APPENDIX 14

Roger Badham

"Post-Race Weather Review"

"POST-RACE REVIEW"

457

A METEOROLOGICAL PERSPECTIVE OF THE 1998 HOBART RACE (by Roger Badham)

MY BACKGROUND

1

I am a meteorological consultant and for 20 years I have specialised in the marine field with almost a total dedication to yachting and yacht racing. I have been involved in all the major yacht races around the world as a forecaster over the last 15 years. I have a PhD in meteorology and have taught marine meteorology both at university and TAFE. Most of my work for the last 10 years has been out of Australia and I concentrate on specific yacht race research as well as detailed marine forecasting.

2

I have forecast for yachts in the Hobart race from 1977. Since 1986 I have offered a commercial service that centres around a weather package that includes a description of the predicted conditions on a day by day basis, with accompanying weather maps, etc. The package also discusses the best course with respect to current and wind etc. In the late 1980's I was the official race forecaster, doing the briefings and also all the forecasts for the Hobart race as well as the then Southern Cross Cup. When the America's Cup moved to San Diego, I was no longer available for this role and the task reverted to the Bureau of Meteorology. My involvement in the race naturally centres around the better, more fancied, yachts as they are prepared to pay for the service and they have skippers and navigators who frequently work with me in other races, particularly overseas.

3

I have quite a detailed forecasting knowledge of all the major yacht races around the world. In 1980, I worked at the UK Met Office on a Churchill Fellowship and spent considerable time discussing with many people, both in the Met Office and also the sailing community, the forecasting problems etc to do with the Fastnet Storm in 1979. A full report of that study, particularly looking at radio broadcasts for sailors/mariners was completed and a copy sent to the BOM.

THE METEOROLOGICAL SITUATION AND MODEL GUIDANCE FOR THE RACE
(see section 33 for a summary of the development)

4

The general development and situation was well forecast by the numerical models, but until the 26th, there was a great deal of uncertainty about the actual location and intensity of the low pressure system. With hindsight, the USA models (MRF) picked it the best and earliest, with the Australian model (GASP) varying somewhat but being particularly good on the morning of the start, while the ECMWF was probably the least accurate of that group.

5

It needs to be pointed out that the numerical models do not provide the forecast. they supply guidance to the forecaster and it is the forecaster's task to pick and choose from the information at hand and construct the forecast accordingly. The model output is vast, with arrays of weather variables; perhaps the most useful for the marine forecaster are the lowest level winds, sometimes at the lowest model level (height of 40 to 120 metres) and other times 20 or 10 metre surface winds. The wind vectors from the models are, by the nature of the models, somewhat conservative; in a light wind situation they often over read while in a strong wind situations, they often under read. The models never forecast extreme events with good accuracy nor will they simulate the extreme sharp horizontal wind boundaries that have been observed around intense low pressure systems.

THE BRIEFING (THU 24th DEC)

6

I attended the briefing (as I usually do) and I have to say that on this occasion that the standard of the briefing from the Bureau's representative was very poor. For approximately 20minute period nearly every weather feature that could possibly develop along the various sections of the race track was discussed. Most of this was quite superfluous to the task and only in the last few minutes was the actual forecast

conditions addressed and then he stated that; "as the models were presently disagreeing with the outcome, he would only give the briefest of outlooks and that everyone would have to wait until the morning of the race." While the uncertain statement is true, there had been some consistency over the days leading up to the morning of the briefing. In my opinion it would have been much more beneficial for the audience had he focussed on the 3 most likely outcomes as indicated by the models.

7
During that week leading up to the 24th December, I had been working very closely with the navigator from 'Wild Thing' (Steve Kemp) and 'Sayonara' (Mark Rudiger) and while the actual outcome was not certain, we had discussed, at length, the 3 likely scenarios. They were:

A
for a low pressure system to form south of Tasmania and the associated trough/front combination to dominate until the fleet were well into Bass St, then for the winds to go NW and then SW at 20-30 knots. This showed a race record very likely.

B
for a low pressure system to form well east of Tasmania with the trough/front arriving earlier and the winds going quickly SW and then subsequently S-SE depending upon the following ridge of the high pressure system. This would not be a record breaking race as it appeared that the ridge and softer winds would get to the race leaders across Bass St.

C
for a low pressure system to develop in Bass St or close to Bass St. That would hasten the arrival of the front/trough and then give SW/30 to 40 knots behind the front, until the low moved east the following day.

8
All these scenarios were discussed on a daily basis and at that stage I favoured A then B and to a lesser extent C. On the morning of the start, I finally went for B and C combination. The point is that the guidance available from the 4 major models (Australia, Europe, USA and UK) made it possible to present 3 likely scenarios and at the briefing, the likely wind strengths of each possibility should have been discussed.

9
I must again stress here that although my actual forecast was not that good with the intensity or positioning of the low pressure system, both navigators said after the race that they felt fully briefed and knew at all times what was happening and how the situation was going to unfold.

MY INPUT TO THE RACE AND OBSERVATIONS
10
I had input to quite a number of yachts on the morning of the event; several simply took the package with no discussion; some had a brief (5 minute maximum) discussion and a few wanted an in depth discussion of all the likely scenarios. The yachts that maximised my time on race morning were; Sayonara, Wild Thing, Brindabella, AMRO and B52. Of these, AMRO and Wild Thing pulled out early, the 2 maxis made it through ahead of the nastiest winds, while B52 suffered badly.

11
Rob Mundle has used me on an informal basis for quite a number of years (circa 1983) to brief him on the weather conditions, both in the lead up to the start as well as during the race. This is generally a one sided relationship; ie he calls when he wants something. This time, after the race had started, I actually called him on 4 occasions... on each occasion to update the likely severity of the developing low pressure system and the implications for the fleet.

12
Mundle called on the morning of the start and asked for update. At that stage, I favoured the low pressure system to form off the Tasmanian east coast and briefed him with the strong running conditions that afternoon and night, then severe electrical storms and then SW winds of 30 to 40 knots with an absolute maximum of 50 knots.

13
I called Mundle later in the afternoon 26th and told him of the updated model output from the 00Z runs (11am) and that the low was now almost certain to form in eastern Bass St and that 50 or more knots of wind would be seen by many of the boats; particularly the middle to back end of the fleet late on Sunday 27th. I thought the severity of the situation was similar to 1984 and unlike the situation of 1993 where the low persisted for some 3 to 4 days and moved steadily southwards with the fleet. At this time, I also attempted to call the yacht 'Wild Thing' and warn them of the impending development with much stronger winds and nasty seas. As it was a brand new boat, I felt they should be aware of the probable conditions. I did not make contact (nor did I really expect to) as their mobile phones were off, however, I left a message which they did not get until they reached Eden (the next day) after pulling out of the race.

14
On Sunday (27th) morning I called Mundle after seeing the 6am observations, the 3am weather map and the 12Z model output. He was not available (flying to Hobart) but I left a detailed message with him, stating that the situation looked very grim for the boats that would enter Bass St later that afternoon and night. The 6am observations showed Wilson's Prom with 71 knots of mean wind speed and although the Prom over reads some 25 to 33% in wind speed, this was a very significant observation and that 50 to 60 knots seemed certain. It also occurred to me at that time, that the 'nastiest' winds were probably in a thin elongated band on the western flank of the low pressure. Such a phenomena has been reported in the literature in the last few years (Pedgley D 1997. WEATHER Vol 52 No 8 p230-242) with similar intense low pressure systems, where a 'low level jet' structure develops in a narrow band around the low.

15
After the 9am observations, I drew a local weather chart for the region and played around with what I thought might be happening on the western flank of the low pressure system. I called Mundle again (now in Tasmania) and informed him of the Prom observation of 250 degrees at 79 knots gusting 92 knots and reaffirmed my belief that the boats would be hit with excessively strong winds and large nasty seas right off the SE tip of Gabo Is at the the confluence of the currents. I believe that I told him that the worst conditions would be between 3pm and 3am the following morning and I estimated that more than half the fleet would be knocked out.

16
The wind reading from the Prom is very significant, even though the channelling and funnelling that occurs across the Prom and the lighthouse causes the anemometer to grossly over read. In all my forecasting experience I can only recall a few occasions where the winds at the Prom have recorded 79 knots or above, and I do not recall ever seeing gusts of 92 knots. This is certainly in the top 1% of readings for that station and nearly all of those occurrences would be during winter. I intend to purchase the data from the BOM and statistically analyse that reading.

THE BUREAU OF METEOROLOGY FORECASTS
17
The BOM forecasts varied somewhat in their ability to convey the correct information to the sailors. There were several sources of BOM forecasts available to the sailors during the race.
The official race forecasts supplied by the Sydney and then the Hobart Offices were made available by the radio relay vessel, Young Endeavour. As well, there were the regular coastal forecasts; NSW coastal waters forecasts from the NSW Office, the Bass St forecast from the Victorian Office and the regular

500

Tasmanian coastal waters forecasts from Tasmanian Office. These routine forecasts and associated actual observations from the reporting stations are available at set times via VHF and HF during the regular marine broadcasts from Sydney Radio and Melbourne Radio.

FORECASTS PRIOR TO THE START

18

The forecasts from all the Bureau offices were (in my opinion) very poor with their outlook for Bass St on the Sunday 27th. At that stage on the morning of the event, SW winds of 30-40 knots should have been forecast for eastern Bass St for Sunday 27th, with the situation not easing until Monday 28th.

A

The Victorian Office forecast at 6am that morning;

"EASTERN BASS STRAIT:

Northeast/northwest wind 10/20 knots ahead of a west/southwest change of 20/30 knots extending from the west during the afternoon and at night. Seas 1 to 2 metres increasing to 2 to 4 metres. Easterly swell about 1 metre decreasing with a westerly swell 2 to 3 metres developing.

Outlook for Bass Strait for Sunday. Moderating west to southwesterly wind."

B

The NSW Office at 5am was; "*South Coastal Waters: Ulladulla to Gabo Island and 60 nm seaward N/NE winds 15/20 knots, reaching 25 knots this afternoon. S'ly change 20/30 knots late tonight. Sea 1 to 2 metres, rising to 3 metres with change. Swell 1 to 1.5 metres.*

Outlook for Sunday : S/SE winds 15/25 knots. "

FORECASTS THE AFTERNOON/EVENING OF THE 26TH

19

The race forecast from the Sydney Office referenced the Storm warning, but the actual wind forecast did NOT match the warning. The outlook for the next 48 hours references gale to storm force winds south of Jervis Bay, which presumably means 40 to 50 knots. The Bass St forecast issued at 1646 hours from the Victorian Office was a better product with 45 to 55 knot wind referenced along with 4 to 6 metre seas.

A

The race forecast issued from Sydney at 1450 hours:

SYNOPTIC SITUATION: A high near New Zealand is ridging onto the central NSW coast. A low 995hPa near Lord Howe Island is slow moving. A cold front is over central Victoria.

WARNINGS: Storm Warning is current south from Merimbula.

Gale Warning is current south from Broken Bay.

WIND: North to northeast wind 20/25 knots ahead of a W/SW change 25/35 knots, with stronger gusts, expected near Jervis Bay around midnight-2am and then near Sydney around 3am-5am Sunday. Wind may tend briefly northwest 15/20 knots prior to the change.

WAVES: 1 to 2 metres, rising to 3 metres offshore with W/SW change.

SWELL: 1 to 2 metres.

WEATHER: Scattered showers and thunderstorms developing tonight ahead of the change then clearing tomorrow.

OUT LOOK FOR NEXT 48 HOURS: Winds moderating north of Jervis Bay Sunday night. Gale to storm force W winds south of Jervis Bay expected to moderate Monday evening.

B

The Bass St forecast issued from Victorian Office at 1646 hours:

EASTERN BASS STRAIT:

Northeasterly wind 20/30 knots in the far east at first. A west/southwest change at 20/30 knots extending throughout this evening and increasing to 30/40 knots tomorrow morning and to 45/55 knots during the

afternoon. Seas/swell 2 to 4 metres increasing 3 to 5 metres during the morning and 4 to 6 metres during the afternoon.

FORECASTS EARLY MORNING OF THE 27TH
20
The race forecasts were very similar to the previous issue, as were the Bass St forecast from the Victorian Office.

A
The race forecast issued from the Sydney Office at 0213 hours;
WIND: W/SW winds 25/35 knots, with stronger gusts. Winds increasing to the south of Merimbula offshore, reaching 40/50 knots this afternoon as low deepens.
WAVES: 2 to 3 metres, rising to 4 to 5 metres offshore in the south.
SWELL: 1 to 2 metres, rising to 3 to 4 metres offshore south of Merimbula.

FORECASTS LATE MORNING AND AFTERNOON OF THE 27TH
21
The race forecasts were again similar though there seems some confusion or double up from the BOM as 2 midday forecasts were issued; one from Sydney at 1209 hours and one from Hobart at 1240 hours. The confusion arises as to the fact they both cover the Bass St region. At the same time, the Bass St forecast from the Victorian Office issued at 1210 hours was superior with slightly stronger winds, higher seas and no differentiation between seas and swell... ie they are just waves.

A
The Race forecast at midday from the Sydney Office at 1209;
"WIND: W/SW 25/35 knots, with stronger gusts, increasing to 40/50 knots offshore south of Merimbula today. Wind decreasing to 15/25 knots north of Merimbula Monday and 25/35 knots south of Merimbula during Monday.
WAVES: 2 to 3 metres, rising to 4 to 5 metres offshore in the south today.
SWELL: 1 to 2 metres, rising to 3 metres in south."

B
Second race forecast issued from Hobart at 1240;
FORECAST FOR NEXT 24 HOURS:
38S to 40S...
West to southwest winds 30 to 40 knots - locally 40 to 50 knots near the Victorian coast - easing to be 25 to 35 knots by early Monday morning then 20 to 25 knots by midday. 5 to 6 metre seas slowly abating. Southwest swell 3 metres. Showers. Visibility fair to good.

C
Victorian Office Forecast for Bass St issued at 1210;
"EASTERN BASS STRAIT:
West/southwest winds at 45/55 knots easing to 30/40 knots overnight and to 20/30 knots tomorrow. Seas/swell 5 to 7 metres abating to 3 to 5 metres overnight and to 2 to 4 tomorrow."

THE BUREAU OF METEOROLOGY WARNINGS
22
The correct warning - a storm warning - was in place at all times. A storm warning is an opened ended wind warning for ex tropical waters, where the wind is observed, or forecast, to average in excess of 48 knots. It corresponds to Force 10 and above on the old Beaufort Scale.

502

23
It would appear that people's and sailor's awareness and understanding of the storm warning is perhaps not as good as it should be:

A. some are not aware of the storm warning being a wind warning.
B. that it is an open ended warning.
C. it was probably doubly confused by the term 'storm' and that fact that there was severe electrical thunderstorm activity associated with the front/trough system on the night preceding the development of the low pressure system.

24
It should also be noted here that at all times, the official race forecast was for 40 to 50 knots, so that at all times, the referenced forecast wind speeds never truly reflected the storm warning that was in place. It seems a very thin connection to forecast 40 to 50 knots of wind with a warning that references winds of 48 knots or more.

THE ACTUAL WINDS ACROSS EASTERN BASS ST
25
There are no official reporting stations in eastern Bass St, where the yachts got into trouble. Only land based observations on the Victorian Coast, the Furneaux Islands as well as the oil platforms off the Gippsland coast report on a regular basis. Clearly, from those reports, the region of strongest winds wrapping around the low pressure centre did not coincide with any of these stations, except Wilsons Promontory that sticks out well into Bass St and was definitely in that region when the low was centred west of the rhumb line on that Sunday morning. Many of the sailors have reported that they 'saw' 70 and 80 knots on their masthead units during the storm. It must be pointed out that the regular B&G masthead unit is not a reliable instrument under these very high wind conditions; they are neither calibrated for these extreme conditions and they can suffer from 'pumping' with the mast rocking. Official observations, as taken by merchant ships or land based stations are averaged over a 10 minute period with the peak gust also included, if measured. On that morning Wilsons Promontory reported a wind from 250 degrees at 79 knots with peak 10 minute gust of 92 knots.
Over the last 25 years, I can recall sometime in the late 1970's a similar frontal low developed south of Adelaide and while that low was quite intense, one of the BHP iron ore ships reported winds from the SW direction at 80 knots.
It seems that from the Wilsons Promontory report and yacht reports in the area, that the winds across the region were probably from a W to SW direction at 60 to 65 knots. The gust ratio under these wind regimes is typically 20 to 30%, so that a peak gust could have been some 12 to 22 knots above that average; namely with peak gusts in the 70's to near 80 knots and such gusts would appear to concur with the observations many sailors made of their wind instruments.

SOME COASTAL OBSERVATIONS

DATE AND HOUR - LOCAL SUMMER TIME
TWD TRUE WIND DIRECTION
TWS TRUE WIND SPEED IN KNOTS
TAIR AIR TEMOERATURE
TDEW DEW PT TEMPERATURE
PPP MSL AIR PRESSURE IN HPA
GUST PEAK GUST AT OBSERVATION TIME

WILSONS PROMONTORY

DATE	HR	TWD	TWS	TAIR	TDEW	PPP	GUST
26	15	250	26	15.0	13.9	994.3	35
26	18	250	45	12.0	12.0	992.4	57

26	21	250	53	13.2	09.1	992.6	
27	00	-	-	-	-	-	
27	03	270	41	12.5	09.6	992.0	-
27	06	250	71	12.0	11.4	983.9	81
27	09	250	79	12.5	10.0	984.9	92
27	12	260	66	12.0	11.0	990.1	91
27	15	260	57	12.5	11.0	992.1	78
27	18	270	58	12.8	11.7	995.2	78
27	21	290	48	13.2	11.7	1000.3	-

EAST SALE

DATE	HR	TWD	TWS	TAIR	TDEW	PPP
27	00	280	20	11.2	08.2	1000.2
27	03	290	17	10.6	05.9	998.6
27	06	310	21	10.2	06.6	996.7
27	09	290	28	10.8	09.0	996.8
27	12	280	36	11.4	09.4	998.2
27	15	270	39	13.0	08.9	998.9
27	18	270	34	12.8	08.2	1000.2
27	21	280	33	12.1	08.9	1003.4

PT HICKS

DATE	HR	TWD	TWS	TAIR	TDEW
27	06	270	17	12.3	08.3
27	09	270	35	13.6	08.2
27	12	270	40	13.0	09.9
27	15	270	36	11.0	11.0
28	06	270	34	13.8	12.3

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DATE	HR	TWD	TWS	TAIR	TDEW	PPP
27	09	270	17	16.6	04.9	994.8
27	12	-	28	14.8	07.1	993.8
27	15	310	30	15.0	08.1	993.5
27	18	270	25	14.0	09.1	994.4
27	21	230	45	14.0	09.1	995.4
28	03	230	38	14.0	10.4	999.7
28	06	230	28	14.0	10.2	1003.0

THE TIMING OF THE BUREAU OF METEOROLOGY FORECASTS

26

I believe that the timing of the official race forecasts is particularly pertinent. The BOM scheduled their race forecasts to be issued at 2am and 2pm during the race period. On most occasions the forecast was actually issued at around 0000 to 0100 hours and 1200 to 1300 hours local time. This is a particularly poor time for a number of reasons.

Firstly, the numerical product that the forecasters use as guidance is run twice daily at the BOM; namely at 0000Z and 1200 UTC or 1100 and 2300 hours local time. That is the time that the models are actually initialised and run; the product from these models becomes available at around 0130Z or 1330Z (ie 1230-1300 and 0030-0100 hours local time). As such, it seems to me to be impossible that any of those forecasts could have used the latest available numerical guidance.

27

504

There are no significant observations made at midnight (local time) so that detailed MSL analysis is done at 2100 and 0300 hours local time. This means that the forecast issued at 0200 hours is prepared on old observations, and old analysis chart and old numerical guidance.

28
Small low pressure system like the one that developed on this occasion, develop and intensify diurnally; ie they have favoured times of the day when they 'spin up' and intensify and this is typically in the early hours of the morning. The reason lies in the associated thermodynamics where cloud top cooling and air-water temperature differences assist in generating significant convective activity and dynamics. As well, when the development is close to land, as in this situation, the frictional differences between the land and the ocean assist in the keeping the winds confined to the ocean areas and thus makes for more low level convergence..

29
One of the major findings that came out of the Fastnet Storm was that there needed to be better timing in the delivery of the forecasts and warnings to the yacht race and that there needed to be better co-ordination or knowledge of behaviour of the meteorologists and the race organisers.

THE SEA AND SWELL FORECASTS
30
It is normal in sea state forecasts to differentiate between sea and swell... however around the intense circulation of a low pressure system, it is somewhat misleading to separate the sea states. Technically, it is sea and not swell, inside such a rapidly developing low where the winds are rising to 50 knots or more and this is even more pertinent for the shallow waters of Bass St. As well, the band of strongest winds shifted eastwards at approximately the same speed as the developing sea, and that makes for a really nasty 'Bass St type sea' develop, where large waves trains or sets of 5 to 10 minute periods develop. This same point was examined in the recent Fastnet reanalysis by Pedgley, 1997. The extra complication undoubtedly occurred where the large waves met the confluence of currents (around the cold eddy) and this must have assisted in standing the waves up - a feature described by nearly all the foundering yachts. The Victorian Office has considerable experience forecasting in Bass St with ESSO and at all times their forecasts for eastern Bass St were superior to those supplied to the race, even though the Victorian forecasts were also less than what was actually observed.

31
I would suggest that the race forecasts for sea state were ultra conservative given the wind forecasts. A wind speed of 50 knots for 9 hours can theoretically produce a maximum wave height of at least 9 to 10 metres, without taking in account the shallowness, the 'in phase' development or the opposing currents.
In November 1995, a situation presently undergoing legal action in Italy, an Italian yacht sank during a race across the Mediterranean Sea. The yacht foundered short of the Baleric Island under 'mistral' conditions when offshore storm force winds of 50 to 60 knots and 10 metre seas. Several papers have been produced on this so called 'Parsifal' storm and the size and fast development of the associated seas.
However, using the old trusted nomograms for calculating a developing sea under certain fetch and time constraints shows that 10 metre seas should have been expected in Bass St. It would seem perhaps obvious that in future race forecasts, that the role of forecasting the Bass St section of the race be given to the Victorian Office.

COMMUNICATIONS
32
I believe that there is probably room for better communication between the Race organisers and the BOM. It would also be better if the BOM provided a small team of dedicated forecasters, where there can be direct open communication of conditions etc, if necessary to the Race organisers or the Radio Relay

Vessel. I found that when I was forecasting for the race, it was in the days, when I either had to call direct the Relay vessel and relay the forecast directly to Lou Carter, or HF fax them, in the early days of satellite fax. Either way, I spoke often directly with the Relay Vessel, and any emphasis or detail or coastal station report that I thought was important could be brought to the attention of the actual person talking to the fleet at sked time.

33
The BOM has no marine weather section, though they have been proposing such a section for at least 10 to 15 years. The quality of the BOM marine forecasts suffer as a result, for it comes down the individual that is on the shift... and I frequently read coastal waters forecasts that are either wrong, poor and often at odds with their other forecasts. It is an area that requires addressing within the BOM to improve their product for sailors all around Australia.

SUMMARY OF THE SYDNEY-HOBART STORM - 27TH DEC 1998
written by Roger Badham for Australian Yachting on December 30th 1998.

34
Intense low pressure systems frequently develop around eastern Australia and the Sydney-Hobart storm on the afternoon and night of the 27th December is right up there on the nasty scale for the winds and seas that it generated. I would not classify this particular system as an 'east coast low' as some have, for it formed from a sharp cold upper trough that slowed, tilted and deepened as it engaged warm humid air drawn in on its NE quadrant. This is a text book frontal low pressure development and is quite common across the waters immediately south of Australia. The most common development with these low pressure systems is for the low to develop over the Bight waters and then travel SE while remaining west of Tasmania. Matsuyker Island frequently experiences NW winds of 50 knots and sometimes as strong as 70 knots with these situations. The region of cold upper air could be seen clearly on satellite images as it crossed the Bight on the days leading up to the 26th of December. The 'cold pool of air' became cut-off from the upper westerly flow when the system deepened to the surface during the early hours of Sunday 27th and it was this region of cold air that brought unseasonal snow to the high country of VIC and NSW that day.

The computer models gave forecasters exceptionally good guidance on how this system was to develop, however, the exact location of the low pressure formation was not really certain until during Boxing day. The MRF (USA global model) picked the development many days before while the other global models were less certain and there had been a fair amount of uncertainty in the positioning the deepening process. It is certainly unusual for such an intense and rapid development to take place over Bass St during December, so it was logical to expect that the actual location (of development) would be further to the south.

It is useful to gain an insight into how the forecasters (and yourself) might be lulled into false thinking. For much of December and certainly for the 2 weeks leading up to the Christmas period, the ECMWF (European global model) had been the preferred model on nearly every day and this model did not offer consistent guidance with this particular low pressure development in the days leading up to the race. Both the GASP (Australia) and ECMWF models were not as 'bullish' with this cold upper trough in forming a surface low; not like the MRF model but then that model has a slight tendency to want to 'spin up' perhaps too many systems like this. So prior to the start of the race, the model guidance had been very useful, sufficiently convincing as to expect the development, but the exact position and intensity was not at all certain.

The upper low began deepening on the evening and night of the 26th as the yachts surfed their way south in strong NNE winds. By dawn on the 27th, the fleet already had W-SW winds and the surface low was evident almost in the middle of Bass St.... not far to the east of Wilsons Promontory. During that day

T56

(27th) the low deepened and shifted east to cross the rhumb line at around 11am at latitude 39 S. It continued to move E-SE during the remainder of that day, before picking up speed and racing away to the SE-SSE on the 28th.

As the low pressure deepened and shifted east on the 27th, the strongest winds were not near the centre of the low, but rather on its western flank in the cyclonic circulation. At 6am through to midday, the most severe winds lay in a narrow band across Bass St from the NW tip of Tasmania to Wilsons Promontory. This band of extreme winds generated the large seas that was to hit the fleet later that afternoon and evening. An average wind speed of 50 to 60 knots for a period of 6 to 8 hours is capable of generating seas with a maximum wave height of 12 metres and an average wave height of 6 to 8 metres. Until mid afternoon, the low was west or close to the rhumb line and as such the nastiest winds and seas never hit the leading yachts. Those nastiest winds and seas appear to have reached 'the corner' and the rhumb line from mid afternoon and they continued through the evening and night. The generation of extreme seas is sufficiently complicated in open ocean waters, but in Bass St and near the 'corner' of VIC/NSW there is the added complication of shallow depths and current. All the sailors knew there was a strong set running down the NSW coast, though it ran offshore around a cold eddy positioned at 38.5 S 151 E. There appears to have been a strong set or push develop out of Bass St towards the E and NE (with the extreme winds and sea), so that there must have been a meeting of these currents in the region where the nastiest seas were experienced.

After midnight, the low pressure system began to pick up speed and pull away to the SE-SSE and as a consequence the pressures rose rapidly and the winds gradually abated. Undoubtedly the serious damage occurred on the evening and night of the 27th when a band of storm force winds and extremely large waves with shallow backs moved in across the rhumb line and that coincided with the bulk of the mid to smaller sized yachts heading out into Bass St. At 9am that morning, Wilsons Promontory reported an average wind of 79 knots from 250 degrees, gusting to 92 knots. The storm force winds that swept the fleet were not that strong, but it does appear that a narrow band of 55 to 70 knot winds did operate for a time. The Bureau's storm warning is the correct warning for those conditions, but the referenced winds in their forecasts were generally 40 to 50 knots and at most 45 to 55 knot winds - substantially down on what was observed. As well, the forecast sea heights appear to have been substantially underestimated.

Fig 1
Output from the MRF (USA) model for the 27th at 11am, from a run of the computer model and available on the morning of the 22nd December 1998.
acknowledge: NOAA

Fig 2 (top image)
Output from the Bureau of Meteorology meso model for the 27th at 11am, from a run of the computer model on the 26th at 11am and available at 2pm that afternoon.
acknowledge: BOM

Fig 3
Output from the AVN (USA) for the 27th at 5pm, from a run of the computer model on the 25th at 11pm and available at 6am on the morning of the start. This output is for the lowest model level at circa 40m above sea level.
acknowledge: NOAA

Fig 4 (top image)
Output from the Bureau of Meteorology GASP model for the 27th at 11pm, from a run of the computer model on the 25th at 11pm and available at 7am on the morning of the start.
acknowledge: BOM

Fig 5
MSL analysis for the 27th at 00Z (actually based on 9am data).

acknowledge: BOM.

Fig 6
MSL analysis for the 27th at 03Z (actually based on noon data).
acknowledge: BOM

Fig 7
MSL analysis for the 27th at 06Z (actually based on 3pm data).
acknowledge: BOM.

Fig 8
Visible satellite image of the fully mature low at 0500Z (4pm) on 27th from NOAA 14.
acknowledge: CSIRO Marine Research, Remote Sensing Facility, Hobart.

Fig 9
IR satellite image at 15Z (2am) on the 26th - the morning of the start. The trough cloud can be seen over Bass St as well as a cold front approaching Bass St at 140 E with a region of very cold air on its western side.
acknowledge: JCU, Townsville and JMA