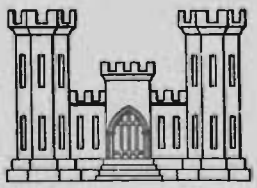
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS

BEACH EROSION BOARD
OFFICE OF THE CHIEF OF ENGINEERS

HURRICANES AFFECTING THE COAST OF TEXAS FROM GALVESTON TO RIO GRANDE

TECHNICAL MEMORANDUM NO. 78



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MARCH 1956

FOREWORD

Waves and high waters accompanying storms of hurricane intensity have periodically wreaked havoc along the Gulf and Atlantic coasts of the United States. Adequate, and economic, design of shore structures to prevent or mitigate this damage requires historical knowledge of past storms. This knowledge, although previously available, is scattered among many sources -- requiring, therefore, a considerable amount of time to gather for use for any particular area. The present report represents a collection of available data on hurricanes reaching and passing inland over the Texas coast between Galveston and the Rio Grande, and certain conclusions as to frequency of occurrence derived therefrom.

This report was prepared by Dr. W. Armstrong Price, formerly Professor of Geological Oceanography at the Agricultural and Mechanical College of Texas, and now a Consulting Geologist in Corpus Christi, Texas. The initial statistical studies were made by Dr. Price in connection with his consulting work for several oil companies; these were later revised, extended, and submitted to the Board for publication. The report is being published at this time in connection with the recently expanded responsibilities of the Corps of Engineers in hurricane damage prevention as outlined in Public Law 71 of the 84th Congress.

Views and conclusions stated in the report are not necessarily those of the Beach Erosion Board.

This report is published under authority of Public Law 166, 79th Congress, approved July 31, 1945.

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HURRICANES AFFECTING THE COAST OF TEXAS FROM GALVESTON TO RIO GRANDE

by
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INTRODUCTION

The hurricane of the tropical North Atlantic Ocean and associated waters, and its counterpart, the typhoon of the Pacific Ocean, have been the subject of much study. Several treatises have been written on it, one or more being the product of the improved techniques and expanded knowledge of the past decade.

The Texas coast lies at the extreme northwestern range of the hurricane, which is there somewhat less frequent and destructive than farther east. Its range during the year is restricted to fewer months and the winds are in general less destructive. Flood damage to low-lying communities may, however, be high.

Hurricanes are the most severe storms of the Texas coast, and as such interest the property owner, the government, the administrator of coastal communities and the scientist. The geologist sees them as an agent of coastal erosion and sedimentation.

The statistical analyses presented deal only with the coast from Galveston to the Rio Grande. However, the maps in the chronicle (Appendix A) include the data available in the United States on storms from Tampico to the Rio Grande. Hurricanes which struck the Mexican coast are shown as such on the maps, but they are recorded in the tables only in the degree and according to the nature in which they appeared at the Rio Grande.

HURRICANES AND OTHER TROPICAL CYCLONES

General - Tropical cyclones of the Atlantic, Caribbean and Gulf of Mexico which have hourly wind velocities of 75 miles or more are called hurricanes, here designated H (lesser ones C). In Weather Bureau reports C storms may be termed gales or a center of gales. The C storms are not specifically studied here.

Early records of marine floods or surges ("tidal waves") for which the type of storm is not known are designated T. These were in nearly all cases probably caused by H or C storms. With either intensity there may be damaging floods (designated F) from land streams and the sheet runoff of flat lands and prairie. Flood danger may come during

or some days after the storm, in the latter case from rainfall occurring inland. Such floods are more often severe on the southern Gulf coast of Mexico, where high mountains approach the coast, than they are in Texas.

Storms with a record of appreciable or notable wind damage or with hourly velocities of 90 miles per hour or more are designated W. Where the month and type of storm are not known, the reported wind damage may have been caused by a non-cyclonic storm.

Tornadoes - Damaging tornadoes have been extremely rare on this coast. From Corpus Christi southward they have, as reported, occurred almost exclusively in, or been associated with, a hurricane and their identification is doubtful. Lately several small tornadoes were observed just west and north of Corpus Christi. Water spouts are common over the bays but have rarely done damage on land. Long, clear, ribbon-shaped, tornado-like movements of air occur at times in large numbers during a single day over the sand sheet between Baffin Bay and the Rio Grande or further north but have not been known to cause damage. The tops of these ribbons may be thousands of feet high but the twisters seem rarely to touch the ground. When they do, they flash black to their disappearing summits.

The Data and Their Sources -- Wind velocities given are averages over 1-hour periods unless designated as maximum (5-minute to 1-minute) or extreme (gust) velocities.

Paths of storms, for which latitude and longitude data were found, were replotted, resulting in some minor corrections of maps made before 1949. Path data have become progressively more accurate as radio messages from ships and surveys by aircraft and radar have been added to the earlier techniques.

For many early storms only the area or point where the storm center reached the coast and presumably passed inland (landfall point) is known. For these, the short lengths of path shown on the maps have no directional significance other than that the coast was affected.

Weather Bureau data and general information on Gulf hurricanes began to be more accurate, timely and full with the inauguration in 1942 of a 24-hour integrated hurricane reporting and forecasting service along the Gulf coast and with a coincidental change in the attitude of coastal communities and the press toward the study of hurricanes and preparations to withstand them.

The compilation of the data for this study was begun in 1930, extended and rechecked in 1947-1949. Data on subsequent storms were added in 1955. Files of the Weather Bureau station at Corpus Christi were searched from time to time between 1930 and 1949 with the aid of the officials in charge, J. P. McAuliffe to 1946 and R. P. Mozeney thereafter.

The basic data were checked by the headquarters staff of the Bureau in Washington in 1949.

The references listed in Appendix A have furnished many of the data used. Original data were obtained at the National Archives in Washington from published and unpublished reports of members of the United States Army and Coast Guard, recorded from 1845 to 1881 and containing items as early as 1818. Official surveys of the Federal archives furnished a few other data.

Much information was obtained by personal observation and storm surveys of the coast between Houston and the Rio Grande from 1930 to 1949. Other unofficial reports and news items that are judged reliable have been used.

The combined official and unofficial information available for the early period, 1829-1886, yields a record less complete than, but in general in harmony with, the mainly official record which begins in 1887. The latter record coincides with the establishment of Weather Bureau stations in the Gulf region, especially the establishment of the Corpus Christi weather station in February 1887.

The data for Texas concerning tropical cyclones of less than hurricane intensity (C) are significant only after 1887, the ratio being 4C to 5H. This low C value, in reference to typhoons and other cyclonic storms of the Pacific Ocean, may indicate incomplete records and only partial appraisal of the wind and pressure data for Texas. The T and F storms of this report were probably mostly C storms, except for the floods of Brazos Santiago Island and Inlet (near the mouth of the Rio Grande) occurring before 1845. These seem to have been caused by the reported hurricanes of those years.

The data are incomplete for wind damage (W). Extensive damage to well built and braced structures by wind alone seems to have occurred on the Texas coast only with sustained wind velocities of 90 miles per hour or more. Such ground velocities here rarely accompany storms other than hurricanes. All storms of June to October with such high velocities have here been designated W, whether or not there was an accompanying record of wind damage.

ANALYSIS OF DATA

Graphs and Tables - The hurricane data are presented chronologically in detail in the chronicle (Appendix A of this report) and more briefly on the maps of hurricane paths. Tables and graphs show several methods of analyzing the incidence and the landfall paths of the hurricanes.

Hurricane Incidence and Cycles*- The records of a total of 54 hurricanes from 1818 to 1955 have been assembled for this coast from all

* See Appendix B for discussion of possible relation of hurricane incidence in Texas to sun spot activity.

sources examined (see chronicle in Appendix A). The data are summarized in Table 1 and Figure 1. The classification (H versus C) of a few is somewhat uncertain. The record is poor before 1829 and not all the H storms from 1829 to 1887 can have been recorded.

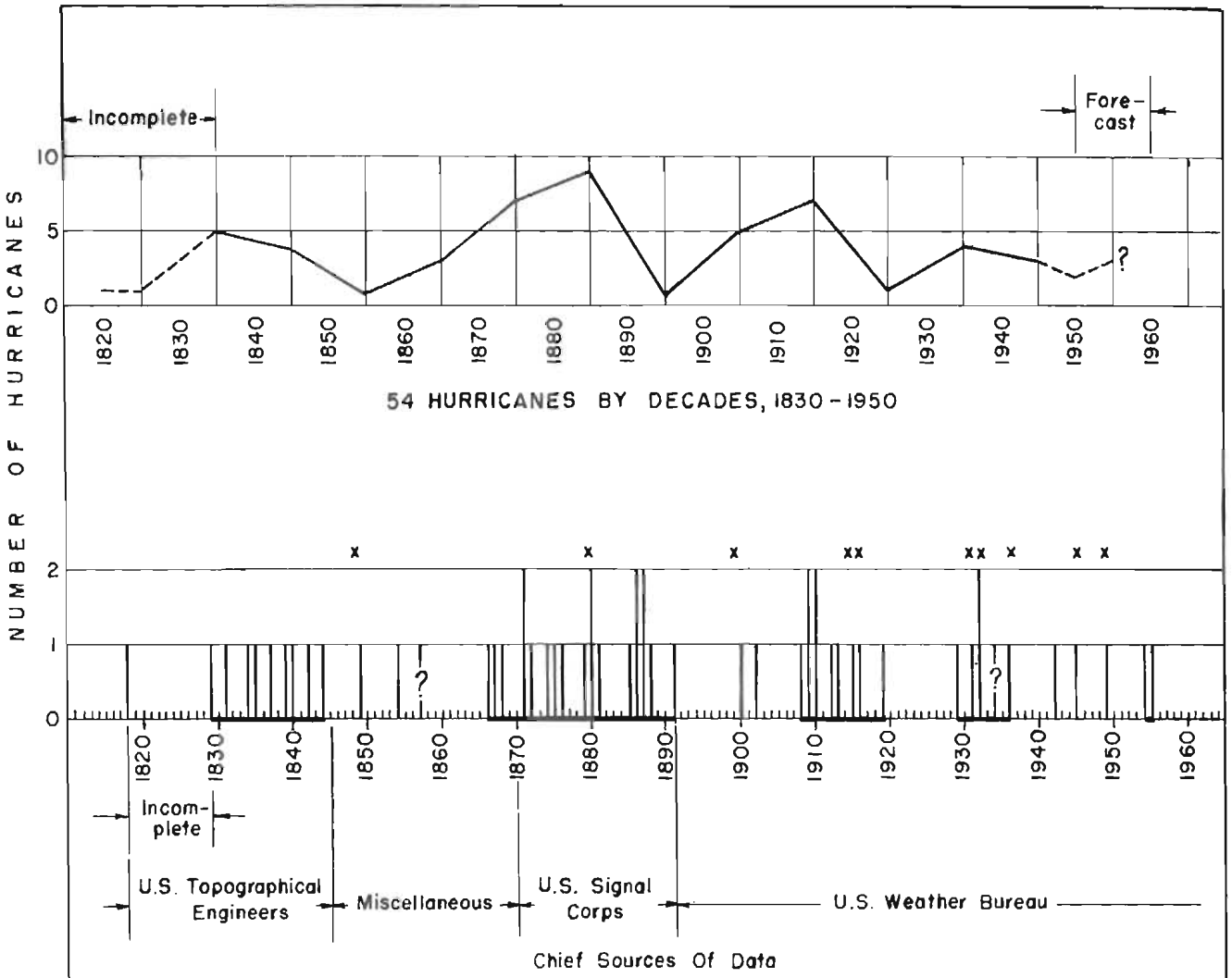
Throughout the 127 years from 1829 to 1955, covered in varying degrees of completeness, 53 hurricanes are known, averaging 1 H every 2.5 years. However, there has been a rough but definitely cyclic alternation of hurricane-rich and hurricane-poor periods which as here delimited, average 15.6 years and vary from 8 to 26 years. During hurricane-rich periods there was 1 H every 1 to 2 years, averaging 1 every 1.4 years. During hurricane-poor periods there was 1 H every 5 to 10 years, averaging 1 every 9.0 years. No rigid use should be made of these incomplete data. They are summarized by periods in Table 2.

The summary shows that from 1829 to 1955 Texas hurricanes alternated between an incidence of about 1 every 9 years and 1 every 1.4 years. The over all average was 1 every 2.5 years with the near-certainty that they actually occurred slightly more frequently. These figures yield an incidence of about 40 hurricanes per century along 300 miles of shore line. A fuller analysis of the data (Table 1) gives a probability of 45H/100 years. When hurricane incidence is analyzed by decades (Figure 1), the peaks are separated by lows every 30 to 40 years. The maximum is 9H per decade and the minimum 1. However, only two peaks are complete, reaching maxima at 1880 and 1910. Another peak may be expected by 1960. The 1880 peak covering the decades 1860-1880 is the highest on the curve, with a progressive decline and shorter periods after 1880.

If 75 miles is arbitrarily taken as an average shoreline width appreciably affected by a hurricane in Texas, a single locality may thus experience 16-year periods with an average of 2H per period and 16-year periods with one every 3 to 4 periods. Only small differences in these figures result if the periods 1850-1949 or 1887-1955 are used for statistical analysis instead of 1829-1955. Because winds of hurricane force sometimes extend out much more than 75 miles from the eye, the actual average incidence is greater than the figures given above if the outer margins of hurricanes are considered. Still more distant hurricanes may affect a locality with winds of less than hurricane force and be classified as a C storm.

Hurricanes of the Present Decade - Because of the well developed observational and record systems now in force, the storms of the current decade are especially instructive. Out of the eleven tropical storms (8H, 3C) mapped for 1950-55, eight originated in the Gulf, while six of these started in the western Gulf and reached or threatened the Texas coast. (See maps of hurricane paths in Appendix A.)

Due to the persistent northerly shift of the paths of the easterlies during the hurricane season, or at the times when hurricanes were present,



Note:

Hurricane - rich periods underlined (average 15.5 yrs.; 11 H per period)

Winds reported 90 mph or more (x).

FIGURE 1 · PERIODICITY OF HURRICANES, GALVESTON TO RIO GRANDE, TEXAS - 127(138) YEARS OF RECORD, 1818 - 1955

TABLE 1

INCIDENCE OF HURRICANES FROM GALVESTON TO RIO GRANDE WITH STATISTICAL AVERAGES

Decade Beginning	June	July	Aug.	Sept.	Oct.	Nov.	Mo. not Known	Total	Remarks
1810 (First record, 1818)							1	1	
1820				1				1	
1830			2	2		1		5	Records
1840			1		2		1	4	incomplete
1850				1				1	
1860					1		2	3	
1870	1	1	1	2	1		1	7	
1880		1	3	3	2			9	
1890		1						1	
1900		2	1	2				5	
1910	1		2	2	2			7	Records
1920	1							1	complete
1930	1		2	1				4	through
1940			2		1			3	1955
1950	1			1				2	
SUMMARIES									
1810-1955	5	5	14 (16)*	15 (17)	9 (10)	1	5	54	
Best 100-yr. record 1850-1949	5	5	11 (12)	11 (12)	7 (8)	-	3	42	Actual record
Based on 1870-1949	5	5	13 (14)	10	6	-	1	39	100-year estimates
Based on 1810-1955	3	3	11	12	7	1	-	37	
Probability	5	5	12	14	8	1	-	45 or more	

*Figures in parentheses are weighted adjustments of hurricanes of unknown months.

TABLE 2

CYCLIC INCIDENCE OF HURRICANES FROM GALVESTON TO RIO GRANDE
1829-1953

	Periods					Summary	Average
H-Rich Periods:	1829-* 1844	1866- 1891	1908- 1919	1929 1936		62/4	15.5 yrs.
Ratio: H/Yr.	9/16	20/26	10/12	5/8		44/62	1/1.4 yrs. or 11 per period
H-Poor Periods	1845- 1865	1892- 1907	1920- 1928	1937- 1953		63/4	15.7 yrs.
Ratio H/Yr.	2/21	2/16	0/9	3/17		7/63	1/9.0 yrs. or 2 per period
Totals:	51 H / 125 yrs or 1 every 2.5 years						

* The data for the 1829-1884 period may be incomplete, as its beginning is not known. The 2 H of 1954-1955, not entered here, seem to mark the beginning of a H-rich period.

only one of these storms recurved strongly enough to the north and northeast to carry it away from the western shore line. This one made a complete circle.

Storms originating in the southern Gulf and protected from the easterlies by the Yucatan peninsula followed a short recurved counterclockwise path to land. One originating at 23° north latitude was driven northwest to land by the easterlies. However, another, originating off Corpus Christi followed a counterclockwise course. Offshore data on these storms have been few, as weather planes have not been available to investigate them.

Because most of the storms that crossed the shore line of Mexico continued to the high mountains, there were record floods with loss of life and property. Losses were heavy in crowded lowland communities such as Tampico. In September 1955 rainfall at Corpus Christi was 7.64 inches in one day and 11.7 inches for the month, but the total for the year was still below normal. A local observation indicates rainfall of 17.02 inches in 24 hours and 6 inches in 4 hours.

Wind damage by the strong Caribbean hurricanes which entered Mexico was heavy, indicating that cities threatened by such hurricanes should expect widespread destruction of buildings.

From September 4th to 29th, 1955 there was at all times a tropical storm of some type in or approaching the western Gulf. Three of these were hurricanes.

Because the periodicity curves indicate that 1954-55 marked the beginning of a hurricane-rich period, Gulf Coast communities should for the next two decades be fully instructed each spring as to hurricane hazards and should be prepared to put emergency measures into effect in advance of hurricane arrival.

Forecast for 1956-1959 - Using the data on the periodicity of the hurricanes affecting the coast of Texas, it is seen that, if the past 125-year period is taken as a guide, a hurricane-poor period ended with 1953 and a hurricane-rich period began with 1954. This forecast is based on the scarcity of hurricanes for 17 years preceding 1954. There were 5 H and 1 C on the Texas coast in 1954 and 1955.

The immediately following period, 1956-1970, may be like the periods centering on 1913 or 1933 in having hurricanes every year or two with a probability of 2 H in some years and one or two quiet periods of two years each.

H. C. Willett (1955) has also predicted an increase in the incidence of hurricanes for the Western Gulf beginning in 1956 but says that the expected increase should be only "slight". Willett's prediction is based on the periodicity in the fluctuations of solar radiation. His data include all hurricanes of the Atlantic and Gulf for 1900-1955 and do not

show an over-all periodicity in hurricane numbers, but only local variations in incidence associated with shifts of hurricane paths and groupings of hurricanes by years.

Incidence of Hurricanesby Month of Landfall (1850-1949) - In the century 1850-1949 of reasonably complete records, hurricanes affected the Texas coast in every month from June to October, the total reaching forty-three or more. In the Atlantic and Caribbean, hurricanes occur from May to December. Two November hurricanes are known for the Texas coast, one in 1839 and one in the 16th Century when a merchant fleet was wrecked on Galveston Island. August and September led with eleven each. On the basis of probability, however (Figure 2), September should be the peak month (31%) here, as it is in the Atlantic and Caribbean. The low on the curve falls in November with 2 percent.

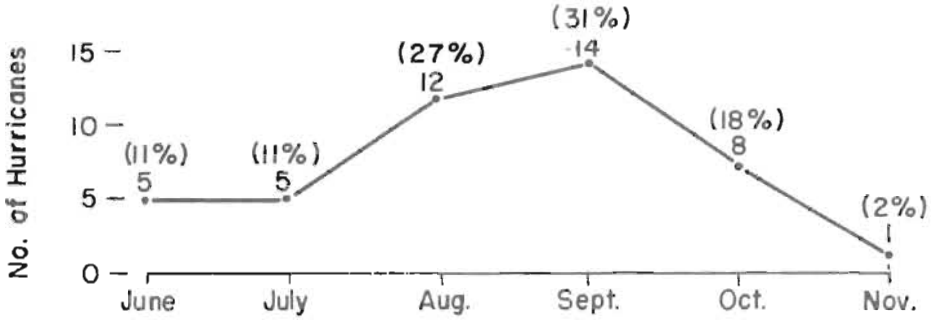


FIGURE 2 HURRICANE INCIDENCE BY MONTHS, 1850 - 1949

Areas of Origin of American Tropical Cyclones - Hurricanes and lesser cyclonic storms originate in the Atlantic, Caribbean and Gulf of Mexico. The storms originating in the Gulf are fewer and in general weaker than those originating farther east. However, they usually reach land in one or two days, giving very short notice after it is discovered that the parent squalls have developed a center with forward motion.

Paths of Storm Centers - Some Gulf hurricanes have the supposedly characteristic hurricane path that curves smoothly northwest-north-northeast. This is, however, not the common path of the hurricanes reaching or originating in the Gulf of Mexico (see maps of hurricane paths in Appendix A). The west to northwest courses of hurricanes reaching the Gulf from the Caribbean often persist to the coast of Texas or Mexico.

The low plains of the peninsula of Yucatan seem seldom to cause

hurricanes to dissipate or veer strongly from their courses. No typhoons seem to be known to have crossed the hilly but narrow Isthmus of Tehuantepec from the Pacific, but Janet of 1955 crossed the Mexican Sierra and re-formed in the Pacific as a hurricane.

Because some hurricanes are 100 or more miles wide and some follow a course parallel with or diagonal to the Texas shore line, individual localities may have a somewhat higher expectancy than the tables indicate.

Path - From any west or northwest path (see hurricane path maps) the storm may continue to or toward Texas or recurve north, west or southwest to reach the Texas coast. Several curving storms have touched the Rio Grande delta on a northwest course and then swung north and northeast to move offshore along the entire Texas coast or to curve away from it.

A storm of October 1910 originating in the Gulf nearshore between Corpus Christi and Port Isabel moved east-northeast to cross northern Florida into the Atlantic. A few others of the southwestern Gulf have followed somewhat similar northeast paths. Gulf hurricane Love, of 1950 was turned back (counterclockwise), south of Louisiana, from a northwest course and crossed Florida on a northeast path.

Terminal Path Approaching Landfall - A fairly close prediction of the direction of movement of the final part of the hurricane path as it approaches the Texas coast can be made from full meteorological data. The variability of this portion of the path is shown by the graph (Figure 3) based on the half-century 1900 to 1949.

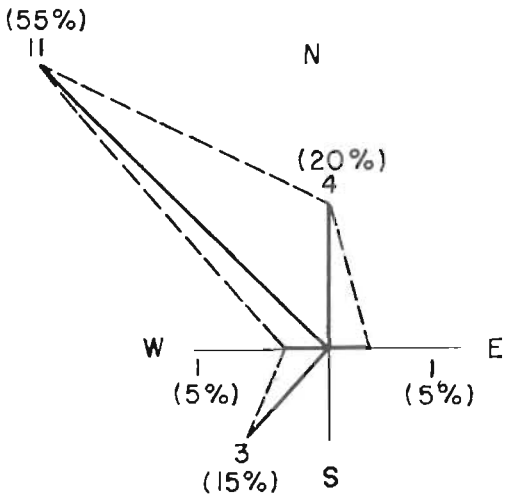


FIGURE 3 VARIABILITY OF HURRICANE PATHS - 50-YEAR PERIOD, 1900-1949

The graph shows that the dominance of directions of travel at landfall in the northwest quadrant is more striking than the 55 percent figure would indicate, the percentage for the quadrant, including the north and west directions, being 80 percent of the total. A hurricane of the 1910 decade is shown in the graph as moving east. This storm did not result in a Texas landfall, as the storm originated at the shore and moved away. A few of the northwest storms moved in over the land a short distance but soon returned to the shore and entered the Gulf again on a northeast course. These northeast emergent paths have not been incorporated in the graphs of Figure 3 but are shown on the hurricane path maps in Appendix A.

SOME LARGE-SCALE WEATHER CONDITIONS REPORTED TO AFFECT HURRICANES OFF THE COAST OF TEXAS

Prevailing Wind Systems - As the young hurricane moves slowly northward from the tropics under the rotational force of the earth it may be deflected to the west or northwest by the upper air easterlies. After it has made enough northward distance (unless it first passes into Mexico or Texas) it may recurve north and northeast under the direction of the upper air westerlies. These east and west wind systems may shift north or south in any year, affecting the hurricane paths.

High-Altitude Masses of Cold Air from Western Mountains - Cold air masses crossing the mountains of Mexico and the southwestern United States from the Pacific are said to reduce hurricane incidence off Texas after September, the season usually ending about the middle of October. Such cold air masses are also reported to have halted hurricanes in the western Gulf and caused them to dissipate, as in the case of the hurricanes in 1944 and 1952 which circled in an area 300 miles off Corpus Christi before dissipating.

Low Pressure Areas on Land - Approach toward each other of a low and a hurricane has been followed by the H storm leaving a northeast course to recurve to the west or southwest and enter the low. Several such occurrences were noted between 1930 and 1955.

Entrainment with Jet-Stream Currents - Strong currents are said at times to loop southward from the easterly-moving high-altitude jet stream of the northern and central parts of North America and entrain hurricanes in the Gulf of Mexico. The hurricane is then carried on a northeasterly path into the continent or to the Atlantic.

Effects of Moon Phases and Atmospheric Tides. - Both J. P. McAuliffe and the writer have verified from the records for a number of decades that hurricanes of the Western Gulf tend to be reduced in wind intensity to less than hurricane grade if they approach the shore as the moon is changing from light to dark and to increase in intensity if the opposite change is taking place. No hurricane for which there are adequate records seems to have crossed the Texas shore line southwest of Galveston during a well-established dark phase of the moon without being reduced to a C

storm. The number of storms known to have been so affected is small, however. This relationship may not hold for other sectors of the Gulf coast.

It was earlier thought that the moon-hurricane relation might be a mere coincidence and no publicity was given to it. However, recently gained knowledge of atmospheric tides suggests a connection between these phenomena. A. G. McNish of the National Bureau of Standards* is reported to have detected twice-a-day atmospheric tides, with occasional spring tides. The latter occur twice in every lunar month, 4 days after new moon and 4 days after full moon.

Because the hurricane is a phenomenon of great height and volume, it seems possible that there is a connection between atmospheric tides and the variations in wind strength noted. The critical values that rule this close adjustment precisely at the shore line of Texas may not rule elsewhere.

H. C. Willett (1955) shows that the causative convection phenomenon of the hurricane depends on a rather small marginal condition of temperature as well as pressure and atmospheric moisture. It seems possible that there is a sufficient difference in heating of air and water surfaces between the phases of the moon to influence the convective instability necessary to maintain the hurricane, at least under the marginal conditions that seem to exist in the extreme northwestern part of the Gulf.

SURGES ("TIDAL WAVES") FLOODING PADRE ISLAND

Padre Island is a narrow sandy, 110-mile barrier island of the Texas coast and is now joined, by filling of Corpus Christi pass, to Mustang Island, another, 18-mile, section of the barrier chain of Texas. Padre Island ranges from about 1 to 3 miles in width. It was once more or less continuously walled just back of its gently sloping beach by a chain of vegetated (15 to 25-foot) foredunes with low gaps. The gaps between the dunes were the sites of washover floods of storm surges. Landward from the beach, the channels remain and lead to the branching distributary channels of the washover fans or deltas.

Surges of hurricanes between 1930 and 1945 followed by drought from 1948 to 1955 have lowered the surface of the Island, lowered and eroded the dunes except in areas in the extreme northern part, and largely destroyed the grassy cover which once supported cattle ranching. The area of bare migrating dune fields has been much expanded.

The lists, table (Table 3) and map (Figure 4) summarize information on floods that have affected Padre Island, including the writers' inferences that certain storms without flood records probably flooded the Island. This flooding varies from a mere reactivation of the washover

*Presidential address, Philosophical Society of Washington, 1953, reported in Science News-Letter, February 14, 1953, p. 102.

TABLE 3

FLOODS CROSSING PADRE ISLAND

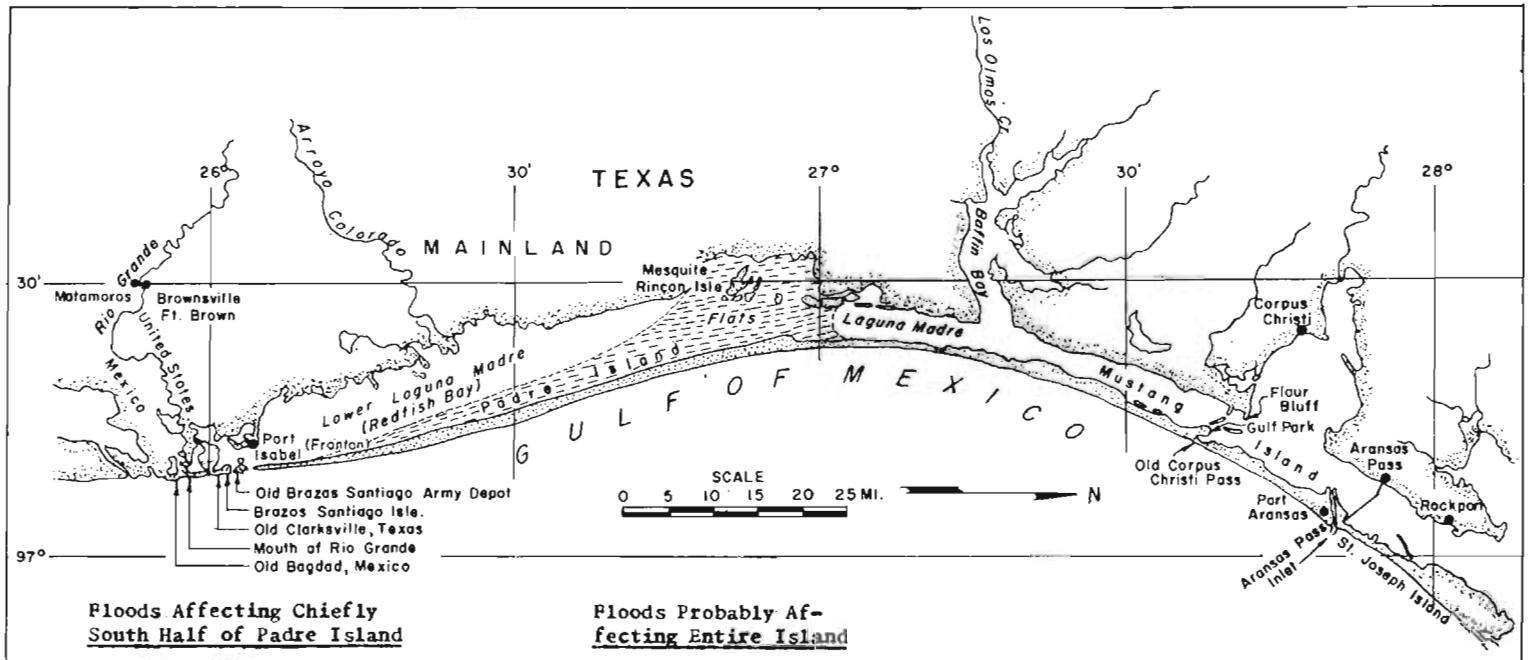
(1829-1949)

(The data on floods are incomplete and the figures given represent an interpretation of information from a variety of sources)

Area	Flood Category	Known Hurricane Floods	Assumed Floods of known Hurricanes	Totals
Padre Island (all or unknown part flooded)	Flood	2	2	
	High Flood	2	2	
	Great Flood	-	-	
North End (solely or chiefly affected)	Flood	-	1	
	High Flood	1	-	
	Great Flood	1	-	
South End & Mouth Of Rio Grande	Flood	11	4	
	High Flood	2	1	
	Great Flood	2	-	
Summary	Flood	13	7	20
	High Flood	5	3	8
	Great Flood	3	-	3
TOTALS		21	10	31

Rate of Flood Occurrence: 1 in 4 years, probably 1 in 3 years.

Maximum Floods: 1 in 40 years, probably 1 in 30 years.



Floods Affecting Chiefly South Half of Padre Island		
1829	Oct. 1867	1866?
1831	Oct. 1880	1872?
1834		Sept. 1887?
1838	Sept. 1921	Sept. 1910?
1840	June 1933	Sept. 1920?
1842	Aug. 1933	June 1922?
1844	July 1947	
1857		

Floods Probably Affecting Entire Island
Sept. 1837
Sept. 1876
Aug. 1909
Jul. 1933
Aug. 1895?
Oct. 1912?
June 1913?
Sept. 1936?

Floods Affecting Chiefly North Half of Padre Island
Aug. 1916
Sept. 1919
Aug. 1934?

KEY:

RECORDED FLOODS:

Flood Category	Example
Flood	1829
High flood	Oct. 1867
Great flood	Aug. 1933

HURRICANES WHOSE PATHS AND STRENGTHS INDICATE FLOODS

Flood	1866?
High flood	1887?

FIGURE 4 · HURRICANE FLOODS OF RECORD AFFECTING PADRE ISLAND, WITH PROBABLE FLOODS 1829-1949

channels by floods from 3 to 4 feet above mean low water to broad floods accompanied by extensive wave-and-current erosion of dunes under surge heights of 5 to 11 feet.

Erosion and the action of salt waters followed by a drought of record length and severity have greatly changed the appearance and economic productivity of the Island. Cattle were not run on the southern half of the Island after 1945 and ranching at the north end has more recently been still further reduced because of loss of grass.

The high, broad, well-vegetated dunes at the north end of the Island in the area of the tidal delta were attacked by wind after 1949. Some of the dunes marched off, allowing debris, including Indian artifacts and relics of early Spanish and other European colonists and visitors, to settle to the level of the stripped plain. Silver Spanish coins dated in the latter part of the 16th Century were found, indicating high stability of this part of the Island and the long protection of these well vegetated dunes from surge erosion.

HURRICANE DAMAGE

Wind Damage - Some general observations may be reported on this subject. Between 1890 and 1955 only about eight Texas hurricanes out of twenty (or 2/5 of all H) seem to have had hourly winds of 90 miles per hour or faster. These two-fifths of the storms include the only storms for which heavy wind damage seems to have been recorded. Nearly all the loss of life reported for this coast was due to stream or marine floods (surges) invading unevacuated and unprotected low-lying flats.

Wind damage observed by the writer as due to storms with winds under 90 miles per hour has been confined largely to advertising billboards in open areas and to weak or previously damaged frame cottages. With higher winds, many structures may be vulnerable, but the damage personally observed by the writer was confined chiefly to (a) the collapse of unsupported upward false extensions of store fronts, (b) the unroofing of these buildings after an entrance for the wind was obtained during collapse of the false front, (c) unroofing of tightly closed buildings after a window had been broken, (d) the collapse of brick buildings after soaking of old mortar when roof, upper floors and upper walls rested on the lower walls instead of on separate framework, and (e) ruffling of some composition shingles. There were also frame buildings which had collapsed for no evident reason. Some old frame buildings have withstood severe hurricanes. Trees and poles may fall under strong wind when earth or soil enclosing the roots or buried ends has become heavily water-soaked.

Maximum wind damage occurs when the center or eye of the storm moves to the shore slightly to the south of the locality, bringing high-velocity winds of long fetch and low frictional loss from off the Gulf. Willett (1955) discusses such damage in more detail.

Surge ("Tidal Wave") Damage - Maximum heights of surge floods occur at the right-hand side (looking shoreward) of the advancing end of a long ridge of water which has been built up by the winds and has moved straight ahead of the storm along its earlier path regardless of whether the center has subsequently veered away from this path. The configuration of this ridge may, of course, become modified by curvings of the storm center. The high water may lag behind the storm by several hours.

A surge height of 11 feet at the Gulf shore line of the barrier chain at Port Aransas in 1919 produced a 12 to 15-foot flood 20 miles away at the mainland shore of the large oval Corpus Christi Bay. The center moved inland just south of the city. The high water at the head of the bay is said to have occurred soon after the washing away of St. Joseph Island for 5 miles north of the Aransas Pass Inlet. The flood in the bay is supposed to have been increased also by water blown into it from the north from the coastal lagoon, after which, the wind veered so as to drive the augmented bay waters toward the head of the Bay.

Observations on Padre Island show that well-vegetated sand dunes may withstand numerous hurricane surges over periods of several centuries while loosely vegetated dunes are washed away or strongly eroded. The vegetation involved was chiefly grassy, but included live oak brush in some areas.

Low "Tide" in Surges - The spiral winds of hurricanes may cause low "tides" in some bays and lagoon sectors. Under such conditions, waves have been known to smash small boats against the bottom. It is possible that a high flood tide may follow such low water.

SOME GEOLOGICAL EFFECTS OF HURRICANES ON COAST OF TEXAS

Spectacular Erosion - As is well known spectacular erosion may occur on sandy beaches and dunes. On this coast, the low, narrow duneless southern ends of barrier islands have at times been eroded down to levels below mean low tide, as on St. Joseph Island in the 1919 storm. New inlets have been cut at the sites of washover channels on such low narrow island ends as that north of Old Corpus Christi Pass in the 1930 and 1940 decades.

Clay bluffs may be recessed 8 to 10 feet in a single surge, as at Corpus Christi in 1919. Low-lying spits and beaches have been recessed as much as 150 feet along many miles of coast, as on the shores of several large bays in the same storm.

A succession of surges with an average or more frequent elevation of 4 feet above mean sea level has cut a low bench along much of the mainland shore of the coastal lagoons from Galveston Bay southwestward. The bench is partly erosional and partly depositional, with low scarps (nips), low storm-built beach ridges and low spits present and in many cases inconspicuous. Low marshy depressions behind such sandy ridges

contain mixed foraminiferal faunas instead of assemblages representing a stable habitat, indicating accumulation by occasional flooding instead of in persisting lagoons.

Deposition - During some hurricanes a layer of organic ooze has been left on lagoonal shores and bars. Saline marls have been deposited on freshwater marsh. Deadening of prairie grasses for miles inland leading to rejuvenation of sand dune activity is reported from the stabilized sand sheet of Kenedy County, Texas.

Oyster shells found in ponds as much as 10 to 20 miles inland have been attributed by some to short-lived stocking of the ponds by spat washed in by surge floods, but the interpretation has not been verified.

On this coast, hurricane surges may build beach ridges 5 to 9 feet above mean low water on low plains. Hurricane surges seem also to be responsible along with surges of lesser storms for the alternate formation of barrier islands around the cone-shaped sandy shoal of the new delta of Brazos River and their destruction or retreat to the mainland as beach ridges during later surges. Surf occurring with a temporarily elevated sea level of a surge or unusually high spring tide will rework any sandy materials that form a shoal in the surf zone when submerged. The contour along which the resulting ridge comes to rest is a function of the bottom profile, the strength of the wave attack and the coarseness of the material.

APPENDIX A

HURRICANE CHRONICLE

The chronicle presents detailed data on the recorded hurricanes, the centers of which reached the coast of Texas southwest of Galveston and those which approached close enough to Texas to produce stormy conditions there. Maps of hurricane paths are presented.

The hurricane chronicle gives the dates and paths of the storms and some additional data, such as wind velocities and damage, but omits barometric pressures, temperatures and other data of interest mainly to meteorologists.

The characteristics and strengths of the storms are designed by initials as follows:

H for hurricanes

C for lesser tropical cyclones

T for storms about which it is known only that they produced abnormally high tides on the Texas coast

F for storms known only for their river floods

W for storms known for wind damage.

Full wind data are given for a few storms to depict the rate of progress of storm development.

For storms which did not reach the Texas coast, the true classification is given on the path on the map, but in the abbreviated digest opposite the maps and in the statistics only their characteristics at the Texas coast are given. Thus, an H storm the winds of which were less than 75 miles per hour at the Texas coast is recorded as a C storm. Accordingly, there were 7 H in the western Gulf in 1930-39. Of these 4 were of hurricane intensity in Texas, and another was doubtful. All known storms making landfall south of Tampico are given for 1950-55. One H of the far southern Gulf is shown for 1947.

C storms are not represented in the earlier records but begin to be increasingly well represented for the more recent decades. Only in recent decades could the formation of hurricanes in the Western Gulf be more than rarely determined.

The chief sources of the data are listed in REFERENCES, immediately preceding the hurricane path maps at the end of this appendix. The Weather Bureau Station in Corpus Christi was established on February 1, 1887. Except as indicated all data for storms subsequent to that date are from that source.

H 1818,_____
Struck Galveston. Four of Lafitte's vessels sunk or driven ashore.

1828?_____
High water at Corpus Christi from hurricane reported by old inhabitants. Could have been the 1829 storm. Source: records of Weather Bureau, Corpus Christi.

H 1829 10? Sept.
Mouth of Rio Grande struck. Coast inundated.

H? 1829, _____
Establishments destroyed, Port Isabel-Brazos Santiago area. Lt. J. D. Webster. Probably the Sept. storm.

H 1831, 18 Aug.
Struck Gulf Coast near mouth of Rio Grande.

H? 1831, _____
Inundations. Establishments destroyed, Pt. Isabel-Brazos Santiago area. Lt. J, D. Webster. Probably the Aug. storm.

H 1834, ___ Sept.
Struck South Texas.

H? 1834, _____
Inundations. Establishments destroyed Pt. Isabel-Brazos Santiago Area. Lt. J. D. Webster. Probably the Sept. storm.

H 1835, 12-18 Aug.
Struck Antigua, Cuba and Galveston.

H 1837, 27 Sept. to 10 Oct.
Racer's Storm, struck Yucatan, Northeast Mexico, Corpus Christi, Galveston and Mobile. Destroyed town of Brazos Santiago; flooded coast for many miles inland.

H? 1837, _____
Inundations. Establishments destroyed, Pt. Isabel-Brazos Santiago area. Lt. J. D. Webster, Probably the Sept. storm.

H? 1838, _____
Inundations. Establishments destroyed in Pt. Isabel-Brazos Santiago area. Lt. J. D. Webster.

H 1839, 5 Nov.
Galveston.

H 1840, _____
Lower Texas struck. Villages destroyed at mouth of Rio Grande. Establishments destroyed in area, with floods. Lt. J. D. Webster.

T 1842, 30 Aug. to 8 Sept.

Antje's Hurricane. Struck Victoria, Mexico, on September 8 at 1:00 P.M. Coast inundated northward to mouth of Rio Grande. Schooner "Antje" dismasted at 26°N. - 63°W.

H 1842, 5 Oct.

Struck Galveston.

H 1844, 6 Aug.

Struck mouth of Rio Grande. Not one house left standing at mouth of river or town of Brazos Santiago on north end, site of which was cut out by Pass. Seventy lives lost. (Lt. Blake's Rpt. Feb. 25, 1845). Lt. J.D. Webster reported floods and loss of Mexican customs office supplies, Brazos Santiago Island. Office maintained on mainland after this storm.

H 1848, 17 Oct.

A Corpus Christi newspaper examined in Austin by Mr. Otway Taylor reported that a hurricane wrecked several vessels at Brazos Santiago Island near present Port Isabel and put more than 2 feet of water on the Island.

H 1854, 16-19 Sept.
W

Struck between Matagorda and Galveston, Texas (Weather Bureau). C.C. Parry in W.H. Emory's U.S. & Mexican Boundary Rpt., Vol. I, Chap. IV, p. 54, met violent hurricane in Gulf between New Orleans and Indianola. Matagorda levelled. Water blown violently out of bay through channel, entrance straightened and deepened from 9 to 11 ft. over bar, all docks in bay but one destroyed.

T 1857, _____
H?

Tidal wave reported at Port Isabel (hurricane?) Survey of Federal Archives. (Not shown on map).

H 1866, _____

Struck Galveston. Survey of Federal Archives reports hurricane affected Port Isabel this year.

H 1867, 3 Oct.

Severe hurricane passed near Galveston. Much of city flooded and property damage placed at $1,000,000. Bagdad and Clarksville, towns at mouth of Rio Grande, destroyed (See Padre Island flood map Figure 4 - text). The winds at Galveston came first from east, turned to northeast, then backed to northwest as center passed, indicating that storm recurved from the southward, following a course somewhat like that of the Racer's Storm of 1837.

H? 1868, _____

A house knocked down by a storm on water front at Corpus Christi (C.W. Young, court testimony, 1914).

H 1871, 4 June

Struck Texas Coast and Galveston. Barometers at Galveston 29.51.

H 1871, 3 Oct.

Struck Galveston.

H 1872, _____

Hurricane struck Port Isabel; recorded in Survey of Federal Archives.

H 1874, 2-4 July

Struck Indianola. Damage along water front at Corpus Christi; shoreline eroded back (Capt. Andrew Anderson, Court testimony, 1914).

H 1874, 6 Sept.

Struck the Gulf Coast of Mexico and moved north-northwest into Texas.

H 1875, 14-19 Sept.

Struck Indianola. "A tremendous gale". Center moved across coastline to NE accompanied by a disastrous inundation from the bay, which caused nearly all the destruction. Lives lost, 176, and three-fourths of town swept away. Highest wind registered was 88 mph when anemometer blew away. Highest wind estimated was 100 mph. Run off from bays was continuing on 23rd at Galveston (U. S. Coast Survey Ann. Rpt. 1875).

H 1876, 16-17 Sept.

Padre Island. 16th, Wind NE. 17th, Wind NW. "Heavy gale and storm wave 8' to 10' above ordinary level. Very heavy surf. Center passed NE of us. Water came in on the island in many places but soon subsided." From R.E. Halter in camp on Padre Island, Annual Reports of Assistants, United States Coast Survey, September Report, 1876.

H 1879, 23 Aug.

Struck Yucatan and Texas Coast.

H 1880, 7-13 Aug.

Struck Yucatan and Matamoros, Mexico.

H 1880, 12-13 Oct.
W

Some erosion of shoreline at Corpus Christi (Capt. A. Anderson, Court testimony, 1914). "Brownsville nearly destroyed by hurricane. Many lives lost. Telegraph wires down from Indianola south and up river from Brownsville. In many places the entire terrain has been changed, especially on the lower end of Padre Island". R. E. Halter; Annual Reports of Assistants,

United States Coast Survey; October 1880 Report. Tannehill reports Hurricane striking Cuba October 3-9 1880. This may be beginning of same storm.

1880 Cold Winter, "Almost continuous norther all November. Snow lay on ground Nov. 28-Dec. 31 (and possibly later) nearly 1 foot deep. Thermometer went as low as 20°F." R.E. Halter.

H 1881, 12,13,14 Aug.
Murdock's Landing, Padre Island, R.E. Halter reports: "Violent hurricane. Signals blown down, flat boat lost" (August Report, 1881).

H 1885, 17 Sept.
Struck Brownsville, Louisiana and Georgia.

H 1886, 19 Aug.
Struck Indianola. Hurricane approached from SE on 19th of August. Center passed inland to SW of Matagorda Bay early in morning of August 20th. Wind at 9 P.M. on 19th 72mph, water in bay rose rapidly. Wind blew stronger from E about 5:00 A.M. on 20th. Not a house remained uninjured. Many houses washed and scattered over plains back of town, which was not rebuilt. Corpus Christi. Strong NW wind, very low water. (E.J. Kilmer. Court testimony 1914). Last hurricane here until after 1914 (Capt. A. Anderson, Court testimony, 1914).

H 1886, 15-25 Sept.
Martinique, Jamaica, Brownsville, Texas, in the path of this hurricane. Tidal wave reported at Port Isabel in Survey of Federal Archives.

H 1887, 11-21 Sept.
Struck Dominica, Yucatan and Brownsville. It moved very slowly on passing inland at Brownsville. Barometer 28.93, and below 29.00 for several hours, wind at 78 mph N.

H 1887, 9-11 Oct.
Passed along entire coast 20 to 50 miles offshore as mapped by O.L. Fassig (1913). Went inland in Western Louisiana.

H 1888, 5 July
Struck Galveston.

H 1891, 3-13 July
Struck Bay of Campeche and east of Galveston.

C? 1892, 25-27 Sept.
Struck Bay of Campeche, Mexico and Barra Sota la Marina at mouth of river Soto la Marina. May not have been of hurricane strength.

C? 1895, 22-29 August

Struck 80 miles south of Brownsville. May not have been of hurricane strength.

C 1895, ___ Oct.

A cyclonic storm not of hurricane intensity. Passed close to Brownsville and struck Galveston area. Fassig reports a similar storm passing over New Orleans this month, probably the same.

H 1900, 6-9 Sept.
W

Struck Galveston, Texas, with "tremendous fury". More than 6000 killed and property damage in excess of $20,000,000 due to storm, tide and wind. Evacuation of low island limited. Tide 15 feet between 8 and 9 P.M. on 8th at Galveston. 2.8 feet between 9 and 12 A.M. on 8th at Port Eads. Wind Maxima: Galveston - 8th, 60 mph NE, 6 P.M., center passed shore line southwest of Galveston Bay; anemometer blew away previously; 120 mph estimated. Port Eads - 7th, 31 mph NE, 12 A.M. Corpus Christi - 8th, 25 mph NW, 7 P.M.

C 1901, 2-10 July

Struck west of Galveston and not severe in Texas, but a hurricane of great intensity in Cuba area.

H 1902, 19-30 June to 1 July

Struck Port O'Connor and passed 30 miles off Rio Grande delta.

C 1903, 7-15 Aug.

Struck near Victoria, Mexico. A cyclonic storm not of hurricane strength.

H 1908, ___ Sept.

Originated in Caribbean. Passed over Brownsville and Corpus Christi. Fassig's map. No other data.

H 1909, 13-22 July

Center passed over Velasco, Texas, and destroyed half of the town. About $2,000,000 property damage; 41 people killed. Tide 10 feet above normal at Galveston.

H 1909, 21-28 Aug.

Many houses wrecked at Mole St. Nicholas, Haiti, on 23rd. Winds of 60 mph at Havana on 24th. Winds 100 mph estimated by master of S.S. Cartago in Yucatan Channel. Passed inland in northeastern Mexico near mouth of Rio Grande on 27th; 1500 people estimated killed by floods. Tide "Highest tides along the South Texas coast for many years" (Newspaper). Padre and Brazos Islands washed over by storm tides.

C 1910, 23-31 Aug.

A cyclonic storm not of hurricane intensity striking a few miles south of Rio Grande.

H 1910, 5-14 Sept.

A hurricane striking mouth of Rio Grande, bringing 4.41 inches of rain in one day. Did little damage inland.

H 1910, ___ Oct.

Moved east from coast near Port Isabel to Florida.

H 1912, 11-17 Oct.

Struck between Mesquite Rincon Island, in Laguna Madre, and Baffin Bay; little effect at Corpus Christi or Brownsville.

H 1913, 22-28 June

Hurricane passing inland at mouth of Rio Grande, night of 27-28. Storm caused what was then a record rainfall in Texas.

H 1915, 5-24 Aug.
W

Hurricane "of great diameter and fearful violence" on reaching Texas coast. Damage estimated as high as $50,000,000 and 275 lives lost. Speed 12 mph. Tides: Galveston - 3 A.M. on 16th, 12 feet, with 5 to 6 feet of water in business district. Tide 11 feet at Sabine; Corpus Christi, no record. Wind Velocity: Galveston - 3 A.M. on 17th, 81 mph E. extreme velocity; 3 A.M.,120 mph E. Corpus Christi - 9 P.M. on 16th, 31 mph NW. Heavy rains in Galveston area, none at Corpus Christi.

H 1916, 12-18 Aug.
W

Originated east of Windward Islands on 12th, passed through Yucatan Channel, moved rapidly across Gulf of Mexico to reach Corpus Christi on 18th. Winds destructive. Maximum 5 minute wind at Corpus Christi estimated at E. 90 mph, extreme vel. NE 100, low barometer 29.07 inches; rainfall on 18th 1.58 inches. Lives lost in area, 15; damage about $1,800,000. Bureau says: "storm moved too rapidly to form an excessive tide but flooded across Padre Island in large volume". First driftwood in memory of living inhabitants of area to appear in quantity strewed the mainland shore of Laguna Madre. Noticeable changes in landmarks in Laguna Madre occurred after this storm (authority Capt. Ben Anderson, age about 61, Corpus Christi, Texas). Steamer Nicaragua wrecked on Padre Island at 26°41'39" (boiler remains).

H 1919, 2-14 Sept.

"Possibly greatest hurricane of present century," to 1919. Passed near Key West on 9th and 10th; the most violent storm

there since the beginning of records. Property damage at $2,000,000. Ten vessels listed as lost. September 14th, storm went inland south of Corpus Christi, possibly 600 lives lost and $20,000,000 damage. Few people evacuated the lowlands. Rain in two days, 3.67 inches. Little or no wind damage. Wind: Key West (20 mi. right of center) 9th (7 P.M.) Anemometer blown away at 80 mph. Wind velocity NE. New Orleans (200 mi. right of center) 13th (12A.M.) 27 mph E. Galveston (158 mi. right of center) 13th (8 A.M. 44 mph E). Corpus Christi (45 mi. right of center) 13th (12 A.M.) 72 mph and anemometer broken; later estimated by Bureau, 95 mph NE. max., 110 mph NE extreme.

Tides (Maximum)

Montegut, La.	:	10 P.M. on 13th, 6'
Sabine, Tex.	:	4 A.M. on 14th, 8'
Galveston	:	3 A.M. on 14th, 8.8'
Aransas Pass	:	10 P.M. on 14th, 11.5'

Padre Is: flood destroyed much of grass cover (authority Burton Dunn, Padre Island Rancher).

Tides (Maximum continued)

Corpus Christi	:	4-6 P.M. on 14th, 16.0'**
Port Isabel	:	10 A.M. on 14th, 8.0'

T 1920 _____

Tidal wave recorded at Port Isabel, Survey in Federal Archives. May have been result of September 21st storm which struck Houma, La. after originating in western Caribbean and passing over Yucatan.

C 1921, 15-26 June

This hurricane first appeared near the Honduras Coast. Entered the Gulf on the 19th. On 21st approached mouth of Rio Grande and passed 80 miles to E. Passed E of Corpus Christi on night of 21-22. Center passed over Palacios (Near Matagorda), Wharton and Wallis (west of Houston), Texas. Not of hurricane intensity at Weather Stations in Texas. Winds: Corpus Christi 58 mph with 68 mph. maximum. NE - 6 A.M. on 22nd. Galveston 52 mph with 60 mph. maximum SE - 3 P.M. 22nd. Houston 49 mph with 60 mph maximum 5:30 P.M. 22nd.

C 1921, 6-7 Sept.

Originated in Bay of Campeche, progressed northward across Rio Grande into Texas. On reaching Texas wind velocities were well below hurricane speeds, but torrential rains fell. Tyler, Texas: 23.11 in. rain in 24 hours. San Antonio: 5-9 feet of water stood in the downtown area; 51 lives lost and $5,000,000 damage estimated. Padre Island: Rain, 1-3 in. Flood destroyed much of grass on southern end of island (authority, Burton Dunn, Padre Island rancher).

* Some records show only 12'

F 1922, 13-16, June

Originated in Caribbean, went into Mexico near Tampico. Unprecedented floods in North Mexico and South Texas. Rio Grande floods were highest of record.

C 1925, 6,7, Sept.

A storm originating over SW Gulf moved northwest to Texas-Mexican coast near Brownsville. Heavy rains and moderate gales in Lower Rio Grande Valley (delta).

H 1929, 28-29, June

Originated in W Gulf, passed inland over Port O'Connor about 4:30 P.M. on 28th, winds 70-80 mph. Area of strong winds only about 20 miles wide.

C 1931, 25-28 June

Storm originated east of Yucatan, moved northwest to Texas Coast, going inland between Brownsville and Corpus Christi. No high winds recorded; rain in vicinity, 8.03 inches.

H 1932, 11-14, August
W

Hurricane of small diameter developed with great rapidity on 12th and 13th. Crossed Texas coast near Freeport on 13th. One death reported. Wind at East Columbia (near Freeport) estimated 100 mph.

C 1933, 27 June - 6 July

Hurricane originated near Trinidad, passed inland about midway between Brownsville and Tampico causing several deaths and considerable property damage especially at Soto la Marina (24° N. Lat.) Brazos Island and Port Isabel flooded, Victoria in Tamaulipas, damaged. Tides reached 5 feet at Port Aransas. South half of Padre Island denuded of grass.

H 1933, 25 July - 5 August

Hurricane originating south of Antigua. Crossed Florida; crossed Mexican coast south of Brownsville August 5th. Maximum wind velocity at Brownsville 72 mph; most of damage there and at Monterrey due to torrential rains. Winds probably of hurricane intensity on Padre Island. Damage at Brownsville estimated at $1,750,000. First severe hurricane damage reported by this city in 53 years.

Tides high from Sabine Pass to Tampico, Mexico, 4.5 feet of water reported between Brazos Island and mainland. River flood on 7th.

H 1933, 28 August to 5 Sept.
W

Hurricane originating about 19° N, 55° W. Center passed inland a short distance north of Brownsville where an extreme wind of 106 mph was measured on the 5th and 110 mph

estimated after the anemometer blew away. (Bureau estimated winds of 120 to 125 mph in short spurts.) There were 40 known dead. Property damage, $12,000,000. Many weaker buildings destroyed, especially at Harlingen and nearby San Benito.

ROUTE

Sept. 1, 9 A.M. Central Cuban Coast, 100 mi., ENE of Havana. Moving W to N of W. 9 P.M. short distance NW of Havana moving WNW.
Sept. 2, 9 A.M. Center about 24°N, 85°W, moving WNW. 9 P. M. Center 25°N, 87.5°W moving WNW.
Sept. 3, 9:30 A.M. Center 25°N., 90°W, moving WNW.
9:30 P.M. 300 mi. East of Brownsville moving WNW.
Sept. 4, 9:30 A.M. Center 160 mi. ESE of Corpus Christi moving WNW. 2:00 P.M. Center about 100 mi. SE of Corpus Christi moving NNW.
Sept. 5, 9:30 A.M. Moved inland near Brownsville.

WIND AND RAIN AT CORPUS CHRISTI

		Rain
Sept. 1,	3-12 mph S, SW, E, SE	Trace
Sept. 2,	3-12 mph S, SW, E, SE	0.00
Sept. 3,	2-12 mph SE, W, NE, E, NE, N	0.23
Sept. 4,	12-18 mph N, 12-8 A.M.	0.64
	22-24 mph N, NE 9-12 A.M.	
	25-37 mph N, 1-5 P.M.	
	35-32 mph NE, 6-12 P.M.	
Sept. 5,	39-33 mph NE, E 12-8 A.M.	0.30
	33-27 mph SE, E 9-12 A.M.	
	27-19 mph E, 1-5 P.M.	
	20-14 mph E, 6-12 P.M.	
Sept. 6,	9-13 mph E, SE, S	0.14

TIDES

Newspaper reported tides high from Sabine Pass to Tampico, Mexico. "North Beach" section at Corpus Christi inundated, estimated 5 feet or more on Sept. 5, with 2 to 3 feet in main business district, "The Flat". Damage to piers and shipping. Padre Island: Flood swept away nearly all dunes on south half of island, overtopping or eroding all but a very few. Casino at S. end stood just above water. Grass destroyed and island abandoned for ranching in south half - (beginning to return in 1946 but made no headway in 1947-1950 drought). Much of south half of island reduced to relatively smooth sand plain at or below beach-ridge levels. Over 40 overflow channels some more than 1 mile wide, active on 6th as water

returned to Gulf (authorities Burton Dunn, Padre Island rancher, report of State Highway Depts.' aerial survey by T. W. Bailey. Report of L. E. Rawalt).

1933

A record year with 21 hurricanes in Atlantic, Gulf and Caribbean. All but 4 followed westward paths.

C 1934, 23 to 25, July

23rd - Disturbance noted at 9 A.M. south of Apalachicola moving west at 20 mph with squalls and shifting winds.

24th - At 10 A.M. SW of Mississippi River mouth, moving west about 14 mph. Winds of gale force near center.

At 3:00 P.M., 200 mi. south of Morgan City, La., moving 14 mph WSW, with increased intensity near center.

25th - at 9:30 A.M. center 100 mi. east of Corpus Christi moving NNW, at 12:00 A.M. crossed coast at Rockport with high tides.

At Corpus Christi - Winds

25th

12 P.M. - 2 A.M.	13	mph	N	
2 A.M. - 12 A.M.	14-32	mph	NW	
12 A.M. - 1 P. M.	22	mph	W	
1 P.M. - 2 P. M.	37	mph	SW	
2 P.M. - 12 P.M.	47-17	mph	S	
Maximum velocity	47	mph	S	3:15 P.M.
Extreme velocity	56	mph	S	3:15 P.M.

Eleven deaths attributed to storm in Texas, damage estimated $1,000,000 to $2,000,000.

? 1934, 26th Aug. to 1st Sept.

Originating in eastern Gulf, hurricane passed close off coast of eastern Louisiana and turned south into Gulf.

On 31st at 9:30 A. M. center in south-central Gulf, At 4:30 P.M. center 200 miles SSE Brownsville, 150 miles NE of Tampico, Mexico.

On September 1st storm passed inland N of Tampico. No effect at Corpus Christi.

H 1936, 26, 27 June
W

A hurricane of small diameter but considerable force developed in extreme western Gulf, passed inland over Port Aransas before noon on 27th.

0300 - Rain
0400 - Squalls
0830 - Heavy tide and sea swell at Aransas Pass.
0930 - Wind increased from 25 mph
1000 - Wind reached 49 mph with a 55 mph extreme blowing E.

1115 - Wind estimated at 90 mph at Ingleside blowing SW.
1130 - Wind 15-60 mph W.
Wind maximum at Corpus Christi 36 mph.
Tide blew out in almost all places here due to strong NW, WNW and W winds. Normal gravity tides at Corpus Christi, fluctuated from - 4 to +2 ft. at Port Aransas, and Rockport +3 to -2 ft.
Damage estimated at $550,000.

C 1936, 11-13 Sept.
Cyclonic storm doing no reported damage.

12th
0700 - Disturbance in SW Gulf
1200 - 175 mi. E. of Tampico moving slowly NW
2030 - 175-200 mi. ENE of Tampico with gale winds near center.

13th
0100 - Squall winds at Corpus Christi from ESE
0800 - Center 100 mi. E of Brownsville
1030 - At Corpus Christi, wind max. = 35 mph E, wind extreme = 40 mph E.
1445 - Storm moved inland 70-80 miles SW of Corpus Christi
Rain at Corpus Christi totaled 1.39 inches for 2 days.
Water spout moved to shore 6 mi. south of town.

C 1938, 23-28 August
23rd Disturbance of hurricane intensity 200 mi. S of Jamaica.
24th 100 mi. S of Grand Cayman Island. Now a severe hurricane.
25th Center crossed NE coast of Yucatan peninsula
26th Off NW coast of Yucatan and 400 mi. E of Tampico moving NNW at 15 mph.
27th Located at 200 mi. SE of Brownsville with hurricane winds at center.
28th
0200 Moved inland 50 mi. N. of Tampico. Squalls on Texas coast.
0735 Winds to 31 mph at Corpus Christi from NE.
0900 Squalls at Corpus Chrusti from N and NE.
No Texas damage reported.

H 1942, 26-30 August
26th Slight disturbance recorded near Grand Cayman and Swan Islands, moving slowly WNW.
27th Winds of gale force 130 mi. NW of Swan Island moving 10-12 mph WNW.
Winds at Corpus Christi average 7.9 mph from ESE and SE.
28th Center at 22°30' and 90° moving 14 mph WNW. Hurricane center and gales over large areas.
29th North Beach Section of Corpus Christi evacuated (7,000 people).
0730 - Estimated center 25° - 92°30' moving NW 15 mph

1530 - Located 26° - 95° moving NW at 15 mph
1940 - Moving into the Galveston-Palacios-Freeport area.
The two 1933 channels of Corpus Christi Pass reopened.
At Corpus Christi winds from N all day. Heavy rain.
Two old cottages on North Beach blown down.
Maximum velocity 40 mph N at 2355
Extreme velocity 42 mph N at 2355
Tide 3 feet above mean sea level.

30th 0230 - Hurricane passed inland at Matagorda Bay
0255 - Winds at Corpus Christi
Maximum velocity - 61 mph W. Heavy rain.
Extreme velocity - 72 mph W.
0500 - Winds at Corpus Christi down to 20 mph S and remained thru the day.

H W 1945, 24-27 August

24th 2100 - Hurricane developing in SW Gulf at 21.5°-95° about 200 mi. ESE of Tampico, 75-100 mph winds in 100-mi. diameter center. Rain at Corpus Christi, Texas .

25th Hurricane 95-170 mi. SE of Brownsville about 24.5°-95.5°. At Corpus Christi, Winds:
Maximum velocity, 26 mph NE at 2010
Extreme velocity, 27 mph NE at 2010
Rain, trace.

26th 0300 - Located 70 mi. NE of Brownsville at 26.7° moving 9 mph NNW.
0530 - Hurricane at 26.9° - 96.9° about 70 mi. SE of Corpus Christi
Wind at Port Isabel 76 mph.
0930 - 46 mi. S of Corpus Christi
1500 - 40 mi. S of Corpus Christi
1800 - 30 mi. E of Corpus Christi
2230 - 30 mi. ENE of Corpus Christi and very near Port Aransas
At Corpus Christi, Winds:
Maximum velocity 56 mph N at 1940
Extreme velocity 70 mph N at 1940
Rainfall for day at Corpus Christi, 4.14 inches.

27th 0300 - Hurricane out of Corpus Christi area.
1210 - Passed inland 60 miles west of Houston.
Wind damage in eastern part of city.
At Corpus Christi, Winds:
Maximum velocity, 45 mph NW,
Extreme velocity, 47 mph NW.
Wind remained NW all day.
Rain Corpus Christi area 0.58 inches.

Two thirds of Texas coast had hurricane winds in this storm. Winds in Port O'Connor area estimated 105 mph; extreme velocity at Corpus Christi, 70 mph, 76 mph at Port Isabel.

Before storm, North Beach area of Corpus Christi evacuated by Texas State Guard with 7,200 persons removed. No loss of life or property.

TIDES:

Corpus Christi	low tide
Matagorda	8 feet
Colorado River mouth	12 feet
Port Lavaca	15 feet
Palacios	8 feet

Heavy damage at Port Lavaca by wind. Large amounts of salt water came over 19-foot bluff. (Mostly by wind ?). Water reported 3 feet deep on Gregory-Aransas Pass Highway, blown from Port Bay under N. wind.

1946 Said to be first year in Weather Bureau history without a Gulf hurricane

C 1947, 31 July

Small tropical storm.

Formed in SW Gulf, moved inland short distance S. of Brownsville. Wind 44 mph at Port Isabel on August 1st. 33 mph maximum at Corpus Christi.

Only damage throughout South Texas due to rainfall.

Corpus Christi	3.28 inches
Brownsville	4.41 inches

Tides at Corpus Christi and Port Aransas +2 to +3 feet. Heavy rainfall.

___ 1947, 12-15 August

No effect in Texas.

Origin in NW Caribbean, crossed Yucatan peninsula, full hurricane intensity. Struck Tampico on 15th, winds 110 mph.

No effect at Brownsville.

H 1949, 1-4, October
W

Origin in southern Gulf of Mexico. Passed 100 miles off Padre Island. Struck Freeport and Houston on 4th at full hurricane intensity. Great damage at Freeport.

TIDES:

Tide at Freeport reached 11.5 feet above mean sealevel. Maximum tides at Port Isabel and Port Aransas (3.4 and 3.6 ft. above mean sealevel) were 0.8 and 1.4 feet above normal fall tides

and occurred on Oct. 3. At Corpus Christi a local tide rose 1.3 ft. above normal. Flood tides in the southern Laguna Madre at Humble Oil & Refining Company guages, at triangulation stations Redfish Bay and Topo, rose steadily for a week to a maximum of 1.2 and 1.6 ft., respectively, above normal. The tide in the Gulf was sustained for 2 days, elsewhere for 1 day only. From the air it was seen that large amounts of fresh water from rains stood on Padre and Mustang Islands on Oct. 13th and 16th between dunes. Floods went through most washover channels on Padre Island and across the low southern half. Minor amounts of deposition occurred in the channels with some scour. The floods through the channels were probably from wave crests. Observation from the air about Oct. 20 failed to show any of the many caterpillar tractor tracks along the lagoon shore of Padre covered by any sediment or otherwise showing evidence of deposition or erosion by floods there.

WINDS:
Maximum winds recorded at Houston were E & NE 90 mph, at Freeport E 92 mph; estimate 100 mph after anemometer failed. Corpus Christi, max. 23 mph at 8 a.m. October 3. These were from the north (NNW, N and NNE) on the 2nd and ENE to NNE to NNW on the 3rd. Observation of the water in Laguna Madre from the air by Humble Oil and Refining Company showed a sheet of water moving southward from the Baffin Bay region across the central Flats on the 2nd. (Observed at S. end of Mesquite Rincon "Island" at 11 a.m.). No observation was made on the 3rd. On the 4th the water had crossed the Flats and was entering Redfish Bay.

C 1950, 1-4 Oct. Tropical Storm HOW.
From origin in central Gulf moved counterclockwise to Mexican coast at Soto la Marina (24° N. Lat.) Squally winds on southern Texas coast, only 25-39 mph at Corpus Christi, 40-60 mph at Brownsville. North end of Padre Island had heavy breakers and tide 3.5 to 4.0 ft. msl. Section of highway north end of Padre Island at Gulf Park washed out.

— 1950, 8-10 Oct. Hurricane ITEM
Small hurricane formed off Tuxpan and moved counterclockwise to coast E of Vera Cruz where damage was "heavy". Winds 90 mph in area of origin. No effect on Texas coast.

C 1950, 16-21 Oct. Hurricane LOVE
Originated off S end of Florida; travelled WNW; stopped south of central Louisiana and circled for a day. Then moved E and NE to cross northern Florida into Atlantic. Winds of 85-98 mph in the E, dying to 40-60 mph at the W and reaching Texas coast only as squalls. As it approached the Florida

peninsula moving NE, it was below hurricane intensity. No damage on Padre Island, maximum tide at Port Aransas, 2.8 ft.

C 1951, 14-23 Aug. Hurricane CHARLIE
A severe Caribbean hurricane with winds up to 130 mph extending out 75 mi. to N. Gales extended out 250 mi. to N. reaching Brownsville. Tides 4-5 ft. above normal extended along entire Texas coast. Storm broke up in high sierra. Tampico area experienced heavy damage and great floods.

__ 1951, 20-21 Sept. Tropical storm GEORGE
Originated NE of Vera Cruz moving inland at Tampico. Winds 60 mph. No damage reported. No effect on Texas coast.

H 1954, 24-25 June. Hurricane ALICE
Originated off Sota la Marina (24°N. Lat.) and moved NW crossing coast 90 mi. S of Brownsville where winds reached 80 mph . Continued far inland up Rio Grande. Tides only 6 inches above msl at Port Aransas and Freeport (26th). No high tide at S end of Padre Island. Record rains caused record floods near Ozona, Del Rio and Eagle Pass and in Trans-Pecos, Texas. Rio Grande flood held by newly finished Falcon Dam.

__ 1954, 11 Sept. Hurricane FLORENCE (Map shows "FLO").
Very small hurricane originating off Tuxpan and curving counterclockwise to coast between Tuxpan and Vera Cruz. Winds estimated 100 mph, but only 35 at landfall. "Broke up in high mountains near the coast".

___ 1955, 4-5 Sept. Tropical Storm GLADYS
Developed off Tampico and moved erratically to shore off Soto la Marina on a NW course. Turned abruptly southward along shore to Tampico. Accompanied by independent (?) squalls in Texas. Evacuations in Corpus Christi area: 500 from North Beach, 6,000 from Padre Island.

H 1955, 6-7 Sept. Hurricane "GLASSCOCK" (locally applied name)
This center of squalls with wind circulation developed off Corpus Christi on the 5th. By the 6th it had a definite center and moved inland south of Baffin Bay of Texas. Glasscock oil platform in Gulf 15 mi. E of Port Aransas observed sustained winds NNE at 75-80 mph, and higher in gusts. Flour Bluff at mainland shore reported 60 mph winds. Cliff Maus airport W of Corpus Christi had winds NNE at 31 mph. High tides 2.9 ft. at Port Aransas and 4.5 ft. at Corpus Christi Bay; heavy rains occurred 7.68 in. in 24 hrs. at Cliff Maus airport and 17.02 in. at Flour Bluff with 6 in. in 4 hrs.; damage in area - $400,000, mostly to streets and shores. Not as yet officially recognized as a hurricane by Washington office of Weather Bureau. Padre Island had been evacuated on the 4th and water then blocked island roads.

C 1955, 10-12 Sept. Squalls

Squalls in western Gulf caused tides 2-3 ft. above normal in Corpus Christi area. Winds 30-35 mph. Scattered showers, locally heavy. No path plotted.

C 1955, 12-20 Sept. Hurricane HILDA

Severe Caribbean hurricane with winds 125 mph moved into Gulf Sept 8th. Followed closely in path of 1951 hurricane CHARLIE but hit north of Tampico. Felt in Texas as a cyclonic storm of less than hurricane intensity with no serious damage. Swells offshore 8-10 ft. high. Tides at Port Aransas, 2.6 ft. Highest wind at Corpus Christi, 22 mph.

C 1955, 21 Sept. - 3 Oct. Hurricane JANET

Caribbean hurricane of great ferocity. Winds at west coast of Gulf estimated 150-200 mph. Hit between Vera Cruz and Tuxpan; reported as breaking up in the high mountains (the usual expectancy) but continued across into the Pacific where it reformed and moved NNE, making a record for the passage of the continent. Heavy floods resulted in Tampico and southward in Mexico. This hurricane judged so severe that it would have leveled any city directly in its path. Offshore swell up to 10 ft. high. Tides in Corpus Christi area 2.0-2.5 ft., in Laguna de la Madre of Mexico (Eighth Pass) 4.0 ft. Moderate to serious flooding at Kingsville and in Rio Grande delta.

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MAPS OF

HURRICANE PATHS

DATA AND SOURCE
See "References" in report herewith
1800 - To - 1839

(1) U. S. Weather Bureau, files, published reports, and books of officials: Cline, Passig, Tannehill.
(2) Lt. Blake, U. S. Topo. Eng. (1845).
(3) R. E. Halter, Asst., U. S. Coast Survey, ann. repts. (1876-81).
(4) Lt. Webster, U. S. Topo Eng. (1848).
(5) Surveys of Federal Archives to 1947.
(6) Andrew Anderson, ship captain, Corpus Christi, Texas.
(7) W. H. Emory, U.S. & Mex. Boundary Survey (1857).

1818

H Exact date unknown: Struck Galveston. Four of Lafitte's vessels sunk or driven ashore. (1).

1828?

Date unknown: High water at Corpus Christi from hurricane reported by old inhabitants; could have been the 1829 storm. Source, local records of Weather Bureau at Corpus Christi, Texas. (1)

1829

H September 10 (?): Struck the mouth of the Rio Grande. Coast inundated. (1)

1831

H August 18: Struck Gulf coast near mouth of Rio Grande. (1)

1834

H September _____: Struck South Texas. (1)

1835

H August 12 to 18: Struck Antigua, Cuba, and Galveston. (1)

1837

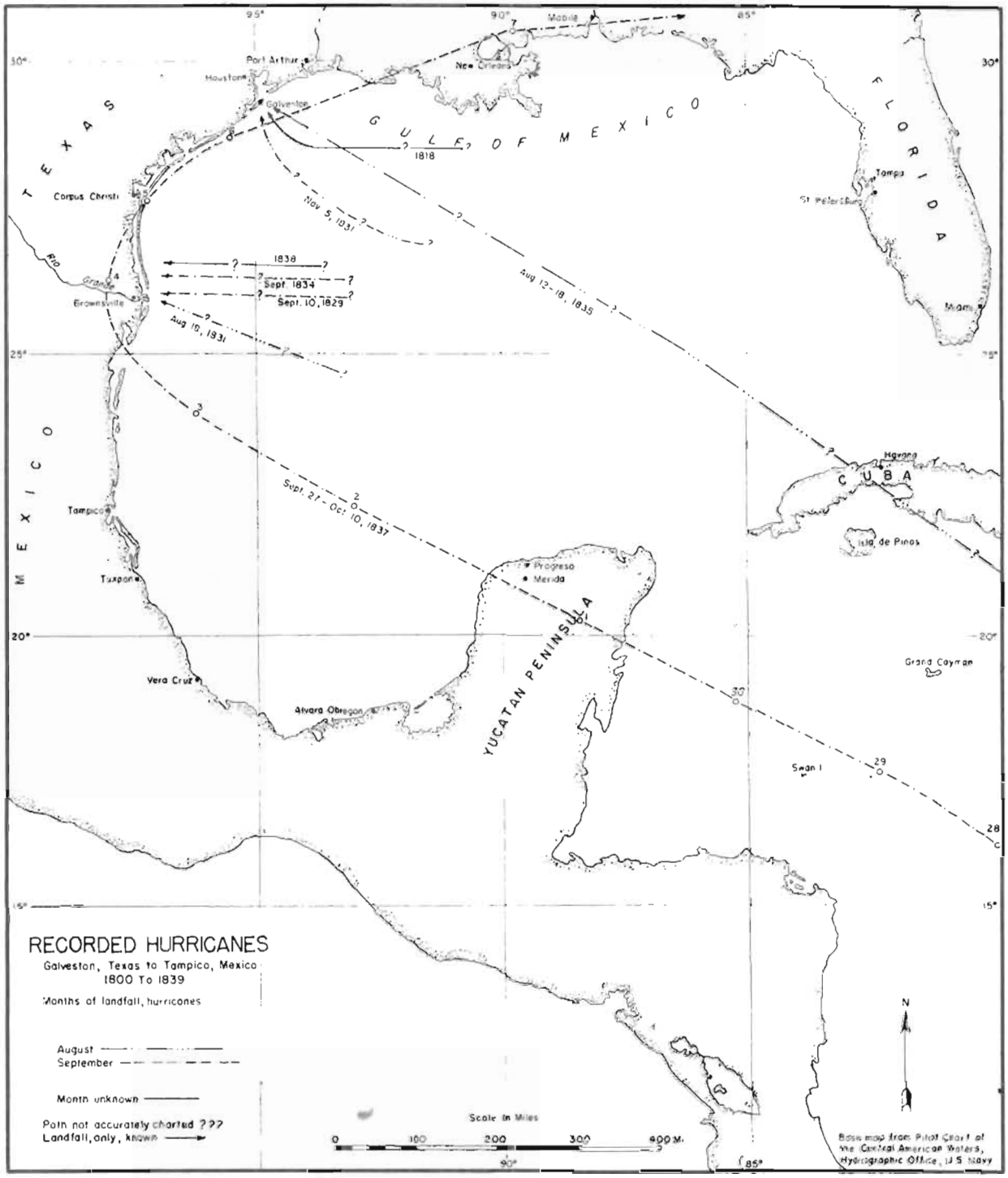
H September 27 to October 10: "Racer's Storm". Struck Yucatan, Northeast Mexico, Corpus Christi, Galveston, and Mobile, Alabama. Destroyed town of Brazos Santiago; flooded coast for many miles inland. (1)

1838

H? Exact date unknown: Inundations in Brazos Santiago area, 8 miles north of mouth of Rio Grande. (4)

1839

H November 5: Struck Galveston. (1)


RECORDED HURRICANES
Galveston, Texas to Tampico, Mexico
1800 To 1839
Months of landfall, hurricanes
August
September
Month unknown
Path not accurately charted ???
Landfall, only, known
Scale in Miles
0 100 200 300 400 M.
Base map from Pilot Chart of the Central American Waters, Hydrographic Office, U.S. Navy
GULF OF MEXICO
TEXAS
MEXICO
FLORIDA
CUBA
YUCATAN PENINSULA
Mobile
Port Arthur
Houston
Galveston
New Orleans
Corpus Christi
Rio Grande
Brownsville
Tampico
Tuxpan
Vera Cruz
Alvaro Obregon
Progreso
Merida
Tampa
St Petersburg
Miami
Havana
Isla de Pinos
Grand Cayman
Swan I
1818
1838
Sept. 1834
Sept. 10, 1829
Aug 19, 1931
Nov 5, 1931
Aug 12-18, 1835
Sept. 21 - Oct. 10, 1837

DATA AND SOURCE

See "References" in report herewith

1840 - To - 1869

(1) U. S. Weather Bureau, files, published reports, and books of officials: Cline, Fassig, Tannehill.
(2) Lt. Blake, U. S. Topo. Eng. (1845).
(3) R. E. Halter, Asst., U. S. Coast Survey, ann. repts. (1876-81).
(4) Lt. Webster, U. S. Topo. Eng. (1848).
(5) Surveys of Federal Archives to 1947.
(6) Andrew Anderson, ship captain, Corpus Christi, Texas.
(7) W. H. Emory, U. S. & Mex. Boundary Survey (1857).

1840

H Month unknown: Struck the lower Texas coast. Small villages destroyed at the mouth of the Rio Grande. (1)

1842

H August 30 to September 8: "Antje's Hurricane". Center struck Victoria, Mexico. The coast was inundated northward to the mouth of the Rio Grande. The Antje was dismasted at 26° N - 63° W. (1)

H October 5: Struck Galveston. (1)

1844

H August 6: Struck mouth of the Rio Grande. All houses destroyed at the mouth of the river and at Brazos Santiago, 8 miles north. Seventy lives lost. (2)

1848

H October 17: Several vessels were wrecked at Brazos Santiago Island in a hurricane. This was a severe gale which put more than 2 ft. of water on the Island. From a Corpus Christi newspaper in Austin, authority Mr. Otway Taylor.

1854

H September 19: Struck between Matagorda and Galveston, Texas. (1)
W

1857

T Month and type of disturbance unknown: "Tidal wave" reported at Port Isabel opposite Brazos Santiago pass. From Survey of Federal Archives. Hurricane?

1866

H Month unknown: Struck Galveston (Tannehill). The Survey of Federal Archives also reports a hurricane affecting Port Isabel this same year. These may be two reports of the same storm. (1) (5)

1866

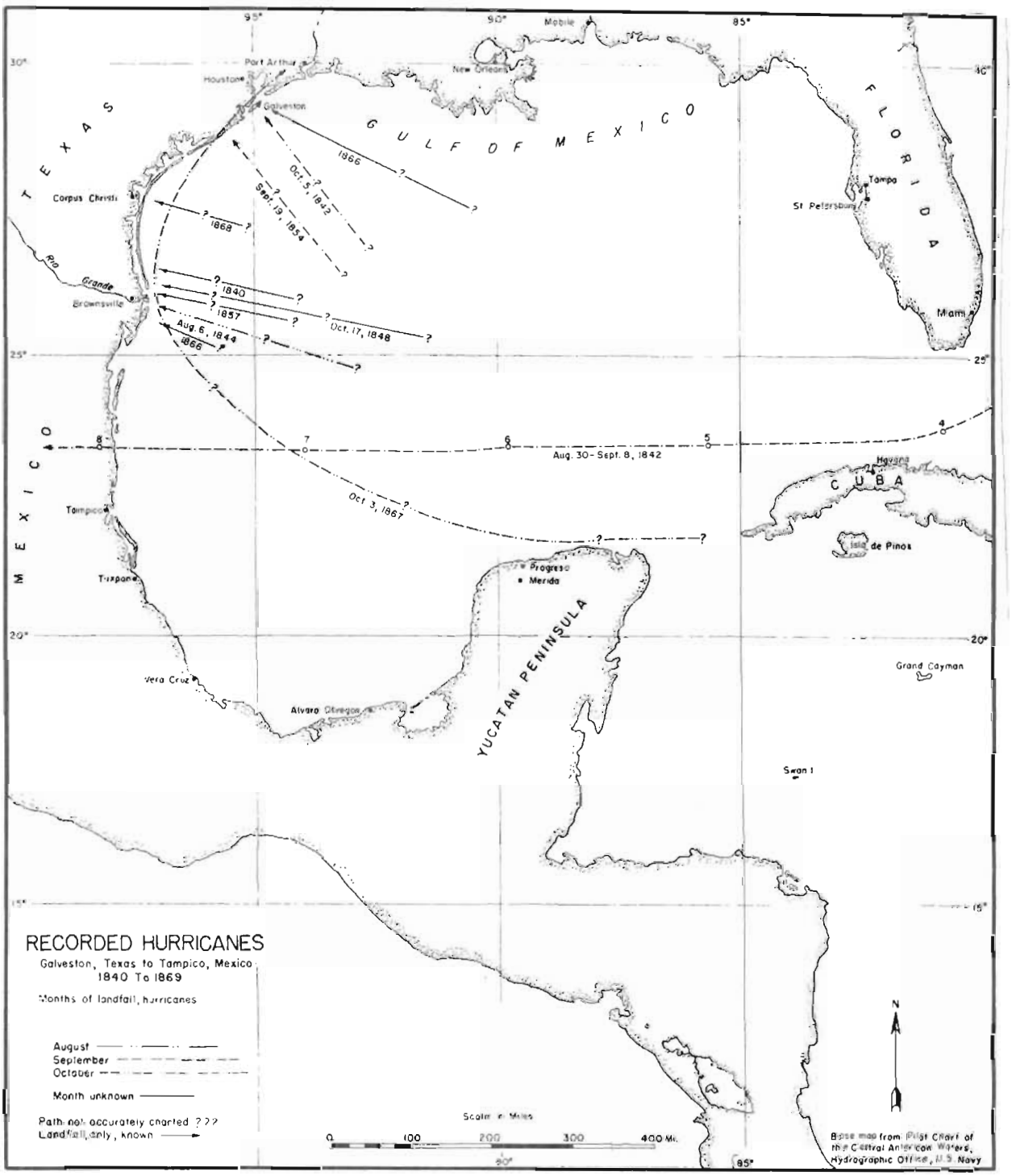
H? See entry above.

1867

H October 3: A severe hurricane passed near Galveston. Much of the city was flooded and property damage was placed at $1,000,000. The towns of Bagdad and Clarksville at the mouth of the Rio Grande were destroyed by this hurricane. (1)

1868

H? Month unknown: House knocked down by storm at Corpus Christi.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New Orleans
Corpus Christi
Rio Grande
Brownsville
Tampa
St Petersburg
Miami
Havana
Isla de Pinos
Tampico
Tuxpan
Progreso
Merida
Vera Cruz
Alvaro Obregon
Grand Cayman
Swan I
1866
Oct. 5, 1842
Sept. 13, 1854
1868
1840
1857
Aug. 6, 1844
1866
Oct. 17, 1848
Aug. 30 - Sept. 8, 1842
Oct. 3, 1867

DATA AND SOURCES

See "References" in report herewith

1870 - To - 1889

(1) U. S. Weather Bureau, files, published reports, and books of officials: Cline, Fassig, Tannehill
(2) Lt. Blake, U. S. Topo. Eng. (1845).
(3) R. E. Halter, Asst., U.S. Coast Survey, ann. repts. (1876-81).
(4) Lt. Webster, U. S. Topo. Eng. (1848).
(5) Surveys of Federal Archives to 1947.
(6) Andrew Anderson, ship captain, Corpus Christi, Texas.
(7) W. H. Emory, U. S. & Mex. Boundary Survey (1857).

1871

H June 4: Struck the Texas coast and Galveston. Barometer at Galveston 29.51. (1)

H October 3: Struck Galveston. (1)

1872

H Exact date unknown: Hurricane struck Port Isabel. From Survey of Federal Archives.(5)

1874

H July 2 to 4: Struck Indianola. (6)

September 6: Struck the Gulf coast of Mexico and moved north-northwest into Texas. (1)

1875

H September 13 to 19: Struck Indianola. The center moved across the coast line to the southwest of Matagorda Bay. The highest wind registered was 88 mph when the anemometer blew away. The highest wind estimated was 100 mph. Tide at Corpus Christi about 5 to 6 feet.U. S. W. B. (1) (3)

1876

H September 16 to 17: Struck between Corpus Christi and Brownsville. Heavy gale and storm wave 8 to 10 feet above ordinary level. Water came in on Padre Island in many places. (3).

1879

H August 23: Struck Yucatan and the Texas coast. (1)

1880

H August 7 to 13: Struck Yucatan and Matamoros, Mexico. (1)

H October 12 to 13: "Brownsville nearly destroyed by hurricane. Many lives lost.
W Telegraph wires down from Indianola south and up-river from Brownsville". (3)

1881

H August 12 to 14: "Violent hurricane striking Padre Island". (3)

1885

H September 17 to 22: Struck Brownsville, Southern Louisiana and Georgia. (1)

1886

H August 19: Struck Indianola. Wind reached 72 mph. Every house destroyed or damaged. Indianola never rebuilt. Record high tides. (1)

H September 15 to 25: Martinique, Jamaica, and Brownsville, Texas in the path of this hurricane. (1)

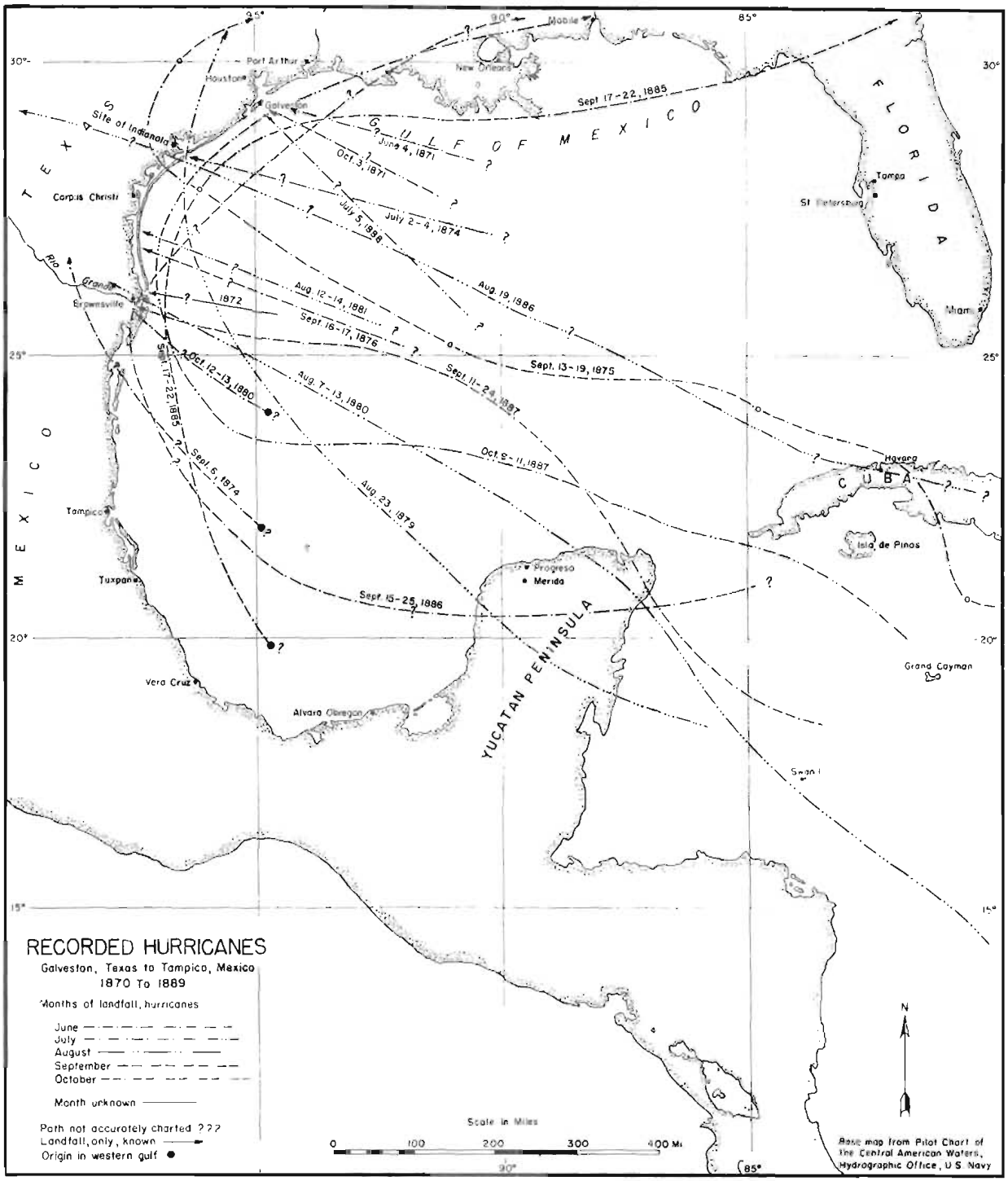
1887

H September 11 to 24: Struck Dominica, Yucatan, and Brownsville. Wind 78 mph north. (1)

H October 9 to 11: Authority O. L. Fassig (1913). (1) Affected entire coast of Texas. Went inland in Louisiana.

1888

H July 5: Struck Galveston. (1)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Mobile
New Orleans
Port Arthur
Houston
Galveston
Site of Indianola
Corpus Christi
Brownsville
Rio Grande
Tampico
Tuxpan
Vera Cruz
Alvaro Obregon
Progreso
Merida
Tampa
St Petersburg
Miami
Havana
Isla de Pinos
Grand Cayman
Sept 17-22, 1885
June 4, 1871
Oct. 3, 1871
July 2-4, 1874
July 5, 1898
1872
Aug. 12-14, 1881
Aug. 19, 1886
Sept. 16-17, 1876
Sept. 13-19, 1875
Sept. 11-24, 1887
Oct. 12-13, 1880
Aug. 7-13, 1880
Oct. 9-11, 1887
Sept. 5, 1874
Aug. 23, 1879
Sept. 15-25, 1886

DATA AND SOURCE

See "References" in report herewith

1890 - To - 1909

(1) U. S. Weather Bureau, files, published reports, and books of officials: Cline, Fassig, Tannehill.
(2) Lt. Blake, U. S. Topo. Eng. (1845).
(3) R. E. Halter, Asst., U.S. Coast Survey, ann. repts. (1876-81).
(4) Lt. Webster, U. S. Topo. Eng. (1848).
(5) Surveys of Federal Archives to 1947.
(6) Andrew Anderson, ship captain, Corpus Christi, Texas.
(7) W. H. Emory, U. S. & Mex. Boundary Survey (1857).

1891

H July 3 to 13: Struck the Bay of Campeche and east of Galveston. (1)

1892

C ? September 25 to 27: Struck the Bay of Campeche and Bara Sota la Marina, Mexico. May not have been of hurricane intensity. (1)

1895

C ? August 22 to 29: Struck 80 miles south of Brownsville. May not have been of hurricane strength. (1)

C October ____: A cyclonic storm not of hurricane intensity. Passed close to Brownsville and struck the Galveston area. (1)

C ? October ____: Origin (?) near Brownsville; passed over New Orleans. Authority O. L. Fassig (1913). Same as storm listed above? (1)

1900

H September 1 to 10: "Galveston Storm". Tide reached 15 feet and the wind estimated at
W 120 mph. Damage estimated at $20,000,000. About 6,000 people killed. Center crossed shore line southwest of Galveston Bay. (1)

1901

C July 2 to 10: Struck west of Galveston. Cyclonic storm, not of hurricane intensity in Western Gulf. (1)

1902

H June 19 to July 1: Struck Port O'Connor and passed 30 miles off the Rio Grande delta. (1)

1903

C August 7 to 15: Struck near Victoria, Mexico. Was a cyclonic storm, not of hurricane strength. (1)

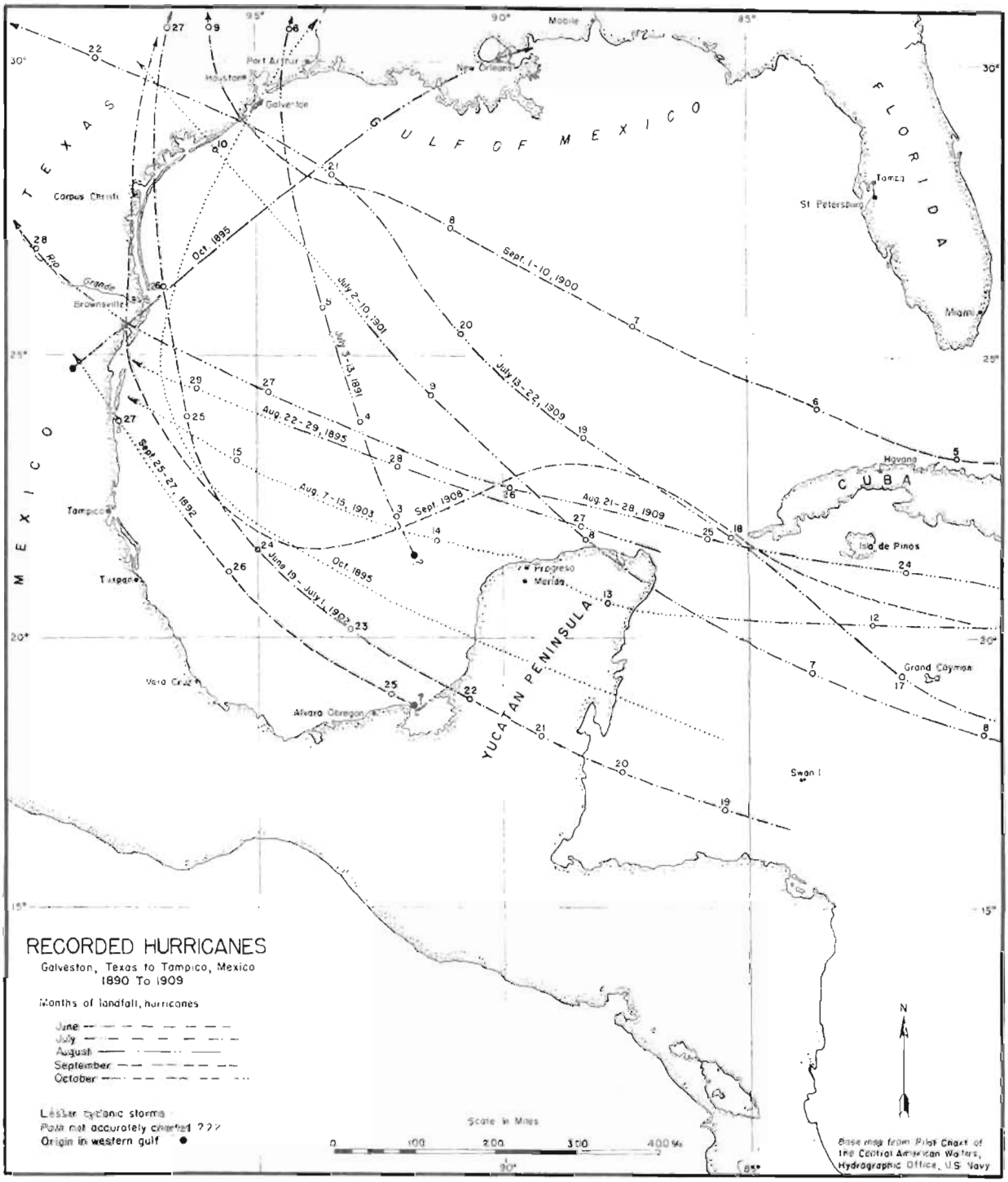
1908

H September: O.L. Fassig (1913) maps. No data. (1)

1909

H July 13 to 22: Center passed over Velasco, Texas. Estimated $2,000,000 property damage and 41 people killed; a 10-foot tide at Galveston. (1)

H August 21 to 28: Struck northeastern Mexico. About 1500 estimated to have perished. Tides reported as the highest along the South Texas coast in many years. (1)


RECORDED HURRICANES
Galveston, Texas to Tampico, Mexico
1890 To 1909
Months of landfall, hurricanes
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July
August
September
October
Lesser cyclonic storms
Path not accurately charted ???
Origin in western gulf
Scale in Miles
0 100 200 300 400 Mi.
Base map from Pilot Chart of the Central American Waters, Hydrographic Office, U.S. Navy
GULF OF MEXICO
TEXAS
MEXICO
FLORIDA
CUBA
YUCATAN PENINSULA
Mobile
New Orleans
Port Arthur
Houston
Galveston
Corpus Christi
Rio Grande
Brownsville
Tampico
Tuxpan
Vera Cruz
Alvaro Obregon
Progreso
Merida
Havana
Isla de Pinos
Grand Cayman
Swan I
Tampa
St Petersburg
Miami
Oct. 1895
Sept. 1-10, 1900
July 2-10, 1901
July 3-13, 1891
July 13-22, 1909
Aug. 22-29, 1895
Sept. 25-27, 1892
Aug. 7-15, 1903
Sept. 1908
Aug. 21-28, 1909
June 19-July 1, 1902
Oct. 1895

DATA AND SOURCE

See "References" in report herewith

1910 - To - 1929

(1) U. S. Weather Bureau, files, published reports, and books of officials: Cline, Fassig, Tannehill.
(2) Lt. Blake, U. S. Topo. Eng. (1845).
(3) R. E. Halter, Asst., U. S. Coast Survey, ann. rpts. (1876-81).
(4) Lt. Webster, U. S. Topo. Eng. (1848).
(5) Surveys of Federal Archives to 1947.
(6) Andrew Anderson, ship captain, Corpus Christi, Texas.
(7) W. H. Emory, U. S. & Mex. Boundary Survey (1857).
(8) Local ranchers.

1910

C August 23 to 31: Cyclonic storm, not of hurricane intensity, striking just a few miles south of the Rio Grande River mouth. (1)

H September 5 to 14: Struck the mouth of the Rio Grande. One day's rain was 4.41 inches. (1)

H October ___: Originated between Port Isabel and Baffin Bay. Moved east across northern Gulf and north Florida. Authority, O. L. Fassig (1913). (1)

1912

H October 11 to 17: Struck between Mesquite Rincon and Baffin Bay. (1)

1913

H June 22 to 25: Struck at the mouth of the Rio Grande River, caused a record rainfall in Texas. (1)

1915

H W August 5 to 24: A hurricane of great diameter, affecting the Corpus Christi-Galveston area. Damage estimated at $50,000,000 and 275 lives lost. (1)

1916

H W August 12 to 18: Struck Corpus Christi. Wind estimated at 90 mph. Damage estimated at $1,800,000 and 15 lives were lost. (1)

1919

H September 2 to 14: Possibly the greatest hurricane of **between** 1900 **and** 1920 **in the** Western Gulf. Affected the entire Gulf coast from Florida to Mexico. Damage in the Corpus Christi vicinity estimated at $20,000,000. The wind at Corpus Christi reached 110 mph and the tides were 10 feet above normal.* Padre Island flooded and much damage to grass. Tide maps in Cline (1946), Figs. 7, 8, for outer coast. (1) (8)

1920

T Date unknown: Tidal wave recorded at Port Isabel in this year. (Not shown on map) (5)

1921

C June 15 to 26: Struck east of Corpus Christi. Winds: at Corpus reached 68 mph.

C September 6 to 7: A hurricane originating in the Bay of Campeche, and crossed the Rio Grande into Texas with much reduced wind velocity. Resulting in torrential rain over the State. Grass denuded or damaged on south half of Padre Island. (1) (8)

1922

F June 13 to 16: Struck Mexico near Tampico. Northern Mexico and Southern Texas flooded. High flood record on the Rio Grande River. (1)

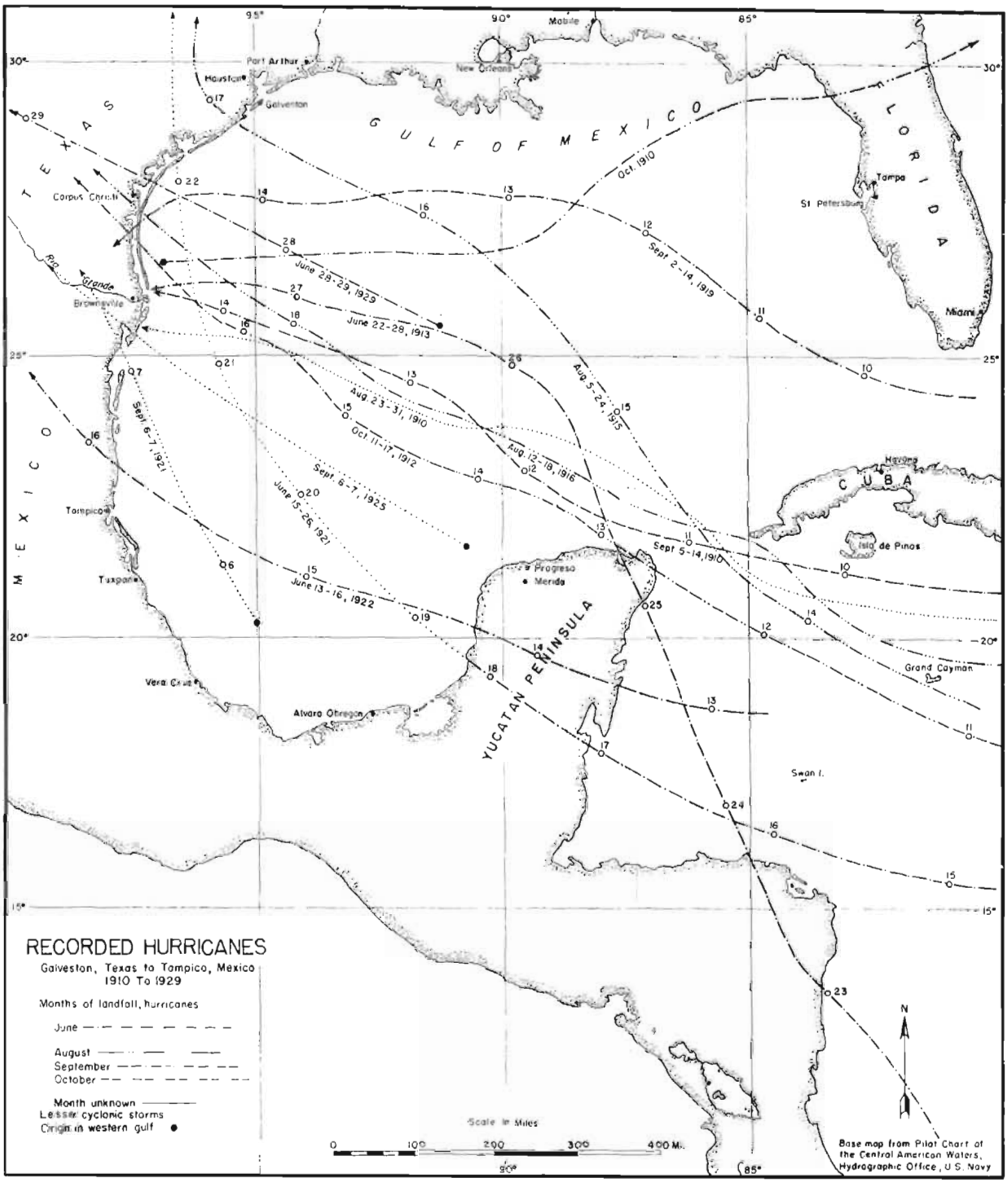
1925

C September 6 to 7: Struck the Texas-Mexican coast near Brownsville. It resulted in heavy rains and moderate gales in the "Valley Area". (1)

1929

H June 28 to 29: Struck Port O'Connor. Winds of 70 to 80 mph. (1)

* Measurements vary from 12.5 to 16.0 feet above msl.


RECORDED HURRICANES
Galveston, Texas to Tampico, Mexico
1910 To 1929
Months of landfall, hurricanes
June
August
September
October
Month unknown
Lesser cyclonic storms
Origin in western gulf
Scale in Miles
0 100 200 300 400 Mi.
Base map from Pilot Chart of the Central American Waters, Hydrographic Office, U.S. Navy
GULF OF MEXICO
TEXAS
MEXICO
FLORIDA
CUBA
YUCATAN PENINSULA
Mobile
Port Arthur
Houston
Galveston
New Orleans
Corpus Christi
Rio Grande
Brownsville
Tampico
Tuxpan
Vera Cruz
Alvaro Obregon
Progreso
Merida
Tampa
St Petersburg
Miami
Havana
Isla de Pinos
Grand Cayman
Swan I.
Oct. 1910
Sept 2-14, 1919
June 28-29, 1925
June 22-28, 1913
Aug. 5-24, 1915
Aug. 23-31, 1910
Oct. 11-17, 1912
Aug. 12-18, 1916
Sept. 6-7, 1921
Sept. 6-7, 1925
June 5-26, 1921
June 13-16, 1922
Sept 5-14, 1910

DATA AND SOURCE

See "References" in Report Herewith

1930 - To - 1949

(1) U. S. Weather Bureau, files, published reports, and books of officials: Cline, Fassig, Tannehill.
(2) Lt. Blake, U. S. Topo. Eng. (1845).
(3) R. E. Halter, Asst., U. S. Coast Survey, ann. repts. (1876-81).
(4) Lt. Webster, U. S. Topo. Eng. (1848).
(5) Surveys of Federal Archives to 1947.
(6) Andrew Anderson, ship captain, Corpus Christi, Texas.
(7) W. H. Emory, U. S. and Mexican Boundary Survey (1857).
(8) Local ranchers.

1931

C June 25 to 28: Struck between Brownsville and Corpus Christi. Rain in the vicinity was as much as 8.03 inches. (1).

1932

H W August 11 to 14: Struck the Texas coast near Freeport. The wind at East Columbia was estimated at 100 mph. (1)

1933

C June 27 to July 6: Struck the Mexican coast midway between Brownsville and Tampico. Brazos & Padre Islands and Port Isabel flooded. South half of Padre Island denuded of grass. (1) (8).

H July 25 to August 5: Struck south of Brownsville, where winds reached 72 mph, probably higher on Padre Island. Damage mostly due to rain, estimated at $1,750,000.

H W August 28 to September 5: Struck the Texas coast north of Brownsville, with an extreme wind of 106 mph measured and property damage estimated at $12,000,000. (1)

1934

C July 23 to 25: Struck the Texas coast at Rockport and produced high tides in that area. This storm may not have been of hurricane intensity. Damage estimated at $1,500,000. (1)

? August 26 to September 1: Storm struck the Mexican coast north of Tampico and had little effect in Texas. (1)

1936

H W June 26 to 27: Struck Port Aransas. Winds estimated at 90 mph at Ingleside.(1)

C September 11 to 13: Struck 70 to 80 miles southwest of Corpus Christi. Winds at Corpus Christi reached 40 mph. No damage reported. (1)

1938

C August 23 to 28: Struck 50 miles north of Tampico, Mexico. No Texas damage reported. (1)

1942

H August 26 to 30: Struck Matagorda Bay. Winds reached 72 mph at Corpus Christi. (1) North Beach area of Corpus Christi evacuated (7,000 people).

1945

H W August 24 to 27: Struck the Texas coast, 60 miles west of Houston. Wind at Port Isabel reached 76 mph and at Corpus Christi reached 70 mph. Two-thirds of the Texas coast was subjected to hurricane winds by this storm. The highest wind estimate was 105 mph at Port O'Connor. The tides at Port Lavaca were 15 feet above normal. Wind damage here was heavy. (1) North Beach area, Corpus Christi, evacuated (7,200 people).

1947

C July 28 to 31: Struck south of Brownsville. Wind 44 mph at Port Isabel. (1)

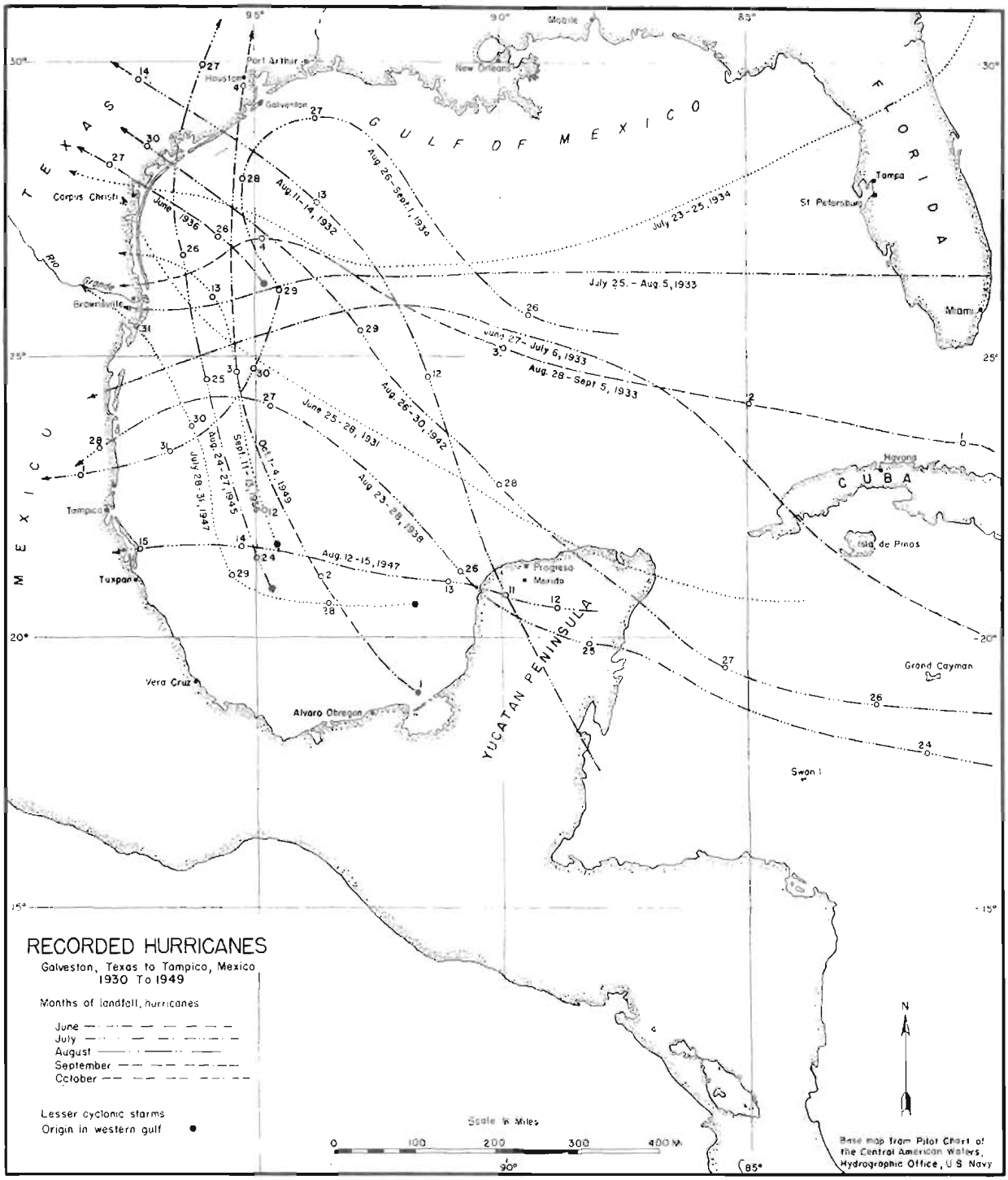
August 12 to 15: Struck Tampico on the 15th with winds at 110 mph. No effect at Brownsville. (1)

1948

No hurricane or tropical storms on Texas coast. (1)

1949

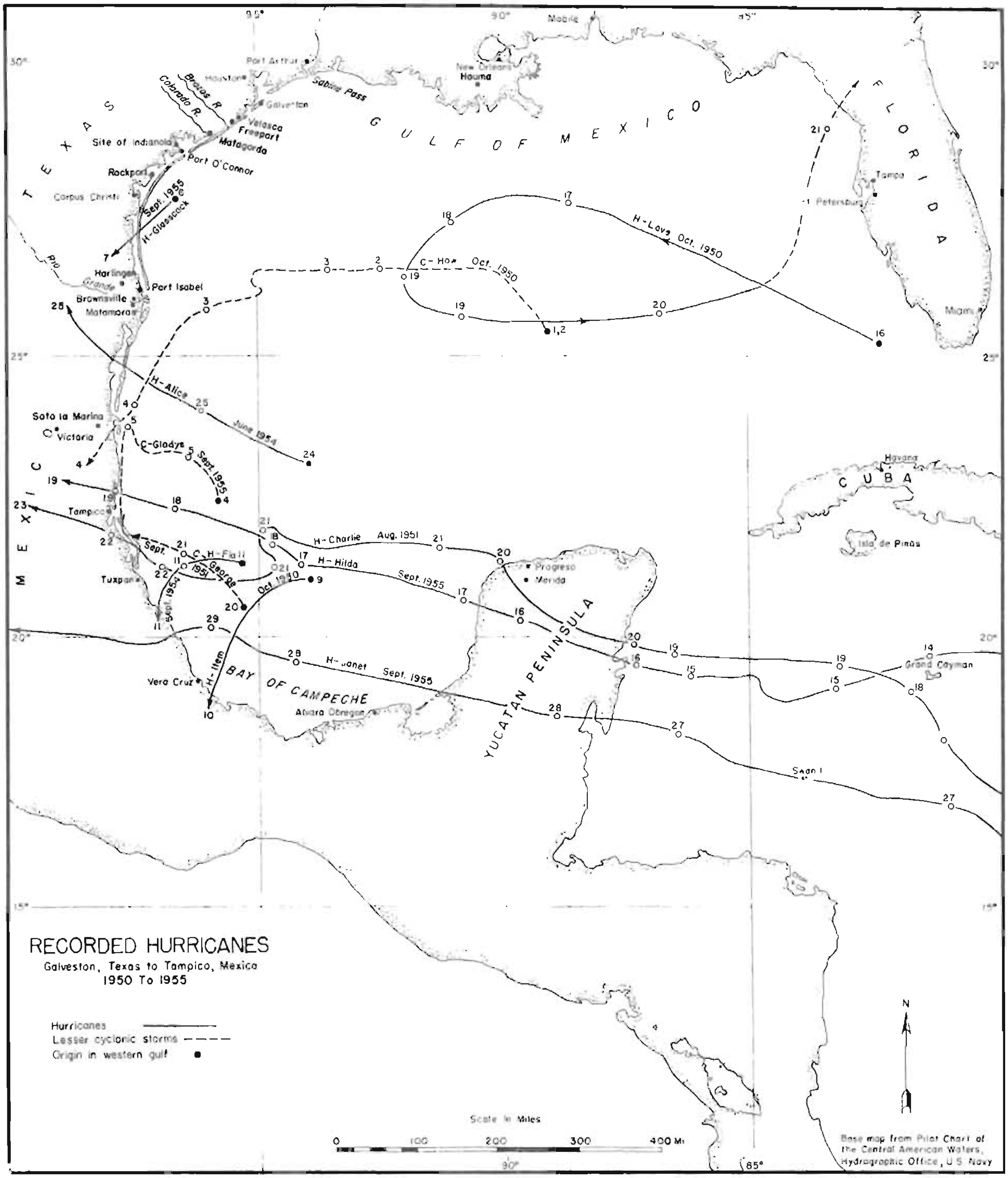
H W October 1 to 4: Origin in Southern Gulf of Mexico. Passed within 100 miles of Padre Island. Struck Freeport and Houston with full hurricane intensity. Tides were 3.6 ft. above msl at Port Aransas and 11.5 feet above msl at Freeport. Winds: Max. at Houston 90 mph; at Freeport 100 mph, and estimated heavy damage.


RECORDED HURRICANES
Galveston, Texas to Tampico, Mexico
1930 To 1949
Months of landfall, hurricanes
June
July
August
September
October
Lesser cyclonic storms
Origin in western gulf
Scale in Miles
0 100 200 300 400 Mi
Base map from Pilot Chart of the Central American Waters, Hydrographic Office, U.S. Navy
GULF OF MEXICO
TEXAS
MEXICO
FLORIDA
CUBA
YUCATAN PENINSULA
Port Arthur
Houston
Galveston
Corpus Christi
Brownsville
Rio Grande
Tampico
Tuxpan
Vera Cruz
Alvaro Obregon
New Orleans
Mobile
Tampa
St Petersburg
Miami
Havana
Isla de Pinos
Progreso
Merida
Grand Cayman
Swan I
June 1936
Aug 11-14, 1932
Aug 26-Sept 1, 1936
July 23-25, 1934
July 25 - Aug 5, 1933
June 27 - July 6, 1933
Aug 28 - Sept 5, 1933
Aug 26-30, 1942
June 25-28, 1931
Aug 23-29, 1939
Aug 12-15, 1947
July 28-31, 1947
Aug 24-27, 1945
Sept 11-13, 1933
Oct 1-4, 1949

DATA AND SOURCE

Source: Corpus Christi Weather Bureau Office

See pages A-15 to A-17 of Hurricane Chronicle (this Appendix) for data.


RECORDED HURRICANES
Galveston, Texas to Tampico, Mexico
1950 To 1955
Hurricanes
Lesser cyclonic storms
Origin in western gulf
GULF OF MEXICO
TEXAS
FLORIDA
MEXICO
CUBA
YUCATAN PENINSULA
BAY OF CAMPECHE
Mobile
New Orleans
Houma
Port Arthur
Houston
Sabine Pass
Galveston
Brazos R.
Colorado R.
Velasco
Freeport
Matagorda
Site of Indianola
Port O'Connor
Rockport
Corpus Christi
Harlingen
Rio Grande
Port Isabel
Brownsville
Matamoras
Soto la Marina
Victoria
Tampico
Tuxpan
Vera Cruz
Alvaro Obregon
Progreso
Merida
Havana
Isla de Pinos
Grand Cayman
Tampa
St. Petersburg
Miami
H-Glasscock
Sept. 1955
H-Love Oct. 1950
C-How Oct. 1950
H-Alice
June 1954
C-Gladys Sept. 1955
H-Charlie Aug. 1951
H-Hilda Sept. 1955
H-Janet Sept. 1955
H-Item Oct. 1950
C-George
Sept. 1954
C. H-Fla
1951
Scale in Miles
0 100 200 300 400 Mi
Base map from Pilot Chart of the Central American Waters, Hydrographic Office, U.S. Navy
N
30°
25°
20°
15°
95°
90°
85°

B58385

APPENDIX B

HURRICANE INCIDENCE AND THE SUN SPOT CYCLE OF 11 YEARS

This appendix was prepared and submitted by the author subsequent to submission of his original report.

Revision of the 15.5 to 16-year periodicity for the incidence of the Texas hurricanes of this report is indicated from comparison of the yearly record of hurricanes (Figure 1 of text) with the sun spot frequency curve (Willett 1956)* which has been applied by its author to weather forecasting.

The close relationship of the two records shows that we may divide the long H-rich period 1866-1891, to give 1866-1876, H-rich; 1877-1884, H-poor; and 1885-1891, H-rich. This revision gives 5 H-rich periods from 1829 to 1936 and 5 H-poor periods from 1845 to 1953. The averages are then 10.8 years for H-rich and 14.2 years for H-poor, or an average of 12.5 years for the 125 years from 1829 to 1953. Hence, the hurricane incidence for Texas south of Galveston is close to the often-heard "11-year sun spot cycle" and to Willett's 20-year cycle. Each H-rich cycle lies under the ascending limb of a sun spot peak except one which lies directly under the peak. Each H-poor period lies under a descending limb except one, in which the available curve does not show a dip.

The forecast for 1956 is that an H-rich period began in 1954 and may continue for from 7 to 16 years total with from 5 to 10 hurricanes. If the reported forecast**, for a sun spot peak having begun in October 1955 and being expected to reach a peak in 1957-1958, is according to the best judgment of sun spot specialists, then we might have only an unusually short hurricane-rich period or the sun spot curve might not be representative of the past century.

The close relationship of the hurricane and sun spot frequency data shows that sun spot data may be used to supplement hurricane data in the analysis and forecasting of hurricane incidence for the northwestern Gulf of Mexico. It may be that the relationship extends to the Mexican coast, but the record there is short.

* "Cold weather ahead", H. C. Willett & J. A. Morris, Saturday Evening Post, March 24, 1956, Vol. 228, No. 39, pp. 23-25, 122-124.

** Newspapers of February, 1956

The result of changing the limits of hurricane frequency periods between 1886 and 1891 is the following:

	Number of Hurricanes Per Period	Range	Lengths of Periods in Years	Range
H-Rich	8.2	5-10	10.8	7-16
H-Poor	2.2	2-4	14.2	8-21
Average	5.2		12.5	

A "cycle" of 1 H-Rich and 1 H-Poor period together averaged 25 years. Thus, an H-Rich period began, on the average, every 25 years. A longer record would probably change this somewhat.