# Tropical Cyclone Season Summary 1997-98

## Introduction

A summary is presented of tropical cyclone activity during the 1997-98 cyclone season for the Regional Specialised Meteorological Centre Nadi - Tropical Cyclone Centre (RSMC Nadi-TCC) area of responsibility (Equator to 25°South, between 160°East and 120°West).

Of the last 20 seasons, this season has been the most active in terms of the number and intensity of cyclones, as well as the length of season. A total of fifteen cyclones formed in the area, and another, Katrina from Brisbane's area of responsibility, visited for a few days. Of these fifteen, eight cyclones reached hurricane force. The season was the longest ever at 208 days, 2 days longer than the previous season, also a remarkably long season.

Another feature of the season was the concurrency of a very strong ENSO event. Monthly values of the Southern Oscillation Index (SOI) were less than -15 for the entire season (except December at -9) and less than -21 from January through June. The most pronounced effect of this was to move the seat of the equatorial Walker circulation from its usual position just south of the Solomons, to 45 degrees of longitude further east in the vicinity of the Northern Cooks. Evidence of this is the fact that 10 cyclones had their genesis (low first identified to initial TC phase) within 3 degrees of longitude of the line joining the points 11º South 172º West to 12º South 160º West to 14º South 150º West. This line of convergence, low pressure and enhanced convection is probably the El Niño analogy of the Southwest Pacific Convergence Zone which is the genisis area for most tropical cyclones in the southwast Pacific basin. This relocation also had the effect of weakening the trade winds west of the Date Line while strengthening them in the east.

**Table 1. Tropical Cyclones in the RSMC Nadi area of responsibility, for the 1997-98 Season. All dates and times are in UTC.**

| | Low first identified | | | Initial tropical cyclone phase | | | |
|---|---|---|---|---|---|---|---|
| Name | Date | Lat. | Long. | Date | Time | Lat. | Long. |
| Lusi | 07 Oct | 10.0°S | 170.0°E | 09 Oct | 1200 | 8.5°S | 169.5°E |
| Martin | 31 Oct | 10.1°S | 165.8°W | 31 Oct | 1500 | 10.1°S | 165.8°W |
| Nute | 18 Nov | 11.2°S | 165.2°E | 18 Nov | 1200 | 12.0°S | 163.4°E |
| Osea | 22 Nov | 9.5°S | 157.0°W | 24 Nov | 0000 | 12.3°S | 157.9°W |
| Pam[o] | 05 Dec | 9.0°S | 166.0°W | 06 Dec | 0600 | 11.5°S | 162.7°W |
| Ron | 01 Jan | 8.9°S | 165.5°W | 02 Jan | 0000 | 9.6°S | 167.8°W |
| Susan | 20 Dec | 6.0°S | 171.0°W | 02 Jan | 1200 | 11.9°S | 174.4°E |
| Tui | 25 Jan | 10.8°S | 174.0°W | 25 Jan | 2100 | 13.0°S | 172.7°W |
| Ursula | 29 Jan | 14.0°S | 152.0°W | 30 Jan | 1800 | 16.0°S | 148.0°W |
| Veli | 31 Jan | 12.1°S | 157.1°W | 01 Feb | 0000 | 13.7°S | 152.8°W |
| Wes | 31 Jan | 12.2°S | 173.4°W | 01 Feb | 0600 | 11.7°S | 168.4°W |
| Yali | 18 Mar | 12.2°S | 165.9°W | 19 Mar | 1800 | 13.3°S | 163.7°E |
| Zuman | 29 Mar | 13.7°S | 171.2°E | 30 Mar | 1200 | 13.9°S | 169.8°E |
| Alan | 19 Apr | 14.6°S | 158.0°W | 21 Apr | 1800 | 11.2°S | 158.0°W |
| Bart | 29 Apr | 16.2°S | 140.4°W | 29 Apr | 1800 | 17.2°S | 139.8°W |

| | Maximum Intensity (knots) | | | | | End of Tropical Cyclone Phase | | | |
|---|---|---|---|---|---|---|---|---|---|
| Name | Date | Time | Lat. | Long. | Int. | Date | Time | Lat. | Long. |
| Lusi | 11 Oct | 0000 | 17.0°S | 173.5°E | 50 | 12 Oct | 0000 | 21.4°S | 176.7°E |
| Martin | 03 Nov | 1200 | 16.4°S | 154.4°W | 80 | 05 Nov | 1200 | 26.0°S | 140.0°W |
| Nute | 19 Nov | 1800 | 16.1°S | 159.6°E | 60 | 21 Nov | 0000 | 20.6°S | 158.5°E |
| Osea | 26 Nov | 0600 | 17.0°S | 152.0°W | 80 | 28 Nov | 0600 | 21.4°S | 148.0°W |
| Pam | 08 Dec | 1200 | 19.5°S | 160.6°W | 60 | 10 Dec | 1200 | 24.9°S | 155.4°W |
| Ron | 05 Jan | 1800 | 13.4°S | 175.7°W | 125 | 08 Jan | 1200 | 25.3°S | 169.7°W |
| Susan | 05 Jan | 1800 | 15.3°S | 170.0°E | 125 | 09 Jan | 1800 | 30.5°S | 173.0°W |
| Tui | 26 Jan | 1200 | 14.2°S | 171.9°W | 40 | 27 Jan | 0600 | 14.6°S | 172.3°W |
| Ursula | 01 Feb | 0000 | 22.5°S | 138.5°W | 55 | 01 Feb | 2300 | 30.0°S | 130.0°W |
| Veli | 02 Feb | 0600 | 19.0°S | 146.0°W | 55 | 03 Feb | 1200 | 22.6°S | 143.1°W |
| Wes | 03 Feb | 0600 | 15.5°S | 159.7°W | 45 | 04 Feb | 0600 | 16.8°S | 158.7°W |
| Yali | 22 Mar | 0600 | 18.7°S | 168.2°E | 70 | 25 Mar | 0000 | 25.1°S | 162.1°E |
| Zuman | 02 Apr | 0000 | 15.7°S | 164.7°E | 80 | 05 Apr | 1800 | 22.0°S | 168.1°E |
| Alan | 25 Apr | 0600 | 15.5°S | 153.1°W | 40 | 25 Apr | 1200 | 15.6°S | 152.5°W |
| Bart | 30 Apr | 0600 | 18.5°S | 138.4°W | 45 | 01 May | 0000 | 19.7°S | 136.1°W |

## Verification statistics

Position forecast verification statistics for each cyclone (Table 2) were derived by comparing the initial and forecast positions (given in warnings issued by RSMC Nadi-TCC) with post analysis 'best track' positions. The table also identifies (the mean error is in bold face) where the 12-hour or 24-hour forecast positions were reckoned to be significantly better than the persistence forecast. This test is satisfied when the probability that the null hypothesis (there is no difference between the mean great circle error of the operational forecast and the persistence forecast) is true is less than 0.10 at the 95% level of confidence.

**Table 2. Position forecast verification statistics for warnings issued by RSMC Nadi. The mean forecast great circle error is depicted in bold face when it is better than the mean persistence great circle error (in brackets); that is, there is little credence in the null hypothesis that there is no difference. All distances are in kilometres**

| Lead-time | 0 hours | | 12 hours | | 24 hours | |
|---|---|---|---|---|---|---|
| Name | Mean error | Number | Mean error | Number | Mean error | Number |
| Lusi | 29 | 18 | 145 (163) | 10 | **211** (312) | 8 |
| Martin | 45 | 19 | 169 (184) | 15 | 320 (357) | 10 |
| Nute | 31 | 15 | 120 (138) | 10 | 200 (213) | 5 |
| Osea | 42 | 25 | 114 (138) | 17 | 222 (255) | 15 |
| Pam | 14 | 23 | 88 (118) | 16 | 137 (205) | 12 |
| Ron | 22 | 29 | 84 (83) | 24 | 163 (169) | 21 |
| Susan | 10 | 23 | 73 (76) | 19 | **180** (231) | 15 |
| Katrina | 16 | 21 | 84 (101) | 19 | **173** (263) | 15 |
| Tui | 36 | 10 | 175 (175) | 5 | 352 (339) | 4 |
| Ursula | 44 | 13 | 164 (157) | 7 | 331 (390) | 6 |
| Veli | 45 | 11 | 180 (197) | 7 | 211 (182) | 2 |
| Wes | 39 | 20 | 131 (139) | 13 | 244 (277) | 12 |
| Yali | 27 | 25 | **126** (141) | 17 | **253** (328) | 16 |
| Zuman | 16 | 30 | **86** (99) | 25 | **166** (203) | 22 |
| Alan | 73 | 23 | **137** (184) | 10 | **160** (301) | 8 |
| Bart | 26 | 9 | 163 (87) | 6 | 94 (144) | 1 |
| Aggregate | 31 | 318 | **113** (127) | 221 | **200** (250) | 171 |

While the mean errors of the persistence forecasts are greater than those of the operational forecasts in many cases, the difference is not always significant when the standard deviations (not shown) and generally small sample size is taken into account in the application of a rigorous statistical test.

When all cyclones are aggregated, the test reveals that in general the operational forecasts are significantly different (better) than the persistence forecasts at both 12 hours and 24 hours lead-time.

**Table 3. Centroid of errors for initial position (0-hour lead time), 12-hour and 24-hour forecast positions given in warnings issued by RSMC Nadi, with the radius of the circle enclosing 50% of the positions. All distances are kilometres.**

| Lead-time | 0 hours | | 12 hours | | 24 hours | |
|---|---|---|---|---|---|---|
| Name | Centroid E-wd, N-wd | Radius of 50% circle | Centroid E-wd, N-wd | Radius of 50% circle | Centroid E-wd, N-wd | Radius of 50% circle |
| Lusi | -7, 3 | 30 | -31, 80 | 110 | -31, 145 | 159 |
| Martin | -8, -3 | 47 | -98, -37 | 117 | -294, -55 | 122 |
| Nute | 0, 13 | 35 | -29,57 | 99 | -95,79 | 144 |
| Osea | -24, 3 | 39 | -18, -41 | 94 | 18, -104 | 171 |
| Pam | 2, 3 | 19 | 2, -12 | 81 | 14, -10 | 122 |
| Ron | 1, 3 | 22 | -20, 24 | 78 | -64, 31 | 144 |
| Susan | 0, -2 | 14 | -52, 13 | 56 | -128, 32 | 105 |
| Katrina | 3, 3 | 15 | 16, -33 | 79 | 62, -88 | 142 |
| Tui | 17, -30 | 40 | 142, -89 | 94 | 333, -114 | 85 |
| Ursula | -7, 9 | 43 | -90, 100 | 98 | -179, 265 | 77 |
| Veli | 10,6 | 50 | 68,-53 | 147 | 127,-129 | 136 |
| Wes | -6,-4 | 40 | 52,-14 | 114 | 170,-13 | 163 |
| Yali | -4,-7 | 25 | 11,10 | 110 | 25,24 | 226 |
| Zuman | -5,-3 | 19 | -47,17 | 83 | -105,22 | 134 |
| Alan | -3,-16 | 70 | 38,-15 | 142 | 35,-27 | 261 |
| Bart | 15,-6 | 21 | 62,-30 | 95 | 95,-56 | 104 |
| Aggregate | -2, -2 | 37 | -9, -2 | 114 | -23, -9 | 194 |

In all cases (except Alan) the radius of the circles (centred on the centroid of the errors) containing 50% of the operational initial positions is smaller than 0.5 degree of latitude (55.5 km). The bias is also generally small (less than 30km). Therefore the warning position could have been given as "Position Good" most of the time.

The forecast error centroids and size of the radius of the 50% circle (centred on the centroid of the errors) indicate bias and consistency of bias in the forecast positions. For example Martin and Ursula, and to a lesser extent Susan and Zuman, consistently ran east of the expected track, so the centroids are baised to the west.

Figure 1: Tracks of Lusi, Nute, Katrina, Susan, Yali, and Zuman.

Figure 2: Tracks of Martin, Osea, Pam, Ron, Tui, Ursula, Veli, Wes, Alan and Bart.

## Tropical Cyclones in the RSMC Nadi area of responsibility

In the discussion that follows, distances are in nautical miles and wind speeds are 10-minute averages.

### Lusi (02P): 08 - 12 October 1997

A tropical depression was first recognized at 0000UTC 08 Oct, located about 750 miles northwest of Fiji. The system moved little for about a day, and then began to move generally to the south. The depression had only moved about 30 miles from its point of origin when it was named at 1200UTC 09Oct. Over the next few days Lusi moved south-southeast, passing between Fiji and Vanuatu, taking the so-called "gentlemen's track". At 0600UTC 11Oct the center of Lusi passed about 225 miles west of Fiji. At this time Lusi was near its peak intensity of 50 knots.

The storm turned a little more to the southeast and seemed to stall about 150 miles southwest of Fiji on 11Oct. Lusi began to weaken about this time due to the effects of cooler sea surface temperatures and increasing vertical shear. The system was down graded to a depression at 0600UTC 12Oct.

Lusi brought gales and some heavy rainfall to some of the southwestern-most islands in the Fiji group; otherwise there were no appreciable effects from this cyclone on any of the South Pacific islands.

### Martin (04P): 31 October - 05 November 1997

Martin developed from a weak tropical disturbance lying to the north of the Northern Cook Islands on 27Oct. Convection was quite unorganized and the system was being affected detrimentally by strong upper-level northeast winds. A weak low-level circulation was apparent, drifting very slowly to the west or southwest. Over the next three days the convection showed only slight improvement in organization, being very diurnal in nature and still affected by moderate to strong vertical shear.

Early on 31Oct the system began to show a marked improvement in organization. During the afternoon and evening it was clear that the system was developing rapidly, and Tropical Cyclone Martin was named at 1500UTC 31Oct close to Manihiki, Northern Cooks.
Early on 4 Nov the cyclone began to weaken steadily and accelerate to the southeast, passing more than 200 miles to the southwest of Tahiti. Warning responsibility was handed to Wellington when the system crossed 25ºSouth at 0600UTC 05Nov.

Tropical Cyclone Martin was quite destructive at Manihiki Atoll. When the center was closest to the island, the AWS reported a lowest pressure of 994hPa, sustained winds of 39 knots, and a highest gust of 56 knots. However, this was the last meteorological report from the station before it was destroyed by storm surge. There were 10 known fatalities on Manihiki with 10 more persons reported missing (and presumed drowned). Almost every building on the island was destroyed by the storm surge.

At its maximum intensity Martin passed near the western-most islands of the Societey group (Bellingshausan, Mopelia, and Scilly) where 8 deaths were reported.

## Nute (05P): 18-21 November 1997

A tropical depression was located about 525 miles north-northwest of Port Vila, Vanuatu at 0000UTC 18Nov. The depression moved southwestward and was upgraded to Tropical Cyclone Nute at 1200UTC. Nute continued to intensify as it moved to the southwest with maximum winds reaching 60 knots by 0600UTC 19Nov. At 1800UTC the storm crossed longitude 160ºEast and entered the Australian region of warning responsibility.

For the remainder of its life, warnings on Nute were issued by the Brisbane TCWC.

## Osea (06P): 22 - 28 November 1997

Osea began as a tropical depression located about 250 miles east-northeast of Manihiki Atoll 0000UTC 22Nov. The depression remained weak and drifted very slowly southward for the next two days. The system was moving very slowly on a southerly course when it was named at 0000UTC 24Nov about 200 miles east-southeast of Manihiki.

Osea began to intensify and moved a little faster on a southeast course. Hurricane intensity was reached at 1200UTC 25Nov about 300 miles west-northwest of Tahiti with peak winds of 80 knots occurring from 0000UTC to 1200UTC 26Nov. From then the cyclone began to weaken steadily. The center of Osea passed more than 200 miles south of Tahiti around 0000UTC 28Nov. At 0600UTC, Osea was downgraded to a depression about 250 miles south-southeast of Tahiti.

Cyclone Osea was quite destructive to some of the islands of French Polynesia. Over 700 homes were destroyed or badly damaged on Maupiti, Bora-Bora, and Raiatea. On Maupiti (population 1100) about 95% of the infrastructure (including the town hall, two schools, and an airfield) were destroyed. On Bora-Bora (population 4500) roughly 30% of the infrastructure was destroyed. There was no loss of life reported from Tropical Cyclone Osea.

## Pam (07P): 05 - 10 December 1998

A tropical depression was located about 425 nm northeast of American Samoa at 0000 UTC 05Dec. The system developed slowly as it drifted to the south-southeast and was named at 0600UTC 06Dec.

Pam passed very close to Suwarrow Atoll around 1800 UTC and was beginning to move a little faster on a southerly course. The AWS on Aitutaki Atoll reported winds of 33 kts at 1800 UTC 07Dec. At this time the center was about 200 nm west-northwest of the atoll.

Pam passed about 40 nm southwest of Rarotonga at 0600UTC 09 Dec. By this time the storm was beginning to weaken as it turned to a southeast course. Rarotonga reported maximum sustained winds of 39 kts with peak gusts of 64 knots.

The weakening cyclone passed about 80 nm southwest of Mangaia around 1200UTC 09Dec. By 0000UTC 10Dec Pam was located about 100 nm south-southeast of Mangaia, and was rapidly weakening and losing its tropical characteristics.

Damage on Rarotonga was light; mainly consisting of fallen trees and power lines. A few houses lost their roofs. There was some flooding of low-lying roads due to both heavy seas and rain. During the passage of Pam 149 mm of rainfall was recorded in a 6 hour period. There were no reports of casualties due to Tropical Cyclone Pam.

## Katrina (12P): 01-25 January 1998

Tropical Cyclone Katrina, a long-lived cyclone which roamed the Coral Sea and South Pacific for over three weeks, formed on 01Jan west of 160º East in the Brisbane TCWC's area of responsibility. While Katrina spent most of its long life in the Australian Region, it crossed 160ºEast into the Fiji TCWC region from 7 to 11 Jan.

Ever since its inception Katrina had been moving on a slow east-northeasterly course. At 0600 UTC on 7 Jan the cyclone was centered about 50 miles southeast of Rennel Island, the southernmost of the Solomon Islands, the northernmost point of Katrina's track.

The storm turned initially to the east-southeast, then more to the southeast as it slowly increased to hurricane strength. Katrina was posing a threat to Vanuatu on 09Jan when it abruptly halted about 200 miles west-northwest of Port Vila at 1200UTC and reversed its direction to a westerly course due to the development of an anticyclone to its south. A slow weakening trend set in as Katrina began to move slowly to the west-northwest. The storm passed about 150 miles south of Rennel Island at 1200UTC 11Jan, and crossed back into the Brisbane area six hours later at a point only about 55 miles south of where it crossed 160º East on its eastbound journey.

One fatality was reported in Vanuatu when a man fishing from a reef was swept away by rough seas. In the Solomon Islands, 200 homes were destroyed on southern Guadalcanal and 450 homes destroyed on the islands of Rennel and Bellona.

## Ron (10P): 01 - 09 January 1998

Tropical Cyclone Ron, with the concurrent Susan, were the two most intense cyclones to form in the South Pacific in recent years. Both generated maximum sustained winds of 125 knots, and minimum central pressures of 900 hPa. The last tropical cyclone to possibly reach this intensity was Tropical Cyclone Hina in March 1985.

A depression was identified at 0600UTC 01Jan when the system was centered about 450 miles northeast of Samoa. The depression drifted slowly on a west-southwesterly course for the next four days, reaching tropical cyclone intensity at 0000UTC 02Jan about 350 nm northeast of Samoa. Ron passed very near Swains Island around 0000UTC 03Jan.

Intensification proceeded at a fairly rapid rate and the peak intensity of 125 knots was reached at 0600UTC 05Jan when Ron was centered about 225 miles north-northwest of Apia, Samoa. The cyclone maintained this strength for about 36 hours. After 1200UTC 05Jan Ron turned to a south-southwesterly course for about 18 hours, then began to move in a south-southeasterly direction. Around 1800UTC 06Jan the cyclone passed very close to the island of Niuafo'ou, where considerable damage occurred.

After passing Niuafo'ou Ron began to weaken steadily as it started to accelerate to the southeast. The storm passed between central Tonga and Niue about 1800UTC 07Jan and

by 0000UTC 09Jan, had been absorbed by the much larger circulation of Tropical Cyclone Susan.

The greatest damage from Tropical Cyclone Ron occurred on the Tongan island of Niuafo'ou (population 735). About 67% of the buildings were either damaged or destroyed. Many of these were Tongan fales (thatched houses). Agricultural losses were also severe. Between 80 and 90% of coconut and breadfruit trees were damaged, and losses of food crops such as taro, kape, manioc, and bananas were estimated at 95%. "The Tonga Chronicle" reported that it would take about five years for crop production to return to pre-cyclone levels. The cost of rehabilitation (houses, food, water, etc) is estimated at $T1.1 million. Fortunately no deaths were reported.

Some damage was also reported on the Tongan islands of Niuatoputapu, Tafahi, and Vava'u but was generally not as severe as on Niuafo'ou.

## Susan (11P): 03 - 09 January 1998

Tropical Cyclone Susan developed from a disturbance which had been tracked since around 20Dec when it was just north of Tokelau. Over the next two weeks the system drifted very slowly west-southwestward. At 0000UTC 03Jan, warnings were issued on the system which was then located west of Rotuma, and Susan was named 6 hours later with the center placed about 450 nm north of Fiji. Susan intensified rapidly, and only 18 hours after being named the storm had reached hurricane force. Tropical Cyclone Susan initially moved slowly westward, then turned to a west-southwesterly course. On the afternoon of 05Jan the storm came within about 225 miles of Port Vila, Vanuatu as it reached its peak itensity of 125 knots. The cyclone posed a severe threat to Vanuatu, but recurved in time to spare the country a direct hit.

After turning away from Vanuatu Susan tracked toward the southeast and accelerated. On 07 and 08Jan Susan passed close enough to Fiji to cause gales in the westernmost islands of the group.

After passing by Fiji Susan continued accelerating on a southeasterly course converging with that of Ron. Cyclone Ron was absorbed by the system by 0000UTC 09Dec and Susan was becoming extratropical by 0600 UTC about 725 nm east-northeast of Auckland, New Zealand. Winds remained well above hurricane force as Susan made the transition to a vigorous extratropical cyclone.

Overall, damage from Susan was minor. However, high seas, heavy swell and storm surge inundated Talaulia village in Kadavu and partly destroyed beach-fronts, roads, jetties and bridges on the island. Beqa island was also affected by high seas and swell. Some damage due to tornadic winds in a feeder band occurred at shops in Lautoka, a port city in western Viti Levu.

## Tui (16P): 25 - 27 January 1998

The depression from which Tui developed was first identified about 225 miles northwest of Apia, Samoa around 0000UTC 25Jan. The system moved slowly on a south-southeasterly course for most of its life. Tropical Cyclone Tui was named at 2100UTC 25Jan about 50 miles northwest of Apia. At 0000UTC 26Jam the center was very close to Asau AWS (WMO 91740).

After crossing Western Samoa Tui intensified slightly, reaching a peak intensity of 45 kts around 1800UTC 26Jan when located about 75 miles south-southwest of Pago Pago, American Samoa. Thereafter, Tui remained quasi-stationary just to the south of Samoa and weakened. Tui was downgraded to a depression at 0600UTC 27Jan and remained in the vicinity of Samoa for several more days.

Tropical Cyclone Tui was a short-lived cyclone whose winds did not reach storm force. The system passed over the eastern part of the island of Savai'i, Samoa causing relatively minor damage but unfortunately causing one death. A young boy was electrocuted when he stepped into a puddle of water livened by a power line brough down by wind.

## Ursula (17P): 29 January - 02 February 1998

A new developing depression was located about 125 miles north-northwest of Tahiti at 0600UTC 30Jan. The system was moving slowly to the southeast. By 1800UTC 30Jan gale intensity had been reached and the cyclone was named Ursula when it was located about 150 nm northeast of Tahiti. Over the next few days Tropical Cyclone Ursula moved on a southeasterly course which took it parallel to and just southwest of the Tuamotu Archipelago.

Ursula accelerated considerably during 31Jan, and by 0000UTC 01Feb the storm was located far to the southeast of Tahiti. The system continued moving rapidly southeast, cought in the west-northwesterly flow, towards the open central South Pacific Ocean.

## Veli (18P): 31 January - 03 February 1998

A tropical depression formed on 31Jan about 250 miles east-southeast of Manihiki Atoll, Northern Cooks. The system began moving east-southeastward, passing about 125 miles north-northeast of Tahiti around 1200UTC 01Feb.
Like Ursula, Tropical Cyclone Veli passed south of and nearly parallel to the Tuamotus. However, unlike the earlier cyclone, Veli did not get caught up in the westerlies and race off to the southeast. The system slowed near 144º West, and drifted slowly southward and weakened. By 1800UTC 03Feb, decayed to a tropical depression.

Tropical Cyclones Ursula and Veli caused damage to three islands in the Tuamotu group: Mataiva, Rangiroa, and Makatea. Mataiva was the worst struck with 39 houses damaged, bridges down and roads washed away. Makatea had 5 houses damaged and operations at the airstrip on Rangiroa were disrupted by wash-up of coral and sand. Ursula was the stronger of the two with damage due to pre-cyclone swell rather than winds. Fortunately there was no loss of life.

## Wes (19P): 31 January - 05 Febrauary 1998

A weak circulation, the remains of Tui, stayed in the vicinity of Samoa for several days. This eventually redeveloped about 125 miles northwest of Apia and was recognised as a potential tropical cyclone about 0600UTC 31Jan. The depression drifted slowly eastward and strengthened, becoming Tropical Cyclone Wes at 0600UTC 01Feb about 200 miles northeast of Pago Pago. Wes initially continued moving on an easterly course, passing about 50 miles south of Nassau, Northern Cooks at 1800UTC 01Feb. At 0600UTC 02Feb the cyclone was moving east very close to Suwarrow Atoll.

After this point, Wes slowed and began to move in a general southeast direction. At 0600UTC 03Feb the system was centered about 225 miles northeast of Palmerston Island, Southern Cooks. By 0000UTC 04 Feb the weakening cyclone had become quasi-stationary near the Southern Cooks. Wes was downgraded to a tropical depression at 1200UTC 04Feb and gales ceased about 0000UTC 05Feb.

## Yali (29P): 18 - 27 March 1998

A well-defined low pressure system was identified in the Southwest Pacific on 18 Mar and drifted to the southwest between Vanuatu and the Solomon Islands while slowly strengthening. Yali was named at 1800UTC 19Mar, located about 350 miles northwest of Port Vila, Vanuatu. Soon after, Yali commenced a recurve to a southeast track.
For the next two-and-a-half days Yali continued on its southeastward course, passing west of the main islands of Vanuatu but finally coming close enough to brush the southernmost islands of Tanna and Aneityum. Yali reached hurricane force at 1200UTC 21Mar when located about 100 miles west-northwest of Port Vila, Vanuatu. The center of the hurricane passed about 60 miles west of Port Vila around 0000UTC 22Mar but no strong winds were reported. Peak intensity of 70 knots with an estimated central pressure of 965 hPa was attained at 0600UTC 22Mar when Yali was centered about 80 miles south of Port Vila, which reported winds of only 11 kts and a pressure of 992 mb. (It is possible that the low wind reading was due to poor exposure of the instrument.)

By 1800UTC 22Mar Tropical Cyclone Yali had reached its eastern-most position about 200 miles southeast of Port Vila. The upper ridge to its north had intensified, increasing shear and suppressing convection; consequently Yali began to weaken to below hurricane force. At the same time a mid-level intensifying anticyclone to the south began to impact the system with an easterly flow turning the system towards the southwest. Yali continued to move southwest and weaken during 23Mar.The wind field at this time was becoming quite asymetric; gales were extending much further to the south than the north. Matthew Island, about 130 miles southeast of the center, reported easterly winds of 40 knots. The main convection at this time was about 140 miles south of the center.

At 1200UTC 23Mar Yali was located about 125 miles east of Noumea, New Caledonia with 45 knot winds near the centre. The weakening cyclone passed just south of New Caledonia late on 23Mar as it continued on its southwest track. By 0000UTC 25Mar an upper cut-off low had captured the cyclone with cold air cumulus working around the west and north sides of the circulation. Yali had now lost its tropical characteristics.
Yali underwent a transformation over the Tasman Sea comming under the influence of a double jet structure (equatorward entrance / polar exit), and strong cyclonic vorticity advection at 500 hPa. The system deepened rapidly and moved quickly towards New Zealand where considerable damage was caused including one death.

Some of the southernmost islands of Vanuatu (Aniwa, the northern and western portions of Tanna, and the southern and western sides of Erromango) suffered rather severe damage from Yali. About 60-70% of the crops and 30% of the houses were badly damaged by winds with some damage to roads on Tanna. Both Tanna and Aniwa had suffered from a drought before the cyclone so stocks of food already quite low. Only minor damage was reported elsewhere in Vanuatu.

## Zuman (31P): 29 March - 06 April 1998

The tropical depression that was to develop into Tropical Cyclone Zuman was first noted about 300 miles northeast of Port Vila, Vanuatu at 2100UTC 29Mar. The system moved slowly west towards the northern islands of Vanuatu, and at 1200UTC 30Mar developed into a tropical cyclone and was named Zuman continued moving westward until around 0600UTC 31Mar as it steadily strengthened, then took a turn to the southwest and intensified quite rapidly. The cyclone moved across the north of the island of Espiritu Santo around 0000UTC 01Apr with sustained estimated at 80 knots. Zuman weakened slightly while crossing the island but soon recovered from the effects of having been over land. Winds remained near 80 knots through 0000UTC 03Apr as the cyclone moved on a fairly slow track to the west. The cyclone recurved to a southeast track about 1800UTC 03Apr, and began to weaken and accelerate embedded in a shearing northwest flow.

The cyclone brushed the entire eastern coast of New Caledonia, passing between the mainland and the Loyalty Islands on 05Apr. The center of Zuman passed a little less than 100 miles east of Noumea at 1800UTC 05Apr. Winds had decreased to about 40 knots by this time and the system was downgraded to a depression about 6 hours later.

The remains of the original vortex induced a depression along a cloudband and tracked southwards towards New Zealand This secondary system produced several short bursts of heavy rain in the far northern and northeastern parts of North Island, New Zealand before slipping away toward the Chatham Islands and eventually into the higher latitudes of the South Pacific Ocean.

The island of Espiritu Santo sustained heavy damage due to Zuman with the eastern and northeastern parts of the island affected most severely. The most serious damage was to dwellings and coconut trees, seriously affecting the island's major industry, copra. All semi-permanent houses in Hog Harbour were partly or completely destroyed. Other towns hard hit were Port Olry and Luganville. No reports of fatalities have been received.

## Alan (36P): 19 - 26 April 1998

A tropical disturbance had been tracked since 1800UTC 17Apr east of the Northern Cooks. By 0600UTC 19Apr, a depression was developing weakly about 300 nm southeast of Manihiki Atoll in the Northern Cooks. The depression continued to organise very slowly over the next several days, moving slowly north. The system was upgraded to Tropical Cyclone Alan at 1800UTC 21Apr and was located about 150 miles eastsoutheast of Manihiki as it began to move west.

Alan remained a weak, minimal tropical cyclone and eventually turned south and was downgraded at 1200UTC 23Apr close to where it was named two days earlier.

Over the next 24 hours the system became better organized again and warnings were resumed at 2100UTC 24Apr. Alan had by this time begun to move to the eastsoutheast and was located about 300 miles westnorthwest of Tahiti. Alan moved very near or over the Society Islands of Maupiti, Bora-Bora and Raiatea. These islands had been heavily damaged by Tropical Cyclone Osea. Maximum winds of Alan at this time were about 40 knots.

Drung the night of 25Apr (UTC) the strong shear tore the system apart and the morning visible imagery revealed the fully exposed low level circulation about 135 miles northwest of its expected position. At 1800UTC Alan was downgraded a second time to a tropical depression. The weakening system continued to drift generally to the southeast and then south. Although weak and diffuse, Alan was not without casualties. There were 8 fatalities caused by the storm, mostly due to mudslides caused by the torrential rain. One report mentioned 6 deaths on the island of Tahaa which had winds gusting to 50 kts.

## Bart (37P): 28 April - 03 May 1998

At 1800UTC 28Apr a tropical depression near 15° South 144° West was identified as developing towards tropical cyclone category. The system was part of a very large area of low pressure which contained the remains of Alan.

At 1800UTC 28 Apr the centre was located about 350 miles east-northeast of Tahiti, in the midst of the Tuamotu Islands. Around 1200UTC 29Apr, stations in the vicinity were reporting 2 to 3 hPa pressure falls per 24 hours with strong winds. Hau (WMO 91944) reported easterly winds of 25 knots at 1200UTC 29Apr. By 1800UTC Hau was reporting southeast winds of 35 knots, and the pressure had fallen a further 5 hPa. Tropical Cyclone Bart was named at this time centered near the island of Hau.

Bart initially began moving fairly quickly to the south-southeast, but a blocking ridge strengthened on 30Apr to the south and caused the cyclone's motion to slow down. Bart's winds peaked at 45 knots on 30Apr and began to weaken steadily on 01May. Satellite imagery around 0000UTC 01May showed that the main convective area had been sheared about 60 miles to the southeast of the exposed low-level center.

The system was downgraded to a depression at 0600UTC 01May but there were still gale strength winds in the southern semi-circle. After 1200UTC 01May, Bart began to accelerate again in an east-southeast direction.

There were reported to be 10 fatalities (drownings when a boat was upset by wave action) caused by Tropical Cyclone Bart.

Tropical Cyclone Bart developed farther east than any previous cyclone in this long and active South Pacific season, although it did not move as far east or south as Ursula. Both are remarkable as being among the furthest east occuring cyclones in any season.