NATIONAL HURRICANE CENTER ANNUAL SUMMARY

2015 EASTERN NORTH PACIFIC HURRICANE SEASON

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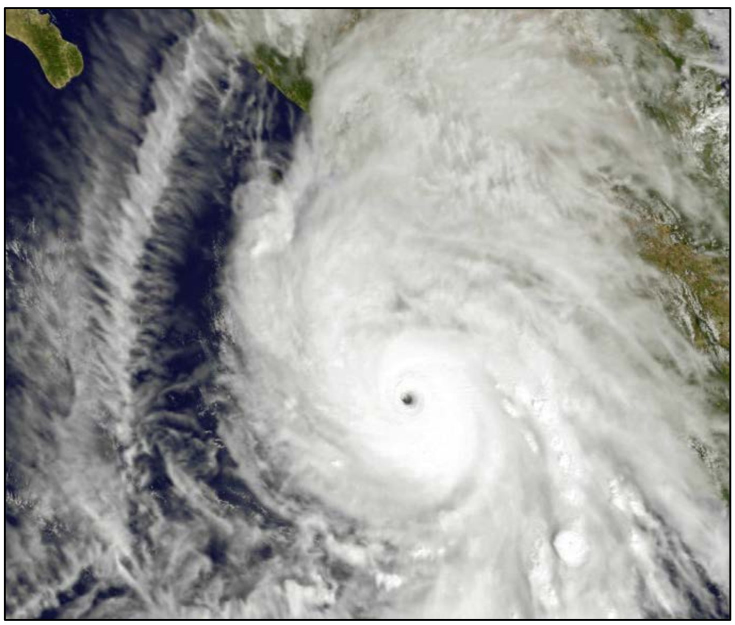

NOAA GOES-West Visible satellite image at at 17:45 UTC 23 October shows the pinhole eye of Hurricane Patricia moving towards southwestern Mexico.

ABSTRACT

The 2015 eastern North Pacific hurricane season was very active with 18 named storms and 13 hurricanes, of which 9 reached major hurricane strength (category 3 or higher on the Saffir-Simpson Hurricane Wind Scale). The genesis of most of the tropical cyclones was associated with tropical waves that moved westward from the Atlantic to the eastern North Pacific basin, where the ocean was anomalously warm and low wind shear prevailed.

Mexico was affected by a few tropical cyclones during the 2015 season. The most significant effects were from Hurricane Patricia, which is now the strongest hurricane on record in the eastern North Pacific. Patricia, however, weakened to category 4 before landfall near Playa Cuixmala, about 50 miles west-northwest of Manzanillo. Moisture from several tropical cyclones caused locally heavy rainfall over portions of northern Mexico and the southwestern United States.

OVERVIEW

The 2015 eastern North Pacific hurricane season was very active. Of the 18 cyclones that reached tropical storm strength, 13 became hurricanes and 9 became major hurricanes (category 3 or higher on the Saffir-Simpson Hurricane Wind Scale) within the basin. The number of major hurricanes observed in 2015 was the highest since reliable records began in 1971. For comparison, the 1981-2010 seasonal averages are 15 tropical storms, 8 hurricanes and 4 major hurricanes. The Accumulated Cyclone Energy (ACE), which measures the combined strength and duration of tropical storms and hurricanes, was about 63 percent higher than the 1981-2010 median value, and the highest observed in the basin since 1993. There were three unnamed tropical depressions, and a fourth that formed within the basin and became a tropical storm (Ela) in the central North Pacific.

The genesis of most of the tropical cyclones was associated with tropical waves that moved westward from the Atlantic to the eastern North Pacific basin. While strong westerly shear in the eastern part of the of the eastern North Pacific prevented most of these waves from developing there, the western part of the basin had much lower shear than average and the ocean was anomalously warm. A large area of an upper-level difluence and rising motion persisted during most of the active portion of the 2015 season (Fig. 1). These very favorable conditions for genesis and intensification are usually present in the basin during strong El Nino events, although the activity was shifted even farther west than is typical.

Most of the cylones intensified and moved away from Mexico. Despite the above-average season, record-breaking Patricia was the only hurricane to make landfall in Mexico during 2015. Patricia, which was the strongest hurricane on record in the eastern North Pacific basin, weakened to category 4 strength before it made landfall near Playa Cuixmala, about 50 miles west-northwest of Manzanillo. Moisture from several tropical cyclones spread northward causing locally heavy rainfall over portions of northern Mexico and the southwestern United States during the season. Table 1 lists the tropical cyclones of the 2015 season, and the tracks of the season's tropical storms and hurricanes are shown in Figures 2a and 2b.

The following section summarizes those tropical cyclones which affected land. More detailed information on the tropical cyclones of 2015 can be found at http://www.nhc.noaa.gov/2015epac.shtml .

SELECTED STORM SUMMARIES

Hurricane Blanca

Blanca appears to have originated from a tropical wave that crossed Central America on 26 May. Over the next few days, the wave moved slowly westward to the south of Central America and Mexico with limited associated shower activity until 30 May, when deep convection increased and became consolidated a few hundred miles south of Acapulco, Mexico. This development trend continued, and by 1200 UTC 31 May the cloud pattern became sufficiently well organized and a tropical depression formed about 320 n mi south-southwest of Acapulco.

The cyclone moved west-northwestward to northwestward, and was affected by strong northwesterly vertical shear associated with the outflow of Hurricane Andres to its west. The vertical shear began to relax on 1 June, allowing the system to strengthen into a tropical storm. In weakening steering currents, Blanca drifted erratically southward. Vertical shear continued to lessen and the cyclone became a hurricane by 1800 UTC 2 June, and a major hurricane with a pinhole eye around 1200 UTC 3 June.

Blanca reached its peak intensity of 125 kt at 1800 UTC 3 June, while centered about 410 n mi south of Manzanillo, Mexico. After that time, rapid weakening occurred, likely due to the upwelling of cooler waters beneath the slow-moving hurricane, as well as an eyewall replacement cycle, and by 1200 UTC 5 June, Blanca had weakened to an intensity of 80 kt. Meanwhile, a mid-level ridge that had been blocking the movement of the cyclone shifted eastward, and Blanca began moving toward the northwest at about 10 kt, allowing the cyclone to move away from its cold wake and re-intensify. Aided by the completion of the eyewall replacement cycle, Blanca reached a secondary peak intensity of 115 kt around 1200 UTC 6 June. Later that day, however, the hurricane moved over cooler waters, and a weakening trend began.

Early on 7 June, Blanca turned toward the north-northwest, and its center passed a short distance to the east and northeast of Socorro Island. With steering provided by a mid-level high over northern Mexico and a trough extending southwestward from the western United States, Blanca continued moving north-northwestward while weakening over progressively cooler waters. Blanca became a tropical storm around 1800 UTC 7 June, and its maximum winds had diminished to near 40 kt by the time it made landfall on the west coast of Baja California Sur shortly before 1200 UTC 8 June. Later that day, the center of the cyclone moved briefly over water to the west of Baja California Sur before and made its final landfall on the west coast of that state, as a tropical depression, late on 8 June. Blanca degenerated into a remnant low over the central Baja California peninsula early on 9 June, and dissipated shortly thereafter.

An automated weather station on Socorro Island reported sustained winds of 300° / 64 kt with a gust to 88 kt, and a minimum pressure of 977.3 mb at 0330 UTC 7 June while the center of Blanca passed about 25 n mi to the northeast, shortly after which the station ceased to function. Cabo San Lucas International Airport reported sustained winds of 40 kt with a gust to 43 kt at 1843 and 2103 UTC, respectively, on 7 June. There were no ship reports of winds of tropical storm force associated with Blanca.

Moisture associated with Blanca’s remnants produced mostly light rains over portions of the southwestern United States. Rainfall totals were generally less than an inch, with higher amounts at some of the more elevated locales.

Blanca made its landfalls in sparsely settled areas of Baja California Sur. There were no reports of damage or casualties associated with this tropical cyclone.

Hurricane Carlos

A prominent eastward-moving Kelvin wave crossed the Pacific Ocean in early June, and the interaction of this feature with a few westward-moving African easterly waves resulted in the formation of a large cyclonic gyre with a substantial amount of disorganized deep convection a few hundred miles south of southeastern Mexico on 8-9 June. On 10 June, the convection became more organized around a well-defined center, and a tropical depression formed around 1800 UTC on that day about 250 n mi south-southwest of Puerto Escondido, Mexico.

The tropical cyclone moved toward the west-northwest to the south of a deep-layer subtropical ridge, affected by 15 kt of 850-200 mb northeasterly wind shear. Under the influence of this moderate shear, warm sea surface temperatures, and a moist, unstable atmosphere, the system gradually intensified from 10-12 June. It reached tropical storm intensity around 1200 UTC 11 June, while located about 200 n mi south of Acapulco, Mexico. From 12-14 June, a mid-level trough over the Gulf of Mexico weakened the ridge and associated steering flow, which caused Carlos to meander just offshore of southern Mexico. After pausing in development on 12 June at an intensity of 50 kt, Carlos quickly intensified, becoming a hurricane with a well-developed eye around 1200 UTC 13 June. At that time, it was located about 125 n mi south of Acapulco.

A mid to upper-level ridge redeveloped north of Carlos on 14 June, helping to move the hurricane on a track toward the west-northwest to northwest during the following couple of days, parallel to the southern coast of Mexico. On late 14 and early 15 June, the convective structure of Carlos deteriorated, perhaps due to upwelled cool water induced by the meandering motion of the tropical cyclone. Carlos weakened to a tropical storm around 0000 UTC 15 June about 65 n mi west-southwest of Acapulco. The cyclone moved away from the upwelled waters late on 14 June and reintensified to a hurricane around 1800 UTC 15 June. Carlos attained a peak intensity of 80 kt around 1800 UTC 16 June, while centered about 90 n mi south of Manzanillo, Mexico. During this period of intensification, the hurricane's size diminished appreciably, with a radius of maximum wind of only 5 n mi and tropical-storm-force winds extending out only 30-40 n mi from the center.

Only 6 h after the cyclone attained peak intensity, Carlos' surface center was dramatically separated from the deep convection and its mid- to upper-level circulation. Carlos rapidly decayed on 17 June before making landfall in Mexico, weakening from 80 kt at 1800 UTC 16 June to 45 kt at 0900 17 June, apparently due to the entrainment of dry and stable air into the inner core. After landfall, the decaying vortex accelerated northwestward just inland of the southwestern coast of Mexico on 17 and early 18 June. Carlos lost its deep convection around 1800 UTC 17 June, becoming a remnant low at that time. After 0000 UTC 18 June, the low dissipated in the vicinity of the Islas Marias, Mexico.

Wind observations from Mexico included a 27-kt sustained wind with a 37-kt gust at 1048 UTC 14 June at Acapulco (MMAA), a 37-kt gust at 1415 UTC 14 June at Isla Roqueta, and a 65-kt gust at 1140 UTC at Chamelucuixmala on 17 June. It is likely that other locations along the southern coast of Mexico experienced tropical storm conditions. Despite the very close approach of Carlos to Mexico as a hurricane, sustained hurricane-force winds likely did not reach the coast because of the very small wind field.

Carlos caused locally heavy rains over portions of southern and western Mexico from 11-19 June. The heaviest amounts were in the state of Oaxaca, where Union Hildago reported 11.97 inches and Chicapa reported 10.83 inches.

La Jornada, a Mexico City newspaper, reported that high surf generated by Carlos damaged a few dozen boats and sank several boats in Acapulco, while strong winds knocked down trees and billboards. According to the news site MiMorelia.com, large waves and heavy rain caused at least 5 million pesos (US $326,000) in damage to coastal structures near Lazaro Cardenas.

Hurricane Patricia

Patricia, the strongest hurricane on record in the eastern North Pacific, and also the strongest hurricane on record to affect Mexico, had a slow and complicated genesis involving the interaction of multiple weather systems. It began as an elongated area of low pressure that extended from the Yucatan Peninsula southward for several hundred miles into the eastern Pacific on 16 October. Deep convection associated with the large cyclonic gyre increased substantially on 17 October, possibly due to more favorable large-scale conditions. The deep convection became well organized, and an ASCAT pass around 0400 UTC 20 October suggested that a small, well-defined circulation had developed underneath the convection within a larger cyclonic envelope, and it is estimated that a tropical depression formed around 0600 UTC that day about 180 n mi south-southeast of Salina Cruz, Mexico.

The depression was located south of a mid-level ridge centered over the Gulf of Mexico that extended west-southwestward into the eastern Pacific. The steering provided by this feature caused the depression to drift west-southwestward while the cyclone gradually strengthened. By early on 21 October, however, Patricia encountered relatively drier and more stable lower- to middle-tropospheric air, and sea surface temperatures that were at least 2ºC lower than the surrounding region. Once Patricia moved outside of the unfavorable environment, a rapid increase in deep convection occurred over the low-level center, and a small central dense overcast (CDO) began to form. A NOAA Hurricane Hunter aircraft reached Patricia that afternoon and discovered it to already be a 50-kt tropical storm. A period of rapid intensification began, and Patricia strengthened into a hurricane shortly after 0000 UTC 22 October while centered about 200 n mi south of Acapulco, Mexico.

Over the next 24 h, Patricia's satellite presentation improved dramatically, as a large band with cloud-top temperatures of -80º to -90º C coilied cyclonically inward over the center, which evolved into an almost perfectly symmetrical CDO around a 10 n mi wide eye. A NOAA plane arrived at the end of this 24-h period around 1800 UTC 22 October, and indicated that Patricia had already reached major hurricane strength, with estimated surface winds of 115 kt and a minimum pressure of 957 mb. The rapid intensification phase continued into the night and by the time an Air Force Hurricane Hunter aircraft reached the cyclone around 0600 UTC, Patricia had intensified into an extremely powerful hurricane with maximum sustained winds of 180 kt and a minimum central pressure of around 879 mb. The satellite presentation continued to increase in organization over the next several hours after the plane left, and Patricia is estimated to have reached a peak intensity of 185 kt around 1200 UTC 23 October while centered about 130 n mi southwest of Manzanillo, Mexico. This intensity makes Patricia the strongest hurricane on record in the eastern North Pacific; it should be noted, however, that records for the most intense eastern North Pacific hurricanes are particularly uncertain prior to 1988.

Patricia reached the western periphery of the mid-level ridge centered over the Gulf of Mexico and eventually turned northward toward the coast of Mexico. By the time the last reconnaissance mission reached Patricia around 1800 UTC 23 October, the hurricane had turned north-northeastward with some increase in forward speed, in response to a shortwave trough moving across the Baja California peninsula and northwestern Mexico. The aircraft found surface winds still near 180 kt on its first pass through the storm in the southeastern quadrant, but a final pass by the plane around 2030 UTC indicated that a rapid filling of the cyclone had begun. In fact, the peak flight-level winds had decreased nearly 50 kt in the same quadrant traversed earlier, while the central pressure had risen 24 mb in the 3 h since the first fix.

Patricia continued to rapidly weaken during the next couple of hours before landfall, and is estimated to have reached the southwestern coast of Mexico in the state of Jalisco, near Playa Cuixmala, around 2300 UTC 23 October with an intensity of 130 kt and a minimum pressure of around 932 mb. The hurricane continued to weaken rapidly during the next several hours while it moved over the high terrain of the Sierra Madre mountains, and Patricia fell below hurricane strength before passing well to the west of Guadalajara around 0300 UTC 24 October. When the mid-level center raced northeastward and separated from the low-level center overnight, Patricia weakened to a tropical depression. The cyclone dissipated later that morning over central Mexico.

Operationally, Patricia was assessed to have been of category 5 intensity with a landfall pressure of 920 mb, but a post-analysis of additional data obtained later suggests that the hurricane had weakened more rapidly than estimated in real time. A minimum pressure of 934.2 mb was observed around 2300 UTC by an automated weather station at Playa Cuixmala, located on the coast near Emiliano Zapata. Although the wind data from this site failed near landfall, a temperature spike to 28˚ C was recorded, suggesting that the eye passed close to this location. A storm chaser in Emiliano Zapata, a couple of nautical miles inland from the landfall point, measured a minimum pressure of 937.8 mb on the eastern edge of the eye at 2313 UTC with simultaneous winds of near tropical storm force. The automated weather station in Pista, located about a mile north-northeast of Playa Cuixmala, measured a station pressure of 939.4 mb at an elevation of 15 m, which converts to a sea level pressure of 941.0 mb. The wind data for this site indicate that the station never experienced a calm, and thus the winds at the time of the minimum pressure are unknown. A minimum central pressure of 932 mb at landfall is inferred from these data, with the uncertainty of this value likely on the order of 2-3 mb. The 932 mb analyzed landfall pressure is the lowest central pressure for a landfalling Pacific hurricane in Mexico in the historical database.

Patricia is the strongest hurricane on record to affect Mexico in the historical data base extending back to 1949, eclipsing the October 1959 Manzanillo hurricane (recently reassessed to have made landfall at an intensity of 120 kt - see recent discussion at http://hurricanes.gov) and Hurricane Madeline in 1976. Because of the sparse nature of station observations over Mexico, however, the reliable record for extreme landfalling Mexican hurricanes is also tied to the availability and interpretation of satellite imagery of these systems, and is thought to be reliable only back to 1988.

Heavy rains occurred in association with Patricia, especially over or near elevated terrain. In general, two to five inches of rain occurred at sites at lower elevation, with amounts not overly heavy due to the storm's fast forward speed. However, rainfall accumulations of about 8 to 13 inches occurred over mountainous terrain, with Nevado Colima in Jalisco reporting a storm total rainfall of 12.50 inches.

Press reports indicate that there were two direct deaths attributed to Patricia. Two women, one from Argentina and the other from Coahuila, Mexico, were crushed when a tree fell on them at a campsite in the Tapalpa forest in Jalisco. Apparently, the camping party of which they were a part was unaware of the hurricane. There were four indirect deaths associated with Patricia, when four passengers were killed in an automobile accident on the Colima-Guadalajara highway during heavy rains and strong winds.

Patricia battered a sparsely populated and rural area of the southwestern coast of Mexico in Jalisco, nearly midway between Manzanillo and Puerto Vallarta. A joint survey conducted by CONAGUA and the United States National Weather Service after the storm indicated that Patricia produced a narrow swath of severe damage along and just inland from the coast near where the hurricane made landfall. The villages of Emiliano Zapata and Chamela sustained the worst damage, according to press reports and eyewitness accounts. Strong winds tore roofs off of homes and businesses, uprooted, snapped and defoliated nearly all trees, and left the hillsides stripped of vegetation. Concrete power poles and transmission lines were also toppled, communication towers were crumpled, and most structures in these small towns were tremendously damaged or destroyed. Overall, more than 10,000 homes were damaged or destroyed by Patricia, with the majority of these in Jalisco. The damage to the agricultural sector was also considerable-- about 100,000 acres of farmland were severely affected, with the primary losses to the papaya, banana, and plantain crops.

Large swells associated with Patricia caused significant coastal flooding for several days that resulted in beach erosion and damage to some structures in the Mexican states from Jalisco to Guerrero.

According to media reports, the preliminary damage from Patricia is estimated to be 5.4 billion Mexican pesos (~US 325 million).

FORECAST VERIFICATION

The 2015 east Pacific hurricane season had above-average activity, with 362 official forecasts issued. The mean NHC official track forecast errors in the east Pacific basin were near average from 12 to 36 h, but higher than the 5-yr mean from 48 to 120 h. The official track forecasts (OFCL) were highly skillful and performed close to or better than the best-performing models. The only model that occasionally bested the official forecast was the multi-model consensus TVCE. The best-performing individual dynamical models, GFSI, EMXI, and HWFI, all had lower skill than the official forecasts.

Mean official intensity errors for the eastern north Pacific basin in 2015 were higher than the 5-yr means from 12 to 48 h, and were close to the 5-yr mean from 72 to 120 h. Decay-SHIFOR errors in 2015 were higher than their 5-yr means at all forecast time periods, indicating the storms were more difficult than average to forecast. Similar to the track forecasts, the NHC intensity forecasts were quite skillful and were only bested by FSSE at 24 and 36 h. Among the guidance, FSSE was the best performer in the short term and IVCN was the best aid from 72 to 120 h.

Table 1. 2015 eastern North Pacific hurricane season statistics.

Storm Name	Class[a]	Dates[b]	Max. Winds (kt)	Min. Pressure (mb)	Deaths	U.S. Damage ($million)
Andres	MH	May 28 –June 4	125	937		
Blanca	MH	May 31- June 9	125	936		
Carlos	H	June 10-17	80	978		0.3
Ela	TS	July 8-10	40 [c]	1002 [c]		
Dolores	MH	July 11-18	115	946		
Enrique	TS	July 12-18	45	1000		
Felicia	TS	July 23-24	35	1004		
Guillermo	H	July 29- Aug 7	95	967		
Hilda	MH	August 6-13	120 [c]	946 [c]		
Ignacio	MH	August 25- September 5	125 [c]	942 [c]		
Jimena	MH	August 26–September 9	135	932		
Kevin	TS	August 31- September 5	50	998		
Linda	MH	September 5-10	110	950		
Marty	H	September 26-30	70	987		
Nora	TS	October 9-15	60 [c]	993 [c]		
Olaf	MH	October 15-27	130	938		
Patricia	MH	October 20-24	185	872	2	325
Rick	TS	November 18-22	35	1002		
Sandra	MH	November 23-28	130	934		

[a] Tropical depression (TD), maximum sustained winds 33 kt or less; tropical storm (TS), winds 34-63 kt; hurricane (H), winds 64-95 kt; major hurricane (MH), winds 96 kt or higher.

[b] Dates begin at 0000 UTC and include all tropical and subtropical cyclone stages; non-tropical stages are excluded.

[c] Peak intensity and minimum pressure was reached outside the eastern North Pacific hurricane basin.

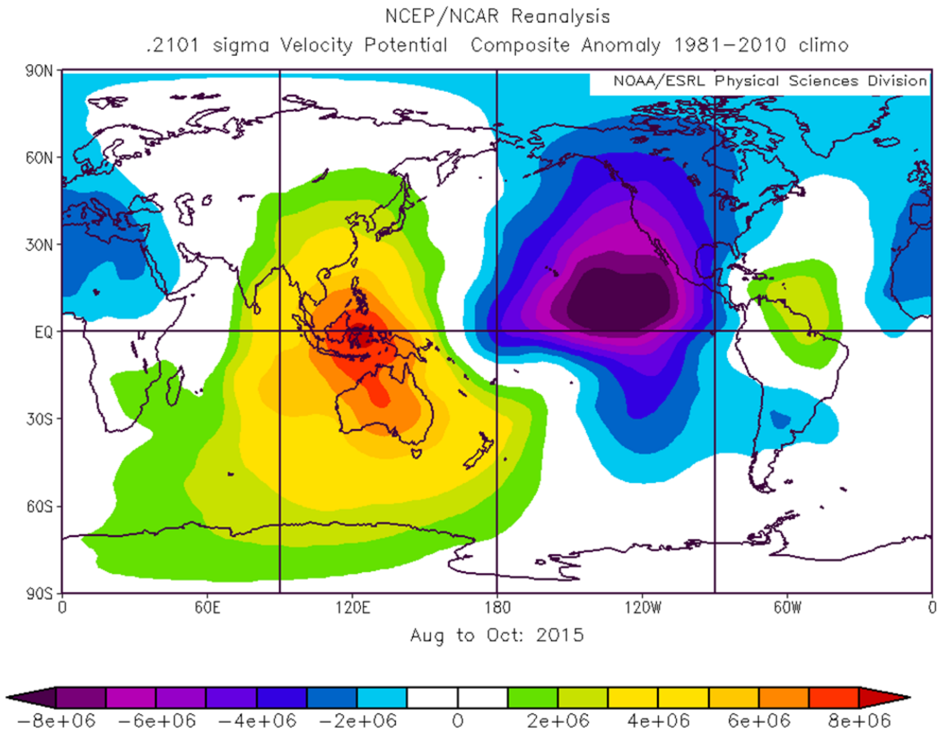

Figure 1. 200 mb Velocity Potential anomaly from August to October 2015. Blue is related to anomalous upper-level divergence or rising motion, and red is linked to anomalous upper-level convergence or sinking air. Anomaly computed relative to 1981-2010 climo from NCEP/NCAR reanalysis.

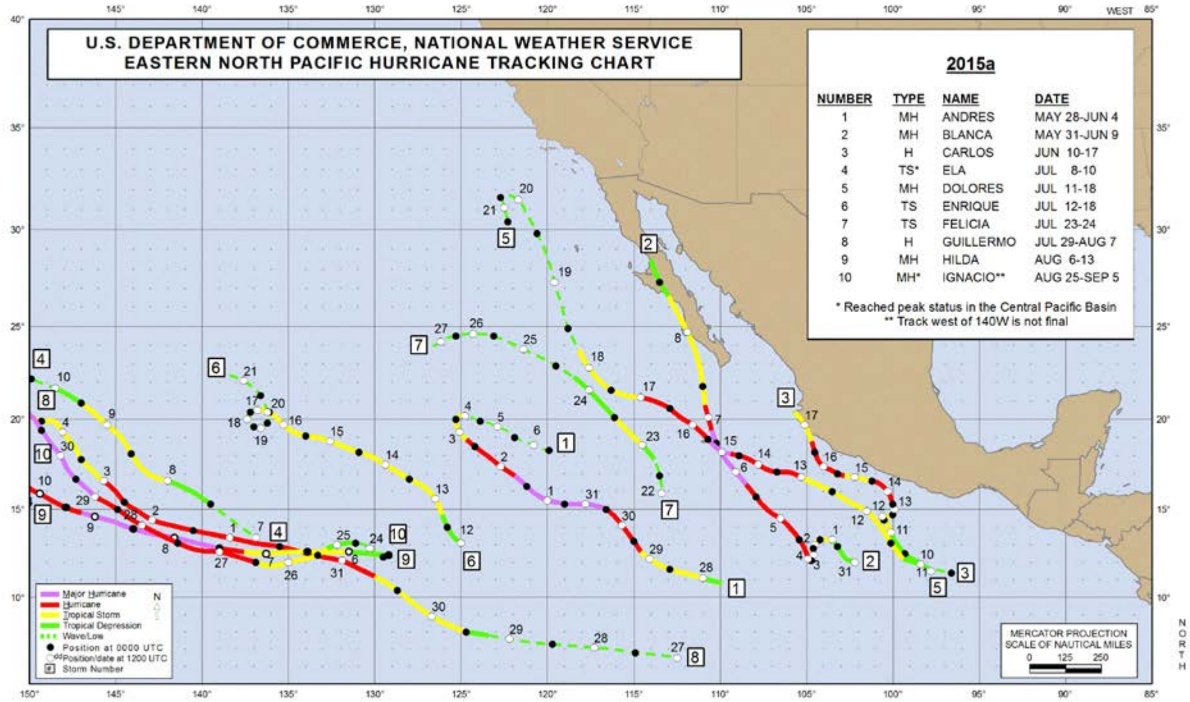

Figure 2a: Tracks of the tropical storms and hurricanes of the 2015 eastern North Pacific hurricane season.

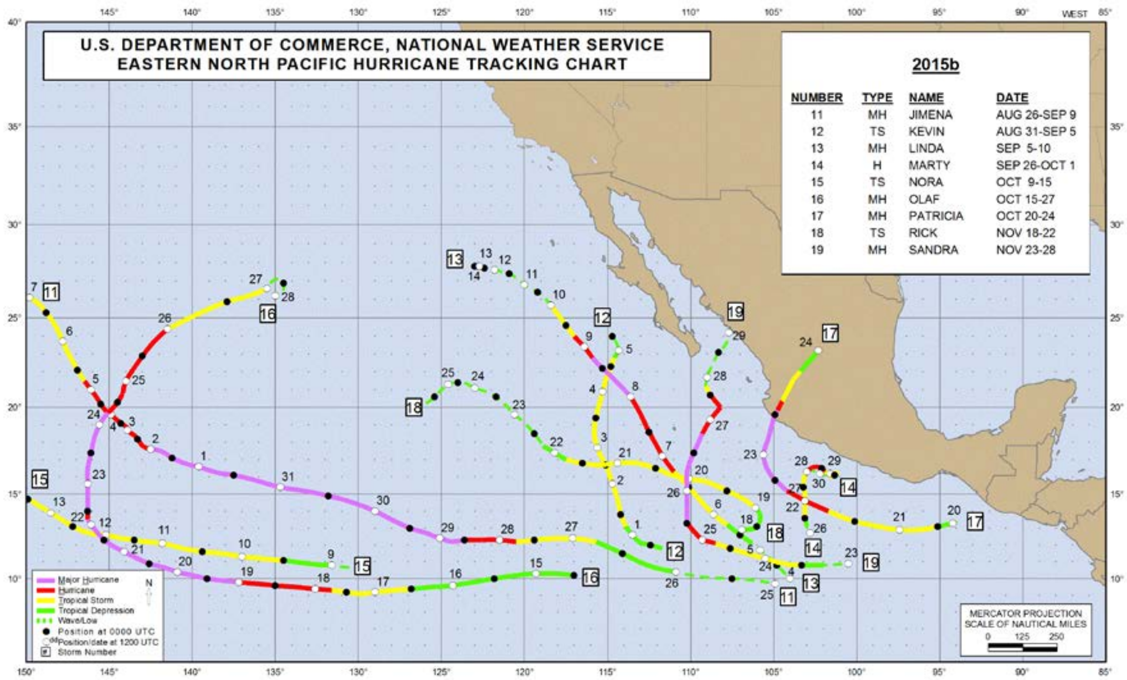

Figure 2b: Tracks of the tropical storms and hurricanes of the 2015 eastern North Pacific hurricane season.