ANNUAL SUMMARIES

Eastern North Pacific Hurricane Season of 2000

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ABSTRACT

There were 11 tropical storms, 6 hurricanes, and 2 tropical depressions during the 2000 eastern North Pacific hurricane season. Two tropical storms made landfall in Mexico.

1. Introduction

There were 11 tropical storms and 6 hurricanes in the eastern Pacific basin in the year 2000, totaling 17 named tropical cyclones. This is two more than the 1966–99 average of 15 named tropical cyclones.[1] In contrast, the total of six hurricanes is three less than the long-term average of nine. There were also two tropical depressions that did not reach tropical storm strength. The named tropical cyclones are listed in Table 1, along with their dates, maximum 1-min surface wind speed, minimum sea level pressure, and directly attributable deaths. Figure 1 is a map showing the best track positions of this year's named storms along with an indication of depression, storm, or hurricane stage.

Tropical Storms Emilia, John, and Kristy originated from disturbances in the intertropical convergence zone (ITCZ). All of the other tropical cyclones were at least partly initiated by tropical waves that moved westward from the Atlantic basin.

A crew of 18 died at sea when a freighter was lost in Hurricane Carlotta. No other deaths are attributed to this year's tropical cyclones. Tropical Storms Norman and Rosa moved onshore along the coast of Mexico and spread rainfall inland. Tropical Storms Ileana and Miriam threatened Mexico and required the issuance of warnings, but neither affected land.

The individual summaries in the next section are based on the National Hurricane Center's poststorm meteorological analyses. After each cyclone has ended, a ''best track'' is determined using all available data. The best track is a table of 6-hourly estimates of the cyclone's center position, maximum 1-min wind speed (10 m above the surface), and minimum sea level pressure.[2] With the exception of a few aerial reconnaissance flights, all of this season's best track data were derived from satellite data and occasional land and ship reports.

The method for estimating the maximum 1-min wind speed from satellite imagery is the Dvorak technique (Dvorak 1984), which uses subjective and objective cloud pattern recognition applied to infrared and visible geostationary satellite imagery. Microwave imagery from polar-orbiting satellites (e.g., Tsai et al. 2000) is a source of information about the structure of the surface wind field in a tropical cyclone.

2. Descriptions of individual tropical storms and hurricanes

a. Hurricane Aletta, 22–28 May

Aletta's precursor was a tropical wave that crossed Central America on 18–19 May and enhanced cloudiness a few hundred nautical miles south of the Gulf of Tehuantepec on 20 May. By 22 May, convective clouds became sufficiently organized and concentrated near a low cloud rotation to warrant the designation of tropical depression about 210 n mi south of Acapulco, Mexico. The depression moved west-northwest to westward from 22 to 25 May at a forward speed slowing from about 10 to 7 kt. By 23 May, a curved band of deep convection

[1] The 1966–98 average is 15.6, which rounds up to 16; while the 1966–99 average is 15.4, which rounds down to 15.

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[2] Best track tables for individual storms, as well as complete tropical cyclone reports, are available from the Tropical Prediction Center's Internet site at http://www.nhc.noaa.gov/2000epac.html.

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TABLE 1. Eastern North Pacific basin hurricane season statistics for 2000.

No.	Name	Class*	Dates**	Maximum 1-min wind (kt)	Minimum sea level pressure (mb)	Direct deaths
1	Aletta	H	22–28 May	90	970	
2	Bud	T	13–17 Jun	45	994	
3	Carlotta	H	18–25 Jun	135	932	18
4	Daniel	H	23 Jul–5 Aug	110	954	
5	Emilia	T	26–30 Jul	55	994	
6	Fabio	T	3–8 Aug	45	1000	
7	Gilma	H	5–11 Aug	70	984	
8	Hector	H	10–16 Aug	70	983	
9	Ileana	T	13–17 Aug	60	991	
10	John	T	28 Aug–1 Sep	60	994	
11	Kristy	T	31 Aug–3 Sep	35	1004	
12	Lane	H	5–14 Sep	85	967	
13	Miriam	T	15–17 Sep	35	1004	
14	Norman	T	20–22 Sep	45	998	
15	Olivia	T	2–10 Oct	55	994	
16	Paul	T	25–29 Oct	40	1003	
17	Rosa	T	3–8 Nov	55	993	

* T = tropical storm, wind speed 34–63 kt; H = hurricane, wind speed 64 kt or higher.
** Dates begin at 0000 UTC and include tropical depression stage (wind speed less than 34 kt).

developed around the center and the system became Tropical Storm Aletta about 190 n mi south of Zihuatanejo.

Aletta slowly intensified on 23 May, in an environment of modest easterly vertical wind shear. However, early on 24 May, the shear diminished and the rate of intensification increased. Aletta reached hurricane strength by 1200 UTC and 6 h later reached its peak intensity of 90 kt, coincident with the appearance of a well-defined closed eyewall on microwave imagery. By the next day, easterly shear returned and the hurricane weakened. At this time, a broad midtropospheric trough approached Baja California and eroded the ridge located north of Aletta, creating very weak steering currents and resulting in a slow meandering motion for the remainder of the storm's existence. The combination of vertical shear and cooling ocean waters from upwelling under the quasi-stationary cyclone promoted continued weakening. Aletta dissipated on 28 May, about 400 n mi south-southeast of the southern tip of Baja California. A remnant swirl of low clouds and intermittent showers lingered in the area for several days thereafter.

Aletta's 90-kt intensity makes it the second-strongest May hurricane on record in the eastern Pacific basin (after Hurricane Adolph of 1992, 95 kt).

b. Tropical Storm Bud, 13–17 June

A poorly organized tropical wave moved into the eastern Pacific Ocean on 6 June. On 11 June, a broad low pressure area formed in the vicinity of the wave a few hundred nautical miles southwest of Acapulco, Mexico. Further development was slow and the overall circulation contained multiple centers for most of 11–12 June. The system became a tropical depression early on 13 June about 370 n mi south-southwest of Manzanillo, Mexico, when one center became dominant. Moving northwestward, the depression became Tropical Storm Bud 6 h later.

Bud reached a peak intensity of 45 kt early on 14 June while turning north-northwestward. This peak intensity was maintained for 12 h, followed by slow weakening. Bud passed just northeast of Socorro Island on 15 June as a tropical storm. It then weakened to a depression on 16 June while slowing to an erratic drift about 70 n mi north of Socorro Island. Bud lost all deep convection on 17 June about 90 n mi north-northeast of Socorro Island and a remnant broad low persisted until 19 June.

The National Aeronautics and Space Administration's Quick Scatterometer satellite (*QuikSCAT*) made an overpass near midday on 13 June, and microwave data indicated that the circulation had become well defined and that winds were near or at tropical storm strength. Another overpass about 24 hours later showed that winds had decreased to less than 25 kt. The ship *Roger Revelle* reported 40-kt winds and a pressure of 1001.0 mb at 0000 UTC 14 June. Socorro Island reported a pressure of 997.3 mb at 1500 UTC 15 June, but did not report tropical storm force winds.

c. Hurricane Carlotta, 18–25 June

Carlotta was a category 4 hurricane on the Saffir–Simpson scale (Simpson 1974) and had a long offshore track parallel to the coast of Mexico. Its maximum winds of 135 kt make Carlotta the second-strongest June hurricane (to Ava in 1973) in the east Pacific basin since 1966. Although the hurricane did not make landfall, it was responsible for 18 deaths when the Lithuanian

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(a)

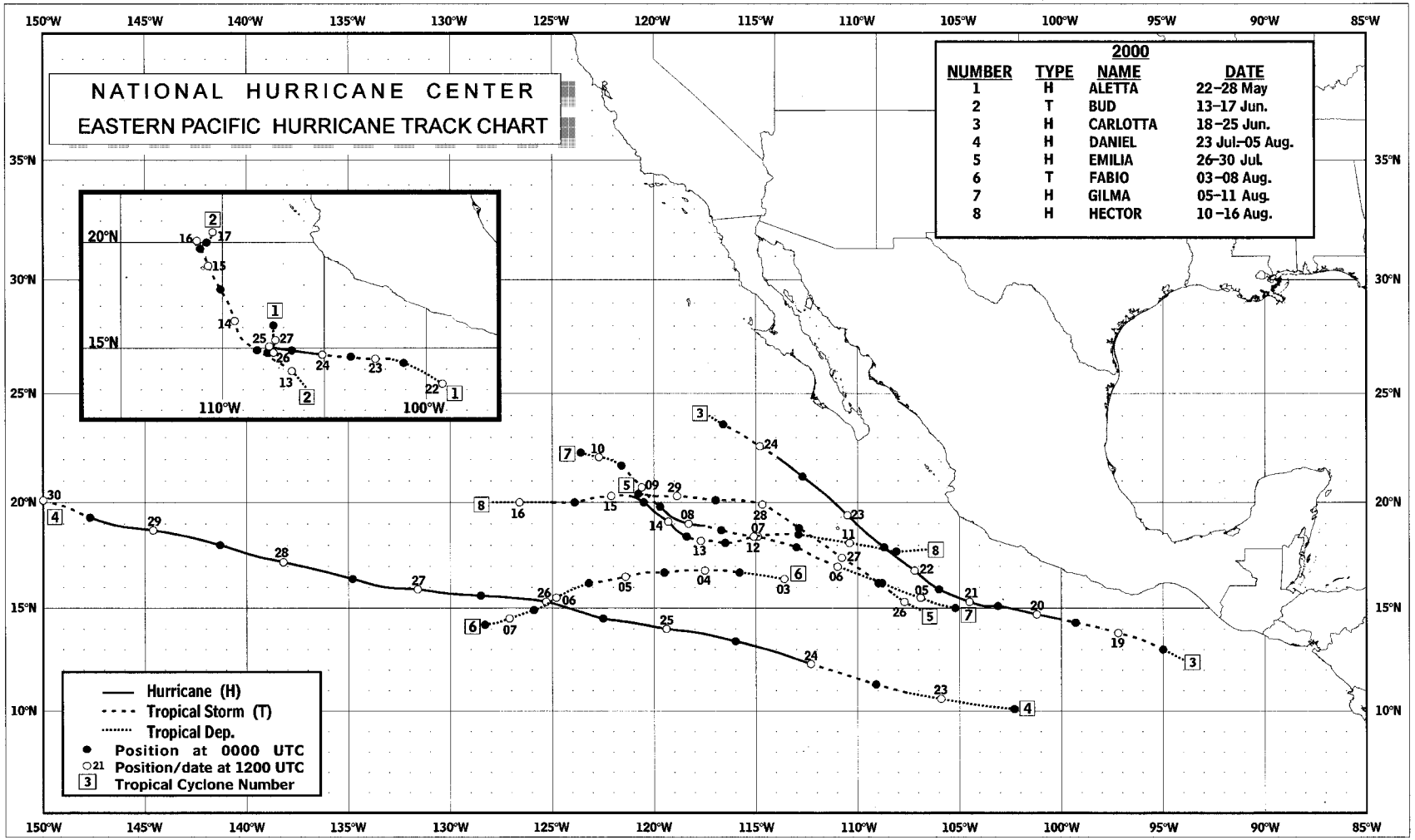

FIG. 1. Eastern North Pacific basin track chart for 2000: (a) storm numbers 1–8, (b) storm numbers 9–17.

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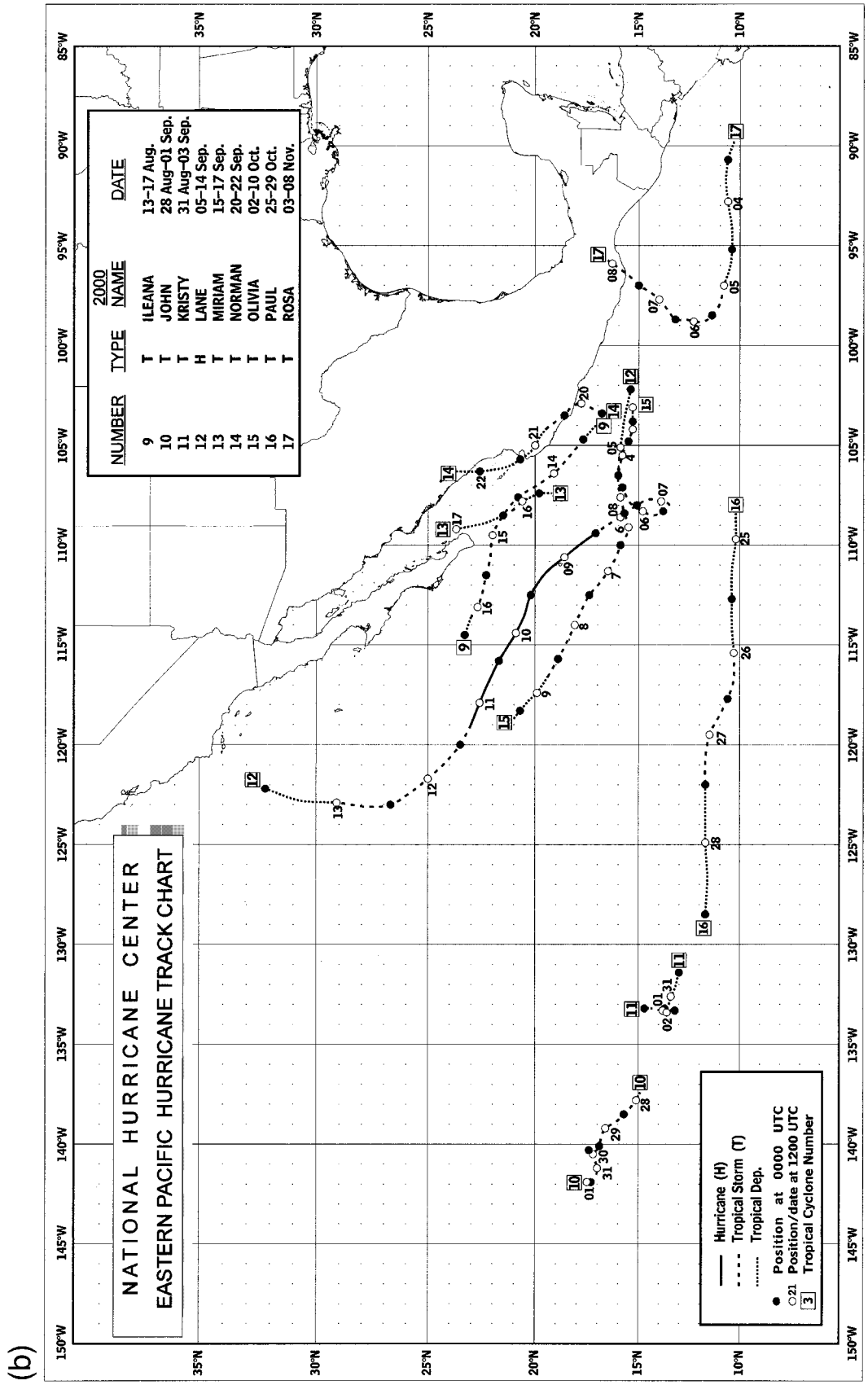

FIG. 1. (*Continued*)

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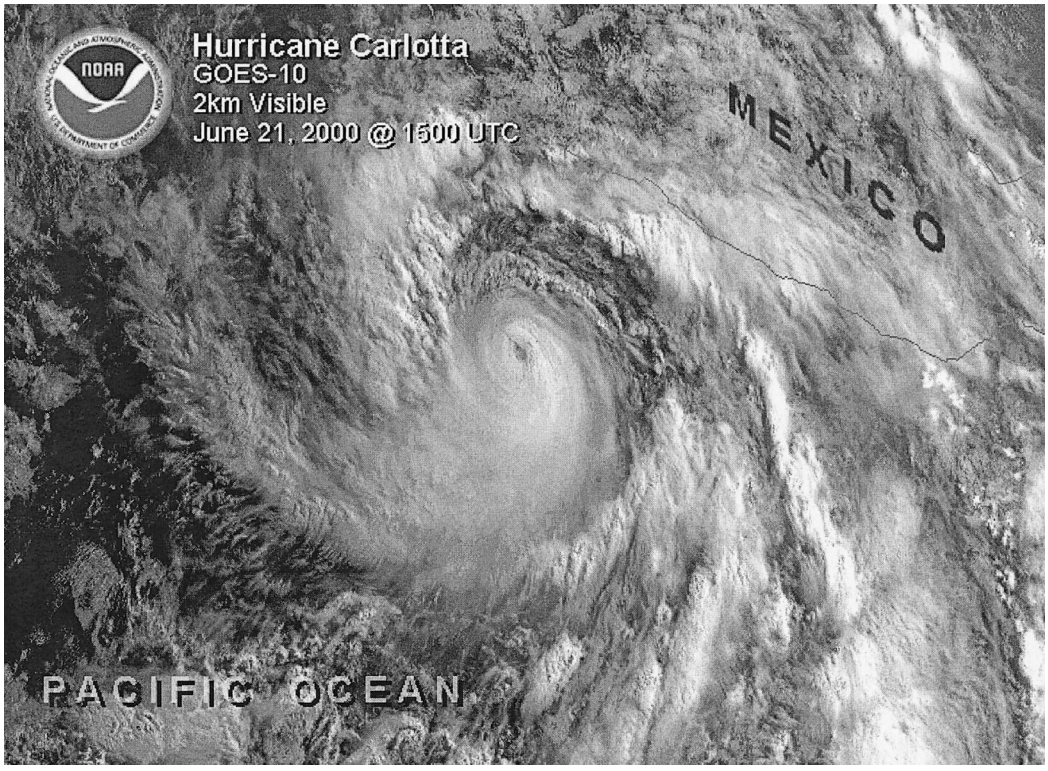

FIG. 2. *GOES-10* visible image of Hurricane Carlotta at 1500 UTC 21 Jun 2000, near the time of 135-kt maximum intensity. (Courtesy of National Climatic Data Center, Asheville, NC.)

freighter *MV Linkuva* was caught in the hurricane and lost at sea.

A tropical wave that emerged from the coast of Africa on 3 June appears to be the precursor disturbance of Hurricane Carlotta. Surface analyses show a weak low beginning late on 16 June about 300 n mi south of the coast of San Salvador. Convection was broadly distributed and disorganized until 18 June, when a concentration of deep convection developed just south of the Gulf of Tehuantepec. Ship reports and satellite scatterometer data suggest that a tropical depression formed from this system on this date about 235 n mi southeast of Puerto Angel, Mexico.

The depression strengthened as it moved to the west-northwest at about 11 kt, becoming Tropical Storm Carlotta on 19 June, when centered about 180 n mi south-southeast of Puerto Angel, Mexico. As Carlotta edged toward the coast, it came under the influence of a mid-tropospheric ridge to its north and turned slightly to the left; its center's closest approach to the Mexican coast was about 120 n mi near 1200 UTC on 19 June. Late that day, a ragged banding eye appeared on satellite imagery. This was followed by very deep convection around the developing eye. Carlotta reached hurricane status early on 20 June, when it was about 135 n mi south of Acapulco. The pace of intensification increased, and 24 hours later, Carlotta reached its peak intensity of 135 kt. Figure 2 shows a visible satellite image of Carlotta near the time of its peak intensity. Although there was impressive upper-level outflow over Carlotta's southern semicircle, outflow was limited to the north during most of the intensification period.

Shortly after reaching peak intensity, Carlotta turned from westward to west-northwestward at a reduced speed of 7–8 kt. By 22 June, Carlotta weakened to about 100 kt, but this trend temporarily halted. There were two oscillations in the convective intensity and eye definition. Weakening resumed on 23 June. Over the next two days, Carlotta moved toward the northwest between 10 and 14 kt over cooler waters and fell below hurricane strength on 24 June, about 225 n mi west-southwest of Cabo San Lucas. Convection continued to diminish and the system became a tropical depression on 25 June. Without deep convection, the tropical cyclone dissipated shortly thereafter about 415 n mi west of Cabo San Lucas. A swirl of low clouds persisted in this area for several days thereafter.

Flight-level and dropwindsonde observations were made from about 1900 to 2200 UTC on 20 June from a Hurricane Hunter flight of the 53d Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command. A comparison of aircraft and satellite-based intensity estimates shows that the satellite intensity estimates were larger by 15–20 kt. The Dvorak-based maximum wind estimate was about 105 kt, while the aircraft found peak 700-mb flight-level winds no higher than

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96 kt. A Global Positioning System (GPS) dropwindsonde at 2040 UTC in the northwest eyewall, where the maximum flight-level winds were located, reported a surface wind of 91 kt.

Dropsonde surface pressures indicated a deepening rate of about 3 mb h^{-1}. Dvorak estimates indicate that Carlotta continued to strengthen rapidly for another 9 h after the conclusion of the aircraft reconnaissance coverage. Conventional Dvorak estimates reached 140 kt (921 mb) at 0600 UTC on 21 June, and the University of Wisconsin objective Dvorak 12-h weighted average estimate peaked at this time with a value of 146 kt. For purposes of determining the best track intensity, it is assumed that the satellite high bias during the period of aircraft reconnaissance continued until the time of Carlotta's peak intensity and this intensity is estimated to be 135 kt at 0600 UTC on 21 June.

The Dvorak pressure–wind curve associates a pressure of 926 mb with winds of 135 kt. However, a comparison of reconnaissance winds and pressures suggests that the observed pressures in Carlotta were 5–10 mb higher than those predicted by the Dvorak pressure–wind curve. Therefore, the minimum pressure, which occurred shortly thereafter, is believed to be somewhat higher than 926 mb. The final value of 932 mb at 0600 UTC on 21 June was obtained by assuming a deepening rate of 5 mb h^{-1} subsequent to the best track estimate of 962 mb at 0000 UTC 21 June. This assumed deepening rate is close to the extreme short-term intensification rates observed in 1988's Hurricane Gilbert and 1995's Hurricane Opal, and as a result, the assigned 932-mb minimum pressure for Carlotta probably represents a lower bound on the true value.

No land stations reported sustained tropical storm force winds. Bahias De Huatulco reported a gust to 38 kt at 1300 UTC on 19 June.

According to media reports, the Lithuanian freighter *MV Linkuva,* along with its crew of 18, was lost when the ship was caught in the hurricane 220 n mi southwest of Acapulco late on 20 June, after an engine failure. The last contact with this ship occurred during the period of rapid intensification and just before Carlotta reached its peak intensity. The vessel was en route to Long Beach, California. There are no other reports of damage or casualties.

d. Hurricane Daniel, 23 July–5 August

Daniel reached its peak intensity of 110 kt in the eastern North Pacific Ocean basin, and later threatened Hawaii while weakening. Daniel passed just north of Hawaii and produced rough surf conditions there.

Daniel's origin is associated with a tropical wave that moved from Africa to the Atlantic on 8 July. The wave moved westward across the tropical Atlantic, the Caribbean, and Central America without distinction. It was not until 23 July that the wave's weather became well organized. It is estimated that a tropical depression formed on 23 July, 575 n mi south-southeast of Manzanillo, Mexico.

Daniel was steered west-northwestward across the eastern Pacific basin from 23 to 28 July, primarily by a subtropical ridge anchored to its north. Daniel gradually strengthened, to a tropical storm late on 23 July, to a hurricane on 24 July, and reached 110 kt on 25 July. The intensity fluctuated from 90 kt on 27 July to 105 kt on 28 July, while the hurricane moved across 140°W into the central Pacific basin.

Daniel weakened to a tropical storm on 30 July and then turned slightly toward the northwest, as it encountered a weakness in the subtropical ridge. The storm center moved parallel to and about 120 n mi north of the Hawaiian Island chain from 31 July to 1 August, and winds varied from 45 to 60 kt. Tropical storm force winds remained north of the islands. Daniel weakened to a depression on 3 August and finally dissipated on 5 August about 1000 n mi northwest of Hawaii.

There was Hurricane Hunter aircraft reconnaissance into Daniel from 30 July to 1 August. The highest flight-level wind speed reported from the aircraft during this period was 86 kt at a flight level of 850 mb. All other flight-level wind speeds were below 60 kt.

There were reports of rough surf conditions on the big island of Hawaii and on Maui's east-facing coast.

e. Tropical Storm Emilia, 26–30 July

A tropical wave crossed Central America on 22 July. On 23 July, a cyclonically rotating area of showers was noted a few hundred miles southeast of the Gulf of Tehuantepec. There was little change for a few days as the system moved westward; then a tropical depression formed about 290 n mi south-southwest of Manzanillo, Mexico, early on 26 July. Later on 26 July, visible satellite images showed a banding convective cloud pattern and the depression strengthened into Tropical Storm Emilia.

A low- to midlevel ridge to the north steered Emilia on a course between northwestward and west-northwestward. On 27 July, the storm's cloud pattern became more tightly wound and microwave imagery suggested a formative eyewall. Emilia strengthened to its estimated maximum intensity of 55 kt at that time, while centered about 60 n mi southwest of Socorro Island. Just 6–12 h later, the storm moved over cooler sea surface temperatures and entrained drier air from a mid- to upper-level trough to its northwest. Deep convection diminished and there was slow weakening. Guided by lower-tropospheric steering flow, the cyclone turned westward, and weakened below storm strength on 29 July. Emilia dissipated soon thereafter, several hundred nautical miles west-southwest of Cabo San Lucas.

f. Tropical Storm Fabio, 3–8 August

A tropical wave moved into the Pacific on 26–27 July. Little development occurred in the west-northwestward-

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moving wave until 1 August, when the first signs of a low-level circulation and convective organization were seen to the south of Manzanillo, Mexico. The system continued to become better organized, and a tropical depression formed about 540 n mi west-southwest of Manzanillo on 3 August.

The depression initially moved west-northwestward at 13 kt. It then slowed and turned westward on 4 August while strengthening into a tropical storm. With easterly vertical shear present, Fabio reached a peak intensity of 45 kt later that day. The storm turned toward the west-southwest while weakening on 5 August, and this motion continued for the rest of the cyclone's life. Fabio weakened to a depression on 6 August and dissipated about 1170 n mi west-southwest of Cabo San Lucas, Mexico, on 8 August. The remnant swirl of low clouds persisted for several more days.

g. Hurricane Gilma, 5–11 August

A tropical wave moved into the eastern Pacific on 2 August. Early on 4 August, a cloud system center became briefly trackable about 300 n mi south of Zihuatanejo, Mexico. This center dissipated, but a second one consolidated late in the day and a tropical depression formed on 5 August about 250 n mi south of Manzanillo.

The tropical cyclone moved toward a generally northwest direction for its entire existence. It remained poorly organized for 36 h and did not have a very well-defined circulation center. By the morning of 5 August, the cloud pattern had become better organized and the cyclone became a tropical storm about 350 n mi south of Cabo San Lucas. Gilma gradually intensified over the next 2 days and became a hurricane early on 8 August about 500 n mi west-southwest of Cabo San Lucas. Gilma's peak intensity of 70 kt was reached a little later that day as water temperatures under the cyclone's center fell below about 26°C. A smooth decline in intensity ensued over the next 60 h, with the system weakening to a tropical depression on 10 August. The tropical cyclone dissipated by 11 August about 750 n mi west of Cabo San Lucas.

h. Hurricane Hector, 10–16 August

Hector formed southwest of Mexico, moved westward, and dissipated over colder water southwest of Baja California. The remnants of Hector passed over the Hawaiian Islands several days later, producing heavy rain over much of the island chain.

Hector developed from a tropical wave that moved across Mexico and emerged into the eastern Pacific Ocean on 9 August. Deep convection increased significantly when the wave moved off the coast and cloud-banding features began to develop on the morning of 10 August. It is estimated that a tropical depression formed later that day about 160 n mi southwest of Manzanillo, Mexico. Banding features became more distinct by late on 11 August, indicating that the depression had reached tropical storm status.

Hector slowly became more organized, except for its outflow which remained restricted in the northern semicircle. A strong ridge to its north steered the storm generally westward into a more favorable upper-level environment for strengthening. Gradually, a central dense overcast formed and a ''ragged eye'' appeared in visible satellite pictures. The storm became a hurricane early on 14 August and it is estimated that the hurricane peaked at 70 kt later that day. Hector rapidly weakened after it took a brief northwest track over much cooler water and less favorable upper-level winds. Most of the deep convection associated with Hector weakened by the afternoon of 15 August. Hector dissipated the next day and its remnants moved westward. On 20 August, the remnants interacted with an upper-trough to produce locally heavy rain and some thunderstorms over Hawaii.

i. Tropical Storm Ileana, 13–17 August

Ileana was a strong tropical storm that briefly threatened the southwest coast of mainland Mexico and the Baja California peninsula, before turning away from land and dissipating over open water.

Ileana originated from a tropical wave that moved over the eastern North Pacific Ocean on 12 August. By the next day, a tropical depression formed about 100 n mi south of Manzanillo, Mexico, and early on 14 August, the depression strengthened to Tropical Storm Ileana.

Ileana tracked northwestward, paralleling the west coast of Mexico, and reached a peak intensity of 60 kt early on 15 August, when it was located about 90 n mi southeast of Cabo San Lucas, Mexico. This peak intensity was maintained for 18 h, followed by slow weakening due to a combination of increasing vertical shear and cooler sea surface temperatures. Ileana made an abrupt turn to the west and passed just south and southwest of the southern tip of Baja California on 15 August as a tropical storm with 60-kt winds. Ileana weakened to a depression late on 16 August and dissipated by the next day. A westward-moving remnant of broad low-level circulation persisted as a swirl of low clouds until 20 August.

Large waves associated with the storm likely affected portions of the coast of Mexico; there were no reports of damage or casualties.

j. Tropical Storm John, 28 August–1 September

John originated as an area of cloudiness in the ITCZ that became concentrated about 1200 n mi southwest of the southern tip of Baja California on 25 August. A low-level cloud circulation developed late on 26 August, and a tropical depression formed early on 28 August about 1700 n mi west-southwest of Baja California.

The tropical cyclone's motion was slow and erratic,

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but generally toward the northwest for the 4 days of its existence. It strengthened from a depression to an estimated 55-kt tropical storm on 28 August, and reached its peak intensity of 60 kt on 30 August. Convection gradually dissipated as John weakened from strong vertical shear and John dissipated on 1 September about 750 n mi east-southeast of the Hawaiian Islands.

k. Tropical Storm Kristy, 31 August–3 September

Kristy's development is partly attributable to a tropical wave that moved off the coast of Africa on 12 August. The northern portion of this wave spawned Tropical Storm Chris east of the Leeward Islands on 17 August and the southern part of the wave continued westward into the Caribbean on 19 August. It crossed Central America on 22 August, and continuity of westward motion puts the wave at about 124°W on 28 August, in the same location as an area of disturbed weather. The next day, a low-cloud swirl was identifiable in the vicinity of 12°N, 128°W. By 30 August, the system crossed 130°W where there was an increase of deep convection just west of the center. Based on the development of deep convection close to the low-cloud center, it is estimated that a tropical depression formed at 0000 UTC 31 August. The system was centered about 1380 n mi west-southwest of Cabo San Lucas at that time.

The cyclone moved slowly west-northwestward for about a day, but steering currents soon collapsed and remained so during the short life of the tropical cyclone, resulting in little overall motion. The meandering depression remained in an environment of moderate easterly vertical shear, and this prevented significant strengthening. Early on 2 September, microwave imagery showed that the system became a little better organized, indicating that the cyclone became Tropical Storm Kristy. Deep convection near the center fluctuated in intensity for a while, but by later on 2 September, the low-level center became separated from the main area of convection, indicating that the system weakened back to a tropical depression. Soon, the low-level center became distorted and the cyclone dissipated on 3 September, not far from where it originated.

l. Hurricane Lane, 5–14 September

Lane was a large hurricane whose track included a loop. It passed directly over Socorro Island and maintained its intensity unusually far to the north.

A tropical wave moved across Central America and into the Pacific on 29 August. The first signs of an organized circulation appeared south of the Gulf of Tehuantepec on 1 September. It was not until 4 September that steady development began. The system became a tropical depression about 140 n mi south-southwest of Manzanillo, Mexico, early on 5 September and, moving westward, became Tropical Storm Lane later that day.

Over the next 3 days, Lane merged with a developing monsoon-type circulation. This resulted in the cyclone center moving in a loop that lasted from 6 to 8 September. After reaching a 50-kt intensity on 6 September, the storm temporarily weakened. Once the loop was finished, Lane strengthened to a hurricane and moved generally northwestward, passing over Socorro Island on 9 September. A 50–60 n mi wide eye developed and a peak intensity of 85 kt was estimated on 10 September. This coincided with a turn to the west-northwest that continued into 11 September. This took the cyclone over cooler water, and Lane weakened to a tropical storm late on 11 September.

A large deep-layer trough located off the U.S. west coast allowed the storm to turn northwestward on 12 September and northward the next day. Lane moved over 20°C water on 13 September, and it weakened to a depression. The cyclone dissipated about 250 n mi west of San Diego, California, on 14 September.

The eye of Lane passed directly over Socorro Island. While the maximum observed winds are not available, the island reported a minimum pressure of 973.7 mb at 1500 UTC 9 September. Although Lane otherwise remained well offshore, rainbands and gusty winds affected portions of the Mexican mainland and Baja California. Manzanillo reported 28-kt sustained winds on 8 September and San Jose del Cabo reported sustained winds of 30 kt with gusts to 40 kt on 9 September.

m. Tropical Storm Miriam, 15–17 September

Miriam was a minimal tropical storm that briefly threatened the southern Baja California peninsula of Mexico before weakening to a tropical depression.

The antecedent disturbance to Miriam was a weak tropical wave that emerged into the eastern North Pacific on 9 September. Westward progression of the wave slowed over the next several days while it moved into a broad area of low pressure south and southwest of the Gulf of Tehuantepec. It then began a more northwestward track. On 15 September, the system developed short banding features and by 1800 UTC that day, ship reports indicated a closed circulation had developed and that a tropical depression had formed about 250 n mi south-southeast of Cabo San Lucas, Mexico.

Over the next 24 hours, the depression moved to the north then north-northwest with only intermittent organized convection. The system became a tropical storm on 16 September, when it was about 175 n mi southeast of Cabo San Lucas, but soon weakened to a depression under southwesterly vertical shear. The depression continued to the north-northwest into the southern Gulf of California, where the circulation dissipated on 17 September, when it was about 60 n mi northeast of Cabo San Lucas. A tropical storm warning was issued by the government of Mexico for a portion of the southern Baja California peninsula, but Miriam weakened to a tropical depression before reaching the area.

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Although Dvorak satellite estimates support tropical storm strength for 24 h or longer, scatterometer data from *QuikSCAT* suggest that this interval was no longer than 12 h, and it is possible that Miriam never was a tropical storm.

n. Tropical Storm Norman, 20–22 September

Norman made landfall as a tropical storm over southwestern Mexico producing torrential rains.

The southern extension of a tropical wave that triggered Hurricane Gordon in the Gulf of Mexico continued moving westward over central America and Mexico from 14 to 16 September. The interaction of this wave with a large low-level cyclonic circulation located over the eastern Pacific produced a large area of disturbed weather. Initially, the shower activity was widely scattered and did not become concentrated until 18 September when the disturbance was located about 180 n mi south-southwest of Acapulco, Mexico. The cloud pattern gradually became organized and developed a circular mass of deep convection with a well-defined outflow. It is estimated that a tropical depression formed early on 20 September about 180 n mi south-southeast of Manzanillo.

The depression drifted northward and became a tropical storm later that day. Norman's peak intensity was 45 kt and the minimum pressure was 998 mb. The storm made landfall between Lazaro Cardenas and Colima soon thereafter. On 21 September, over land, Norman weakened to a depression.

The depression center moved slowly northwestward over the high terrain of southwestern Mexico while maintaining an area of very deep convection primarily within bands over water. On 22 September, the depression moved back over water just north of Puerto Vallarta and turned northward. The cyclone never recovered from its passage over the mountains and made its second landfall as a tropical depression in the vicinity of Mazatlan on the afternoon of 22 September. It then quickly dissipated over land.

Norman was upgraded to a tropical storm based on two ship reports: The *Imwanuma Maru* reported 38-kt winds and a pressure of 1001.5 mb at 1200 UTC on 20 September and the *Star Grip* reported 39 kt and 1003 mb pressure at 1300 UTC on the same day. Both ships were located just west of the circulation center.

Rainfall occurred over southwestern Mexico. The highest rainfall amounts reported from southwestern Mexico were 356 mm at Callejones, Colima, and 241 mm in La Villita, Michoacan.

Despite the heavy rains, no reports of deaths or damage were received. A tropical storm warning was issued for a portion of the coast of Mexico from Zihuatanejo to Manzanillo early on 20 September.

o. Tropical Storm Olivia, 2–10 October

Olivia formed off the southwest coast of mainland Mexico, and generally moved west-northwestward. After dissipating as a tropical cyclone, the remnant low-level circulation tracked northeastward across central Baja California, northwestern Mexico, and the southwestern United States.

Olivia originated from a tropical wave and first showed signs of a low-level circulation on 1 October some 150 n mi southwest of Acapulco, Mexico. The lack of development in the eastern Pacific prior to this time may have been due to the proximity of Hurricane Keith in the western Caribbean Sea. Keith's upper-level outflow created northeasterly vertical shear over the pre-Olivia wave. But the shear relaxed when Keith weakened over the Yucatan Peninsula, and, on 2 October, the wave developed into a tropical depression while centered about 250 n mi southeast of Manzanillo.

By 3 October, the depression strengthened into Tropical Storm Olivia, about 220 n mi south of Manzanillo. Olivia strengthened to 55 kt late on 3 October while moving slowly westward. The storm maintained this intensity for 36 h and then weakened, apparently from an increase in vertical shear again created by Keith, now strengthening over the southwestern Gulf of Mexico. Once Keith moved inland over northeast Mexico and weakened again, the shear over Olivia relaxed and Olivia again strengthened to 55 kt on 8 October. Moving northwestward, Olivia encountered cooler sea surface temperatures and began its second and final weakening. Olivia became a tropical depression on 9 October and dissipated on the next day while located about 525 n mi west-southwest of the southern tip of Baja California.

The remnant low-level circulation of Olivia moved northward and then northeastward. It moved inland on the west coast of Baja California, then tracked across mainland Mexico and the southwestern United States. The remnant circulation brought considerable rainfall to Baja California, northwest Mexico, and the U.S. desert southwest. Rainfall totals exceeded 75 mm across those areas and produced some localized flash flooding.

p. Tropical Storm Paul, 25–29 October

Paul developed as a disturbance in the ITCZ and was first identifiable as an area of thunderstorms on 22 October, located several hundred nautical miles south-southeast of the Gulf of Tehuantepec. It is possible that a wavelike area of thunderstorms located in the western Caribbean on 21 October may have moved into the vicinity of the ITCZ disturbance on 22 October and contributed to its development. The convection moved westward and gradually consolidated. First visible satellite imagery on 25 October showed a low-level center had formed overnight and tropical depression status began on that day.

Paul's track was generally westward at 15 kt for the

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TABLE 2a. National Hurricane Center eastern North Pacific basin average track forecast errors in nautical miles.

	Forecast period (h)					
	0	12	24	36	48	72
Official error for 2000	10.4	33.7	62.3	89.4	117.0	170.4
CLIPER model error for 2000	10.4	37.3	74.1	114.3	157.1	225.9
No. of cases for 2000	195	195	169	146	124	81
Official error for 1990–99	11.6	37.1	69.1	101.3	131.6	188.6
CLIPER model error for 1990–99	11.6	39.5	76.1	115.8	155.2	227.4

nearly 4 days that it was a tropical cyclone. It turned west-northwestward and slowed on 26 October while passing south of an amplifying trough along the west coast of North America, but resumed a westward motion within 24 h.

The cyclone experienced strong, mostly westerly, vertical shear and the low-level center was often exposed to the west of the deep convection. Paul is estimated to have become a tropical storm at 1200 UTC on 26 October about 900 n mi south-southwest of the southern tip of Baja California, and 6 h later reached its peak intensity of 40 kt. Convection occasionally flared up over the next 2 days and Paul dissipated on 29 October about 1200 n mi southwest of the southern tip of Baja California.

q. Tropical Storm Rosa, 3–8 November

Rosa made landfall near Huatulco, Mexico, as a minimal tropical storm.

During the last few days of October, an area of disturbed weather was located over the southwestern Caribbean Sea. This feature was associated with a tropical wave that emerged from Africa on 18 October. As the system moved over the eastern Pacific on 2 November, it developed curved cloud bands and a concentration of deep convection located 200 n mi south-southeast of El Salvador. There was no development during the next day or so and the disturbed weather continued moving slowly westward. On 3 November, there was a well-defined circulation in the low clouds, and by 1800 UTC, deep convection was close enough to the center to indicate the formation of a tropical depression about 200 n mi south of the El Salvador–Guatemala border.

With a low- to midlevel ridge to its north, the depression moved westward over the next 2 days. By 5 November, the organization of the system improved slightly and the depression became Tropical Storm Rosa. A midtropospheric trough was located to the northwest of Rosa. This feature eroded the ridge, which induced a slowing of Rosa's forward speed and a turn toward the north on 6 November. The storm reached its peak intensity of 55 kt around 1800 UTC on 6 November, and then underwent a very slow weakening until landfall. Under the influence of the trough to its northwest, the storm turned toward the northeast with some increase in forward speed on 7 November. Tropical storm warnings were issued along the south coast of Mexico from east of Acapulco to Tonala, and a hurricane watch was issued from Acapulco to Salina Cruz. Rosa made landfall early on 8 November, not far from Huatulco, Mexico, with estimated maximum winds of 35 kt, and then quickly dissipated over mountainous terrain.

There was a Hurricane Hunter aircraft mission into Rosa from about 1500 to 1700 UTC on 7 November, while the storm approached the coast. Interestingly, the mission crew reported a closed eyewall, even though the maximum winds were well below hurricane strength. A GPS dropsonde measured a surface wind of 47 kt. The minimum pressure reported from the aircraft was 1000 mb.

A rainfall total of 103 mm was reported from Puerto Angel, Mexico. Rosa was a weakening, minimal tropical storm at landfall, so its wind impact was not serious. No reports of casualties or damages have been received.

3. Verification

The National Hurricane Center issues an official 72-h track and intensity forecast every 6 h, for all tropical cyclones in the eastern Pacific basin (and in the Atlantic basin). These forecasts are verified by comparison with the final best tracks. Only tropical storm and hurricane stages are verified. A track error is defined as the great-

TABLE 2b. National Hurricane Center eastern North Pacific basin average absolute 1-min wind speed forecast errors in knots.

	Forecast period (h)					
	0	12	24	36	48	72
Official error for 2000	2.6	6.8	11.3	14.5	15.2	14.3
SHIFOR model error for 2000	2.6	8.1	12.1	14.6	16.2	15.1
No. of cases for 2000	195	195	169	146	124	81
Official error for 1990–99	3.0	7.1	12.1	15.9	18.6	21.3
SHIFOR error for 1990–99	3.0	8.0	13.2	17.2	20.2	23.7

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circle distance between a forecast position and a best track position for the same time. An absolute intensity error is defined as the magnitude of the difference between a forecast wind speed and a best track wind speed for the same time.

Table 2a lists the official average track forecast errors for the eastern Pacific basin for 2000, along with the previous 10-yr averages. The CLIPER model is a simple statistical model, based on climatology and persistence that is used as a benchmark to define ''skill.'' Errors for the CLIPER model (Neumann 1972) are also listed for the same forecast cases. If an official (or model) forecast does not improve on the CLIPER forecast, it is not considered skillful. There were 195 official forecasts verified at the 0- and 12-h forecast periods. By 72 h, the number of cases decreases to 81, due to many of the cyclones being short lived. The official track errors for this year are about 10% smaller than the previous 10-yr average and are less than the CLIPER errors at all forecast periods.

Table 2b lists the average official intensity errors, along with the benchmark Statistical Hurricane Intensity Forecast model (SHIFOR), which is also a simple statistical climatology–persistence model. While the official errors are only about 5% smaller than the previous 10-yr average at 12 h, they decrease to about 20%–30% smaller at 48 and 72 h. These errors are also less than the SHIFOR model errors at all forecast periods.

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