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## TROPICAL CYCLONES OF THE EASTERN NORTH PACIFIC OCEAN

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Nearly all published works upon the cyclones of the Northern Hemisphere rather emphasize the statement that storms of the Tropics, except in the Arabian Sea and the Bay of Bengal, have their natural habitat only over the lower western waters of the great oceans. It is unfortunate that this supposition yet obtains in many quarters. The Indian seas have long held a unique position in this particular, that cyclones have formed indifferently east and west over their waters, while no other west-coast area north of the Equator has been connected generally with the cyclone history of the Tropics. Assuredly, then, it is time that a certain considerable area of the sea off the Mexican west coast, or the southeastern North Pacific, be definitely recognized in all meteorological publications as a place of dangerous summer and autumn cyclones, more especially since, with the opening of the Panama Canal in 1914, this region has sprung into increasing importance by reason of its waters being crossed by greater volumes of trade.

*Region of occurrence.*—Draw a line southwestward from Point Eugenia on the middle coast of Lower California to meet the tenth parallel of north latitude, in longitude 125° west, thence eastward to the Costa Rican coast, and with the intermediate land boundary for one side, there is inclosed in a rough triangle the principal part of the region affected by tropical storms. To be sure, cyclones sometimes form farther to the southward, sometimes extend their activities farther to the northward and eastward, and occur occasionally within a comparatively narrow belt running 30° or so to the westward of the meridian given as the western apex of the triangle, yet within the boundaries delineated they are exhibited to the fullest, and here the most of them have birth, progression, and dissolution.

*Summer weather of this region.*—The summer weather here is usually hot and humid. The normal wind circulation is light and more or less unsteady over a great part of the area. Calms are frequent in most portions, and conditions are as ideal for atmospheric overturnings as they are east of the Leeward Islands. In coastal localities the rainy season begins usually in June, except that it arrives considerably later over Lower California than along the coast proper farther to the southward. With October, precipitation generally begins to lessen.

*The cyclone season.*—The period of cyclone occurrence fairly well coincides with that of the general rains, but whether the wet season for any year begins earlier than June or not, there is little reason to expect a cyclone prior to that month. May had long been recognized as a month without such storms, but the existence of a moderate cyclone from the 24th to the 27th of May, 1928, to the southward of the Revillagigedo Islands, on the route between Panama and Honolulu, put an end to

its record of entire immunity. With this exception, the earliest cyclones previously known formed a week or 10 days later in the season. There is an average occurrence for June of a trifle more than one in two years. In July and August there is a slight increase in numbers and activity, but September is preeminently the month of most frequent storminess of this character, about two-fifths of the entire number of cyclonic disturbances occurring then. In October they wane appreciably in frequency, though gaining slightly in intensity, and November adds only an occasional outburst—a violent one more often than otherwise—to close the activities of the season. After November there is only one record of a Pacific tropical cyclone occurring within 2,000 miles or so of the Mexican littoral. This is shown in the Mexican Climatological Atlas (1) in the track of December 22–26, 1925, where it appears as approaching nearest the coast below Cape Corrientes, at a distance of approximately 200 miles. Another December cyclone comes from the records of the Deutsche Seewarte (2) as occurring in 1832 southeast of the Hawaiian Islands. There is further record of a still later cyclone, one of January many years ago, but it does not seem to be sufficiently verified to permit of tabulation as such.

*Northers.*—Often, a month or two before the cyclone season ends, another class of frequently violent winds blows along portions of the west coast, particularly over the Gulf of Tehuantepec and to a lesser extent along the Central American shores. These, if exceptionally strong, are often called hurricanes, and might be mistaken for cyclones were it not that a study of their behavior shows them to be otherwise, for the region they most persistently haunt is also the most common breeding place of the coast cyclone. They are, however, anticyclonic winds, and, although known by various local names, are true northers. They last from a few hours to a few days, depending upon the period during which an excess of air piles up against the northern buttress of the Cordilleras from the Gulf of Campeche, whenever strong anticyclones from the United States extend sufficiently far across the Gulf of Mexico in fall and winter. The spill of this overpouring air down the opposite slope to the Pacific is sometimes so forcible that hurricane winds rage over the entire southern gulf and for some distance to the southward. A recent instance of one of these northers of considerable violence is that of the so-called hurricane of November 24, 1928, experienced by the U. S. S. *Maryland* during the good-will tour of President-elect Hoover. The gale usually blows seaward from a direction anywhere between east-northeast and west-northwest, and is frequently associated with a temporary slight fall in pressure.

*Early history of the stormy weather of this coast.*—During Sir William Dampier's voyages (3) in the late years of

the seventeenth century, he encountered many strong winds in this locality. For instance, when off Guatemala in September, 1685, he met with very bad weather, and in writing of it said that "seldom a day passed but we had one or two violent tornadoes."

Many interesting comments upon the wet-season weather of the coast from Guaymas far southward, ascribed to British and American naval officers early assigned by their respective Governments to the various harbors, are related by Findlay (4). All harbors in the days of sailing vessels were considered to be dangerous, owing to the frequent violent winds which might be expected, and to the accompanying heavy seas which were likely to drag a ship from her anchor and pile her upon a frequently rocky shore. Such gales came on with so little advance warning that a vessel might not be enabled to seek the greater safety of the open sea before they were at hand. In addition to these dangerous conditions that were likely to occur at any time, even harder storms might be expected, especially toward the end of the season, near or after the day of the Feast of Saint Francis, in October, when the west coast people looked for el cordonazo, the "lash of Saint Francis," a southerly hurricane that not only wreaked havoc among the fishermen's boats, but destroyed their houses as well, so that some villages due to the fear of it were deserted during the threatening months.

Among the earliest recorded destructive hurricanes of this coast were those of November 1, 1839, during which most of the 12 ships then in the harbor of Mazatlan were lost with their crews, and of November 1, 1840, during which three vessels were lost at San Blas. The other storms—"tornadoes" and violent winds—were probably for the most part heavy thunder storms and squalls of a local character, or they were northers of the autumn months. El cordonazo, while expected with apprehension annually, was thought not actually to occur much oftener on the average than once in six or eight years, whence the idea of its infrequency was handed down in meteorological history. The name applied most specifically to the strong southerly winds on the eastern sides of cyclones going up the coast. Gales from contrary directions were of course sometimes experienced, if the storm went inland, but, being comparatively infrequent, were not fixed upon by the popular mind.

Present-day observations show a far greater number of these dangerous on and off shore cyclones than were earlier hinted at, in addition to a considerable number of moderate to violent cyclones occurring too far at sea to affect the coast weather. All told, an average of five annually have been recorded during the last 19 years, with an extreme number of 13 for a single season.

*The cyclones of Redfield.*—In 1856 William C. Redfield (5) traced a number of progressive gales and hurricanes for the Atlantic and Pacific Oceans. Thirteen tracks of storms occurring between 1842 and 1855 were drawn for the region lying between Mexico and the one-hundred and twenty-fifth meridian of west longitude, and another track was projected still farther to the westward, south-east of the Hawaiian Islands. One as drawn indicated that the cyclone had originated in the Pacific, but had moved thence into the Gulf of Mexico.

*Cyclones of the Deutsche Seewarte.*—For the 61 years, 1832 to 1892, the Deutsche Seewarte has a record of 45 cyclones for this region. A comparison of data in this record with that of Redfield indicates the possibility, though not the certainty, that two storms in the respective lists were identical. Some analysis of these cyclones appears in the summary to this article.

*Later cyclones.*—From 1893 to 1909, inclusive, sporadic mention has been made here and there of various storms, both far at sea and in coastal waters, but little attempt has been made as yet to gather or to coordinate the probably existent data concerning the cyclones of this period, although it is expected the material will form the basis of a subsequent study.

*Cyclones of the 19-year period, 1910–1928.*—For these years the writer has found his most valuable and prolific medium of information in the weather reports of seamen cooperating with the Weather Bureau. In no other region north of the Equator traversed by tropical cyclones have reports, received by mail, been more necessary to the furtherance of knowledge of such storms, and already, from this source alone, 85 distinct cyclones have been isolated for these waters for the period given. Nor can the known list be yet considered as complete, if one may judge from the numbers recently added to it because of information received from vessel masters who, noting the growing interest in the subject, have forwarded copies of logs descriptive of cyclones experienced in earlier years. Often the only information regarding a storm has been drawn from the report of a single vessel that merely happened, as may be said, to encounter it. Were these waters even sparsely dotted with island radio reporting stations such a condition could by no means be as true. To be sure, radio must play no unimportant part in broadcasting storm information, yet withal it is only of late that it has seemed to be of distinct advantage in this interesting locality.

*Cyclones traced by the Mexican weather service.*—Another and a highly important factor must now be taken into consideration as a source of information about the storms of this coast. In a letter of February 19, 1925, to the writer, Prof. Pablo Vazquez Schiaffino, then chief of the meteorological observatory at Mazatlan, Sinaloa, Mexico, and now chief forecaster of the weather service, spoke of the difficulties often experienced in detecting and forecasting the presence and movements of these storms. It is of interest to quote in part from his communication:

I would very much like to furnish information of many of these storms which have occurred during the past 40 years, but I have failed, since there are no records of meteorological information in the various ports of this coast to depend upon. I have searched in Acapulco, Manzanillo, and San Blas in the files of the old capitaniyas de puerto (captains of the harbor headquarters), and although in some cases was lucky to find reports of vessels that were taken by storms on sea and also observations and notes made by the captains themselves, it was all a mixture of data \* \* \* from which nothing could be properly used, be it to plot the track of a storm or to appreciate its magnitude \* \* \*. In this observatory we have very reliable records of weather observations since 1880, the study of which makes me believe that not less than 70 tropical storms have occurred and passed near or far from Mazatlan during that period, but \* \* \* it is uncertain if not impossible to determine the direction of the trajectory, how far it passed from Mazatlan, etc. Since 1920 the Mexican Weather Bureau took control of the meteorological observations on both coasts \* \* \* (and) we count in this coast, with nine stations equipped with all the principal instruments to make observations \* \* \* a real meteorological service started; and with this observatory as a center \* \* \* we are now able to forecast and follow the storms when they come from the south and more or less parallel to the coast and near enough to detect them, but when they come from the SW. or WSW. it is very difficult to make a forecast, plot the track, or locate the center. Sometimes the storms move parallel to the coast, but very far from it; in this case all the harbors experience heavy south sea swell and backing of the wind to SE. or E., but it blows only with gentle or moderate velocity. This I have observed in November and December, and once up to January, and it would not surprise me to know that ships en route to Panama from San Francisco, hundreds of miles west of the Mexican coast, have encountered storms of tropical characteristics during the winter months.



Caribbean. Unless these storms die out at an early stage, or go inland meanwhile, they usually follow a course that will take them across or slightly to the westward of the entrance to the Gulf of California, and therefore to one side or the other of Cape San Lucas. The region of greatest storminess, as a rule, lies between this cape and the latitude of Manzanillo, where the cyclones arrive at their highest degree of intensity. A few examples of this class may be mentioned.

A destructive hurricane of September 13-17, 1918 (fig. 1, Track VI), first reported west of Acapulco, ran slightly east of Cape San Lucas, and proceeded with unusual violence for some distance up the inner coast of Lower California. Mr. B. F. Yost, United States consul at Santa Rosalia, said of the storm that it was extremely damaging to the maritime communities, especially at La Paz, where every boat in the bay was damaged or destroyed, and at San Jose del Cabo, where dwellings and industries were damaged and several people lost their lives. A number of small vessels, in addition, were reported lost at sea.

The hurricane of September 7-12, 1927 (fig. 1, Track XIV), took the unusual course of entering and crossing a long strip of coast between Salina Cruz and Manzanillo, then finished its course outside of Lower California, dying out when about half way up the peninsula.

Another, the hurricane of October 22-25, 1925 (fig. 1, Track XIII), after proceeding for nearly three days on a usual course, began recurring shoreward in time to cross Cape Corrientes, then to enter the continent in the neighborhood of San Blas.

The December cyclone of 1925, plotted by the Mexican weather service, although running a little farther out at sea than any of the foregoing mentioned, must be considered as belonging to this group.

*Cyclones of the second group.*—Tracks I, V, X, and XII on the chart may be taken as illustrating the type of cyclones that have inception generally farther south, or at least farther from land, than those of the first group. They move in a northerly direction (northwest to northeast), and finally strike upon the coast. They have a wide longitudinal range of origin, the particular ones delineated on the chart having formed at various points between  $90^{\circ}$  and  $113^{\circ}$  W. Few of this type skirt the coast in any portion of their track, but come up from the sea and move more or less directly upon the continent. Of these cyclones, the following may be mentioned as illustrative:

The hurricane of September 29-October 1, 1895 (fig. 1, Track I), was at the time considered to have been one of the severest known in the vicinity of La Paz, where it caused considerable property damage and loss of life. It originated somewhat west and south of Clipperton Island, or near  $10^{\circ}$  N.,  $110^{\circ}$  W., at which place strong southwesterly squalls were experienced by a vessel at anchor there on the 29th. The storm moved rapidly throughout its course, but during the forenoon of October 1 its speed must have been extraordinary, since the gales began off Cape San Lucas at a very early hour and the storm was at its height at Culiacan, Sinaloa, shortly after noon.

The moderate disturbance of July 4-6, 1915 (fig. 1, Track V), may be cited as the most southeasterly in point of origin of any plotted. Other cyclones have been found still farther south and east, but, with data confined to a single day's observation in a given case, not even an approximate track could be drawn. The one mentioned was first discovered well south of the tenth parallel, near the ninetieth meridian, and its course followed with fair certainty as it moved northward then northwestward

toward Salina Cruz, near which port it entered the Mexican coast.

*Cyclones of the third group.*—Included in this division are such cyclones as occur largely near or to the southward and westward of the Revillagigedo Islands, a small group situated near  $19^{\circ}$  N.,  $111^{\circ}$  to  $112^{\circ}$  W. Therefore, these storms may be met with, roughly, anywhere between  $15^{\circ}$  and  $20^{\circ}$  N.,  $110^{\circ}$  and  $120^{\circ}$  W. Cyclones of the first group sometimes move into this field while on their way northward, or northeastward toward Lower California, but the third group, as differentiated, actually includes only those storms that here progress toward the westward (northwest to southwest), and therefore out to sea. The most frequent direction is toward west-northwest, and the least frequent, probably, toward southwest or west-southwest. Two cyclones during the last 50 years or so are known to have traveled southwestward, and fugitive data indicate that a recent storm may have taken that direction. Of the known instances, one was the hurricane of September, 1899, shown in Figure 1 as Track III. The other was an occurrence of July, 1882, near  $13^{\circ}$  N.,  $118^{\circ}$  W.

Redfield drew approximate tracks of several cyclones of this region that came to his knowledge for the years 1847 to 1855, but all are indicated as having straight paths in a direction slightly west of northwest. In recent years it has been found impossible to plot even approximate tracks for other than a mere fraction of the cyclones of this group, owing to lack of extended observations. An instance of a highly important uncharted storm of this class is to be found in the hurricane experienced September 9, 1922, by the American steamer *Bessemer City*, bound eastward from Honolulu. At noon of the 9th the vessel was in  $16^{\circ} 22' N.$ ,  $113^{\circ} 44' W.$ , wind NNE., force 12. At 3 p. m. her barometer read 27.96, which, with a similarly low pressure observed on another occasion, is the lowest on record for these waters. From 1 to 3 p. m. the pressure drop on board was 0.94 inch. The vessel was in the full grip of hurricane winds from 11 a. m. to 11 p. m., except for a period following 3:30 p. m., during which she crossed the eye of the storm, a region estimated to be 18 miles across.

A cyclone of the same group, that of September 1-3, 1928, is seen in Track XVII on Figure 1. It is plotted with good approximation, since its course was fairly well followed by two steamers, the *Santa Isabel* and the *Chattanooga City*, en route from the canal to Honolulu. The two were on courses which carried one immediately north and the other immediately south of the storm center during a considerable portion of its period of activity. It may be remarked that other cyclones have been similarly followed by vessels on this route, which indicates one of the principal sources of information for the storms of group 3.

*Cyclones of the fourth group.*—This includes all those somewhat rare—at least, infrequent—disturbances of low latitudes met with between longitudes  $125^{\circ}$  and about  $155^{\circ}$  W. Seven known summer cyclones have been allocated to this region, in addition to the December cyclone of 1832, located by the *Deutsche Seewarte* in  $13^{\circ}$  N.,  $148^{\circ}$  W. Four formed in September and three in July or August. The "Cyclone of the Lark" was the name given by Redfield to the storm of September 23, 1843, observed in  $15^{\circ}$  N.,  $138^{\circ}$  W. The cyclone of September 21-24, 1870, was traced westward by the *Deutsche Seewarte* from a position in  $17^{\circ}$  N.,  $141^{\circ}$  W. Other cyclones were those of September 29, 1911, force 10, near  $20^{\circ}$  N.,  $147^{\circ}$  W.; of July 21, 1926, lowest pressure 29.49 inches, in  $19^{\circ}$  N.,

131° W.; and of August 22-23, 1926, force 9, pressure 29.60, in 18° 38' N., 125° 36' W. Two cyclones in this field were encountered by one steamer, the *West Calera*, in 1925. The first was on July 31-August 1, near 15° N., 152° W., accompanied by strong northeast gales. From August 1 to 4 easterly gales occurred at Honolulu, although without appreciable barometric depression, the storm remaining well south of the islands. The second was that of September 27-28, near 22° N., 137° 30' W. This was a hurricane of great depth, the barometer falling to 28.53 inches. It may be remarked that the Hawaiian Islands are very rarely affected in any way by tropical cyclones, their kona storms being wet southerly winds on the eastern sides of winter depressions that have extended far southward from their Aleutian base.

*Cyclones of the "No Man's Land."*—Beyond the western limit of the tropical cyclones already described lies a region southwest of the Hawaiian Islands, from 155° W. to slightly beyond the one hundred and eightieth meridian, that as yet is largely unknown, or at least somewhat questionable, as a place of origin of storms. Outside this zone, or west of 175° E., one enters upon the habitat of the typhoon, which, however, forms only rarely over its eastern limit, perhaps the only occurrence of recent years near this boundary being the hurricane of December 4-5, 1927, over one of the islands of the Gilbert Group, in 3° N., 173° E. (6). Few observations cover the little-known zone, and those available in recent years for these low latitudes have given no evidences of cyclonic disturbances. For earlier years the Segelhandbuch (2) lists two cyclones in this region. One was charted as of November 2, 1858, in 21° N., 174° W.; the other, as of November 19, 1874, in 16° N., 161° W., pressure 29.68 inches, highest wind force 10, from the southwest. Whether or not these were actual tropical storms, or mere extensions southward of extratropical disturbances, is problematical. The appearance of the latter, so far below the line of the Tropic, gives special weight to the assumption that it may have been of tropical origin. It seems apparent at times, especially during the autumn months, that northward-bearing cyclones of some consequence do spring up from this "No Man's Land" far below and southeast to southwest of Midway Island (lat. 28° 12' N., long. 177° 22' W.), since land observations at Midway and vessel observations between there and Hawaii sometimes point to such a probability. If disturbances of this seeming tropical character can assuredly be isolated as such, the existing hiatus between the typhoon of east longitudes and the hurricane of this side of the Pacific will have become well-nigh bridged. The range of the cyclone of the northern Tropics will then have become extended, with few slight lapses, from the eastern Atlantic westward across the intervening seas and narrow continental strips to Arabia.

*West coast cyclones that cross to the Gulf of Mexico.*—In Redfield's Chart of Gales and Hurricanes, 1855 (5), appears the track of a cyclone which sprang up from the southeastern waters of the Gulf of Tehuantepec, crossed lower Mexico to the Gulf of Campeche, thence moved northeastward across the Gulf of Mexico and Florida, and finally died out far east of Hatteras.

In 1924 Prof. P. Vazquez Schiaffino, then chief of the meteorological observatory at Mazatlan, sent to the Weather Bureau the tracks of two cyclones which occurred in September of that year. In a report upon the second of these storms (fig. 1, Track XII), which originated near 10° N., 102° 30' W., on the 6th, and passed inland between Acapulco and Manzanillo on the 9th, he said:

This cyclone followed a somewhat unusual path, since it is very rare for a cyclone from the Pacific to cross the Mexican Republic, as this one did. The cyclones that have previously passed to the Gulf of Mexico have crossed the Isthmus of Tehuantepec, but never to the west of the one hundredth meridian.

Generally, when the direction of the path is like that of the present storm, from southwest to northeast, the cyclone disappears on reaching the land and encountering the foothills of the Sierra Madre, and only causes heavy rains and strong winds over a limited area.

This storm gave torrential rains from Acapulco to Mazatlan and copious rains over the greater part of the Mexican Republic. At Acapulco the depth of rainfall was more than 100 millimeters (11.80 inches) in 54 hours. \* \* \*

On passing to the Gulf of Mexico the storm produced heavy rains and strong winds on the coasts of the States of Tamaulipas and Vera Cruz.

In considering the possibilities that a west-coast cyclone may enter upon the land and rise above the Mexican Cordilleras sufficiently intact to enable it to proceed and finally emerge upon the waters of another ocean, one finds them to be rather remote. Ordinarily the storm that heads inshore will break up completely against the western or southern face of the highlands. That part of the continental barrier of Mexico that offers least resistance to a further passage is the Isthmus of Tehuantepec.

C. L. Mitchell, in his study of West Indian hurricanes (7), covering the period 1887-1923, shows only two North Atlantic storms that originated in or bordering upon Pacific waters. One, in October, 1902, had inception, so far as data show, at the southern boundary of Guatemala, on the eastern extremity of the Gulf of Tehuantepec, and proceeded northward across the Gulf of Mexico. The other formed near 12° N., 92° W., October 12, 1923, entered Mexico at or near Salina Cruz on the 13th, crossed the isthmus and the Gulf of Mexico, and struck into southeastern Louisiana.

According to the Mexican atlas (1), and to certain weather maps of Mexico, a few cyclone tracks have been extended across various parts of the republic at a considerable distance from the isthmus, and thence eastward well into the Gulf of Mexico, since 1921. It is evident, however, from a study of the conditions surrounding the final movements of the remnants of the cyclones after leaving the Pacific that the continental line or area of progressive unsettledness is generally very ill defined, an enormous tract of country coming under the influence of a shallow, but wide-spread depression, within which heavy rains, accompanied by more or less violent local squalls, occur. Although rough weather may follow along the east Mexican coast at this time, it is difficult to establish its connection, through vessel weather reports, with such actual central Gulf depressions as have sometimes been seen to occur simultaneously. The latter are usually found to have an independent origin, so that their inclusion as a part of the Pacific cyclone track actually results in an amalgamation of two separate tracks.

*A sea and land cyclone extraordinary.*—Before leaving the subject of cyclones that go inland, it seems necessary to remark upon a most interesting and extraordinary occurrence—that of September-October, 1921, partly shown as Track VIII, in Figure 1. This cyclone ran from an apparent beginning off Acapulco, on a long sea route to above the thirtieth parallel. While yet half way up the western coast of Lower California—beyond which point very few of these cyclones go—it was still of considerable depth, a reading of 29.44 inches having been made by a steamer on the 29th. On the 30th the disturbance struck the coast as a weak depression and entered the semipermanent low-pressure area over southwestern Arizona, which at once developed great activity,

causing very heavy and damaging rains over a considerable area in the dry belt. The fall for the day in Yuma amounted to 3.63 inches. On October 1 the depression, clearly defined, moved eastward then northeastward, crossing the continent and entering the Gulf of St. Lawrence on the night of the 4th. It gathered energy east of Newfoundland on the 6th, but finally disappeared on the 8th near the twenty-fifth meridian west of the British Isles.

*Length of cyclone tracks.*—Except for those few storms whose courses, by reason of extensive observations, have been closely plotted with little error from known beginnings to known endings, the actual or even approximate lengths of tracks are in most instances problematical. Where paths have been drawn from few data covering two or three days only, over areas somewhat remote from the coast, further data, if obtainable, would undoubtedly result in extensions both backward and forward in date. But it is among the cyclones of the first group—those that are generally possible to be under observation for a lengthier period—that one must look for actual longest tracks. Preeminently, the longest track yet plotted is that of September–October, 1921, mentioned in the preceding paragraph, which, during more than two weeks of existence, covered a distance of approximately 6,000 to 7,000 miles. The shortest tracks may be found most probably among the cyclones of the second group that originate near or below the tenth parallel and disintegrate among the lower foothills of the land masses 500 or more miles to the northward. These also are probably most likely to move out of their usually restricted field in the Pacific.

Apart from these known progressive storms, one should not fail to make note of those areas of high wind velocity which sometimes occur coincidentally with barometrically depressed regions of considerable magnitude in coastal waters. At such times, while it is evident that strong cyclonic influences are at work, the observer is often unable to detect any regular progressive movement beyond that shown in an enlarging field of gale-swept waters. At other times, however, a marked intensification has been noted in one or two localized regions, a distinct vortex or two develop, and progression follows.

*Storm diameter.*—While the width of the gale area of these cyclones can not generally be known as closely as in a region like that traversed by the majority of Atlantic hurricanes, where there is a more widespread distribution of observations, yet it is evident that on the average they are much the narrower. Sometimes the actual affected path is 50 miles or less across it, with an extremely narrow central area swept by gales, either fresh or dangerous. Now and then, however, a cyclone of huge proportions is met with. That of August 27–31, 1899 (Track II, fig. 1), was more than 500 miles wide. That of September, 1921, while lying outside the entrance to the Gulf of California, strongly affected the coast 5° to 6° to the eastward, in addition to a distance unknown to the westward. The intense hurricane of September 9–10, 1922, with an "eye" diameter estimated by the steamship *Bessemer City* to be 15 or 18 miles, must have been of great width. This vessel, Honolulu to Panama, met the storm and entered its northwestern quadrant with a moderate gale early on the 9th, leaving it, when the gale abated 32 hours later, from the southeastern quadrant. During this time the steamer advanced only a few miles on her course, as she was forced backward for several hours of the 12 in which she was engaged with a full hurricane. The storm made esti-

ated progress in excess of 10 miles an hour, and had a gale-swept width probably in excess of 300 miles.

*Rate of progression.*—Owing to the usually scattered condition of observations covering the cyclone field, positions for a given hour on any day or days are often only roughly to be approximated, yet some idea of speed may be obtained from many of the storms of this region, whence it appears that an average of 8 to 10 miles an hour is a fair estimate. The cyclone of September 7–12, 1927, averaged 12 miles, though during the first two days of its existence it made some 19 miles an hour. That of September 13–24, 1928, averaged between 7 and 8 miles an hour for several days, then, before recurving landward, suddenly abated its speed to between 2 and 3 miles.

*Violence.*—Beside those cyclones that are unquestionably of moderate intensity only, others of indeterminate strength occur—one merely knows they are cyclones, the violence of which, if the facts were known, might place many of them in the list of hurricanes. As it stands, about 34 per cent of all accredited cyclones are known to have developed whole storm to hurricane winds, which appear on the Beaufort scale as forces 11 and 12, and in miles per hour, from 64 upward. The winds in several instances have been estimated at from 100 to 130 miles an hour.

*Lowest pressure readings.*—The extreme lowest reading of atmospheric pressure recorded in any of these cyclones, and reported in two instances, was 29.96 inches. The first was read at 3 p. m., September 10, 1922, wind NE. by E., 12, on board the American steamer *Bessemer City*, near 16° 12' N., 113° 44' W. The second was made at 7.29 a. m., September 30, 1927, wind WSW., 12, on board the American steamer *President Hayes*, near 22° 02' N., 108° 39' W.

*Seasonal extremes.*—From our own record of 19 years, the earliest cyclone occurred on the 24th to 27th of May, 1928, maximum experienced force, 8 NW., lowest pressure 29.77, in 15° 20' N., 107° 16' W. The latest occurred November 10–11, 1925—a severe hurricane experienced by the Norwegian steamer *George Washington*, lowest barometer 28.15 inches, in 17° N., 102° W. The Mexican atlas has a still later cyclone, that of December 22–26, 1925, at some distance off the coast. These disturbances of late May, 1928, and of late December, 1925, may be taken as the authenticated extremes in point of season.

*Longitudinal extremes.*—Early in September of 1925, preeminently the cyclone year, cyclonic developments in the lower southeastern Tropics gave a southerly hurricane, pressure 29.78, on the 8th, in 4° 23' N., 92° 13' W. On the 13th, in 8° N., 85° W., fresh gales, with lowest pressure at 29.54 inches, gave undoubted indications of a cyclone, though further data concerning either disturbance are wanting. For occurrences farthest west, our vessel weather reports tell of the cyclone of July 31–August 1, 1925, near 15° N., 152° W., and the Segelhandbuch has two cyclones in the region earlier referred to as "No Man's Land," that occurred as far west as 161° W. and 174° W., respectively, the former in 1874, and the latter in 1858.

*Monthly trends.*—In most regions subject to tropical cyclones, there is a strong tendency for them to vary somewhat in locality of formation and direction of progression, according to the age of the season. This tendency does not seem to be as common among the cyclones of the Mexican west coast, except that with progress westward into the regions subject to the storms of the third and fourth groups, which comprise approximately a tenth of all the storms, the season appears to be retarded, not beginning until July or August.

## SUMMATION

## CYCLONES OF 1910-1928

A study of all the vessel weather reports received by the Weather Bureau from these waters for the period 1910 to 1928, inclusive, together with information furnished by the Mexican meteorological service, indicates that at least 95 cyclones have occurred here during the past 19 years. In only two years of that period—1914 and 1916—has there been a seeming complete lack of revolving storms. The number of annual occurrences, arranged chronologically, is as follows:

1910, 3; 1911, 7; 1912, 4; 1913, 1; 1915, 4; 1917, 4; 1918, 3; 1919, 2; 1920, 3; 1921, 9; 1922, 7; 1923, 5; 1924, 3; 1925, 13; 1926, 8; 1927, 9; 1928, 10. The year 1925, with its record of 13 known cyclones, shows a season of maximum frequency and violence.

Thirty-two cyclones of the 95, or 34 per cent of the whole number, have been reported as sufficiently violent to cause full storm (force 11, Beaufort scale) to hurricane velocities within a restricted to a considerable area. Of these, by the year, 1 each occurred in 1913, 1918, 1919, 1923, and 1926; 2 each in 1911, 1912, 1917, and 1921; 4 each in 1922 and 1928; 5 in 1927; and 6 in 1925.

A distribution of the 95 cyclones for the 19-year period by months gives—

May, 1; June, 11; July, 14; August, 15; September, 34; October, 17; November, 2; December, 1.

The distribution of the known hurricanes for the period gives this result:

June, 1; July, 5; August, 6; September, 11; October, 8; November, 1.

## CYCLONES OF THE DEUTSCHE SEEWARTE

A list of storms of these waters published by the Deutsche Seewarte (2) and covering the years 1832 to 1892, a period of 61 years, gives the following numbers by months:

June, 2; July, 8; August, 8; September, 11; October, 10; November, 5; December, 1—a total of 45.

Of these the following are recorded as having known wind forces of 11 to 12:

June, 1; July, 6; August, 2; September, 6; October, 9; November, 3; December, 1—a total of 28 out of the 45 cyclones enumerated, of which 62 per cent were thus of great violence, as against 34 per cent among the cyclones tabulated for the more recent period.

It is evident that the tabulation of known cyclones of very recent years is much more complete than for any previous period or years, owing to the fuller network of

observations covering these waters, made possible by the opening of the canal, but more especially due to the rehabilitation of trade in these waters in 1921, following upon the depression caused by the World War.

The Segelhandbuch remarks upon the curious diminution in the numbers of hurricanes from July to August, according to the 61-year record. In the later record for 19 years, a practically equal number is assigned to each month, August having one the more. September in both cases sees the maximum in numbers, but the German record shows more cyclones of hurricane force in October than in September, while our record gives the greater number to September. Most November cyclones appear to be of considerable energy. In all cases the records are undoubtedly incomplete, very much so among the earlier years, and certainly in considerable measure, especially with reference to storm movements and violence among the later years. It seems well-nigh certain that many cyclones with reported maximum wind forces of 9 or 10 would have yielded higher velocities had the experiencing vessels been involved somewhat nearer to the respective centers.

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NOTE.—Further information as to the histories of individual storms, etc., may be found in an article written for the use of seamen by Willis Edwin Hurd, entitled "Tropical Storms of the Eastern North Pacific Ocean," appearing on various U. S. Hydrographic Office Pilot Charts, including that of the North Pacific Ocean, September, 1923, and of the South Atlantic Ocean, for the quarter, September, October, November, 1928.