Chapter 5

The Great Galveston Hurricane of 1900

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The effectiveness of community efforts to cope with a hurricane depends upon an interactive process involving technical procedures for tracking and warning, societal issues including public response to warnings, and government-sponsored preparedness and safety measures.

In this first of four chapters in Part II, we turn to events leading up to and during the landmark tragedy at Galveston in 1900, as a bridge between Part I with its emphasis on technology and later chapters in Part II that address the socio-economic impact of hurricanes. Here we display the limitations of technical procedures in 1900, as well as the societal impact, including public responses in the face of differing perceptions of imminent danger. In this saga the concern is primarily with the sudden lethal threat that confronted residents and responsible authorities alike in search of means for coping with the crisis.

In our view, this terrible event is a suitable benchmark for evaluating progress during the 20th century. Chapters 6 and 8 review and analyze other aspects of the societal and economic problems imposed by hurricanes, including policy planning. Chapter 7 stresses the urgency for proper engineering design and standards for new construction, and suggests appropriate guidelines.

INTRODUCTION

On September 8, 1900, a fifteen-foot storm surge associated with a great hurricane inundated Galveston Island killing at least 8000 people according to Rappaport and Partagas [1995]. The actual death toll will never be known

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because the magnitude of the disaster far exceeded the ability to accurately count and identify bodies. It is very likely that many of the dead were washed out to sea. Nevertheless, it was the deadliest natural disaster in this nation's history.

Improvements in tracking and forecasting hurricanes during the 20th Century, examined in Part I and later in Part III, have been very significant. Unfortunately, as discussed in Chapter 2, the rate of improvement in hurricane forecasting has not kept pace with the rate of increase in coastal population. Even today, a perfect hurricane warning could result in a disaster if people do not respond. Emergency managers and hurricane forecasters, faced with a rapid influx of new coastal residents, have been hard pressed to educate and properly prepare these residents for a direct hit by a major hurricane. And with these increases in populations-at-risk, the increases in warning time required for relocation of residents exceeds that which can be dependably provided by forecasters.

These and other problems that relate to the progress made, as well as our present ability to cope, may be instructive as we revisit the events before, during, and after the Great Galveston Hurricane of 1900. In considering overall progress during the 20th Century, together with what has happened on Galveston Island during that period, we will project an opinion as to whether Galvestonians are prepared for another Great Hurricane.

Weems [1957] and, more recently, Larson [1999] present excellent reviews of the Great Hurricane of 1900. I have used several of the eyewitness accounts from Larson's book in this chapter.

We are now reasonably confident that this hurricane had its origin in Africa. The logs from two different ships reveal the presence of a tropical weather disturbance well east of the Caribbean on Monday, August 27th, and again on Tuesday, August 28th.

About 100 weather disturbances are tracked each summer in the tropical Atlantic. Of these more than 50 have their beginnings in Africa. Every three to five days, May through November, an African disturbance enters the Tropical Atlantic and moves slowly westward under the influence of the trade winds. Many strengthen as they pass over the warm waters of the western Atlantic in late summer. Each year in the Atlantic and eastern Pacific over half of the named storms are spawned from African disturbances. With increases in ocean area observations since the two World Wars, it has been possible to trace nearly all major hurricanes that struck the United States to an African source. From the records available and the climatology of Atlantic hurricanes, we consider it likely that the Great Galveston Hurricane had similar roots.

From whatever source, this embryonic hurricane passed across the Leeward Islands into the eastern Caribbean late on Thursday, August 30th. A small drop in surface pressure was observed at Antigua on that date, suggesting that the disturbance might have been a depression at that time, with a closed wind circulation. It moved south of Puerto Rico and Hispaniola over the weekend and made landfall in extreme southeast Cuba early Monday morning, September 3rd. The

strength at time of landfall in Cuba is unknown. However, the slow forward motion resulted in very heavy rains. One station in southeast Cuba reported 17 inches in 36 hours. The system finally moved into the Florida Straits near Havana early Wednesday morning September 5th. By afternoon the wind at Key West was blowing from the northeast, gusting to 45 mph. Late Wednesday evening, the pressure at Key West dropped to 996 mb, and the wind shifted to the southeast, suggesting the passage of a strong tropical storm or weak hurricane. The Weather Bureau in Washington, D.C. assumed the system was recurving to the north and east and decided to issue storm warnings for coastal areas in the southeastern United States. This was an unfortunate decision because the system continued moving between west-northwest and northwest toward the Texas coast, strengthening rapidly before it devastated Galveston late Saturday, September 8th.

Because no warnings had been issued for the Gulf of Mexico, the steamship *Louisiana* departed New Orleans Wednesday morning enroute to New York. During the night the skipper, Captain T. P. Halsey, noted a steady drop in pressure. Thursday morning, September 6th, one week after the system had entered the Eastern Caribbean, he observed the weather deteriorating rapidly with a sharp increase in wind. By afternoon, winds were gusting in excess of 100 mi/hr, and the barometer had dropped to 965 mb - near the threshold of a Category-3 hurricane on the Saffir/Simpson hurricane scale. Apparently, it had grown from a minimal hurricane to a Category 3 in approximately 24 hours. Nevertheless, the *Louisiana* survived the hurricane with minor damage and continued its journey to New York.

Again, because there were no warnings for the western Gulf of Mexico, another steamship, the *Pensacola*, left the Port of Galveston at 7 am, Friday morning, September 7th, some 36 hours before the arrival of the eye of the Great Hurricane. Captain Simmons was never aware that storm warnings were issued for Galveston Island thirty minutes later. Shortly after clearing the Bolivar Channel, the *Pensacola* encountered heavy seas and rough winds. Why Captain Simmons did not turn and run from the storm will never be known. He decided to stay on course for Pensacola. Faced with huge waves and winds near 100 mi/hr, Simmons ordered engines stopped Friday evening and dropped anchor.

The anchor chain parted Saturday morning at 10:30 AM and the *Pensacola* was at the mercy of the winds and the waves for the next 24 hours. Captain Simmons did not regain control of his ship until Sunday morning. He estimated they had drifted over 50 mi (80 km) during the night. Engines aboard the Pensacola were restarted and the ship steamed back into Galveston Sunday afternoon and docked amidst a mass of broken ships and dead bodies. Simmons had trouble navigating the harbor. Most of the familiar landmarks were missing or badly damaged.

The lowest pressure observed aboard the *Pensacola* was 965 mb on Friday night. The ship was never in the eye, where the pressure would have been much lower. The weather observations on the *Pensacola* and *Louisiana* show that the

Great Hurricane intensified very rapidly over the warm waters of the Gulf of Mexico from Wednesday until Friday. Unfortunately, forecasters did not realize this was happening.

It is unfortunate that Galveston remained unaware of what the *Pensacola* and the *Louisiana* were encountering. If they had known what the ships were experiencing, a train certainly would not have departed Beaumont early Saturday morning for Galveston. The plan called for the train to travel to the end of the Bolivar Peninsula, where it was to be transported to the Island by ferry. By the time the train reached the dock at midday, water was already up to the tracks and winds were near gale force. After numerous attempts to dock, the Captain of the ferry aborted the mission. The conductor ordered the train back to Beaumont. Ten of the 95 passengers ignored the order and waded in waist deep water seeking shelter in a nearby lighthouse. When the door to the lighthouse was finally opened, they found the spiral staircase jammed with almost 100 people. Amazingly, they all survived. All 85 passengers who stayed with the train perished when the train was washed off the track.

Furthermore, if there had been ship reports, a second train would not have departed Houston Saturday morning for Galveston. The Houston train made it across the bridge to the Island before being stranded by a washout. A second Houston train was dispatched on an adjacent track that was higher. By the time it arrived at midday, water was already over the tracks. Following a treacherous transfer of passengers from Train 1 to Train 2, the latter resumed a very slow, dangerous journey over flooded tracks to the downtown terminal. Train 2 lost all power about 100 yards from the terminal when rising water snuffed out the fire in the engine. Fortunately, all of the passengers were able to wade to the terminal. All bridges were destroyed, and the Island was cut off for several days.

The apathy on the Island at midday was appalling. Keep in mind this was only about eight hours before the arrival of the eye of a Category-4 hurricane. Most people felt the squalls would soon pass as they always had in the past.

A prime example of the apathy was the action of one of the passengers on Houston Train 2 who waded in waist deep water to keep a luncheon appointment. When he arrived at the office to meet his clients, he was told they had already departed for lunch. He then re-scheduled an appointment for 3 pm and waded back to the terminal to wait for the meeting.

Ironically, some of this apathy may have developed from public statements by Isaac Monroe Cline, including a local newspaper article he published in 1891. As meteorologist in charge of the Galveston Weather Bureau until 1901, they were statements he lived to regret when the Great Hurricane demolished Galveston in 1900. That they were conclusions of a broadly educated, erudite scientist, intellectual, and revered citizen of Galveston was sufficient for his constituents to consider his published accounts to be credible. Unfortunately, the statements were at best misleading. His statements and assertions, shared with various groups in Galveston were:

West Indies hurricanes are not a problem for Texas because they always recurve to the north before reaching the Western Gulf of Mexico.

Isaac was aware of the major hurricanes in 1875 and 1886 that destroyed Indianolia. He felt these were freak accidents. Indianolia was located on the south shore of Matagorda Bay and was the second biggest seaport in Texas in the mid-1800s before being destroyed.

Shallow water offshore from Galveston will protect the island from hurricane waves.

Just the opposite is true. Forecasters at the turn of the century did not understand the difference between wind waves generated by the hurricane and the storm surge. We now know the height of the storm surge is inversely related to the depth of the water and shallow water makes Galveston Island more vulnerable to the storm surge.

Buildings can be constructed to survive a hurricane.

Isaac had a chance to test this hypothesis when he rebuilt his home after it had been destroyed by fire in 1896. As we will see, the belief that his house was safe was, in part, responsible for the death of his wife.

These statements notwithstanding, I am not criticizing Dr. Cline's worthiness as a scientist. Isaac was a man of impeccable character and public credibility, holding advanced degrees in both physical and medical science. He was a notable pioneer in tropical meteorology with numerous authoritative publications on hurricanes. In 1901 he was appointed Meteorologist in charge of the Weather Bureau office at New Orleans and became one of the most highly regarded forecasters of his time. However, we will never know for sure whether his newspaper article in 1891 was at least partially responsible for the apathy.

The apathy in Galveston on September 8th came to an abrupt halt at Ritter's Café during the noon hour. Someone noticed there were thirteen men having lunch. They all had a big laugh. Shortly thereafter a gust of wind lifted the roof from the two-story building and the second floor came crashing down into the restaurant killing five immediately and seriously injuring another five. They sent one of the waiters for help, and he drowned in the flooded street.

News of this disaster quickly spread across the Island and people panicked. Hundreds converged on the posh Tremont Hotel. At the height of the storm, water covered the plush lobby and people retreated to the upper floors. It is estimated over a thousand people survived the hurricane in the Tremont.

On the east end of the Island, a tragedy was developing at the three-story Lucas Terrace Apartment. The apartment complex was surrounded by one-story, single-family homes. Before noon, rising water was entering the homes, and residents

were forced to seek higher ground. Many sought refuge in the second and third floors of the Lucas Terrace Apartment. Early in the afternoon the water was so deep, it was impossible to leave the area. The people in the apartment were trapped. By mid-afternoon huge timbers from a government construction project on the east end of the Island began battering the Lucas Terrace. One by one the 64 rooms in the apartment were destroyed. Only one room survived with its 22 occupants. Several hundred people probably died in this one apartment building.

The Saint Mary Orphanage was located on the beach three miles to the west of town. Two buildings housed 93 children, ages two to 13, with a staff of ten nuns. Boys occupied the older building located to the east; the new building to the west was reserved for girls. Water crested the sand dunes before noon, and the boys were moved to the newer stronger building with the girls. The older building collapsed early in the afternoon, and when the newer building with all the children began breaking apart, the nuns took pieces of clothesline and tied six to eight children to each nun. This was a deadly decision because, when one or two of the children went down, it dragged everyone else down. The only survivors were three thirteen-year-old boys who were not tied to others. They spent the night clinging to a tree that had been uprooted. Ninety children and all ten of the nuns died.

Galveston lost all contact with the outside world shortly after 3:30 pm when the last communication line to the mainland was severed. Joseph Cline, Isaac's brother, worked for Isaac in the Weather Bureau office. Since there was no longer any way to forward weather reports to Weather Bureau headquarters in Washington, Joseph decided to leave the office and check on Isaac's family. He waded in chest deep water to reach Isaac's home. Joseph urged Isaac to evacuate and take the family to the weather office, but Isaac insisted they stay, confident that his house was safe. He was also concerned his sick and pregnant wife could not survive the trip. In addition to Isaac's family, 50 other people had sought refuge in the Cline house.

Shortly after 6 pm, rising water forced everyone in Isaac's home to the second floor. One by one houses around them collapsed until the Cline home was the only one standing. Between 7 and 8 pm the Cline house shuddered, lifted off its foundation and gradually turned over. Joseph grabbed two of Isaac's daughters and leaped through the front window. Isaac, his wife, and youngest daughter were trapped inside the house. Isaac was knocked unconscious and does not know how he got out of the house. When he regained consciousness, lightning flashes revealed a small child nearby. He rescued her from the water and was delighted to find that the child was his youngest daughter. Moments later they made contact with Joseph and the other two daughters. The Clines floated on debris for around eight hours before being deposited on a pile of broken homes four blocks from the original location of the Cline home.

Isaac's wife was not located until September 30th when a demolition gang uncovered a body in a pile of rubble that was believed to be part of the Cline home. The body was identified by the wedding ring.

Years later, Isaac said, "We probably would have weathered the storm, but for the trestle." For a nickel you could take a trolley ride from downtown to the beach. Several hundred feet of the trolley track was over the water. The hurricane dislodged the track and the supporting trestle. As the trestle moved inland, it gathered wreckage, and the mass of broken debris acted like a giant bulldozer knocking down everything in its path. It was the trestle that finally destroyed Isaac's home.

Words cannot begin to describe the horrendous conditions that the survivors faced. Initially, there were the corpses to contend with: both human and animal. Early Monday there was an attempt to identify and bury the dead humans, at least. But this effort was quickly abandoned when city officials realized the number of bodies greatly exceeded their capabilities.

A second plan, initiated Monday afternoon, called for bodies to be buried at sea. The bodies, with weights attached, were to be transported out into the Gulf of Mexico on barges. City officials found, however, that the only way they could entice men to work on this task was to offer them free whiskey. The offer drew men to the job, but they soon became drunk, and incapable of attaching the weights properly. Tuesday morning hundreds of bodies washed back ashore.

This left one alternative: the bodies had to be burned. For weeks, rising plumes of smoke could be spotted on the Island and the air was filled with the stench of burning flesh.

LESSONS LEARNED FROM THE GREAT GALVESTON HURRICANE

What Lessons did the Islanders Learn?

First, and most important, they learned Texas is not immune from West Indies hurricanes. All five of the Category-4 hurricanes that hit Texas in the 20th Century had their origin in Africa.

Second, they learned the storm surge is the killer part of the hurricane. Historically, nine out of ten people who have died in a hurricane have drowned in the storm surge. Although the greatest potential for loss of life remains the storm surge, a recent study by Rappaport [2000] indicates that, since 1970, freshwater floods have caused more than one-half of all deaths in the United States directly associated with tropical systems[1]. They also learned that storm surge is not a series of big waves. It is a dome of water more than 50 miles (80 km) wide that sweeps across the coast near the point where the eye makes landfall. Superimposed on the dome are wind-driven waves. The height of the storm surge is inversely correlated to the depth of the water. Accordingly, the shallow water offshore from Galveston makes the Island vulnerable to a high storm surge.

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[1] Loss of life from hurricanes, as well as data on incidence of hurricanes and progress in prediction and warning skills, are based upon landfalls in the U.S. For example, they do not include loss from Hurricane Mitch in Central America in 2000.

Third, they learned that they did not understand the awesome forces associated with a hurricane; therefore, few people took any action to protect life and property until the water started to rise on Saturday, when it was too late.

Fourth, they learned if they were going to continue living on the Island, they must build some kind of a structure to protect the city. Almost immediately discussions focused on the need for a seawall. In September 1902, a contract for the seawall was signed. It was to be 17 ft high and more than 3 mi long. Before the project was completed in 1904, the U.S. Government paid to extend the seawall another mile to protect a fort. Down through the years the seawall was extended westward and is now over 10 mi long.

A second engineering project involved elevating portions of the city itself. The plan called for the Island to be filled to the level of the seawall on the beach with a gradual lowering of the grade to 10 feet at the center of the Island. To accomplish this task, a canal was dredged behind the seawall to the east end of the Island. Dredges were brought in from Europe to move fill from the bay to the Island. Two thousand one hundred fifty-six buildings had to be raised to accommodate the fill. In addition, streets, sidewalks, sewer lines, and the entire infrastructure had to be moved. The task of obtaining permits from over 2,000 landowners was an administrative nightmare. The contract for this fill project was signed in 1903, and the job was completed in 1911. Bixel and Turner [2000] devote a whole section in their book to these two remarkable engineering projects.

The wisdom of these two projects was verified in 1915, when another Category-4 hurricane hit the Island with a death toll of only 275. The seawall did exactly what it was designed to do; it protected the city.

Were These Lessons Applied in Adjacent Coastal Areas?

In the century that followed the Great Hurricane, have we been faithful in applying the lessons learned at Galveston in developing the Texas coast and other coastal areas?

The final westward extension of the seawall was completed in 1960 just before the arrival of Hurricane Carla in 1961 — the most recent Category-4 storm to strike Texas. Even though the eye crossed the coast near Port O'Connor, Carla was huge in size with tentacles reaching out to the Galveston/Houston area with a force comparable to the impact of a Category-3 hurricane. The water rose 9 ft along the beaches of Galveston, but the seawall protected the city. On the west end of the Island beyond the seawall, where ranching and fishing were the main activities, few buildings stood and thus damage was limited when Gulf waters spread across the Island.

By the time Alicia arrived in 1983, the west end of the Island had changed. The communities of Jamaica Beach, Pirates Beach, Terramar, Sea Isle, and Bay Harbor were all products of rapid development in the 1970s. With no consideration for hurricanes, homes in each of these villages were located on the beach with an average elevation of less than 5 ft.

Alicia, a Category-3 hurricane, produced weather conditions similar to what occurred in Carla. The seawall protected the city from the ten-foot storm surge. Beyond the seawall, however, there was extensive damage, particularly to homes near the beach. Of 207 homes on the beach, 99 were severely damaged or destroyed. Inland from the beach there was a remarkable decrease in damage. For example, on the second row (approximately 150 ft back from the beach) only 28 of the 169 homes suffered the same fate as those fronting the beach. More than 100 yds inland, homes were flooded but suffered very little damage.

This is an extremely important observation. If realistic setback lines for construction are established, beaches can be developed and potential damage from hurricanes can be reduced. This did not happen during reconstruction in the west end of Galveston Island after Alicia. Initially an attempt was made to enforce a Texas law that gives ownership to the State of all land seaward of the vegetation line. Because of erosion during Alicia, most of the homes on the first row were ahead of the vegetation line and were claimed by the State. However, after numerous lawsuits and intense pressure by the real-estate lobby, the State finally allowed the county to issue building permits for repairs to damaged homes.

The State and Galveston County missed a golden opportunity to do it right, and as a result, the west end of the Island is more exposed than before Alicia. Fifty-seven of the 99 destroyed beachfront homes and 23 of the 28 second-row homes were rebuilt. In addition, by 1994, 82 new beachfront homes had been constructed with another 83 on the second row.

In the decade prior to this publication, four new expensive beach projects have been started where beachfront lots have sold for about $200,000. As of 1999, there were 53 new beachfront homes and 36 new second-row homes in The Dunes, Kahala Beach, Indian Beach, and Acapulco Beach. In summary, before Alicia there were 207 beachfront homes on the west end of the Island. Today, there are over 300, and the number is growing every year.

The folly of rebuilding the west end of the Island with few restrictions was dramatically revealed during Tropical Storm Frances, which made landfall on the upper Texas coast in 1998. While Frances was only a tropical storm, the erosion was just as bad as had occurred during Alicia. The sand dunes that had been laboriously rebuilt during the 15 years that followed Alicia once again were swept away.

Again there was an attempt to enforce the Open Beaches Act. The Texas General Land Office identified 104 beach homes that were now on State land and were obstructing access to the beach. By law, the owners are required to remove these homes. Unfortunately, the Texas Attorney General refused to enforce the law and confusion reigned. This left the Land Office and local officials, who must issue building permits, in limbo. The result was that new developments on the west end were left just as exposed to hurricanes as Galveston was prior to the Great Hurricane.

POTENTIAL IMPACT OF AN EQUIVALENT "GREAT HURRICANE"

The following scenario is partially based on observations I have made of coastal damage in the aftermath of all major hurricanes that have hit the United States since Camille in 1969.

The height of the storm surge will range from 15 ft along the seawall to near 25 ft at the north end of Galveston Bay. Huge waves on top of the surge will break against the top of the seawall cascading tons of salt water onto the buildings on the north side of Seawall Boulevard, the street on top of the seawall. Water will be 5-10 ft deep in buildings in the center of town on the north side of the Island.

Out west beyond the seawall, water up to 10 ft deep will flow rapidly across the Island, causing catastrophic damage, particularly to beachfront homes. The damage will be much greater than what occurred during Alicia, and all 300 beachfront homes will be destroyed. Water will be deep enough to float the broken remains of beach homes, which will become battering rams — destroying homes on the second, third, and fourth rows. Over 1,000 homes on the west end of the Island will likely be destroyed.

Wave erosion will cut one or two channels through the Island, and road access to the west end might not be possible for weeks.

The two bridges connecting the Island to the mainland could also suffer damage, cutting off access to the Island for days or weeks.

The storm surge will cause water to rise 15-20 ft along the west side of Galveston Bay and in Clear Lake where the NASA complex is located. The beautiful waterfront recreational development in Kemah at the mouth of Clear Lake will probably be destroyed.

A 25-ft surge at the north end of Galveston Bay will cause serious flooding along the ship channel and close interstate highway I-10 East.

Winds up to 100 mi/hr will sweep inland more than fifty miles, causing extensive roof damage as far as Conroe to the north and Katy to the west. Building codes used in Southeast Texas are designed for winds up to around 75 mi/hr. When winds are in excess of 100 mi/hr, roofs start blowing off, weakening the building and causing walls to collapse. Winds over the inland areas could destroy over 100,000 homes.

The recovery process will be staggering. It could take weeks to restore water and power to many parts of Southeast Texas, and two to three years or more to rebuild all the destroyed homes.

It is a given that the west end of Galveston Island will be devastated during Category-4 or -5 hurricanes. What isn't known is how many people will die. This is a difficult question to answer because we do not know how soon people will respond to a call for action when a hurricane threatens. This is a major concern. Evacuation studies indicate it will take almost 36 hours to relocate residents-at-risk from Galveston Island and mainland coastal areas when a Category-4 or -5 hurricane threatens, even if all concerned act immediately when evacuation notices are issued.

Behavioral scientists tell us the first thing people do when faced with an official warning, particularly those who have little or no experience with a major hurricane, is to seek additional information to confirm the threat. Yet still another factor looms in this evaluation: when Carla hit Texas in 1961, the population of coastal counties from Matagorda Bay to Port Arthur was 1.6 million. Today it approaches 5 million.

As an additional concern, this explosive growth of coastal population occurred during a regional lull in hurricane occurrences. Out of the 36 hurricanes that hit Texas during the 20th Century, 21 have been in the Galveston/Houston area. But on closer examination, an interesting anomaly emerges. By dividing hurricane occurrences for the period 1896 through 2000 into three 35-year periods, we find the first third featured few but quite powerful hurricanes. The second was a very active hurricane period; the decade of the 1940s alone produced six hurricanes. During the final 35 years, there have been only five hurricanes, and with the exception of Alicia, they all have been weak. Hurricanes Chantal and Jerry in 1989 were the last hurricanes in Southeast Texas, and they were both Category 1 in strength. Clearly, the design of protective measures and plans of action to cope with the hurricane menace should not lean too heavily on hurricane climatology.

When the Great Hurricane threatened Galveston, neither residents nor local officials were prepared to respond appropriately. Today Island residents are well informed and better prepared. During the last 25 years, there has been a major effort to educate the people about hurricanes. In the 1970s, the Texas Marine Council started focusing on the hurricane problem and developed an excellent educational package. Every year newspapers and TV stations start the hurricane season with a hurricane special. Emergency managers, weather service personnel, and representatives of the media have given thousands of public talks. Free hurricane tracking charts are available at local supermarkets, with a map on the back showing what areas will be flooded by the storm surge. If there are people on the Island who are uninformed, they are in a state of denial and have their heads buried in the sands of ignorance.

However, the current lull in hurricanes enjoyed by Galvestonians may be coming to an end if the recent sharp increase in Atlantic "named storms" indicates a long-term future trend. Seventy-nine "named storms" occurred in the Atlantic basin from 1995 to 2000. This is the most active six-year period in the history of our hurricane records and represents a dramatic upturn from the 54 "named storms" that occurred in the previous six years (1989-1994).

Goldenberg and his collaborators [2001] suggested alternating patterns of quiet versus active hurricane periods related to decadal fluctuations in the temperature of the ocean. More hurricanes occur when the ocean water is warm. The tropical Atlantic was warm during the 1940s, 1950s, and 1960s when the number of hurricanes was above normal. The 1970s, 1980s and early 1990s featured cold water and fewer hurricanes. The recent increase in "named storms" appears to be in response to a warming of the ocean, and this could be the beginning of a long-term trend. If true, the early 21st Century may have some dramatic surprises for the United States.

The absence of major hurricanes, coupled with a large influx of new coastal residents in the years preceding this publication, could prove a deadly combination, if multitudes of new residents ended up wasting precious time trying to confirm the reality of a warning, rather than evacuating promptly. There remains, as well, the possibility of a meteorological surprise with inadequate warning time for people to respond. The nightmare hurricane forecasters fear most is explosive intensification of a weak hurricane as it approaches landfall. Either way, multitudes could be trapped on the Island, making the possibility of another Galveston disaster very real.

Psychologists tell us memories of bad events tend to dim with time. A wise philosopher once said those who ignore history are condemned to repeat it. Ignorance and fading memories are both evident today in planning and developing coastal areas.

So, what are we doing to prevent major lose of life in a future Great Hurricane? Very little, if the development of the west end of Galveston Island is an indication of what is occurring in other areas vulnerable to hurricanes. Our observations suggest that the Galveston Island development and vulnerability is not uncommon along the Gulf and Atlantic coasts. Despite the advances in understanding hurricanes, documented in other chapters, I consider the United States more vulnerable to hurricanes today than at any time in its history.

TABLE 1. Hurricanes Striking Southeast Texas

Years	Number of Hurricanes	Number of Major Hurricanes
1896-1930	5	3
1931-1965	11	4
1966-2000	5	1

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