RSMC NADI – TROPICAL CYCLONE CENTRE

TROPICAL CYCLONE SUMMARY
2000-2001 Season

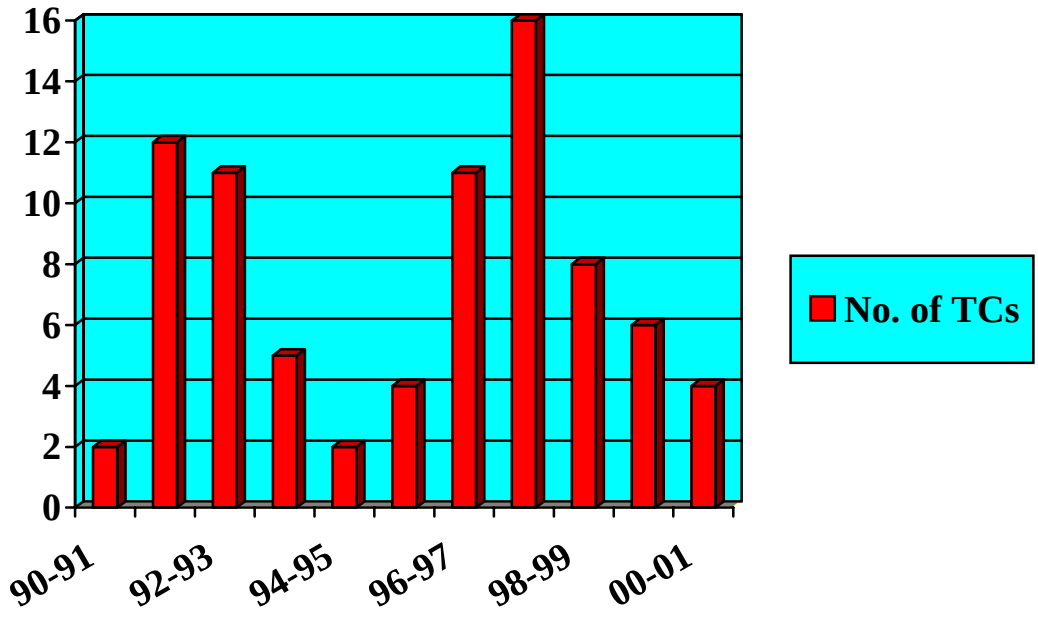
Introduction

A summary is presented of tropical cyclone activity during the 2000/2001 Tropical Cyclone Season for the Regional Specialised Meteorological Centre Nadi - Tropical Cyclone Centre (RSMC Nadi-TCC) Area of Responsibility (AOR) covering from Equator to 25°South Latitude and 60°East to 120°West Longitude.

Tropical Cyclone activity during the 2000/2001 Tropical Cyclone Season in the RSMC Nadi AOR was well below average with the occurrence of a total of only four tropical cyclones. This was a continuation of the downward trend since the 1997-98 TC Season (refer **Figure 1**) when the region was arguably at its most active phase, at least in the last 20 years or so. Of the four tropical cyclones that formed, only one attained hurricane force intensity.

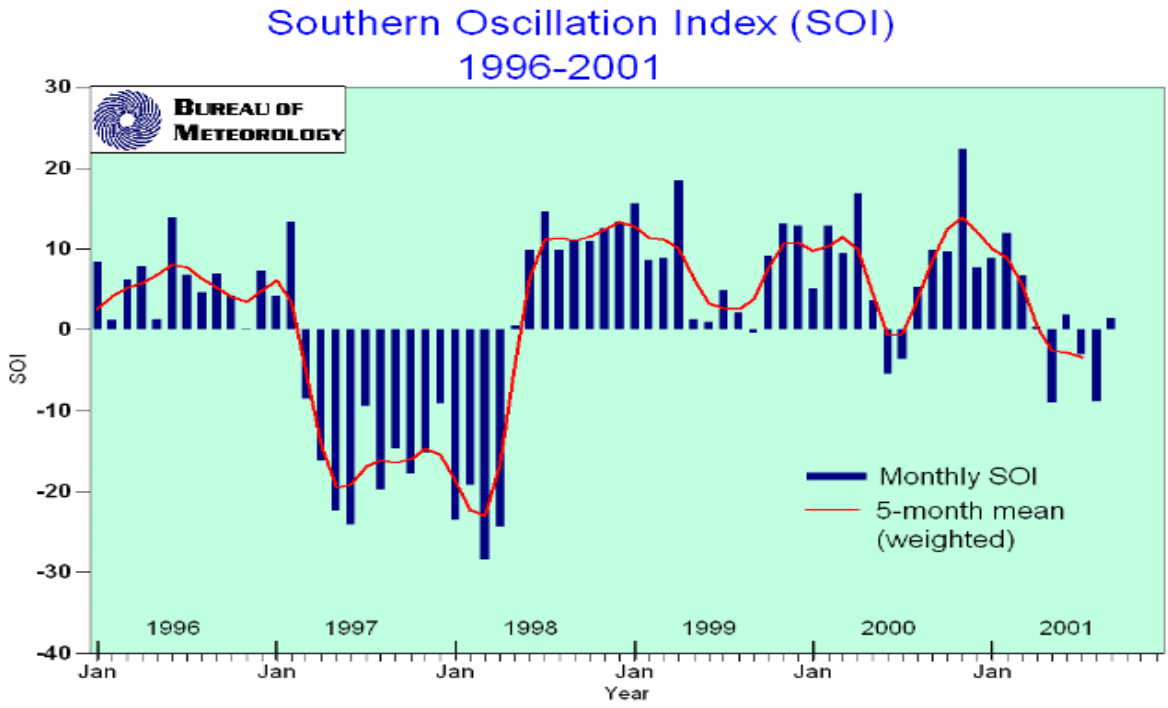
Perhaps intriguing, though not unique, the first half of the 2000/2001 Season (November, December and January) was tropical cyclone-free. From records available, the last time this occurred was during the 1944/1945 TC Season about 56 years ago.

Figure 1: Tropical Cyclone Activity in RSMC Nadi AOR in the last 10 Seasons.



ENSO generally hovered about the neutral during the 2000/2001 Tropical Cyclone Season, a pattern it assumed since mid-1998, after recovering from one of its coldest episodes to date. Monthly values of the Southern Oscillation Index (SOI) (refer **Figure 2**) were +22 in November, +8 in December, +9 in January, +12 in February, +7 in March, 0 in April and -9 in May. Neutrality was perhaps better reflected in the fact that two of the total four cyclones developed over the Coral Sea region, while the other two, to the east of the Dateline (refer **Table 1**).

Figure 2 **Southern Oscillation Index values vs 5-Month Running Means for the period January 1996 to September 2001.**



As in the last Season, both tropical cyclones developing east of the Dateline formed further south than their counterparts in the Coral Sea region. This was attributed to the persistence of the cold Sea Surface Temperature (SST) anomaly about the equatorial region, east of the Dateline. Additionally, *Oma* and *Rita* did not undergo extra-tropical transition till well into the sub-tropics, as opposed to *Paula* and *Sose*. This was, to a greater extent, the consequence of the northward migration of the colder SST anomaly together with stronger upper westerlies west of the Dateline throughout the Season.

TC Oma was more of a hybrid, developing off a tropical upper tropospheric trough (tutt), rather than a spin-up, in a high-vorticity strip of the monsoon trough.

Table 1. **Tropical Cyclones in the RSMC Nadi area of responsibility, for the 2000-2001 Season. All dates and times are in UTC[1].**

	Low first identified			Initial tropical cyclone phase			
Name	Date	Lat.	Long.	Date	Time	Lat.	Long.
Oma	18 Feb	17.1°S	162.1°W	20 Feb	0600	21.3°S	163.9°W
Paula	25 Feb	10.9°S	163.5°E	26 Feb	0600	12.2°S	164.9°E
Rita	27 Feb	19.5°S	139.0°W	01 Mar	0000	19.7°S	136.5°W
Sose	04 Apr	13.5°S	170.0°E	05 Apr	1800	14.0°S	165.5°E

[1] UTC - Universal Co-ordinated Time (same as Greenwich Mean Time)

Name	Maximum Intensity (knots)					End of Tropical Cyclone Phase			
	Date	Time	Lat.	Long.	Int.	Date	Time	Lat.	Long.
Oma	21 Feb	0600	24.8°S	158.9°W	55	22 Feb	1200	36.0°S°	150.0°W
Paula	02 Mar	0000	21.1°S	179.0°E	95	04 Mar	0600	29.0°S	172.0°W
Rita	02 Mar	0600	20.6°S	134.6°W	45	05 Mar	0600	32.0°S	134.0°W
Sose	08 Apr	0000	18.6°S	167.9°W	60	11 Apr	0600	26.5°S	169.5°E

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. It must be noted here, that the Australian Tropical Cyclone Workstation (ATCW) verification programme, which is used by RSMC Nadi, is sensitive to insufficient data. Consequently, *Oma* could not be verified, beyond the 12-hour forecast positions.

Overall, initial position errors for individual cyclones showed a general decrease, at least for the past five seasons. However, the large error contributed by *Oma*, by virtue of being a hybrid developing under strong vertical shear, kept the aggregate to within similar values as those for the past seasons.

At 12 hours, the aggregate revealed forecasts performing better than persistence. This has shown a marked improvement, despite the large errors associated with *Oma*, when compared with the past five seasons.

Again, at 24-hours, the aggregate reveal that forecasts showed skill over persistence. Compared with the previous five seasons, position forecast errors have maintained a significant decreasing trend.

Table 2. Position forecast verification statistics for official warnings issued by RSMC Nadi. Forecast positions are verified against the official best track. Persistence errors (in brackets) are included for comparison. *Oma* could not be verified beyond 12 hours due insufficient data.

Lead-time	0 hours		12 hours		24 hours	
Name	Mean error (km)	Number	Mean error (km)	Number	Mean error (km)	Number
Oma	110	17	143(247)	5	-	-
Paula	19	23	80(107)	18	176(258)	15
Rita	19	14	120(120)	10	163(219)	18
Sose	18	22	98(90)	19	170(245)	17
Aggregate	39	76	100(117)	54	180(278)	46

In **Table 3**, 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) for all cases, except for *Oma*. The aggregate, however, revealed a value within the threshold. Therefore the warning positions 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, as reflected by *Oma*. *Sose's* relatively large easterly bias was attributed to difficulty in forecasting the cyclone's southwest turn when it was persistently heading southeast.

Table 3. Centroid of errors for initial (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 in 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
Oma*	-14, 39	94	-98, 73	108	-	-
Paula	-4, -2	24	-33, -8	69	-107, -10	129
Rita	5, -6	30	4, -54	101	14, -73	148
Sose	8, 2	15	74,6	65	159, 10	111
Aggregate	-1, 7	53	7, -6	97	-4, 11	173

***** *Oma* could not be verified beyond 12 hours due to insufficient data.

Figure 3 : **Tracks of Oma, Paula, Rita and Sose.**

Tropical Cyclones in the RSMC Nadi Area of Responsibility (AOR), 2000-2001.

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

Oma (08F) : 20 - 22 February 2001

The first tropical cyclone of the 2000/2001 Tropical Cyclone Season in RSMC Nadi's AOR developed from an upper-level cut-off low (TUTT) which spun its way down to the surface about 300 nm[2] west-northwest of Rarotonga in the Cook Islands around 19/1800 UTC. Prevailing conditions at the time were quite favourable for cyclogenesis, with warm SSTs around 30ºC and weakly sheared environment. Through the night hours of the 20th, 08F underwent very rapid development, with deep convection erupting over the Low-Level Circulation Centre (LLCC) (exposed during the previous daylight hours). Cloud tops steadily cooled while the whole convective concentration increased spatially. Cold convective bands were also seen to wrap tightly around the LLCC. Subsequently the system was named around 20/1800 UTC while located about 180 nm southwest of Rarotonga and moving towards the southeast at about 10 to 15 knots. However, in retrospect, TC Oma could have been named before 20/1200 UTC.

Oma then accelerated to about 20 knots toward the southeast, rapidly intensifying to reach storm intensity at 21/0000 UTC. Peak intensity of 55 knots was attained six hours later at 21/0600 UTC. However, 6 hours further on, it was downgraded to a gale at 21/1200 UTC. It was around this time, as the cyclone was rapidly moving towards New Zealand's AOR under a strong northwesterly steering regime, that primary responsibility for warnings was subsequently handed over to RSMC Wellington. Oma was declared extra-tropical at 22/1200 UTC, some 1000 nm south-southeast of Rarotonga.

The first Special Weather Bulletin for Rarotonga and Mangaia in the Southern Cooks was issued around 20/2053 UTC, when Oma was about 180nm to the southwest of Rarotonga. Against initial expectations, gales suddenly developed over these islands, when very strong surface convergence, and subsequent active convection, erupted in the general eastern semi-circle. Maximum winds recorded at Rarotonga were gale force with gusts to 70 knots. Despite this, damage over the Southern Cooks was mainly to crops, vegetation and a couple of houses used for outside cooking, unroofed.

Paula (09F) : 26 February - 04 March 2001

Tropical Depression (09F) was first identified embedded in an active monsoon trough just south of the Solomons, or about 210 nm northwest of Espiritu Santo in Vanuatu, at 25/1800 UTC. It was then lying under an upper outflow centre and drifting slowly southeast. Shear was minimal. SST was around 30º C. By 26/0000 UTC, due to a surge in surface flux, convection suddenly erupted close to the LLCC though it was confined to the northern and eastern quadrants. Convective bands also began to wrap around the LLCC with increased curvature. With deep convection around the centre expanding spatially and cooling further, atmospheric pressures at the surface dropped steadily. QuikScat and SSM/I data on the local evening of the 26th confirmed that gales were persisting in the northeastern semicircle of the system. Consequently, 09F was named Tropical Cyclone Paula at 26/1200 UTC while located about 120 nm northwest of Espiritu Santo in Vanuatu.

[2] nm = nautical mile = 1.15 statutory mile

Paula was then moving southeast at about 10 knots with gales confined to within 90 nm of the centre in the northeastern semicircle, but rapidly intensifying. The system then began to rotate in a clockwise loop under a weak steering current. Six hours later, at 27/0000 UTC, Paula reached storm category. By 27/0600 UTC and while completing the loop, the cyclone developed a small CDO with a ragged eye-like feature. At 27/1200 UTC hurricane intensity was attained as the eye was becoming better defined with marked increase in overall organisation and convection. The cyclone was then located about 90 nm northwest of Espiritu Santo and beginning to accelerate southeast while still intensifying.

With a slightly cloud-filled eye, Paula moved across Vanuatu, making landfall just north of Port Vila around 28/1200 UTC with winds of 85 knots close to the centre. Special Advisories for Vanuatu commenced around 25/2344 UTC, some two and a half days earlier, when it was anticipated that TD-09F would reach tropical cyclone status within the next 12 to 24 hours and pose a threat to the country. The final one was issued at 0230 UTC on March 1st. In all, fourteen Special Advisories were issued for Vanuatu at six hourly intervals.

Fiji was first put on *Tropical Cyclone Alert* in the first Special Weather Bulletin, issued around 28/0330 UTC, when it was anticipated that Paula could move reasonably close to the country and possibly cause damaging gale-force winds or stronger by early March 2nd. This was later upgraded to a *Tropical Cyclone Warning* with prediction of Damaging *Gale Force* Winds for Southwest Viti Levu, Yasawa and Kadavu around 28/1730 UTC when the need became apparent. Vatulele, Beqa and nearby smaller islands, as well as Lomaiviti and Southern Lau, were later included in subsequent issues. At 0800 UTC on March 1st the *Gale Warning* for Vatulele, Beqa, Kadavu and nearby smaller islands was upgraded to a *Storm Warning* as Paula further intensified. However, this was downgraded to a *Gale Warning* around 01/2000 UTC when the cyclone was rapidly moving away from the area. The final Special Weather Bulletin for Fiji was issued around 01/2300 UTC as the cyclone raced away from the country. Altogether, there were eighteen Special Weather Bulletins issued for Fiji. The closest Paula came to any part of Fiji was around 01/1800 UTC when the cyclone passed about 90 nm south-southwest of Kadavu. Paula, after re-analysis, peaked around March 02/0000 UTC, with 95 knots.

After Paula had passed Fiji, it steadily accelerated southeastward under increasing northwesterly steering current into an environment of very strongly vertical wind shear. Under the conditions weakening was imminent, with peak winds dropping from 90 knots to 60 knots in a period of 30 hours. Primary responsibility for warnings was officially handed over to TCWC Wellington at 03/0600 UTC with the cyclone at marginal hurricane intensity and weakening further. Paula became extra-tropical at 04/0600 UTC when it was located about 850 nm east-northeast of the northern tip of New Zealand.

In Vanuatu, many locally-styled houses, gardens and tree crops were destroyed in the northern parts while in Port Vila many yachts were either sunk or set adrift and a number of small coastal ships were forced aground. One death was reported in central Vanuatu. OCHA (Office for the Coordination of Humanitarian Affairs) reported that damage was sustained to 45-50% of homes and gardens, 35% of water supplies, 20% of schools, 15% of medical centres and to 25% of other infrastructure.

In Fiji, surge and swell generated by Paula caused severe damage to the Coral Coast coastline of the main island of Viti Levu. A number of homes especially in this area were also damaged or destroyed, together with crops including sugar cane and vegetation.

Minor landslides were also reported and roads were closed due to floods, fallen trees and sea-borne debris. Preliminary damage assessment in these areas estimated that damage totalled around $F2-3 million. In Tonga, pounding surf extensively damaged *The Good Samaritan Resort* at Kolovai on the west coast of Tongatapu, while badly damaging a wharf on the nearby island of Eua.

Rita (10F) : 1 - 5 March 2001

A tropical disturbance was first identified at 0000 UTC on 27 February as it drifted slowly southeastward just southeast of Hao in the Tuamotu Group. At this time, the disturbance was embedded in an active SPCZ and positioned slightly north of a diffluent upper ridge. During the next day the system was significantly influenced by southerly wind shear, which displaced its cloud canopy to the north and exposed the LLCC to the south. However, overnight on the 28th, convection began to develop close to the centre, against the shear and diurnal variations. SST was around 30°C. With the active eastward-progressing MJO cycle, potential for development into a tropical cyclone was high. By 28/2000 UTC convection had continued to increase about the centre with further cooling of cloud tops. 10F was consequently named Tropical Cyclone "Rita" while located about 210 nm northeast of Mururoa and moving slowly southward under a weak northerly steering field.

By 02/0000 UTC, overall convective organisation showed significant improvement resulting in a small CDO-type feature appearing with cloud tops cooling steadily. Based on this, the intensity was increased to storm category at 02/0600 UTC as Rita moved towards south-southeast at about 05 knots. However, convective tops warmed rapidly thereafter under strong wind shear with steady signs of weakening. The system was subsequently downgraded to gale intensity six hours later.

After 02/1200 UTC, Rita turned toward the south and into strong northwesterly wind shear. The strong subtropical ridge to the east steered the system more south-southwestward, resulting it its passage just northwest of Rikitea. The cyclone maintained this track and intensity as it moved into TCWC Wellington's AOR after 03/1800 UTC. Rita retained its circulation and identity as a cyclone for at least another 36 hours after exiting Nadi's AOR. It finally became extra-tropical around 05/0600 UTC while located about 500 nm south-southwest of Pitcairn Island.

Sose (13F) : 5 - 11 April 2001

A weak disturbance was first identified on April 3rd located about 180 nm east-northeast of Espiritu Santo, Vanuatu. It was then drifting northwest at about 5 knots along a quasi-stationary convergence zone. Upper-level shear was quite evident with consequential dense cirrus outflow making low-level centre location extremely difficult. By the 4th, the system reached tropical depression stage under a developing upper-level outflow pattern which significantly improved overnight. SST was around 30°C, and shear also began to ease a little, thus allowing for organization. TD-13F continued to track west-northwestward just north of Espiritu Santo throughout the 5th, still substantially being affected by diurnal effects. However, by 05/1200 UTC convection about the centre and overall organization showed a marked improvement, with spiral bands feeding into the central feature. Potential for development into a tropical cyclone at this stage was considered high. Subsequently, the first *Gale Warning* was issued mentioning the anticipated presence of gales in the next 12 hours. By 05/1800 UTC, with convection erupting about the centre, the system was upgraded to Tropical Cyclone and named

“Sose”, while located about 60 nm northwest of Espiritu Santo and moving slowly westward.

At 06/0000 UTC shear and diurnal effects were somewhat pronounced on Sose, exacerbated by frictional interference from the mountainous landmass of Espiritu Santo located about 90 nm to the east-southeast. The cyclone lingered about this area for almost 24 hours as it was blocked by an intense middle-level subtropical ridge to the south. By 06/1800 UTC an approaching middle-level trough from the west and the subsequent collapse of the mid-level subtropical ridge finally allowed for a southeast movement. Surface convergence then improved under good upper outflow in all quadrants. Though effects of environmental entrainment were apparent, overall organisation and convection especially in feeder bands were still increasing markedly. Consequently, at 07/0000 UTC the cyclone was upgraded storm category while located about 60 nm west of the northernmost tip of Espiritu Santo and moving southeast at about 10 knots. Six hours later convection had increased around the central area resulting a well organised CDO. By 08/0000 UTC the CDO had become more compact with spiral bands wrapping tightly around it. Intensity was subsequently raised with maximum average winds now estimated to be 60 knots close to the cyclone centre. This was incidentally Sose's peak intensity. A slow-moving surface subtropical high pressure system over New Zealand latitudes forced the tightening of the pressure gradient to some 400-500 nm to the south of the system. Consequently, gales spread further out from the cyclone circulation. However, this area of gales gradually diminished as Sose moved further south and started losing intensity.

As Sose steadily tracked to the southeast, it was gradually being subjected to increasing vertical wind shear, enhanced by an approaching upper level trough. However, the cyclone was also running into a strong mid-level ridge, which effectively blocked any further eastward movement and forced it to deflect towards the south. Under the circumstances, the CDO top was sheared off to the southeast while the low-level circulation was steered southward. With consequent weakening, the cyclone was downgraded to gale intensity at 09/1800 UTC while located about 180 nm to the southeast of New Caledonia and drifting towards the south-southwest at 05 knots. Primary responsibility for further warnings was eventually handed over to TCWC Wellington soon after 10/1200 UTC when the system was entering its AOR. Eighteen hours later Sose became extra-tropical roughly 150 nm north-northeast of Norfolk Island.

In Vanuatu a 6-year old boy was swept away whilst trying to cross a swollen river at Nawalala Village on Espiritu Santo with his father. An inter-island vessel, the M.V. Omale, also sank in heavy seas off the coast of Malo Island near Espiritu Santo. Fortunately, all its 16 passengers and crew made it ashore safely after spending four hours in the water. Villages on the south coast of Espiritu Santo and in the vicinity of Luganville, the main town on the island, suffered from flooding which cut off roads and destroyed crops already adversely affected by Cyclone Paula that passed the area a month earlier. Some 59 houses were completely destroyed and 101 houses partially damaged by wind. On tiny Ahamb Island, four classrooms and all food crops left by Paula, plus those planted since, were destroyed. On Ambae, buildings were damaged and at least two schools lost classrooms. In Port Vila, 50 people were evacuated due to flooding. Power lines were brought down and roads were blocked by floodwaters and accumulated debris. Roads and water catchment areas were also blocked and reservoirs sustained damage from the debris. Most school classrooms and crops were destroyed. On the island of Mare in the French territory of New Caledonia, a 37-year-old man was reported missing and feared drowned after he got swept away by a large wave. This occurred while he was reported to be watching huge waves crash into the Island's high cliffs at night when one engulfed him. Sose’s large circulation, combined with the effect of a high pressure system

near New Zealand generated huge waves that battered portions of Australia's East Coast. Reports of waves up to 8 metres were recorded at Cape Moreton and waves in the 4-5 metre range battered the Gold and Sunshine Coasts. There were two cases of drowning reported in Queensland on the 8th when large swells forced into an area usually protected from southeasterly swells.

References:

1. ***Australian Bureau of Meteorology web site***, http://www.bom.gov.au/, for Monthly SOI values and 5-month running mean, from 1996 to September 2001.
2. ***Fiji Meteorological Service*** – Individual reports on the above-mentioned tropical cyclones.