

**Incident:** Super Typhoon Paka 1997

**Date of Incident:** Dec. 2- 21, 1997

**Date Final Report Issued:** June 1998

**Incident Cost:** \$ 580 million

**Fatalities:** 0

**Maximum Intensity:** Super Typhoon (185 mph sustained winds)

### **Executive Summary**

Tropical Storm Paka formed in early December 1997, just after the conclusion of the official Central Pacific hurricane season (June 1 -November 30). It was named by the Central Pacific Hurricane Center (CPHC), Honolulu, on 1200 Coordinated Universal Time (UTC), December 2, 1997 (2 a.m. Hawaiian Standard Time [HST]), when it was approximately 1200 nautical miles (nm) southwest of Kauai.

This unusual post season tropical cyclone genesis was part of a twin development (Tropical Cyclone Pam formed at about the same time in the Southern Hemisphere and eventually moved southward, causing significant damage in the Cook Islands). This was the result of the strong El Nino-Southern Oscillation (ENSO) episode that produced an environment favorable for tropical cyclone genesis. Tropical Cyclone Paka tracked westward between 8-14 kts well south of the Hawaiian Islands, maintaining tropical storm strength (45-55 kts). Tropical Storm Paka crossed the dateline on December 7 (06/1800 UTC) and entered the tropical northwestern Pacific. Responsibility was then transferred from the CPHC to the JTWC, Guam. Paka moved through the Marshall Islands on December 10-13, moving slightly south of west. Paka initially maintained tropical storm strength but was predicted by the JTWC to diminish in strength and to eventually dissipate as it approached the Marshall Islands. Conditions cited by JTWC in predicting Paka to diminish in intensity included moderate vertical wind shear. Table 1 shows the initial predictions issued by JTWC that were used as guidance by WSO Majuro, Republic of the Marshall Islands (RMI) and NWSO Tiyan in their forecasts for Paka's path through the Marshall Islands. The initial track forecasts issued by JTWC called for the storm to move west-northwest into increasing westerly winds aloft and slightly cooler sea surface temperatures (SST). However, Paka's more west to west-southwest track through the eastern Marshall Islands (before exiting on a more northwest track) encountered less shear and warmer SST (2 degrees C) that was just enough to overcome an earlier sheared upper level environment, and resulted in a more favorable outflow pattern that led to rapid intensification on December 11.

Tropical Storm Paka reached typhoon strength in the Marshall Islands on December 11 at 0600 Local Standard Time (LST) (1800 UTC). Typhoon Paka continued to intensify as it tracked northwest into the FSM on December 12, with Typhoon Watches issued for Kosrae, Pingelap, Mokil, and Ujelang. Paka came within about 40 nm of Ujelang Atoll, the extreme western atoll of the Marshall Islands. Because Ujelang is believed to be uninhabited, the extent of damage is unknown. At 1700 LST Guam local time (2300 UTC), Sunday, December 14, a typhoon watch was

issued by the NWSO Tiyan, Guam, for all of the Mariana Islands when Paka was about 750 nm east-southeast of Guam. Typhoon warnings were declared for Guam, Rota, Tinian, and Saipan at 0930 LST (1530 UTC), Monday, December 15. At this time, Typhoon Paka was upgraded by JTWC to a super typhoon with sustained winds of approximately 140 kts (161 mph).

The predicted track of Paka continued to be near or directly over Guam with the eye making its closest point of approach (CPA) in the early evening of Tuesday, December 16. This turned out to be an accurate forecast as the CPA was about 2100 LST (0300 UTC) on Tuesday, December 16. As Paka bore down on Guam, it slowed to about 7 kts (8 mph). This resulted in maintaining typhoon force-winds across the central portion of the island for over 8-10 hours (Forbes, et al., 1998). Based on anemometers, and damage patterns, sustained west to southwest winds of 100-125 kts (115-144 mph) in the southern most part of the outer eyewall affected the northern two-thirds of the island. Paka, like many of the more intense typhoons, contained a concentric eyewall structure (20 and 5 nm based on the U.S. Department of Defense [DOD] NEXRAD). Best estimates for central surface pressure and maximum sustained winds for Paka are 935 mb and 130 kts, making it a super typhoon (Guard, 1998) (JTWC, 1998).

At the Air Force Base, located on the northeast end of the island, winds were at first northerly then turned to southerly as the outer eyewall moved across the island. A hot wire anemometer, an FMQ-13, located at the southwest end of the runways recorded a gust of 205 kts, but this is not supported by post-analysis (Forbes, et al., 1998). The incomplete inner eyewall stayed offshore. The island of Rota was north of the eye and thus received strong easterly winds from the outer eyewall. Rainfall reached 20 inches for Guam over 48 hours.

### Deaths and Damages

There was no loss of life in the Marshall Islands caused by Typhoon Paka. However, the devastation caused by tropical storm strength winds in the Ailinglaplap, Arno, Majuro, Mili, Jaluit atolls of the Marshall Islands resulted in considerable damage. This included losses to hundreds of homes, businesses in the hundreds of thousands of dollars, along with heavy losses to island staples such as breadfruit, bananas, and pandanus. The impacts of a damaging typhoon in the midst of a devastating drought (caused by ENSO) will likely result in a longer recovery period for the Marshall Islands.

There were no deaths on Guam and Rota, a tribute to the experienced population, a superior building code, and adequate warning times. Concrete roofed housing and the concrete telephone poles withstood the onslaught of Paka well. In fact, only about 75 of the concrete poles were downed (Guard, 1998). Older structures with tin roofs and wood telephone poles were either damaged or destroyed. Many of these had been compromised by prior typhoons, termites, and salt corrosion. Several thousand people were made homeless; generally these were people living in older

structures that did not meet the new building codes. Fortunately, the southern third of the island, which was beyond the outer eyewall, suffered little damage.

Interviews with the public demonstrate that the duration (8-10 hours of greater than 64 kts sustained) of the destructive winds, in conjunction with an evening and night passage, gave them the perception that Paka was the worst of the typhoons in the last 25 years (see Figure 12). This includes Omar (1992) and Pamela (1976). Vegetation damage was impressive due to the duration of the winds and the heavy rains. Damage estimates ranged upward of 600 million U.S. dollars (GOV Guam, Super Typhoon Paka, 1998).

The NWSO Tiyan, Guam, in conjunction with JTWC, did an excellent job predicting the intensity and arrival time of the typhoon. NWSO Tiyan, Guam, provided timely updates about the storm until its emergency backup generator failed at 1825 LST, the result of copious amounts of water that had blown into the space where the generator was kept. The JTWC assumed the burden of providing weather updates to the few radio stations still left with power and able to broadcast. The NWSFO in Honolulu, Hawaii, became the backup forecast office for several days and produced the official NWS statements, warnings, and advisories until power was restored after storm passage, operations stabilized, and responsibility was transferred back to NWSO Tiyan, Guam. Fortunately, Paka continued its track to the west away from Guam during this period when most radio and TV stations were out and roads were blocked.

The primary issue for the NWSO Tiyan, Guam, and the island in general was sustaining reliable power supplies. Power supply failures and fluctuations caused the DOD NEXRAD radar, the NWSO Tiyan, Guam, and the Automated Surface Observing System (ASOS) to cease operations during the initial passage of the outer eyewall over the island. Failure of island communication links or radio stations could have led to a greater disaster if people had left their shelters during a lull in the winds, or if the typhoon had looped back toward the island.

Post analysis of Paka's wind structure was compromised by the loss of all level two radar data, the ASOS located at Guam International Airport, and the failure or loss of other anemometers on the island. The loss of ASOS data during the peak wind period of tropical cyclone passage is a recurring problem (Powell, M., Houston, S., Monthly Weather Review, May 1998). Another issue was communications. A popular TV and radio personality did forecast a much earlier CPA that was at variance with the official forecast. Additionally, the last forecast made by NWSO Tiyan before power failure also changed the CPA to a number of hours later than previous forecasts; this was a result of confused communications between JTWC and the NWSO. By this time, the high winds were affecting the island and preparations were as complete as they were going to be.

## Recommendations

1. NWS PRH, CPHC and JTWC should work together to reanalyze Paka's evolution in the vicinity of the Marshall Islands. This analysis should be directed at determining the rationale behind the issued forecast. Further study should then be conducted to determine what additional information might be used to improve the forecast intensity and track in the future.
2. NWS PRH should re-site replacement wind measuring instruments to obtain better exposure and place these sensors at the standard 10 meter height. In addition, the NWS PRH will better ensure that ASOS data are preserved after power is restored by establishing maintenance procedures that put equal priority on downloading archived data before restoring ASOSs to full operation.
3. Since Guam is frequently affected by typhoons, more robust wind sensors capable of measuring high winds found in tropical cyclones should be developed and deployed, which would be beneficial for understanding future damage patterns.
4. NWSO Tiyan, Guam, should not release their advisory until they have received the JTWC official tropical cyclone forecast.
5. NWSO Tiyan, Guam, should develop a checklist to pass to JTWC and NWSFO/CPHC Honolulu so that these offices, if they assume NWSO Tiyan, Guam, responsibilities, can use the terminology that is understood by the citizens in the forecast area. Furthermore, the NWS must establish more standard procedures for typhoon products issued by NWSO Tiyan, Guam.
6. The NWS PRH should work with the local media on Guam, ensure that the media clearly and frequently identify the source of their information and, if necessary, inform the public that their forecasts are at variance with the NWS typhoon warnings.
7. The NWS PRH should develop procedures so that NWSO Tiyan, Guam, will establish provisions to have their home page backed up when and if they have to transfer operations to NWSFO/CPHC Honolulu.
8. NWS PRH needs to establish procedures whereby the primary and back-up office provide more frequent advisory bulletins as a typhoon impacts the local area.
9. NWS PRH should establish and maintain reliable emergency power to the NWSO Tiyan, Guam, and to all vital sensors. Place back-up generators for the NWSO Tiyan, Guam, in locations where personnel can safely reach them during high winds and heavy rains.

10. NWS PRH should work with the Guam Civil Defense and the local media to establish more robust communication links (between the NWSO Tiyan and emergency teams and the NWSO Tiyan and the media) to ensure timely updates.
11. The NWS should request that the three NEXRAD agencies review the requirement for a more reliable and robust level two archive data recording system.
12. The current construction plans for a new Weather Forecast Office (WFO) should be modified to ensure that the new WFO Tiyan building can withstand super typhoons. It should include a media access room to provide for timely release of information to the media and the public. The emergency power source to this building must be located such that technicians can reach this power source to make adjustments during the height of the typhoon.
13. Authorize and fill a SOO position at NWSO Tiyan.
14. NWS PRH should seek permission to access the Kwajalein radar for NWSO Tiyan, Guam, and NWSFO/CPHC Honolulu.