Coastal Geology Retreat

Galveston, Texas

Hosted by Sheila, Katy, and Jenni, Geology Instructors for TPWD Becoming an Outdoors Woman, April 2019

TENTATIVE ITINERARY

Day 1

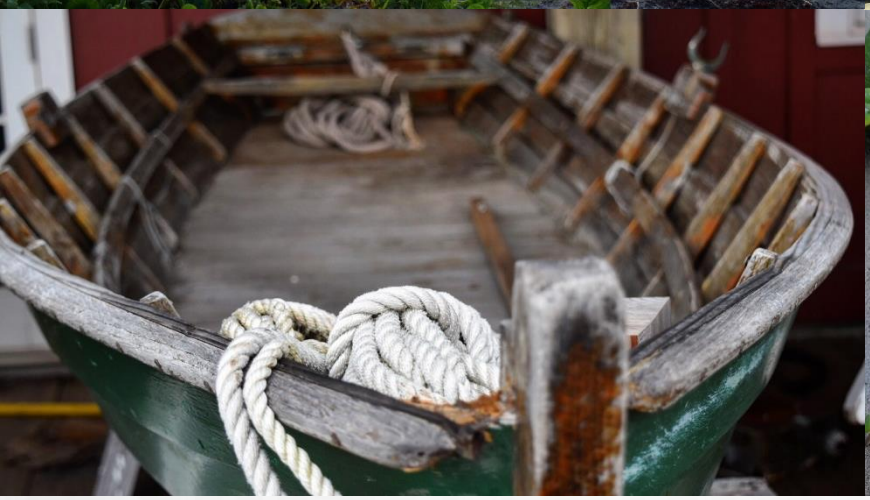
Participants may arrive at beach house as early as 8am
Beach geology, history, and seawall discussions/walkabout

Day 2

Drive to Galveston Island State Park, Pier 21 and Strand, Apffel Park, and Seawolf Park

Day 3

Participants choice!
Check-out of beach house by 11am
Activities may continue after check-out



GEOLOGIC POINTS OF INTEREST

Seawall

Barrier island formation, shoreface, swash zone, beach face, wrack line, berm, sand dunes, seawall construction and history, sand composition, longshore current and littoral drift, wavelengths and rip currents, jetty construction, Town Mountain Granite geology

Parks and Museum

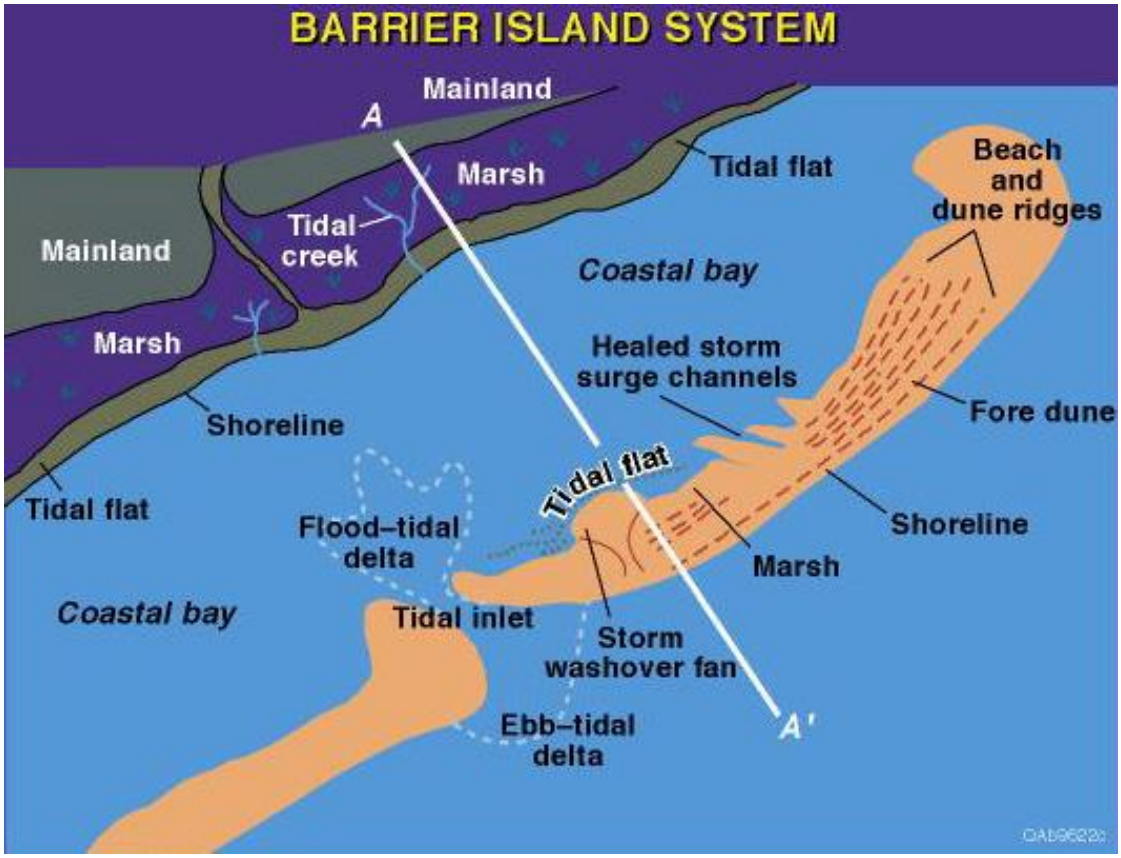
Beach foreshore, backshore, dunes, lagoon and tidal flats, back bay, salt marsh wetlands, prairie, coves and bayous, Pelican Island, USS Cavalla and USS Stewart, oil and gas drilling and production exhibits, 1877 tall ship ELISSA

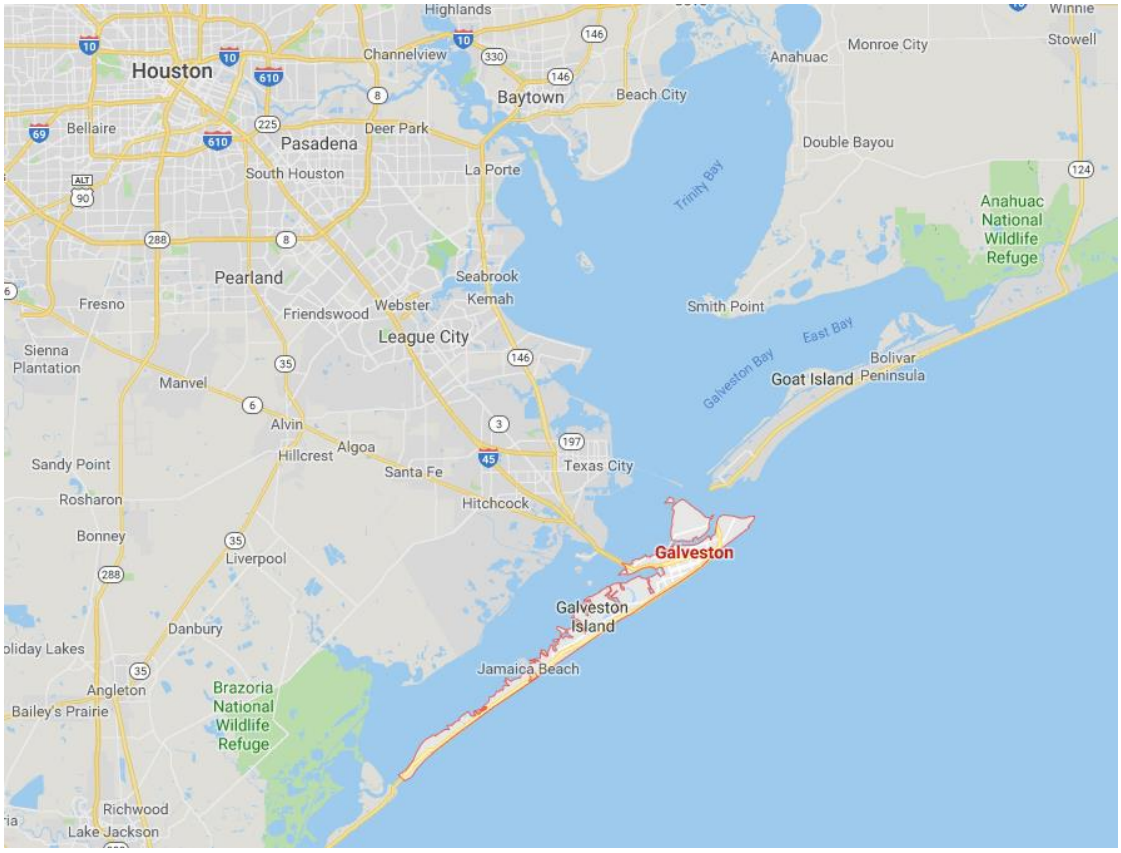
Optional

Bishop's Palace, historic homes, Pleasure Pier, Tremont Hotel, Galveston Railroad Museum, Galveston's Own Farmers Market, ArtWalk

TABLE OF CONTENTS

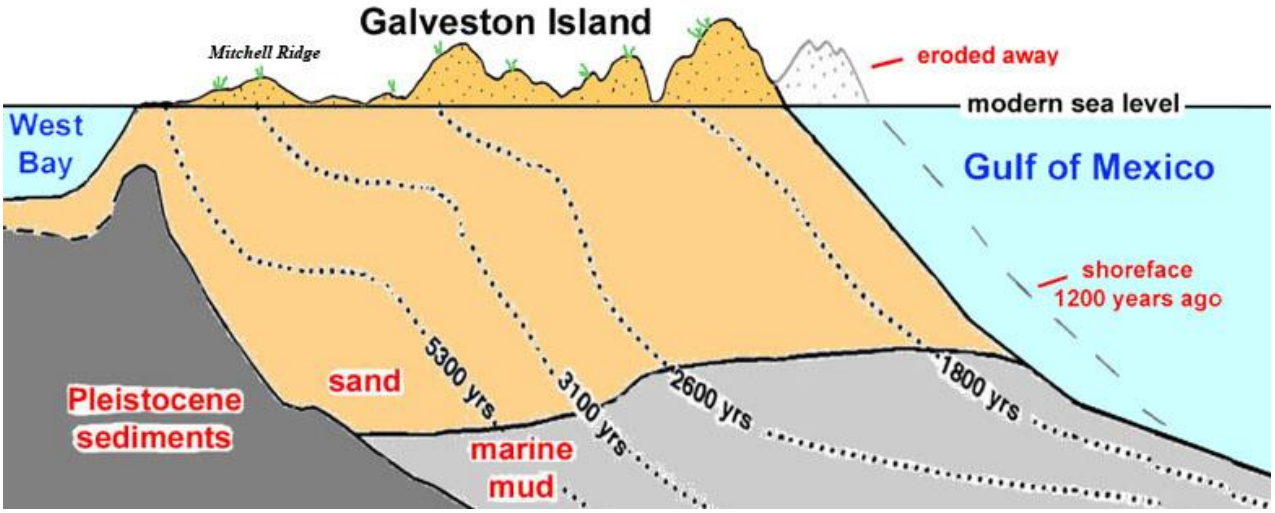
BARRIER ISLAND





BARRIER ISLAND

Barrier islands are coastal landforms and a type of dune system that are exceptionally flat or lumpy areas of sand that form by wave and tidal action parallel to the mainland coast. They usually occur in chains, consisting of anything from a few islands to more than a dozen. They are subject to change during storms and other action, but absorb energy and protect the coastlines and create areas of protected waters where wetlands may flourish.
(From Wikipedia)



Schematic cross-section showing the evolution of Galveston Island. Based on Rodriquez et al. 2004 and Fisk et al. 1972.

Formation of Galveston Island

Galveston Island is a classic example of a barrier island, a long narrow strip of sand and shell that runs parallel to the shore, separated by a bay or lagoon. Such islands are formed by deposits of sand and shell piled up by ocean waves and long-shore currents.

Measured in geological time, Galveston Island is a very young landform that had not yet begun to form as recently as 6,000 years ago, during the mid-Holocene geological period. As compared to today, 8,000 years ago sea level was considerably lower by perhaps 5-10 meters (16-33'). At this time the Texas coastline and earlier barrier islands were considerably farther out into the Gulf by an estimated 55 kilometers (34 miles) at the west end of Galveston Island. An ancestral Galveston Bay existed as a much narrower and deeper feature that formed as sea level climbed in the early Holocene and flooded the deeply incised valleys of the Trinity and San Jacinto Rivers.

Around 5000 years ago, Galveston Island began forming as wave action, particularly that generated by high-energy storm surges (such those as caused by hurricanes), pushed back the bay shoreline, destroyed and reworked the ancient barrier islands, and piled up sandy deposits along the coastline and across the mouths of the bays. The newly piled-up sand and shell hash deposits ("wash-over fans") gradually built up seaward and protruded above the water, forming an island behind which was an early version of today's West Bay.

By 3000 years ago the sea reached its modern level. By 2000 years ago the higher sand ridges that form the core of Galveston Island were no longer being penetrated by storm surges. The island built seaward ("prograded") and sand dunes formed behind the beach (or "shoreface") as the predominant easterly-to-southerly winds reworked the piled-up ridge sand. Grasses and other plants spread and stabilized the most of the surface of the island.
(https://www.texasbeyondhistory.net/mitchell/setting.html)

BARRIER ISLAND

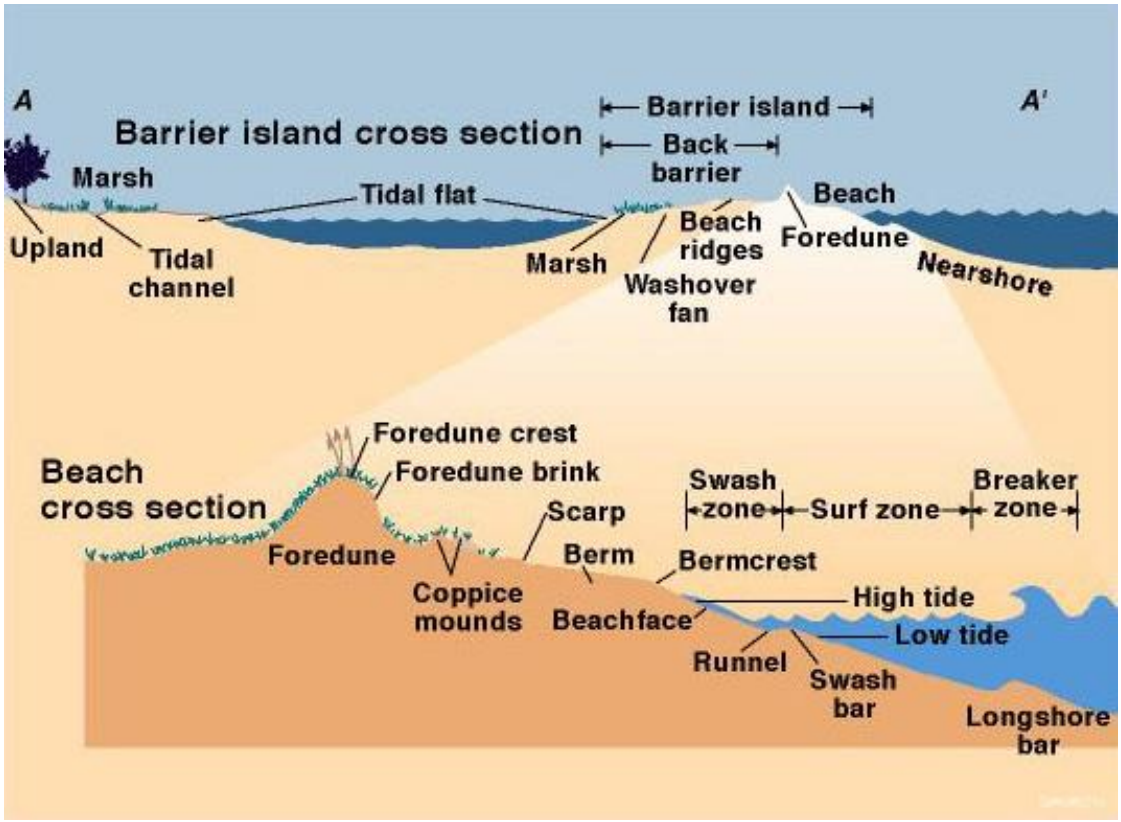


Figure Barrier island system. Seen in this photo are the beach dune, back-barrier marsh tidal flat, lagoon and mainland.

DUNE SYSTEM

Coastal Dunes: Coastal dunes form when wet sand is deposited along the coast and dries out and is blown along the beach. Dunes form where the beach is wide enough to allow for the accumulation of wind-blown sand, and where prevailing onshore winds tend to blow sand inland. The three key ingredients for coastal dune formation are a large sand supply, winds to move said sand supply, and a place for the sand supply to accumulate. Obstacles—for example, vegetation, pebbles and so on—tend to slow down the wind and lead to the deposition of sand grains. These small "incipient dunes or "shadow dunes" tend to grow in the vertical direction if the obstacle slowing the wind can also grow vertically (i.e., vegetation). Coastal dunes expand laterally as a result of lateral growth of coastal plants via seed or rhizome. Models of coastal dunes suggest that their final equilibrium height is related to the distance between the water line and where vegetation can grow.

Lower Shoreface: The shoreface is the part of the barrier where the ocean meets the shore of the island. The barrier island body itself separates the shoreface from the backshore and lagoon/tidal flat area. Characteristics common to the lower shoreface are fine sands with mud and possibly silt. Further out into the ocean the sediment becomes finer. The effect from the waves at this point is weak because of the depth. Bioturbation is common and many fossils can be found here.

Middle Shoreface: The middle shore face is located in the upper shoreface. The middle shoreface is strongly influenced by wave action because of its depth. Closer to shore the grain size will be medium size sands with shell pieces common. Since wave action is heavier, bioturbation is not likely.

Upper Shoreface: The upper shore face is constantly affected by wave action. This results in development of herringbone sedimentary structures because of the constant differing flow of waves. Grain size is larger sands.

Foreshore: The foreshore is the area on land between high and low tide. Like the upper shoreface, it is constantly affected by wave action. Cross bedding and lamination are present and coarser sands are present because of the high energy present by the crashing of the waves. The sand is also very well sorted.

Backshore: The backshore is always above the highest water level point. The berm is also found here which marks the boundary between the foreshore and backshore. Wind is the important factor here, not water. During strong storms high waves and wind can deliver and erode sediment from the backshore.

Dunes: The dunes are typical of a barrier island, located at the top of the backshore. Dunes are made by the wind. See Coastal Dunes for more information. The dunes will display characteristics of typical aeolian wind blown dunes. The difference here is that dunes on a barrier island typically contain coastal vegetation roots and marine bioturbation.

Lagoon and Tidal Flats: The lagoon and tidal flat area is located behind the dune and backshore area. Here the water is still and this allows for fine silts, sands, and mud to settle out. Lagoons can become host to an anaerobic environment. This will allow high amounts of organic rich mud to form. Vegetation is also common.

(From Wikipedia)

BEACH ACTIVITY

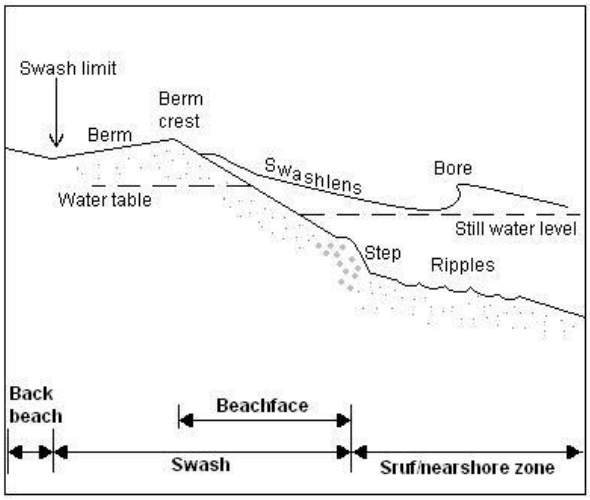
Swash Zone: Swash, or forewash in geography, is a turbulent layer of water that washes up on the beach after an incoming wave has broken. The swash action can move beach materials up and down the beach, which results in the cross-shore sediment exchange.

Beach Face: The beachface is the planar, relatively steep section of the beach profile that is subject to swash processes (Figure 2). The beachface extends from the berm to the low tide level. The beachface is in dynamic equilibrium with swash action when the amount of sediment transport by uprush and backwash are equal.

Wrack Line: The wrack zone or "wrack line" is a coastal feature where organic material (e.g kelp, seagrass, shells) and other debris is deposited at high tide. This zone acts as a natural input of marine resources into a terrestrial system, providing food and habitat for a variety of coastal organisms.

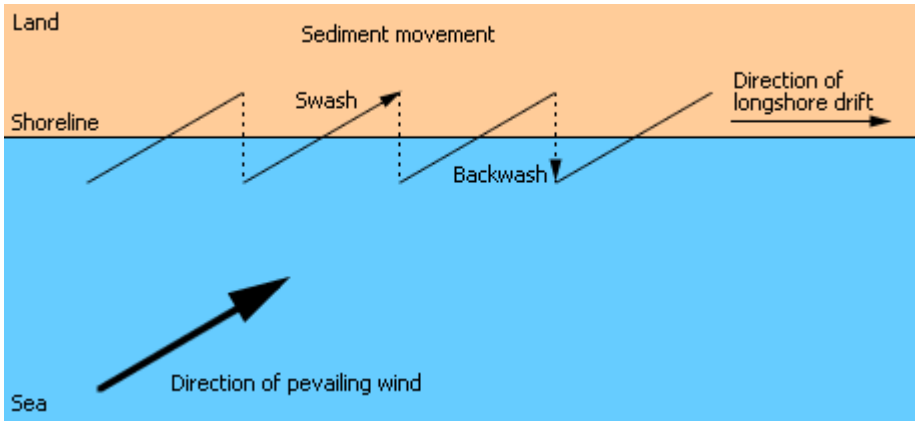
Berm: The berm is the relatively planar part of the swash zone where the accumulation of sediment occurs at the landward farthest of swash motion (Figure 2). The berm protects the backbeach and coastal dunes from waves but erosion can occur under high energy conditions such as storms.

Longshore Current: Longshore drift from longshore current is a geological process that consists of the transportation of sediments (clay, silt, sand and shingle) along a coast parallel to the shoreline, which is dependent on oblique incoming wind direction. Oblique incoming wind squeezes water along the coast, and so generates a water current which moves parallel to the coast. Longshore drift is simply the sediment moved by the longshore current. This current and sediment movement occur within the surf zone.



Littoral Zone: The littoral zone or nearshore is the part of a sea, lake or river which is close to the shore. In coastal environments the littoral zone extends from the high water mark, which is rarely inundated, to shoreline areas that are permanently submerged. It always includes this intertidal zone and is often used to mean the same as the intertidal zone.

(From Wikipedia)



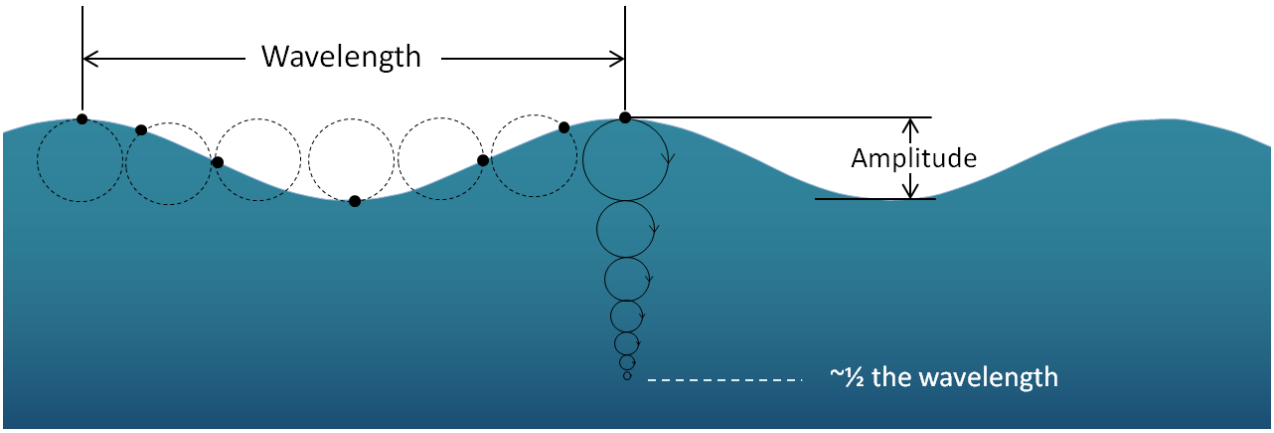
WAVES

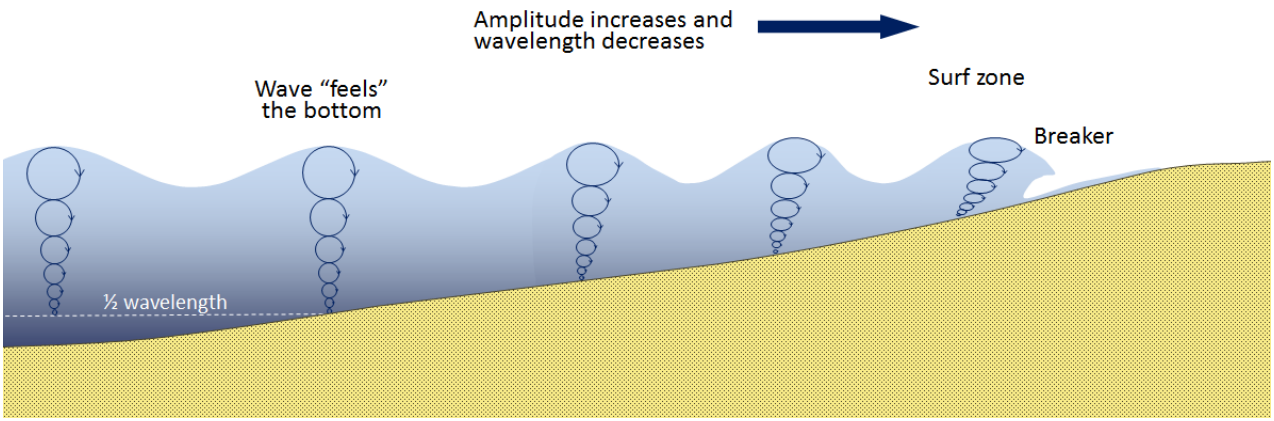
Wind Wave: In fluid dynamics, wind waves, or wind-generated winds, are surface waves that occur on the free surface of bodies of water (like oceans, seas, lakes, rivers, canals, puddles or ponds). They result from the wind blowing over an area of fluid surface. Waves in the oceans can travel thousands of miles before reaching land. Wind waves on Earth range in size from small ripples, to waves over 100 ft (30 m) high. The main dimensions associated with waves are:

- Wave height (vertical distance from trough to crest)
- Wave length (distance from crest to crest in the direction of propagation)
- Wave period (time interval between arrival of consecutive crests at a stationary point)
- Wave propagation direction

Rip Current: A rip current, often simply called a rip, or by the misnomer rip tide, is a specific kind of water current which can occur near beaches with breaking waves. A rip is a strong, localized, and narrow current of water which moves directly away from the shore, cutting through the lines of breaking waves like a river running out to sea, and is strongest near the surface of the water.[1] Rip currents can be hazardous to people in the water. Swimmers who are caught in a rip current and who do not understand what is going on, and who may not have the necessary water skills, may panic, or exhaust themselves by trying to swim directly against the flow of water. Because of these factors, rips are the leading cause of rescues by lifeguards at beaches, and rips are the cause of an average of 46 deaths by drowning per year in the United States.

(From Wikipedia)



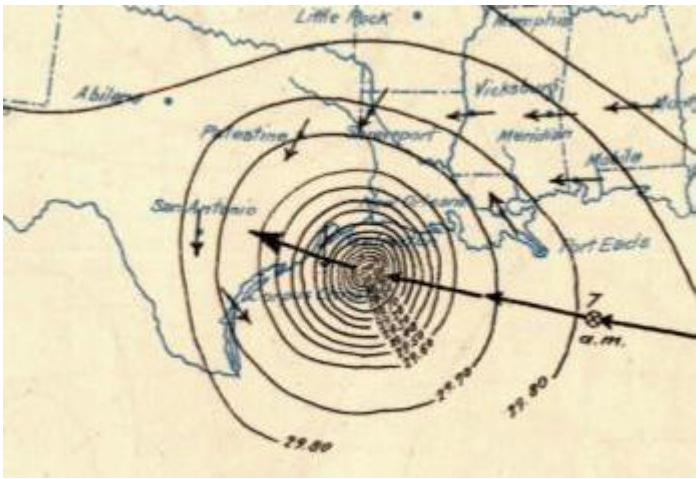


GREAT STORM OF 1900

Overview: The Great Galveston Hurricane, known regionally as the Great Storm of 1900, was the deadliest natural disaster in United States history, one of the deadliest hurricanes (or remnants) to affect Canada, and the fourth-deadliest Atlantic hurricane overall. The hurricane left between 6,000 and 12,000 fatalities in the United States; the number most cited in official reports is 8,000. Most of these deaths occurred in the vicinity of Galveston after storm surge inundated the entire island with 8 to 12 feet of water. In addition to the number killed, every house in the city sustained damage, with at least 3,636 destroyed. Approximately 10,000 people in the city were left homeless, out of a total population of nearly 38,000. The disaster ended the Golden Era of Galveston, as the hurricane alarmed potential investors, who turned to Houston instead. The Gulf of Mexico shoreline of Galveston island was subsequently raised by 17 ft and a 10 mi seawall erected.

Landfall Summary: Upon reaching the Gulf of Mexico on September 6, the storm strengthened into a hurricane. Significant intensification followed and the system peaked as a Category 4 hurricane with maximum sustained winds of 145 mph on September 8. Early on the next day, it made landfall near present day Jamaica Beach, Texas. The cyclone weakened quickly after moving inland and fell to tropical storm intensity late on September 9.

Background: In 1900, the city of Galveston, Texas, was a booming town. According to the 1900 Census, the population of Galveston was 37,788, an increase from 29,084 people recorded in the 1890 Census. The city was fourth largest municipality in the state of Texas in 1900 and among the highest per capita income rates in the United States. Galveston had many ornate business buildings in a downtown section called The Strand, which was considered the "Wall Street of the Southwest." The city's position on the natural harbor of Galveston Bay along the Gulf of Mexico made it the center of trade in Texas, and one of the busiest ports in the nation. With this prosperity came a sense of complacency. A quarter of a century earlier, the nearby town of Indianola on Matagorda Bay was undergoing its own boom and was second to Galveston among Texas port cities. Then in 1875, a powerful hurricane blew through, nearly destroying the town. Indianola was rebuilt, though a second hurricane in 1886 caused residents to simply give up and move elsewhere. Many Galveston residents took the destruction of Indianola as an object lesson on the threat posed by hurricanes. Galveston is built on a low, flat island, little more than a large sandbar along the Gulf Coast. These residents proposed a seawall be constructed to protect the city, but their concerns were dismissed by the majority of the population and the city's government. Since its formal founding in 1839, the city of Galveston had weathered numerous storms, all of which the city survived with ease. Residents believed any future storms would be no worse than previous events. In order to provide an official meteorological statement on the threat of hurricanes, Galveston Weather Bureau section director Isaac Cline wrote an 1891 article in the Galveston Daily News in which he argued not only that a seawall was not needed to protect the city, but also that it would be impossible for a hurricane

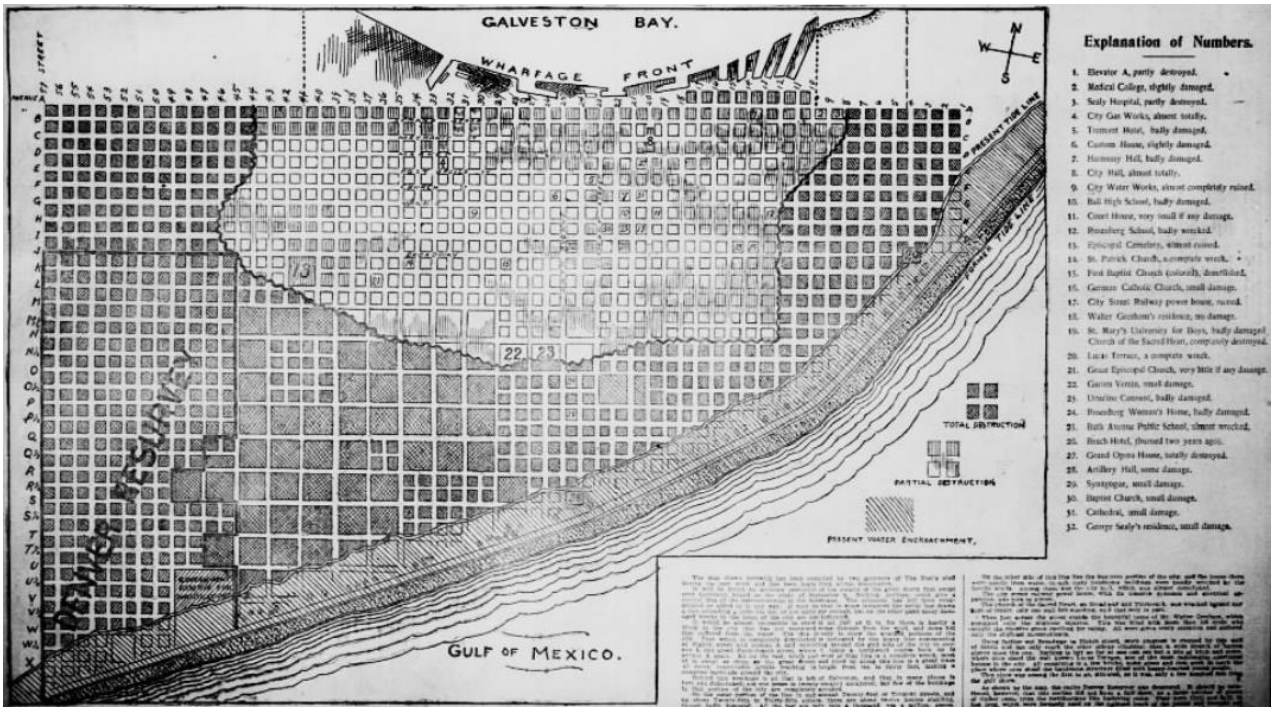


September 8 Surface Weather Analysis (Source: http://docs.lib.noaa.gov/rescue/mwr/028/mwr-028-09-c11.pdf)

of significant strength to strike the island. The seawall was not built, and development activities on the island actively increased its vulnerability to storms. Sand dunes along the shore were cut down to fill low areas in the city, removing what little barrier there was to the Gulf of Mexico.

Preparations: On September 4, the Galveston office of the National Weather Bureau (as it was then called) began receiving warnings from the Bureau's central office in Washington, D.C., that a tropical storm had moved northward over Cuba. At the time, they discouraged the use of terms such as *tornado* or *hurricane* to avoid panicking residents in the path of any storm event. The Weather Bureau forecasters had no way of knowing the storm's trajectory, as Weather Bureau director Willis Moore implemented a policy to block telegraph reports from Cuban meteorologists at the Belen Observatory in Havana – considered one of the most advanced meteorological institutions in the world at the time – due to tensions remaining in the aftermath of the Spanish–American War. Moore also changed protocol to force local Weather Bureau offices to seek authorization from the central office before issuing storm warnings. Weather Bureau forecasters believed the storm would travel northeast and affect the mid-Atlantic coast. Cuban forecasters adamantly disagreed, saying the hurricane would continue west. One Cuban forecaster predicted the hurricane would continue into central Texas near San Antonio. On the morning of September 8, the swells continued despite only partly cloudy skies. Largely because of the unremarkable weather, few residents saw cause for concern. Few people evacuated across Galveston's bridges to the mainland, and the majority of the population was unconcerned by the rain clouds that began rolling in by midmorning.

Landfall and Aftermath (Galveston): At the time of the 1900 hurricane, the highest point in the city of Galveston was only 8.7 ft above sea level. The hurricane brought with it a storm surge of over 15 ft that washed over the entire island. Storm surge and tides began flooding the city by the early morning hours of September 8. Water rose steadily from 3:00 p.m. CST until approximately 7:30 p.m., when eyewitness accounts indicated that water rose about 4 ft in just four seconds.



GREAT STORM OF 1900

An additional 5 ft of water had flowed into portions of the city by 8:30 p.m. The cyclone dropped 9 in of precipitation in Galveston on September 8, setting a record for the most rainfall for any 24-hour period in the month of September in the city's history. The highest measured wind speed was 100 mph just after 6 p.m. on September 8, but the Weather Bureau's anemometer was blown off the building shortly after that measurement was recorded. Contemporaneous estimates placed the maximum sustained wind speed 120 mph. However, survivors reported observing bricks, slate, timbers, and other heavy objects becoming airborne, indicating that winds were likely stronger. Later estimates placed the hurricane at the higher Category 4 classification on the Saffir–Simpson Hurricane Scale. Few streets in the city escaped wind damage and all streets suffered water damage, with much of the destruction caused by storm surge. All bridges connecting the island to the mainland were washed away, while approximately 15 mi (24 km) of railroad track was destroyed. Winds and storm surge also downed electrical, telegraph, and telephone wires. The surge swept buildings off their foundations and dismantled them. Many buildings and homes destroyed other structures after being pushed into them by the waves, which even demolished structures built to withstand hurricanes. Every home in Galveston suffered damage, with 3,636 homes destroyed. Approximately 10,000 people in the city were left homeless, out of a total population of nearly 38,000. The Tremont Hotel, where hundreds of people sought refuge during the storm, was severely damaged. All public buildings also suffered damage, including city hall – which was completely deroofed – a hospital, a city gas works, a city water works, and the custom house. The Grand Opera House also sustained extensive damage, but was quickly rebuilt. The area of destruction – an area in which nothing remained standing after the storm – was approximately 1,900 acres of land and was arc-shaped, with complete demolition of structures in the west, south, and eastern portions of the city, while the north-central section of the city suffered the least amount of damage.

(From Wikipedia)

GREAT STORM OF 1900

In the immediate aftermath of the storm, a 3 mi long, 30 ft wall of debris was situated in the middle of the island. As severe as the damage to the city's buildings was, the death toll was even greater. Because of the destruction of the bridges to the mainland and the telegraph lines, no word of the city's destruction was able to reach the mainland. At 11 a.m. on September 9, one of the few ships at the Galveston wharfs to survive the storm, the *Pherabe*, arrived in Texas City on the western side of Galveston Bay. It carried six messengers from the city. When they reached the telegraph office in Houston at 3 a.m. on September 10, a short message was sent to Texas Governor Joseph D. Sayers and U.S. President William McKinley: "I have been deputized by the mayor and Citizen's Committee of Galveston to inform you that the city of Galveston is in ruins." The messengers reported an estimated five hundred dead; this was initially considered to be an exaggeration. The citizens of Houston knew a powerful storm had blown through and had prepared to provide assistance. Workers set out by rail and ship for the island almost immediately. Rescuers arrived to find the city completely destroyed. In less than 24 hours the city of Galveston was effectively obliterated. The final death toll is not known with certainty but the most conservative estimate is around 6,000. Most historians believe the loss of life to be in the area of 8,000 with some suggesting as many as 12,000 perished.

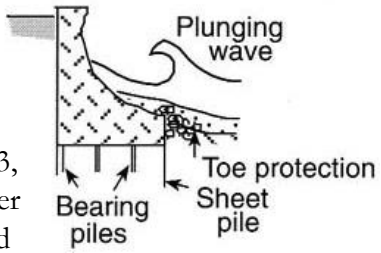
Rebuilding: By September 12, Galveston received its first post-storm mail. The next day, basic water service was restored, and Western Union began providing minimal telegraph service. Within three weeks, cotton was again being shipped out of the port. Survivors set up temporary shelters in surplus U.S. Army tents along the shore. They were so numerous that observers began referring to Galveston as the "White City on the Beach". In the first two weeks following the storm, approximately 17,000 people resided in these tents, vacant storerooms, or public buildings. Others constructed so-called "storm lumber" homes, using salvageable material from the debris to build shelter. The building committee, with a budget of $450,000, opened applications for money to rebuild and repair homes. Accepted applicants were given enough money to build a cottage with three 12 by 12 ft rooms. By March 1901, 1,073 cottages were built and 1,109 homes had been repaired. A number of cities, businesses, organizations, and individuals made monetary donations toward rebuilding Galveston. By September 15, less than one week after the storm struck Galveston, contributions totaled about $1.5 million. Before the hurricane of 1900, Galveston was considered to be a beautiful and prestigious city and was known as the "Ellis Island of the West" and the "Wall Street of the Southwest". However, after the storm, development shifted north to Houston, which reaped the benefits of the oil boom, particularly after the discovery of oil at Spindletop on January 10, 1901. The dredging of the Houston Ship Channel in 1909 and 1914 ended Galveston's hopes of regaining its former status as a major commercial center.

(From Wikipedia)

SEAWALL

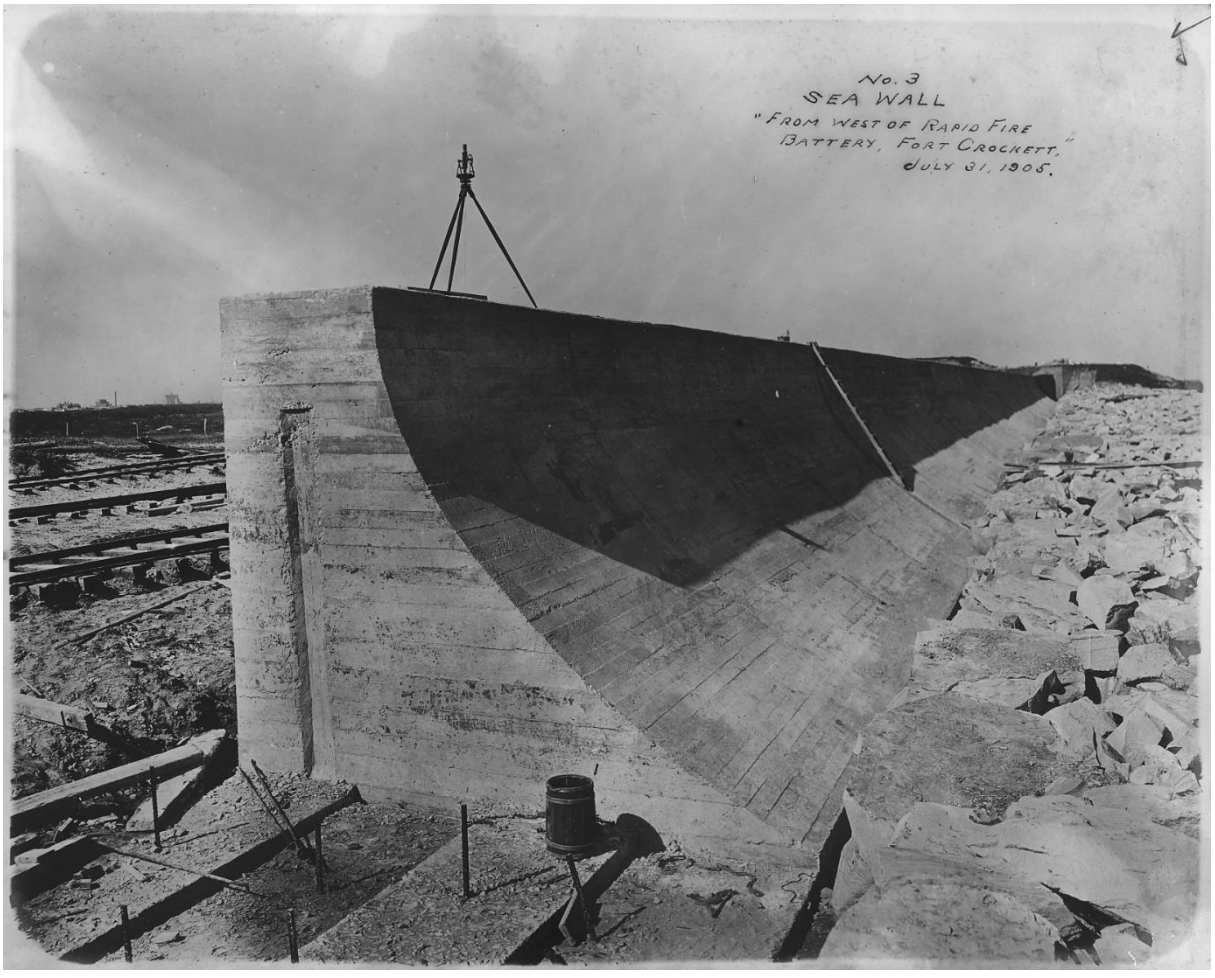
Seawall: A seawall (or sea wall) is a form of coastal defense constructed where the sea, and associated coastal processes, impact directly upon the landforms of the coast. The purpose of a sea wall is to protect areas of human habitation, conservation and leisure activities from the action of tides, waves, or tsunamis.

Curved Seawall: Curved or stepped seawalls are designed to enable waves to break to dissipate wave energy and to repel waves back to the sea. The curve can also prevent the wave overtopping the wall and provides additional protection for the toe of the wall.



Galveston Seawall: The Galveston Seawall is a seawall in Galveston, that was built after the Galveston Hurricane of 1900 for protection from future hurricanes. Construction began in September, 1902, and the initial segment was completed on July 29, 1904. From 1904 to 1963, the seawall was extended from 3.3 miles to over 10 miles long. Another dramatic effort to protect Galveston was its raising, also recommended by the [three engineers that designed the Galveston Seawall]. Approximately 15,000,000 cu yd of sand was dredged from the Galveston shipping channel to raise the city, some sections by as much as 17 ft. Over 2,100 buildings were raised in the process of pumping sand underneath.

(From Wikipedia)



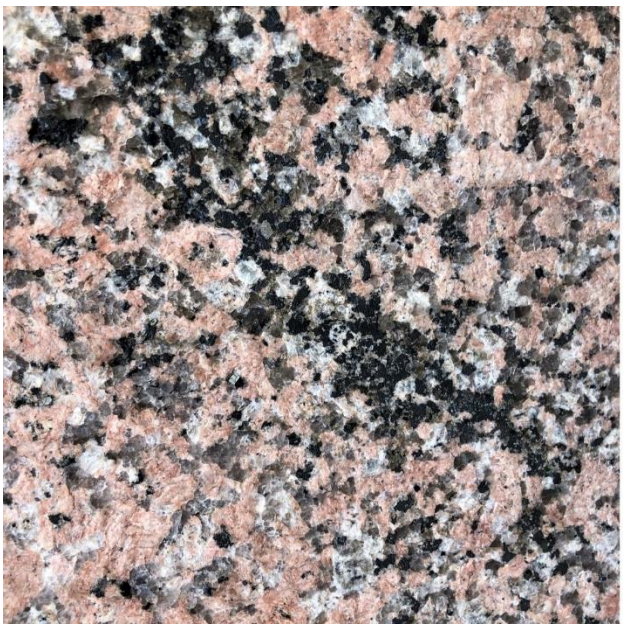
SEAWALL

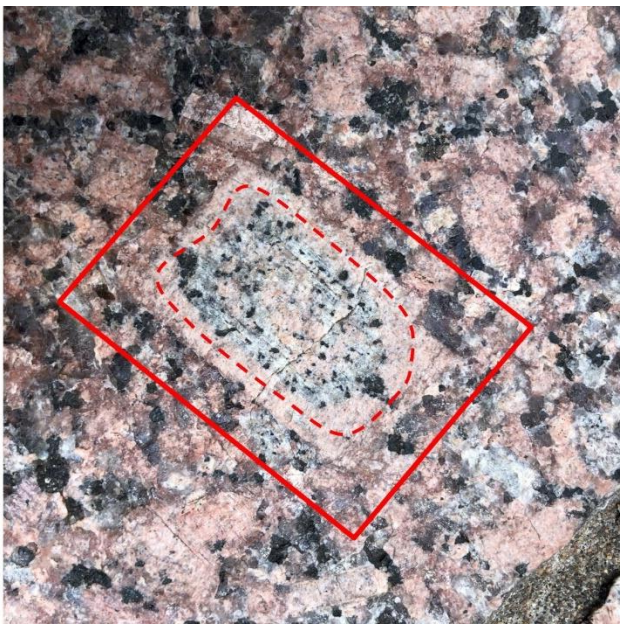
Galveston Seawall Construction: On September 7, 1901, the Texas State Legislature approved an act providing for the construction of a seawall for Galveston. A board comprised of three engineers, Brigadier General Henry Martyn Robert, Alfred Noble, and H. C. Ripley, organized to draft plans for the future protection of Galveston, including the construction of a seawall and the raising of the city's elevation. In January 1902, the Board issued its report, calling for the construction of a seawall that ran from the south jetty near 8th street to Avenue D and 6th Street, and westward to 39th Street along the Gulf of Mexico. The Galveston County Commissioners' Court adopted a resolution on February 5, 1902, that the county would underwrite its construction through the issuance of bonds. On September 19, 1902, J. M. O'Rourke and George Steinmetz signed the construction contract, which provided that the work was to be completed within fifteen months. The initial segment of the Seawall was completed July 29, 1904. This portion, made of concrete, was 3.3 miles long, 16 feet at its base, and 5 feet wide on top, and 17 feet high. The outer face of the Seawall was curved to carry waves upwards. Riprap was placed along the base facing the Gulf of Mexico to break up wave action. The initial segment was completed at a cost of almost $1.6 million. It proved its worth first during the hurricane of September 21, 1909. Its critical test came with the hurricane of August 16, 1915. The seawall dramatically lowered the loss of life and destruction. A second segment was built between December 1904 and October 1905 to protect Fort Crockett. It received Congressional funding. This portion ran 4,935 feet from 39th to 53rd streets. The Seawall was extended westward to 61st Street in 1927 and 99th Street in 1963. *(From Galveston and Texas History Center, Rosenberg Library)*

View of Fort Crockett from 45th and Seawall (Photo Credit: Rosenberg Library, Galveston, TX)

GRANITE IN GALVESTON

Jetty/Breakwater: A jetty is a structure that projects from the land out into water. Breakwaters are structures constructed near the coasts as part of coastal management or to protect an anchorage from the effects of both weather and longshore drift. Breakwaters reduce the intensity of wave action in inshore waters and thereby reduce coastal erosion or provide safe harbourage.
Riprap: Rock or other material used to armor shorelines, streambeds, bridge abutments, pilings and other shoreline structures against scour and water or ice erosion. Common rock types used include granite and limestone. Concrete rubble from building and paving demolition is sometimes used.
(From Wikipedia)
Town Mountain Granite (Galveston): The jetties and riprap along the seawall is the same granite used in the State Capitol in Austin and is quarried from Granite Mountain near Marble Falls. It's geologic age is PreCambrian (>1.37-1.23gy). Coarse-grained, pink, quartz-plagioclase-microcline rock, in part porphyritic with large microcline phenocrysts. Makes up Enchanted Rock granite mass, Gillespie and Llano Counties.

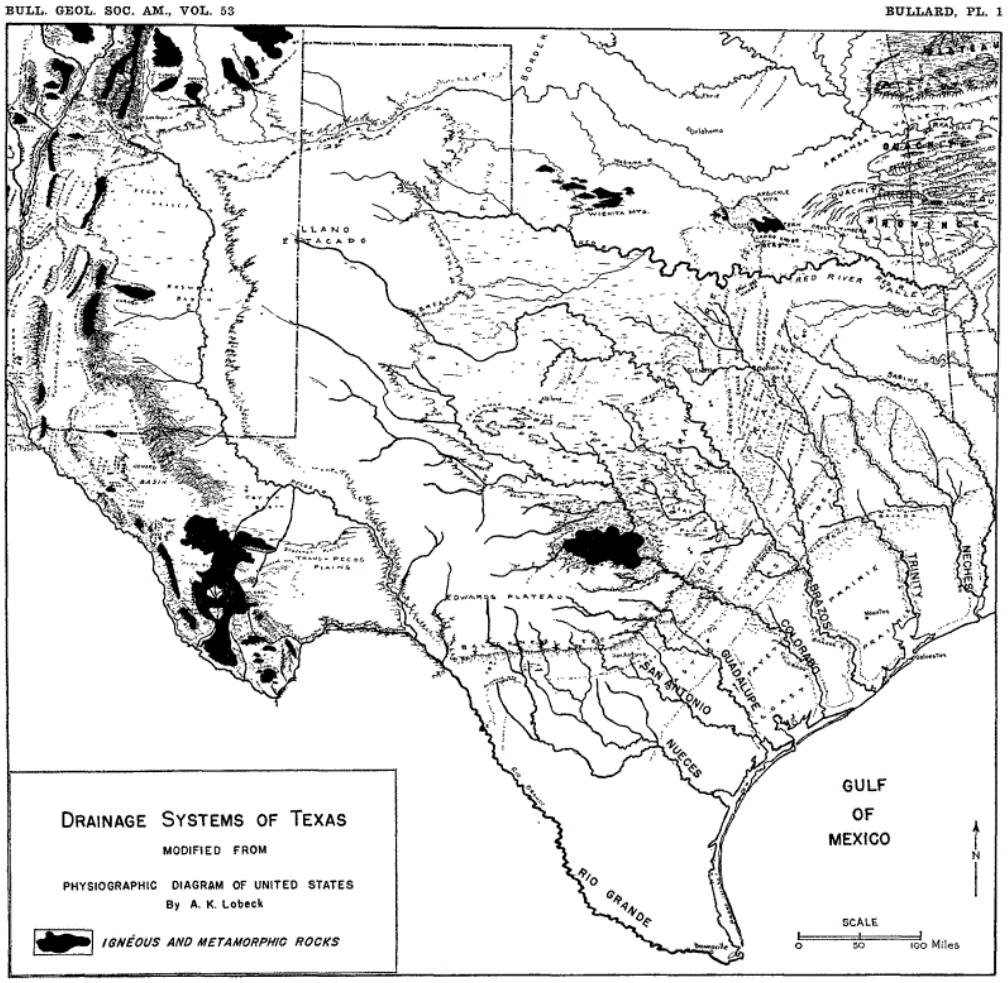




SAND COMPOSITION

Source of beach and river sands on Gulf Coast of Texas: The value of correlations based on heavy minerals is tested on the sands now being deposited on the beaches of the Texas Gulf Coast. Each of the principal rivers carries a distinct suite of heavy minerals. The Nueces, San Antonio, Brazos, Trinity, and Neches rivers derive their load from sedimentary rocks giving a high content of more stable minerals in the heavy-mineral residue with only minor amounts of hornblende and pyroxene. The Colorado River derives its load from igneous, metamorphie, and sedimentary rocks. Its suite of heavy minerals, exclusive of the opaque black minerals, is more than 60 per cent green hornblende with the remainder the more stable minerals. Galveston Island, where the mode shifts to the 1/16 mm. grain diameter size, but the 1/8 mm. grain diameter size is almost as abundant. The distribution of material along the Texas Gulf Coast beaches is effected by a southward longshore current carrying sediment brought to the Gulf of Mexico. The offshore bars on the Texas Gulf Coast may have been formed in this manner.
(From Fred M. Bullard, GSA Bulletin, 1942)

Sand Management: "Nearly 3 miles of pipe has been laid in preparation for pumping fresh sand onto beaches in front of the Galveston seawall. The pipe runs from a sand deposit on the eastern end of the island known as Big Reef to a point about 100 feet east of 10th Street, the first stage of a $19 million project." *(Chron, 2017)*



DRAINAGE SYSTEMS OF TEXAS

BACK BAY

Prairies: Prairies define the land lying between the beach and dunes and the bay. Once prairie habitat dominated Galveston Island's landscape, which had very few trees. Today very little prairie remains. Despite the loss of habitat, birds, coyotes, opossums, rabbits, and snakes still find homes in the Galveston Island prairie. These animals depend on the small, rain-filled ponds that dot the prairie along the high points of the island. The native grasses that prairie birds depend on have largely disappeared under assault from invasive plants that carpet much of the island today. However, you can help restore and protect the prairies. Go birding or hiking and share the pictures you take with others. If you live nearby, plant native prairie grasses or talk to a ranger about helping with habitat restoration here at the park.

Salt Marsh Wetlands: Salt Marsh Wetlands lie beyond the prairie's edge, on the bay side of the island, and form a transition zone where land gradually gives way to water. In this murky world, many fish and marine animals begin their lives. Spotted seatrout, red drum, flounder, blue crab, and shrimp all depend on the shallow waters and tangles of seagrasses for refuge. Great blue herons, snowy egrets, and roseate spoonbills gather in the salt marshes to feed on fish and crustaceans. The wetlands also offer sunset views, fishing, crabbing, and ten miles of paddling trails. Wetlands protect the environment by filtering impurities from the water and soaking up excess water from storms. The park is building new wetlands and protecting them with a rock breakwater. Here are some things you can do to protect the wetlands. Staying on the trails helps preserve habitat and control erosion. To protect submerged seagrass beds, lift your engine and let your boat drift or move it solely by a pole or trolling motor.

(From Interpretive Guide to Galveston Island State Park, Texas Parks & Wildlife)

PELICAN ISLAND

Pelican Island: Pelican Island is an island located in Galveston County, Texas. It is part of the city of Galveston and is linked to Galveston Island by the Pelican Island causeway. The island is home to the Texas A&M University at Galveston as well as USS Stewart (DE-238), USS Cavalla (SS-244), and Seawolf Park. Seawolf Parkway is the only street that runs across the island.

Seawolf Park: Seawolf Park is a memorial to USS Seawolf (SS-197), a United States Navy Sargo-class submarine mistakenly sunk by U.S. Navy forces in 1944 during World War II. It is located on Pelican Island, just north of Galveston, Texas, in the United States. Seawolf park is unique in that it has a submarine, the remains of a merchant ship, and a destroyer escort designed to conduct antisubmarine warfare -- the hunter, hunted, and the protector -- all in one museum area. It is the home of two preserved U.S. Navy ships, the Gato-class submarine USS Cavalla (SS-244) and the Edsall-class destroyer escort USS Stewart (DE-238), and the remains of the World War I tanker S.S. Selma, the largest concrete ship constructed, can be seen northwest of the park's fishing pier at. Also preserved at the park is the conning tower of the Balao-class submarine USS Carp (SS-338) and the sail of the Sturgeon-class nuclear attack submarine USS Tautog (SSN-639). At one point in time, the park also had a LVTP 5 armored personnel carrier on display. The park has a picnic area, and fishing is allowed on the pier for a small fee. There is also pedestrian access to the shoreline on either side of the park where anglers can fish for free. Fish that can be caught in the park area include sand seatrout, speckled trout, gafftopsail catfish, drum, and flounder, among others.

USS Stewart (DE-238): USS Stewart (DE–238) is an Edsall class destroyer escort, the third United States Navy ship so named. This ship was named for Rear Admiral Charles Stewart (28 July 1778 – 6 November 1869), who commanded USS Constitution during the War of 1812. The Stewart is one of only two preserved U.S. destroyer escorts and is the only Edsall class Escort to be preserved.

USS Cavalla (SS-244): USS Cavalla (SS/SSK/AGSS-244), a Gato-class submarine, was a ship of the United States Navy named for a salt water fish, best known for sinking the Japanese aircraft carrier Shōkaku, a veteran of the Pearl Harbor attack. Her keel was laid down on 4 March 1943 by Electric Boat Co., Groton, Connecticut. She was launched on 14 November 1943 (sponsored by Mrs. M. Comstock), and commissioned on 29 February 1944, Lieutenant Commander (LCDR) Herman J. Kossler, USN, (Class of 1934) in command.

(From Wikipedia)

1877 TALL SHIP ELISSA

1877 Tall Ship ELISSA: The tall ship Elissa is a three-masted barque. She is currently moored in Galveston, Texas, and is one of the oldest ships sailing today. Launched in 1877, she is now a museum ship at the Texas Seaport Museum. She was designated a National Historic Landmark in 1990. Elissa was built in Aberdeen, Scotland as a merchant vessel in a time when steamships were overtaking sailing ships. She was originally launched on October 27, 1877. She was named for the niece of Henry Fowler Watt, Elissa's first owner, though according to his descendants the ship was named for the Queen of Carthage, Elissa, Aeneas' tragic lover in the epic poem The Aeneid. Elissa also sailed under Norwegian and Swedish flags. In Norway she was known as the Fjeld of Tønsberg and her master was Captain Herman Andersen. In Sweden her name was Gustav of Gothenburg. In 1918, she was converted into a two-masted brigantine and an engine was installed. She was sold to Finland in 1930 and reconverted into a schooner. In 1959, she was sold to Greece, and successively sailed under the names Christophoros, in 1967 as Achaeos, and in 1969 as Pioneer. In 1970, she was rescued from destruction in Piraeus after being purchased for the San Francisco Maritime Museum. However, she languished in a salvage yard in Piraeus until she was purchased for $40,000, in 1975, by the Galveston Historical Foundation, her current owners. In 1979, after a year in Greece having repairs done to her hull, Elissa was first towed to Gibraltar. There, she was prepared for an ocean tow by Captain Jim Currie of the New Orleans surveyors J.K. Tynan International. The restoration process continued until she was ready for tow on June 7, 1979. Elissa has an iron hull, and the pin rail and bright work is made of teak. Her masts are Douglas fir from Oregon, and her 19 sails were made in Maine. She has survived numerous modifications including installation of an engine, and the incremental removal of all her rigging and masts. Elissa made her first voyage as a restored sailing ship in 1985, traveling to Corpus Christi, Texas. When she's not sailing, Elissa is moored at the Texas Seaport Museum in Galveston. The ship is sailed and maintained by qualified volunteers from around the nation. In July 2011, the U.S. Coast Guard declared Elissa to be "not seaworthy." Officials at the Texas Seaport Museum in Galveston where Elissa is berthed were astonished when a Coast Guard inspection in 2011 revealed a corroded hull. Texas Seaport Museum raised the $3 million that paid for hull replacement and other long-overdue maintenance projects, finishing in January 2013. The museum also replaced the 22,000 board feet of Douglas fir decking. Including building new quarter deck furniture out of high quality teak. Elissa returned to sailing once again in March 2014. She ran a series of daily sails for a period of two weeks out of her home port of Galveston TX. Elissa's sail training program for the 2017-2018 sailing season is currently underway with plans to compete as the Flagship in the Tall Ship Challenge-Gulf Coast in April 2018 where she will sail to Pensacola, FL and New Orleans, LA.

(From Wikipedia)

OFFSHORE OIL AND GAS IN THE GULF OF MEXICO

Overview: Offshore oil and gas in the Gulf of Mexico is a major source of oil and natural gas in the United States. The western and central Gulf of Mexico, which includes offshore Texas, Louisiana, Mississippi, and Alabama, is one of the major petroleum-producing areas of the United States. Oil production from US federal waters in the Gulf of Mexico reached an all-time annual high of 1.65 million barrels per day in 2017. Oil production is expected to continue the upward trend in 2018 and 2019, based on ten new oil fields which are planned to start production in those years. According to the Energy Information Administration, "Gulf of Mexico federal offshore oil production accounts for 17% of total U.S. crude oil production and federal offshore natural gas production in the Gulf accounts for 5% of total U.S. dry production."
Major fields include Eugene Island block 330 oil field, Atlantis Oil Field, and the Tiber oilfield (discovered 2009). Notable oil platforms include Baldpate, Bullwinkle, Mad Dog, Magnolia, Mars, Petronius, and Thunder Horse. Notable individual wells include Jack 2 and Knotty Head. *(From Wikipedia)*

History of Gulf Oil Production: As technology has progressed over the years, oil companies have extended drilling and production farther and farther from shore, and into deeper and deeper waters. In 1937 Superior Oil of California and Pure Oil constructed a platform just over a mile from the shore at a depth of 13 feet. A year later, Humble Oil built a mile-long wooden trestle with railway tracks into the sea at McFadden Beach on the Gulf of Mexico, placing a derrick at its end - this was later destroyed by a hurricane. A platform was installed in a hundred feet of water for the first time in 1955; in two hundred feet of water in 1962; and in a thousand feet of water in 1979. "By 1970, the technology existed to drill in 2,000 feet of water and actual exploratory drilling was taking place at 1,400 feet." By 2009, more than 70% of Gulf of Mexico oil production came from wells drilled in depths greater than 1,000 feet (300 m), almost double from the percentage ten years ago. The deepest water depth in which a discovery has been made is 9,975 feet (3,040 m), at Lloyd Ridge 370 (Diamond). The federal government has not allowed drilling in federal waters in the eastern Gulf of Mexico, which includes offshore Florida and part of offshore Alabama, since 1995. In March 2010, President Barack Obama announced plans to allow drilling in the eastern Gulf of Mexico, in federal waters greater than 125 miles (201 km) from the coasts of Alabama and Florida. In December 2010, following the Deepwater Horizon oil spill, the Obama administration reversed its plans to open the eastern Gulf, and imposed a moratorium on new drilling in the eastern Gulf of Mexico for at least seven years. *(From Wikipedia)*

Offshore Platform, Gulf of Mexico (From Wikipedia)

OFFSHORE OIL AND GAS IN THE GULF OF MEXICO

First Well Offshore of Texas

The first offshore well in Texas was drilled in 1938, but the first oil discovery was not made until 1941, off of Jefferson County. Through 2007, Texas state waters have produced 39 million barrels (6.2×106 m3) of oil and 4.0 trillion cubic feet (110 km3). In 2007, Texas state waters produced 600,000 barrels (95,000 m3) of oil and condensate and 26 billion cubic feet (0.74 km3) gas. *(From Wikipedia)*

Oil Platforms

An oil platform, offshore platform, or offshore drilling rig is a large structure with facilities for well drilling to explore, extract, store, and process petroleum and natural gas which lies in rock formations beneath the seabed. In many cases, the platform contains facilities to house the workforce as well.

Most commonly, oil platforms engage in activities on the continental shelf, though they can also be used in lakes, inshore waters and inland seas.

Depending on the circumstances, the platform may be fixed to the ocean floor, may consist of an artificial island, or may float. Remote subsea wells may also be connected to a platform by flow lines and by umbilical connections. These sub-sea solutions may consist of one or more subsea wells, or of one or more manifold centers for multiple wells. *(From Wikipedia)*

NAVIGATION AND BATHYMETRY