HURRICANE ABBY

June 2 - 6, 1968

Hurricane Abby will go into the record books as one of the most beneficial tropical storms ever to affect the state of Florida. Hurricane force winds were not observed anywhere in the state and reported wind damage was slight. Heavy rainfall accelerated the recovery from the severe spring drought in the central peninsula. There was considerable local flooding of roadways and some low-lying areas but no serious flooding was observed. No deaths were directly attributable to the storm. Total damages statewide are estimated at less than $250,000.

Abby moved northward between the Dry Tortugas and Key West on the evening of Monday, June 3, with maximum sustained winds of barely hurricane force near the center of the storm. Although winds of gale force were observed in the Keys for about 26 hours, maximum sustained winds were only about 45 mph from the southeast and highest tides at Key West were less than one foot above normal. Damage was minor. One death indirectly caused by the storm occurred at Key West when a year-old girl wandered away from her grandmother and drowned in a pool of rainwater eight inches deep.

Abby moved inland on the southwest coast near Punta Gorda in Charlotte County after weakening rapidly on the morning of Tuesday, June 4. Maximum sustained winds along the coast were about 25 mph with peak gusts near 40 mph. Only minor local flooding and wind damage occurred. Tides were only slightly above normal wouth of Punta Gorda and one-half to one foot below normal in the Tampa Bay area.

Abby became disorganized and continued northeastward, exiting the peninsula near Titusville late Tuesday afternoon. During her trip across the state, she was attended by maximum sustained winds of 25 to 30 mph with gusts

to about 45 mph. Damage was minor and due primarily to local flooding.

After moving off the east coast, Abby made a southward loop to the Vero Beach area before moving north northwestward along the coast on Thursday, June 6, crossing into Georgia Thursday night. Abby intensified over the Atlantic coastal waters but did not regain hurricane intensity. Maximum sustained winds in exposed coastal sections were about 40 to 55 mph with peak gusts to about 70 mph. Wind speeds dropped off a short distance inland to 30 to 40 mph with occasional gusts as high as 55 mph. Highest tides were two to three feet above normal. At the NASA Pad 39A, a five-minute wind speed of 69 mph with a peak gust of 87 mph was measured on a 60-foot tower.

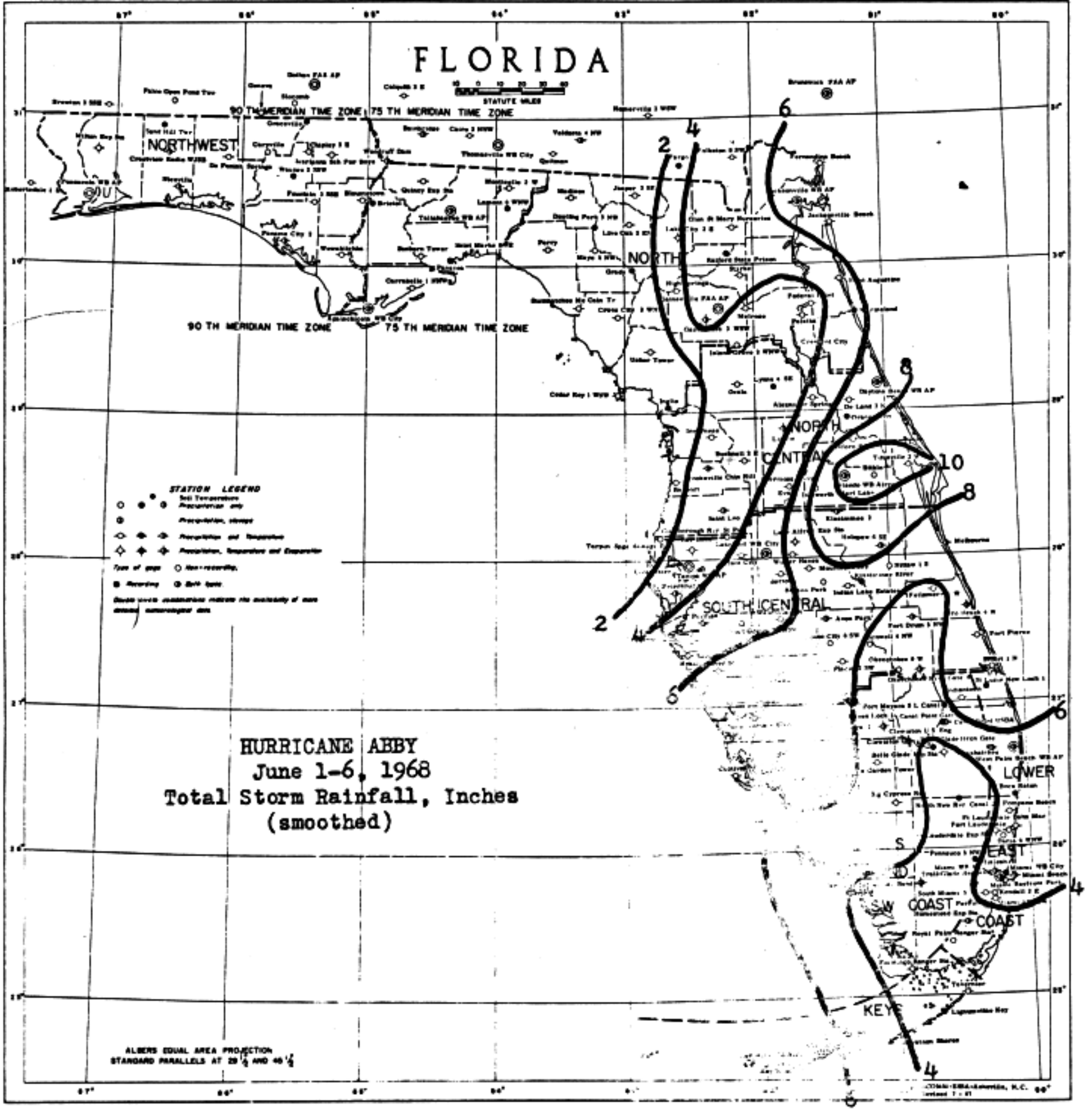
Damage along the east coast from Brevard County northward was minor and consisted mostly of broken tree limbs; downed small trees, signs, and power lines; some beach erosion; and minor rainfall flooding. Local flooding was most extensive in the Titusville-Cocoa area, where some stations measured storm totals of about 14 inches. Damage estimates ran as high as $150,000 in the Titusville-Cocoa area mostly in extra man-hours for clean-up crews.

Two small tornadoes occurred around the periphery of Abby's circulation, both on the morning of Tuesday, June 4. The first occurred at Pineda Bar in Brevard County at 6:30 EDT. It moved about 600 yards along the bank of the Indian River. No injuries were reported and damage was estimated at less than $5,000. The second tornado occurred at Haines City in Polk County at 9:10 EDT. It resulted in no injuries and damage of less than $500 consisting of damaged television antennas and some broken windows. A funnel cloud was observed at Cape Kennedy on the morning of the 4th at 8:10 EDT but it did not touch the ground.

From an agricultural point of view, Abby could not have come at a much better time. Most of the current year's orange crop as well as most spring vegetables have already been harvested. The harvest of potatoes, watermelons, and sweet corn was delayed a few days by the storm. Some sweet corn acreage in the muckland areas of central Florida was lost due to over maturity.

Rainfall totals of about 3 to 10 inches were especially welcome in the north central peninsula, where drought conditions were still severe prior to Abby's arrival. Moderate drought conditions in the south central and northeast sections were alleviated by 4 to 8 inches of rain. Lesser amounts fell along the west coast from Tampa northward. In the Everglades National Park, plagued for months by water shortages, water levels were raised to the second highest level since 1952 for this time of year. On the lower east coast, where the drought was already ended by a very wet May, the heavy rains resulted in much run-off and considerable pumping of excess water.

Jack E. Mickelson
State Climatologist
June 13, 1968


FLORIDA
STATUTE MILES
90 TH MERIDIAN TIME ZONE
75 TH MERIDIAN TIME ZONE
NORTHWEST
NORTH
NORTH CENTRAL
SOUTH CENTRAL
LOWER
EAST
SW COAST
COAST
KEYS
STATION LEGEND
HURRICANE ABBY
June 1-6, 1968
Total Storm Rainfall, Inches
(smoothed)
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29 1/2 AND 45 1/2

to be well below normal over most of the ocean—a pattern that experience has shown to be unfavorable for development. (For example, see Andrews (1968) for an inspection of the anomaly fields.) August produced only one named cyclone. This is less than the monthly average for hurricanes, not to mention the combination of storms and hurricanes. The relatively quiet month was not surprising.

The pattern remained unfavorable into September. Posey (1968) states there were below-normal heights at 700 mb from the western Atlantic to the Black Sea. Again, this is not what the forecaster looks for as a favorable pattern for the development of the long-trajectory, Atlantic-Cape Verde-type cyclones so typical of August and September. In figure 1, note that Edna never attained hurricane force and failed to hold together long enough to make the usual recurvature or landfall.

Two conclusions might be drawn from this general summary. The first is most obvious and can be stated as a good forecasting rule: *tropical cyclone development is not favored by blocking Highs at northern latitudes that produce westerlies and below-normal heights in the midtroposphere at midlatitudes and in the subtropics.*[3] For the second conclusion, we return to the month of June.

The authors can only reaffirm what several others have said before, that the environment and its changes near the disturbance or depression are just as important for development, if not more so, than the large-scale features discussed in previous paragraphs. Riehl (1963) has emphasized that there are two schools of thought and goes on to comment on whether most of the research should be done on the "internal factors" or the "external forcing mechanisms." In this reference, he apparently thinks the latter very important, for he alludes to the influences produced by the passing (to the north) of midlatitude troughs in the westerlies. He postulates external cooling from this arrangement but is quick to point out "There would be only a few days in each hurricane season when formation from external forces was a possibility." The following paragraphs will attempt to flag some of the more obvious internal features of the June storms and touch on some of the applied research in progress by hurricane specialists recently assigned to the National Hurricane Center.

First of all, let us examine the depression, located at lat. 18.8°N, long. 85.8°W, at 1900 EST, June 1; central pressure was 1055 mb. Figure 2 is an ESSA–5 picture of the circulation on the same day. Intensification processes produced storm force winds (Abby) within 12 hr and a central pressure of 997 mb after 24 hr. Riehl and Malkus (1961) have remarked on the importance of "hot towers" that cover only a small fraction of the developing cyclone. Later, Malkus and Williams (1963) concluded that the "interaction between large cumuli and severe storms (hurricanes) is essential to the dynamics of both." We believe the satellite picture shows the presence of isolated and tall cumuli near the area of minimum pressure which support the research mentioned above. Besides the visual evidence, figure 3 is presented to show the very weak shear in the vertical at Swan Island, the station nearest the depression. This would certainly seem to support the conclusion of Gray (1967)—". . . most disturbances from which storms form are generated from an environment in which a horizontal trade-wind current is present with minimum vertical shear." Similarly, it supports the conclusions of Simpson and Riehl (1958), who had demonstrated that where "ventilation" exists it acts as a constraint upon the hurricane heat engine (development).

Another interesting observation, and surely a clue to the formation of Abby, is presented in figure 4. Here we see the unanalyzed data from the so-called "TOE chart" (top of the Ekman layer)[4] regularly prepared by the Regional Center for Tropical Meteorology (RCTM) at NHC. By inspection, one can easily see the obvious inflow which is so important. A computation of the radial component with these data within a radius of 4° lat. produced a speed of 0.8 kt. This value yields greater convergence than the threshold radial inflow of 1.5 kt around the Gulf of Mexico (much larger radius) which is considered favorable for development by Riehl, Baer, and Veigas (1962). A second computation was not made; however, contrast figure 4 with figure 5. The latter is the TOE chart for a September depression that persisted for several days; the winds show no net inflow; the depression never developed. For the track of this depression and others the reader is referred to the accompanying article by Simpson et al. (1969).

Damage and casualty figures for the 1968 hurricane season are given in table 2. Table 3, presenting hurricane statistics in the United States in less than a century of hurricanes, helps to emphasize the small amount of damage and relatively low loss of life in 1968.

2. INDIVIDUAL CASES

HURRICANE ABBY, JUNE 1–13

When the 1968 hurricane season officially began on June 1, processes underway during May had already indicated it would start actively. A midtropospheric trough had persisted over the extreme northwestern Caribbean Sea during the latter part of May. A short-wave trough moving eastward through the semipermanent Caribbean trough pushed a weak cold front southward into the Florida Straits near the end of the month. The low-level convergence field gradually increased, and satellite pictures showed the merging of the cloud systems associated with the frontal zone and upper trough. The extensive and prolonged rains produced by these systems, together with another minor midtropospheric trough that moved into

[3] This circulation pattern does not preclude the development in the westerlies of the cold hybrid system or subtropical cyclone that

[4] This chart utilizes surface ship winds and

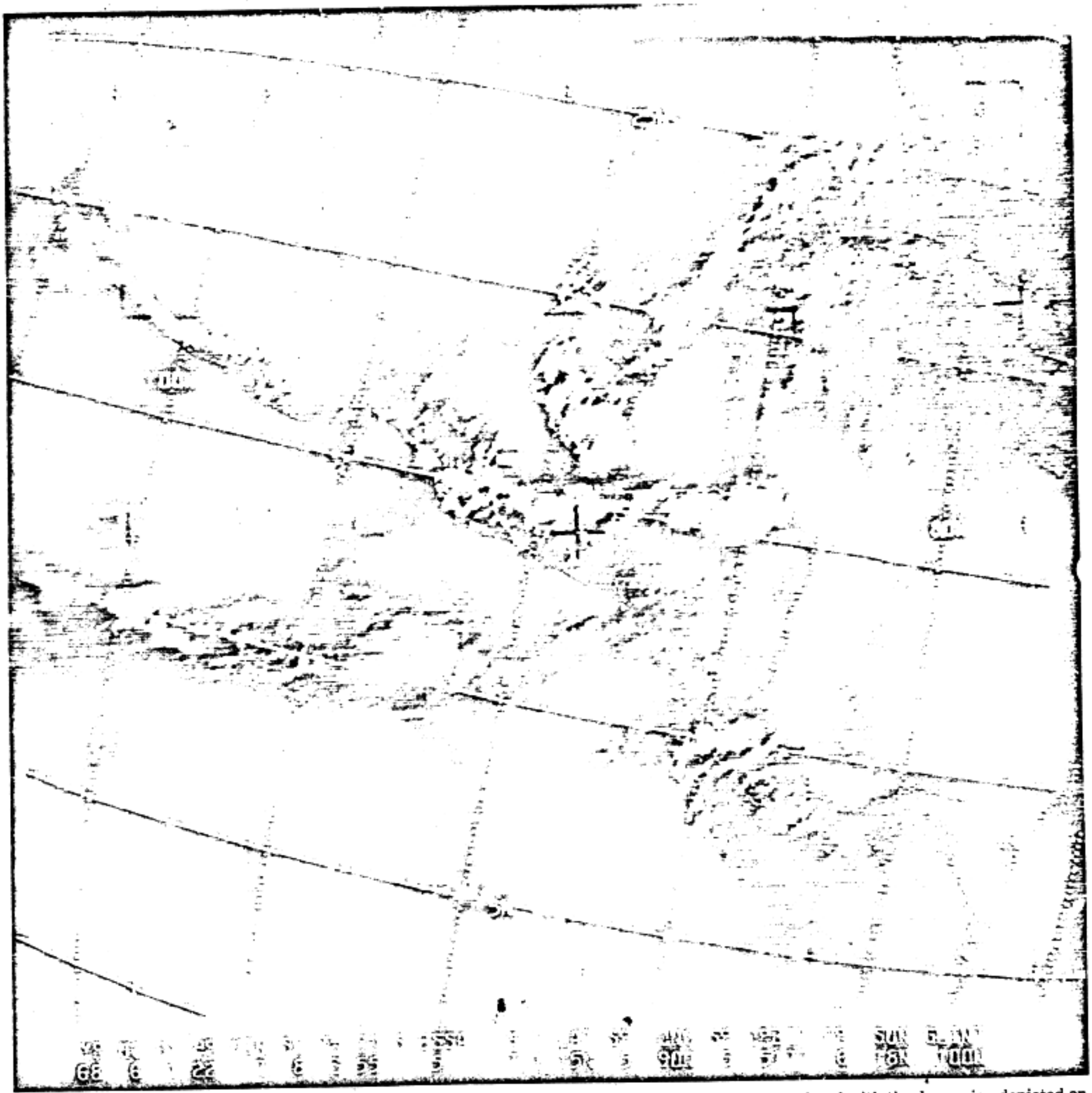


FIGURE 2.—An ESSA–5 satellite picture taken June 1, 1968, 1707 EST, showing the circulation associated with the depression depicted on the TOE chart in figure 4.

the mean trough on the 1st, caused general pressure falls throughout the extreme western Caribbean Sea. The trough probably also helped start Abby on her northward trek. As the pressure fell, deep southwesterly flow began through Central America and over the adjoining Pacific Ocean (a *temporale*) advecting very warm and moist tropical air into the area of maximum pressure falls. A warm-core tropical cyclone gradually organized on June 1 and reached tropical storm intensity on June 2. A general warming of the upper troposphere took place over the Gulf of Mexico and western Caribbean Sea during this time, and a strong west-southwesterly jet-

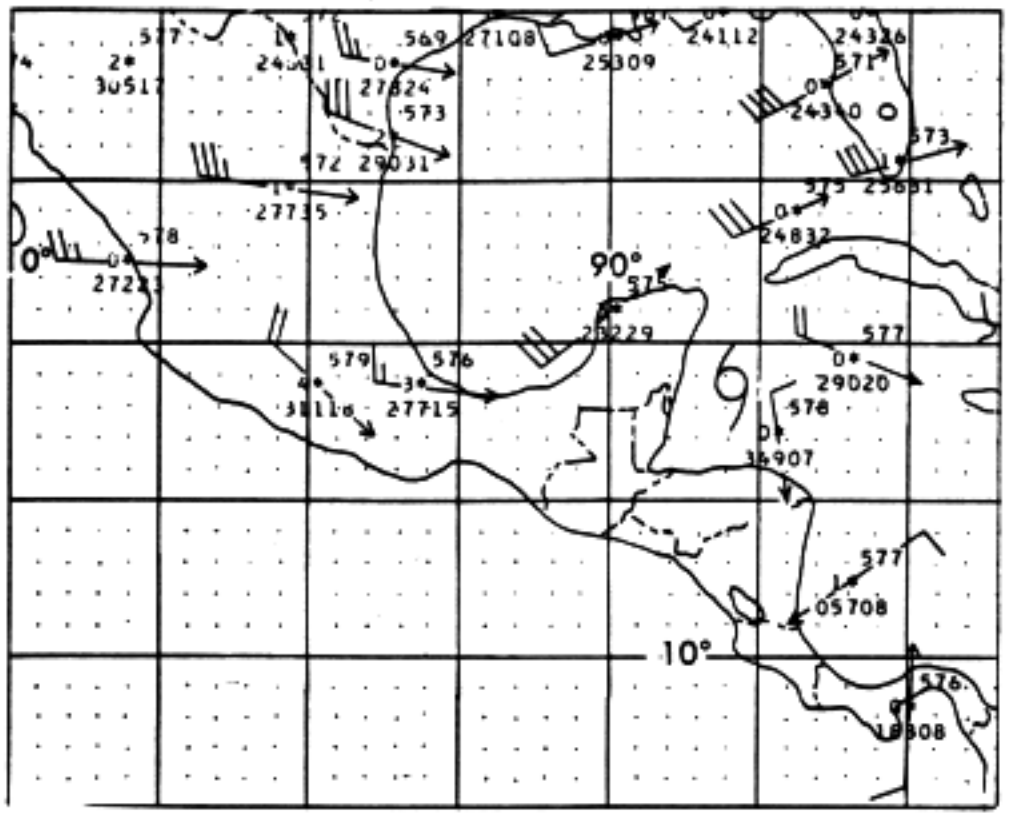


FIGURE 3.—Troposphere mean temperature (shear) chart 600- to 200-mb layer minus 1000- to 600-mb layer on June 1, 1968, 1900 EST. Note that besides the two charts used to prepare this shear chart, the Regional Center for Tropical Meteorology at the National Hurricane Center, Miami, Fla. (RCTM), also produces a deep-layer mean chart from 1000 mb to 100 mb.

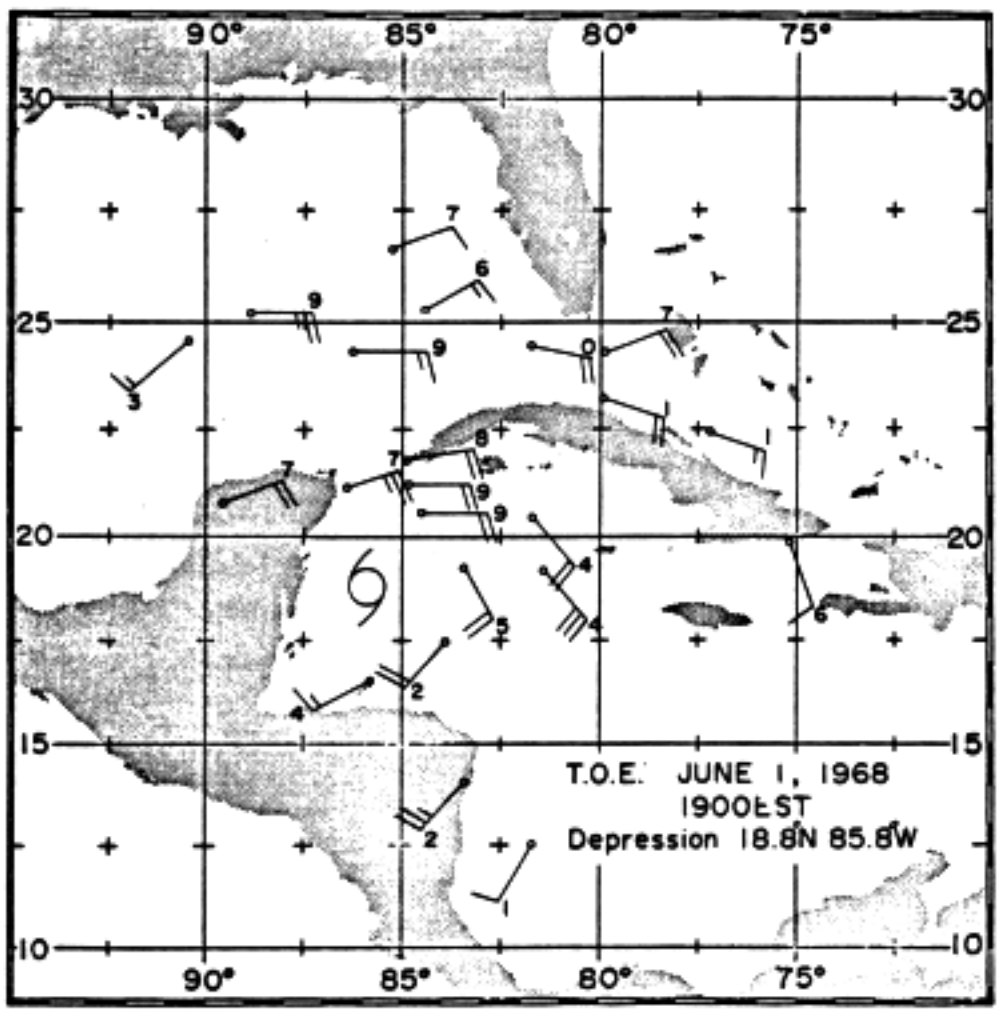


FIGURE 4.—TOE chart (top of the Ekman layer ships and 3,000-ft winds chart), June 1, 1968, 1900 EST, depression 18.8°N, 85.8°W.

stream persisted from southern Mexico to southern Florida; conditions were quite similar to the predevelopment stage of hurricane Alma in 1966.

Tropical storm Abby crossed extreme western Cuba on the evening of June 2, moving on a north-northeast

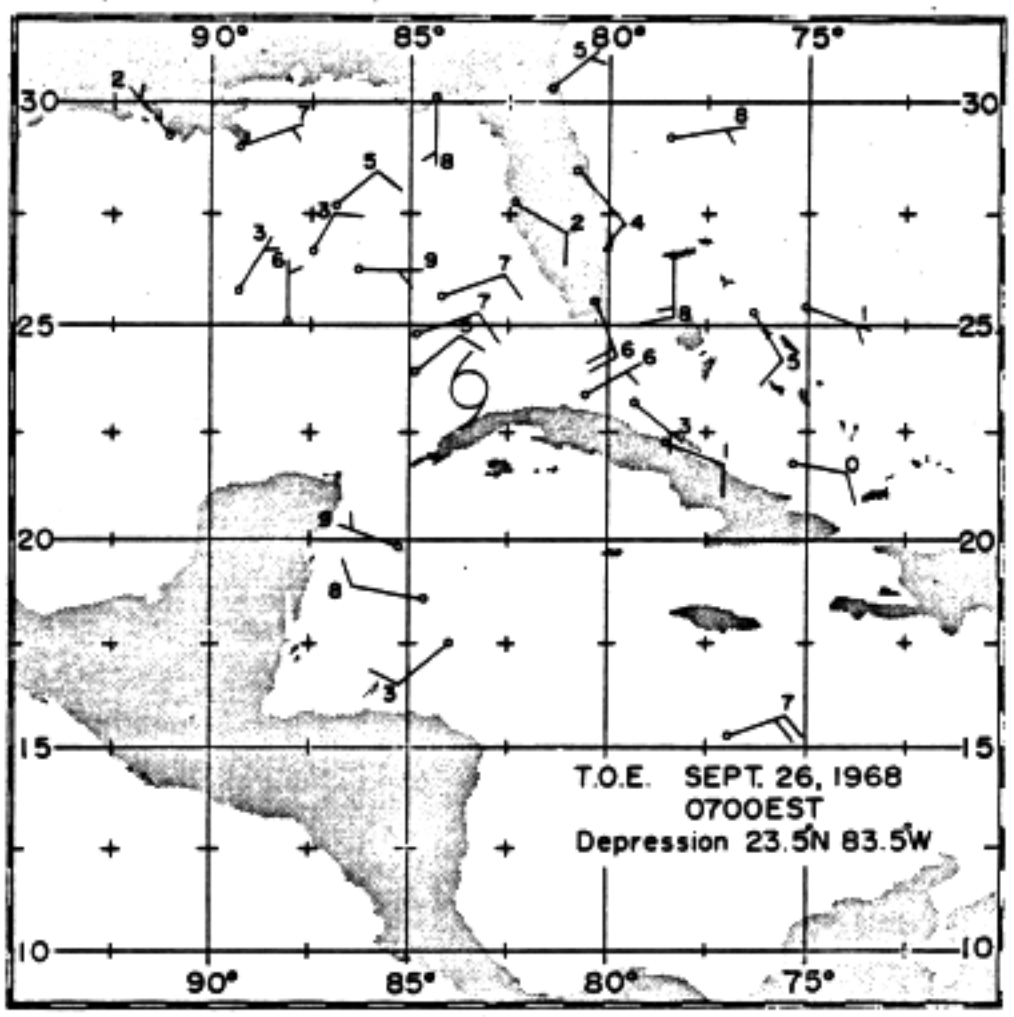


FIGURE 5.—TOE chart (top of the Ekman layer ships and 3,000-ft winds chart), Sept. 26, 1968, 0700 EST, depression 23.5°N, 83.5°W.

TABLE 2.—*Estimated damages and casualties, hurricane season 1968*

Date		United States		Other Areas	
		Deaths	Damages	Deaths	Damages
June 1-13	Abby (H)	Florida 6	$450,000	0	(*)
June 17-26	Brenda (H)				
June 22-26	Candy (TS)		2,730,000		
Aug. 9-16	Dolly (H)				
Sept. 10-19	Edna (TS)				
Sept. 23-30	Frances (TS)				
Oct. 13-21	Gladys (H)	Florida 3	6,700,000	Cuba 1 Nova Scotia 1	(*)
Totals	3 tropical storms... 4 hurricanes.	9	9,880,000	2	

*There were conflicting reports on damages in Cuba. The authors have concluded there was little if any connected with Abby, but some unknown amount should be attributed to Gladys in connection with crop losses.

TABLE 3.—*Memorable hurricanes of the United States*

	Year	Damages ($ million)		Year	Deaths
Betsy	1965	1419.8	Galveston	1900	6000
Diane	1955	800.0	Louisiana	1893	2000
Carol	1954	450.0	South Carolina	1893	1000-2000
Carla	1961	400.0	Okeechobee	1928	1838
New England	1938	387.1	Keys and Texas	1919	600-900
Donna	1960	386.5	Georgia and South Carolina	1881	700
Hazel	1954	251.6	New England	1938	600
Dora	1964	250.0	Audrey	1957	550
Beulah	1967	200.0	Keys	1935	405
Audrey	1957	150.0	Atlantic coast	1944	390
Cleo	1964	128.5	Mississippi and Louisiana	1909	350
Miami	1926	111.8	Galveston	1915	275
			Mississippi and Louisiana	1915	275

TABLE 4.—*Hurricane Abby, meteorological data, June 1–13, 1968*

Station	Date	Pressure (in.)		Wind (mi/hr)				Highest tide (ft)	Date/ time	Storm rainfall (in.)	Remarks
		Low	Time (EST)	Fastest mile	Date/ time	Gusts	Date/ time				
Cuba											
Havana	2					50					
Isle of Pines										12.00	
Florida											
Avon Park										6.62	
Big Pine Key	3	29.53	2100	55* SSE	04/0400	60* SSE	03/2320			5.47	
Bradenton										5.84	
Cape Kennedy	5	29.41	0300	28	1230	46 NE				8.55	
Clearwater	4	29.56		30* NNW						1.93	
Cocoa	5	29.46	0000	60* E	1000	65* E	1000			14.20	
Daytona Beach WBO	6	29.48	0400	37 N	05/1656	62 NE	05/2205	2.6 AN	05/1758	6.17	
Dry Tortugas	3	29.46	2230								
Everglades City	4	29.52	0330	30* SSE	0255	50* SSE	04/0255	5.6	04/0800	4.82	
Flamingo	4	29.56	0310			56 SSW	0108			3.10	
Fort Lauderdale										4.99	
Fort Myers WBO	4	29.38	1353	23 W	1353	35 SW	1815			6.20	
Fort Pierce	5	29.39	0530			35 SSW	04/1200			7.12	
Hillsboro Light	4	29.57	1500	41	03/1900						
Homestead AFB	4	29.55	0158	29 S		45 S				3.18	
Jacksonville WBO	6	29.49	1816	52 N	0854	66 NNE	0908	2.2 AN	07/0600	6.61	
Jupiter Light	4	29.50	2225	45 SE	2000	48 SE	2004				
Key West WBO	3	29.51	2230	43 SE	0917	47 SE	2156	0.7 AN	03/1424	6.65	
Lake Alfred										7.05	
Lakeland WBO	4	29.41	1430	30 NE	0316	37 NNW	05/1056			5.53	
Lake Placid	3	29.44	1400	35* WNW	04/1800	45* WNW	1800			6.25	Eye passage
Lake Wales										7.78	
Merritt Island	5	29.45	0300			64 NE	1442			9.50	
60-Ft Tower	5			69**		87	05/1500				
Miami NHC	4	29.58	0350	46 SW	1200	52 SW	1200			4.82	
Miami WBAS	4	29.56	0400	32 SW	1732	38 SSW				4.67	
Naples	4	29.46	1900	40* WSW	05/0200	45* ENE	05/0200	2.0 AN		4.54	
North Key Largo	4	29.74	1330	46	0530						
Orlando WBO	4	29.47	1456	29 ENE	1456	46 NNE	05/0810			10.87	
Patrick AFB	5	29.37		28 N	0357	38 N	0357			9.03	
Plantation Key	3	29.68	0600	52	04/0255						
Punta Gorda	4	29.35	0430			80* NNW	2130			6.50	
St. Petersburg	4	29.52	0700	35* SW	03/2000	45* SW	03/2000			2.25	
Sanford				30* ENE		45* ENE				6.50	
S. Melbourne Beach	5	29.38	1700			46* ESE	04/2316			6.12	
Tampa WBO	4	29.50	0655	25 N	05/1413	39 NE	1030			2.51	Tide BN
Titusville	5	29.49	0615	40 NNE	1221	55 NNE	1221			13.86	In eye 0600–0642
W. Palm Beach WBO	4	29.54	1730	29 WSW	05/1457	41 WSW	05/1759			5.34	
Georgia											
Savannah WBO	7	29.63	0400	30	06/2346	41 E	07/0043	2–3 AN	06/1700	3.90	
South Carolina											
Charleston WBO	7	29.77	0445	46 SE	0211			2.2 AN	06/2200	1.05	
North Carolina											
Charlotte	8	29.78	0400	20 NW	09/1947	46 NW	09/1938			5.11	

*Estimated; AN, above normal; BN, below normal.

**5-min measurement.

lotte, N.C. Damage in Monroe was minor, although many trees were blown down or their tops twisted off. Damage in Charlotte was considerably greater and probably exceeded $30,000.

There were six deaths reported, all in Florida, but non of them can be directly attributed to the storm. The include three drownings, two electrocutions, and on traffic fatality. Damage from hurricane Abby was est mated to be $250,000 in Florida and was probably les than $100,000 each in Georgia and the Carolinas. N casualty figures or damage statistics have been received from Cuba.

HURRICANE BRENDA, JUNE 17–26

Conditions antecedent to the formation of Brenda were similar in several respects to those preceding Abby's development. A closed 500-mb Low formed over south Florida on the 14th as a trough in the westerlies sheared to the north. Brenda began as a tropical depression over the Florida Straits on June 17, forming under the per-

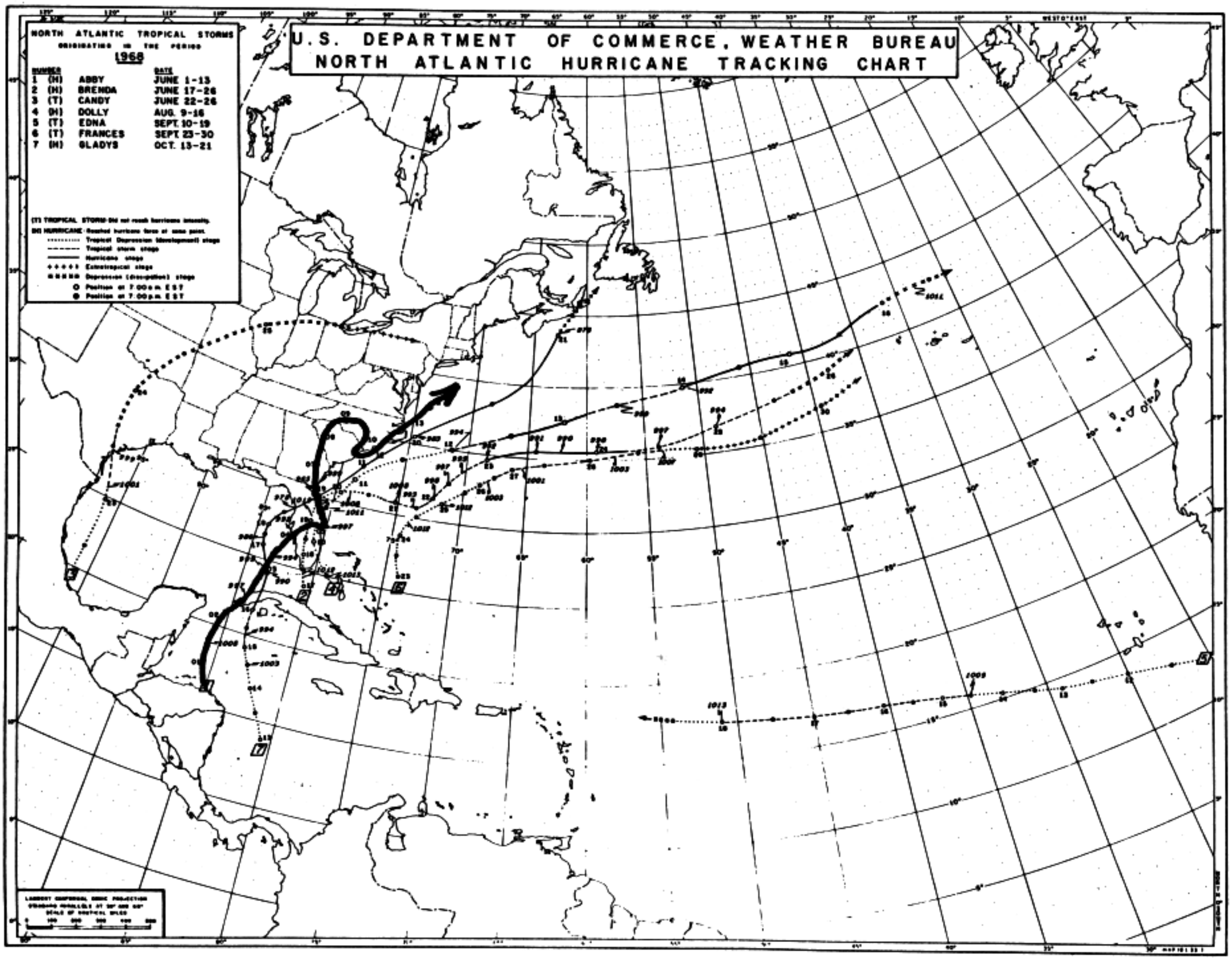


FIGURE 1.—Tracks of hurricanes and tropical storms, North Atlantic, 1968.