reviewed scientific study published in the British medical journal "The Lancet" in 1998. Gastroenterologist and medical researcher Andrew Wakefield was the lead author of the study titled "Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children". The study received wide notoriety, and initiated many research efforts to reproduce its results. Eventually scientific research found that the conclusions of this initial study – that vaccines had a role in causing autism - were not correct. Unfortunately, the initial credibility that had been afforded to the idea has allowed it to sustain a significant degree of public acceptance. This type of challenge to science literacy requires a sustained effort by the science community to continue to generate research and publications that address the issue.

The principal challenge to science literacy posed by the anti-vaccination movement is the confusion of correlation with causation. Rebecca Goldin is Professor of Mathematical Sciences at George Mason University and Director of STATS.org, a collaborative project run by the organization Sense About

Science USA. The project is also run in association with the American Statistical Association to "improve statistical literacy among journalists, academic journal editors, and researchers". Dr. Goldin used the anti-vaccination movement as a subject in a 2015 essay about correlation and causation:

> ***Causality, Correlation is not Causation***
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> "When the stakes are high, people are much more likely to jump to causal conclusions. This seems to be doubly true when it comes to public suspicion about chemicals and environmental pollution. There has been a lot of publicity over the purported relationship between autism and vaccinations, for example. As vaccination rates went up across the United States, so did autism. And if you splice the data just right, it looks like some kids with autism have had more vaccinations. However, this correlation (which has led many to conclude that vaccination causes autism) has been widely dismissed by public health experts. The rise in autism rates is likely to do with increased awareness and diagnosis, or one of many other possible factors that have changed over the past 50 years."

The challenges to science literacy posed by the anti-vaccination movement are nearly identical to those presented by the coastal litigation model. The original lawsuit makes the contention that "Hundreds of thousands of acres of the coastal lands that once protected south Louisiana are now gone as a result of oil and gas industry activities – all as specifically noted by the United States Geological Survey". Like the anti-vaccination movement, this latter contention has its origins within the science community, and is a clear case of confusing correlation with causation. The original publication referred to in the coastal litigation model is U.S.G.S. Open File Report 00-418 "Process Classification of Coastal Land Loss between 1932 and 1990 in the Mississippi River Delta Plain, Southeastern Louisiana" published in 2000. The document is actually a map of the coastal wetlands upon which scientists at the U.S.G.S. made graphical and tabular allocations of the causes of wetlands loss across south Louisiana. There is minimal explanatory text accompanying the map, and so there is no discussion of any causal processes associated with the allocations. The determination by this report that the direct removal of marsh material by the dredging of oil and gas canals was responsible for 11.14% of wetlands loss between 1932 and 1990 is roughly consistent with the findings of OCS Study MMS 87-0120 "Causes of Wetland Loss in Coastal Central Gulf of Mexico" published by the U.S. Minerals Management Service, another branch of the Department of Interior, in 1987. The latter study did not contain any maps or graphic representations of the areas of land loss, but it determined that "Total canal area is estimated to be 10% of the Louisiana coastal region in 1978 and directly accounts for approximately 6.3% of the total wetland loss from circa 1955 to 1978. However, a strong statistical relationship between canal density and total wetland loss indicates that the indirect impacts of canals account for a substantially larger percentage of total wetlands loss." In other words the study found that there appeared to a correlation between the location of canals and areas of wetland loss.

This "strong statistical relationship", or correlation, noted by the MMS study appears also to be the primary explanation for the allocation of 24.92% of total wetlands loss to the category "Submergence due to Altered Hydrology associated with Oil and Gas" on the Open File Report 00-418 map. Without any scientific explanation of causal effects that would relate the areas of land loss to their association with oil and gas canals by either report it is not possible to make any scientific assessment beyond the observation of an apparent correlation.

The U.S.G.S. appears to have remedied this situation by replacing Open File Report 00-418 with an updated land loss study. Scientific Investigations Map 3164 "Land Area Change in Coastal Louisiana from 1932 to 2010" was published in 2011. The newer report replaced the older one with new and more accurate assessments. The more recent report is also significant in that it recognized the difficulty in attempting to make correlations of land area changes and specific causes:

Scientific Investigations Map 3164 - Land Area Change in Coastal Louisiana from 1932 to 2010

> "This assessment provides a comprehensive analysis of historical trends and rates of land area change in coastal Louisiana. The primary improvement over past efforts is an increased temporal frequency of analysis. This gives scientists the ability to better quantify the amount of wetland loss and the time period in which it was lost. Having this information can allow gradual loss patterns to be distinguished from losses due to episodic events such as hurricanes. The spatial and temporal patterns observed reveal a dynamic landscape changing as a result of the complex and often interactive effects of natural and human-induced processes… These analyses have shown that episodic events, such as hurricanes and other extreme storms, have contributed significantly to coastal land loss, particularly in recent years."

The U.S.G.S. changed its interpretation of land loss from an attempt to allocate cause based on correlation in the older report to the recognition by the newer report that spatial and temporal patterns of change are the result of complex and often interactive effects of natural and human-induced processes. In simplest terms the report found that it is not possible to allocate causes of wetlands loss, and the most recent U.S.G.S. study does not support an allocation of cause. The extent to which the Coastal Litigation Model promotes the idea that the U.S.G.S. attributes causal relationships to wetlands loss is a direct measure of the threat that it poses to science literacy.

Accuracy in Media Coverage of Science
The anti-energy industry equals pro-environment paradigm

These challenges to science literacy are considered together because the latter appears to offer the best explanation for the oversights in accurate reporting on science as it relates to the energy industry. Journalistic coverage of issues involving the coastal wetlands of south Louisiana have played a prominent role in developing the commonly-held set of beliefs upon which the coastal litigation model is built. Each of the elements of the coastal litigation model listed previously herein has been included in some form by countless publications in the popular media over the last few decades. The content of one of those publications will be used here as a representative for an examination of scientific accuracy. "The Most Ambitious Environmental Lawsuit Ever" by Nathaniel Rich was published by The New York Times Magazine on October 23, 2014.

The Most Ambitious Environmental Lawsuit Ever

> "In Louisiana, the most common way to visualize the state's existential crisis is through the metaphor of football fields. The formulation, repeated in nearly every local newspaper article about the subject, goes like this: Each hour, Louisiana loses about a football field's worth of land. Each day, the state loses nearly the accumulated acreage of every football stadium in the N.F.L."

This metaphor, that comprises the first sentence of the article, is by far the most commonly used description of the status of the coastal wetlands in the popular press. It is completely inaccurate, and its pervasive use underscores a significant problem with the press and science literacy. The metaphor originates with the U.S.G.S. Scientific Investigations Map 3164 "Land Area Change in Coastal Louisiana from 1932 to 2010". The pamphlet that accompanies the map includes the sentences "Trend analyses from 1985 to 2010 show a wetland loss rate of 16.57 square miles per year. If this loss were to occur at a constant rate, it would equate to Louisiana losing an area the size of one football field per hour." The analysis done by the U.S.G.S. was a very accurate trend analysis of rates and patterns in changes in land area over a fixed period of time. The football-field-an-hour metaphor was used to provide a visualization for the reader. It was clearly intended to represent an average rate of land loss determined by trend analysis over a quarter of a century time span. It was not intended to represent a constant rate of present-day land loss, as it was used in the article. The U.S.G.S. document clearly states that land loss rates have been decreasing from the high rates observed in the 1970s. It also noted "an interesting finding of this analysis may be observed in the increase in net land area in the 2009 and 2010 datasets." These are the last two years of the study. The data indicate that not only is NY Times article's application of the football metaphor for present-day land loss incorrect, the actual present day figures for land area change are closer to net gain than they are to net loss.

> "The land loss is swiftly reversing the process by which the state was built. As the Mississippi shifted its course over the millenniums, spraying like a loose garden hose, it deposited sand and silt in a wide arc. This sediment first settled into marsh and later thickened into solid land. But what took 7,000 years to create has been nearly destroyed in the last 85."

These sentences were directly inspired by the text of the first lawsuit, and they capture the essence of the coastal litigation/creationist concepts of a continuous and progressive increase in land area by the deposition of sediment by the Mississippi River to build up the coastal wetlands. The article makes no attempt to explain the cyclical patterns of land-building and land loss that went into the formation of the wetlands.

> "Beneath the surface, the oil and gas industry has carved more than 50,000 wells since the 1920s, creating pockets of air in the marsh that accelerate the land's subsidence. The industry has also incised 10,000 linear miles of pipelines, which connect the wells to processing facilities; and canals, which allow ships to enter the marsh from the sea. Over time, as seawater eats away at the roots of the adjacent marsh, the canals expand."

There is nothing in the content of these sentences that resembles scientific accuracy. Not a single sentence is supported by demonstrable facts. There are no peer-reviewed scientific publications that support any of the conclusions of these sentences. Ideas such as the acceleration of subsidence rates due to pockets of air created by drilling oil wells can only have arisen as fabrication from the author's mind. The concept has no tangible relationship to anything that could be considered physical science. Canals dredged by the oil and gas industry were done so to allow for the access of drilling rigs and small work boats to the well locations. Any canal that was large enough to have allowed ships to enter the marsh from the sea, such as the Mississippi River Gulf Outlet, were dredged primarily for the benefit of the shipping industry.

The prevalence of the concept that anti-energy industry equals pro-environment in the popular media appears to have led to a certain degree of laxity in fact-checking content. Certainly, if the contents of this article were about allegations made against specific individuals or about stories in which numerical accuracy was important such as sports or the economy, the facts, figures and allegations would have been checked for accuracy. There appears to have been no effort made to generate content based on the support of published science literature, nor to verify the accuracy of the content using the resources of the science community. It would also appear that the unspoken justification for the laxity in constructing and editing the content of the article is that its intention was to be pro-environment - as if to say that the good intentions of publishing a pro-environmental article supersede the importance of scientific accuracy. There is nothing in the content of the article that expounds on how coastal litigation qualifies as "environmental" lawsuits beyond the implicit observation that they are anti-energy industry. The collaborative engagement of the popular media with the supporters of the coastal litigation science in articles like this one amounts to an aggressive attack on science literacy in the coastal community.

Unrealistic expectations about future outcomes in natural systems

The coastal lawsuits are based on two fundamental assumptions that challenge science literacy primarily because they are taken as fact and do not allow for any measure of uncertainty or discussion within the coastal community. The first is perhaps the foundational contention of the coastal litigation model – that wetlands provide a buffer against storm surge. The second is the basic premise for the lawsuits to seek monetary damages – that if humans caused land loss, then humans can reverse it. Neither of these assumptions is treated with any measure of certainty within the science community, and they are often the subject of vigorous debate. Neither assumption is based on sound and realistic expectations that are supported by a broad base of scientific research. The promotion of unrealistic expectations about future outcomes by the coastal litigation model is the essence of the existential thread that it poses to the long-term sustainability of the coastal zone. In order to achieve the goal of sustainability it is essential that all stakeholders maintain realistic expectations about future outcomes.

Several prominent scientists have expressed doubt about the ability of wetlands to buffer storm surge. Dr. Jeff Masters is the Director of Meteorology for the Weather Underground website owned by The Weather Channel. He publishes a blog on meteorological science including hurricanes and storm surge. In blog posting about storm surge he said "The inland penetration of the storm surge is an extremely complicated function of storm track, speed, duration, size, and associated waves; the regional topography, geometry of the shore, presence of barrier islands, and slope of the ocean bottom; plus the type and thickness of vegetation, and presence or absence of levees. If a marshland is subject to strong winds for long enough, the wetlands will completely flood, and there will be no reduction of storm surge at all--and an increase in storm surge is even possible, according to the mathematical equations governing the surge (Resio and Westerink, 2008). This has occurred in Louisiana during a number of storms--Hurricanes Rita, Katrina, Gustav, Ike, and Hurricane Betsy." Dr. Stephen Baig, who retired in 2008 as the head of the National Hurricane Center's storm surge unit, also contributed to the Weather Underground blog on storm surge saying "Once a marsh has more than a few feet of water overlying it the frictional effect of the grass is erased. The mythical '2.7 feet of surge reduction per inland mile of marsh' is just that, a myth. Also, it's unfortunate that the sand islands that front the shoreline are called 'barrier' islands. They are certainly not barriers to storm surge. They get over-topped or breached with regularity. They are functionally useless as surge protection."

The integration of realistic expectations has been a centerpiece in the development of the 2017 Master Plan for Coastal Restoration. The Master Plan document states under the heading "Clear Expectations": "Evaluations were made with the understanding that we cannot recreate the coast of the 20th century. Instead, we must seek to fashion a new landscape that will support viable natural and human communities into the future." This stands in stark contrast to the commonly held conceptions promoted by the coastal litigation model that wetlands can be restored to a previous state of existence. In order to hold on to the premise that humans have been the primary cause of wetlands loss, and therefore humans can restore the lost wetlands, the model must ignore the geophysical forces of subsidence that have driven changes in the wetlands for millennia. The 2017 Master Plan bases all future changes in land area on the combined effects of subsidence and sea level rise. Any effort to achieve long-term sustainability in the coastal zone must recognize that subsidence and sea level rise are the principal causes of the submergence of the wetlands, and it must maintain realistic expectations about what can be done to reverse the effects those processes.

FINDING A SOLUTION

The existential threats to long-term sustainability in the Louisiana coastal zone are the threats to science literacy that are embodied in the coastal lawsuits. The effort to find solutions to these threats must come from within the science community. The energy industry is a science-based industry. It is one of the largest employers of scientists in the Louisiana coastal zone. It is imperative that energy industry must take a leadership position in bringing science to the forefront of coastal sustainability planning.

The essential role that the energy industry must play in developing science research to support coastal sustainability was captured by Dr. Sherwood Gagliano, a prominent coastal geologist, in two publications from 2003 and 2005 respectively:

> **Neotectonic Framework of Southeast Louisiana and Applications to Coastal Restoration**
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> "A century of oil and gas activity has made the subsurface of Southeastern Louisiana, which lies in the Gulf Coast Salt Dome Basin (Gulf Basin), one of the most understood geological provinces on earth. Thousands of wells have been drilled; hundreds of thousands of seismic lines have been run; and the geological literature is voluminous. The success of the oil and gas industry in this and other similar sedimentary basins throughout the world attest to the validity of the process-response models of sediment loading, compaction, salt movement and fault adjustments developed by geologists and geophysicists working in the Gulf Basin. A working premise of the present study was to use this solid foundation of research as a basis for understanding and predicting land form and environmental change."
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> **Effects of Earthquakes, Fault Movement, and Subsidence on the South Louisiana Landscape**
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> "Remarkably, there has been an information disconnect between the geologists and geophysicists working in the petroleum industry and the community of scientists, engineers and planners engaged in

coastal restoration. The restoration community is largely oblivious to the tectonic dynamics of the region. A major goal of the research reported herein is to apply the knowledge gained from the interactive tectonic depositional model, as derived from the rock and landform record, to a better understanding of modern coastal change. This in turn will strengthen the basis for planning and design of coastal restoration projects."

The models developed as a result of research in the Gulf Salt Basin include David Frazier's model for the formation of the coastal wetlands of Louisiana. Frazier's determination of a cyclic process of building, destruction and rebuilding of historical deltas was the result of his studies at the Exxon Research Lab. The role of the energy industry in supporting coastal research must also extend beyond sharing research and knowledge base. The industry must engage with the academic research community. Since 2013 the integration of industry seismic data into academic research has proven to be one of the most valuable advances in coastal sciences. Research projects at the University of Texas at Austin, Tulane University, the University of New Orleans Coastal Research Laboratory, the University of Louisiana at Lafayette, and Louisiana State University have all advanced the science and technology of understanding coastal processes by using industry seismic data over the past four years. In just the past few months several of these academic institutions have begun to work collaboratively to expand the scope of their research to directly address the challenges of coastal sustainability. There is nothing more important that the energy industry can do to insure a sustainable existence in the coastal wetlands than to support this research.

chris_mclindon@att.net