REPORT ON TORNADO INVESTIGATION - PORT MACQUARIE, JULY 1962

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Abstract: An on-the-spot investigation was made three days after Port Macquarie on North Coast New South Wales was struck by two small but intense tornadoes, which left a trail of devastation across the town. From inspection and eye-witness reports the nature of the major damage and the paths of the tornadoes were obtained. The damage is illustrated by photographs and diagrams. There was some evidence that the sense of rotation of the tornadoes was different, one being anticyclonic.

The synoptic situation prevailing about the time of occurrence and the condition of the atmosphere with reference to stability are discussed. A list of the noteworthy features of these tornadoes is given.

1. INTRODUCTION

In the early afternoon of Monday, 9 July 1962, the New South Wales North Coast holiday resort of Port Macquarie was struck by two small but intense tornadoes which claimed three lives and caused damage estimated in excess of £60,000.

Originating as waterspouts at some distance out to sea they crossed the coast almost simultaneously and about half a mile apart. The more destructive of the two moved on an almost straight westerly heading across the town leaving a trail of devastation a little more than two miles in length and varying from fifteen to one hundred yards in width. The other, apparently less intense, moved in from the northeast causing severe damage along a strip which was generally less than 50 yards across. The last evidence of its existence as an identifiable tornado was found just under a mile to the southwest of the spot where it first crossed the coast.

The on-the-spot investigation (by the author) was not commenced until three days after the event, by which time cleaning-up operations were well under way; but even then the path of the more destructive tornado could be easily identified over most of its length from any high vantage spot.

The three days devoted to the investigation proved insufficient for the collection of all the available information on extent of damage and to obtain a full description of events associated with the passage of the tornadoes. Particularly lacking was any dependable and accurate information on the sequence of events. However, from the collated descriptions by more than one hundred persons it was possible to reconstruct a reasonable picture of what happened both prior to and during the tornadic passage. All accessible sections of the tracks and areas well beyond their limits were examined, but a severe handicap in the search for information on wind speeds and senses of rotation was the rapid progress of tidying-up operations.

There is strong, if not completely conclusive, evidence to support the belief that although the shorter-lived and less destructive tornado possessed the normal cyclonic sense of rotation, the second (marked II in Fig. 1) was rotating anticyclonically. Some of the evidence for and against this contention is presented in Section 3.
Fig. 1 Map of Port Macquarie showing paths of Tornadoes.
Section 2 consists of a description of the more significant broadscale features of the tracks and a reconstruction of events based on the distribution, nature and severity of damage, as well as on eye-witness reports (often, however, found to be inconsistent with information implicit from the distribution of damage and treated as less reliable than the latter), press and other photographs. Unfortunately, however, no photographs of the pendant cloud, either in the waterspout or tornadic stages, could be located.

In Section 4, is given a brief discussion along the lines suggested by Southern (1960) of the prevailing synoptic situation.

Section 5 discusses a few interesting features of the Port Macquarie tornadoes, including an observation from which it should be possible to make an estimate of the order of magnitude of the wind speeds involved.

2. FEATURES OF THE TRACKS AND RECONSTRUCTION OF THE PASSAGE OF THE TORNADOES

Figure 1 is a scale map of the town of Port Macquarie showing the paths of the two tornadoes as reconstructed from inspection of the damage and consistent, so far as this was possible, with the various eye-witness reports. The nature of the major damage along the tracks is indicated according to the code shown.

Over most of their length the width of the bands of major destruction was not much in excess of 20 to 25 yards with minor damage also contained for the most part within a 75-yard wide strip. An exception to this generalisation was the area between Bridge and Gordon Streets where at times the apparent width of the track carved by Tornado II was well in excess of 100 yards. Throughout the length of Tornado I the most severe damage was found on the left flank where, almost without exception, fallen trees, bushes, and television antennae lay parallel to the track. On the right flank there were several instances of trees and TV masts lying anti-parallel to the direction of the motion. This is discussed further in Section 3.

With the notable exception of parts of Gordon Street the damage caused by Tornado II showed the opposite pattern, viz. the most severe damage was to be found on the right flank.

There is general agreement among eye-witnesses, and it is confirmed by the orientation of the tracks, that both tornadoes originated as waterspouts out at sea, probably in excess of a mile from the coast. A number of persons reported having seen two waterspouts moving slowly southward and their appearance was variously reported as resembling an inverted pyramid, a pillar of water, a hand with five fingers down-stretched, and a huge ice cream cone extending downward from the cloud. Most persons remarked on the "ominous" and "confused" appearance of the eastern sky. At noon the sky was more than half covered by cumulus and stratocumulus with a layer of altostratus above and, from descriptions of the appearance of the cloud base, it is inferred that well developed mammatus was present by 12.45 p.m.

Tornado I

Observations from Hindman Street, Stewart Street and the Fort Macquarie High School ((b) in Fig. 1) indicate a fairly slow southwestward movement onto the coast about half a mile south from the entrance to the Hastings River. Students, and at least one master, at the High School had been watching a waterspout, which was apparently almost stationary at a quarter to half a mile from the coast, for about 15 minutes before it struck at about 12.55 p.m. Most persons are agreed that the landfall of the tornadoes (there is reason to believe that I preceded II by a matter of a few minutes) was accompanied, or immediately preceded, by a single loud peal of thunder. On this basis the observer at Fort Macquarie Pilot Station reported past weather as "thunderstorm" in the 3 p.m. observations. Reports of a "fireball" at about this time could not be substantiated and only a few people mentioned having seen lightning discharges.

Crossing the coast suddenly, and virtually without warning, the centre of the tornado appears to have passed just to the left of a group of tall pine trees in front of the High School, stripping numerous branches from the three southernmost trees. The proprietress of the Burrawan Hotel (c) confirmed reports from High School students that these pine trees were momentarily bent almost to the ground.
Fig. 2 Sketch of damage at locality [b] of Fig. 1.
Fig. 3 Sketch of damage at locality [c] of Fig. 1.
Fig. 5 Sketch of damage at locality [r] of Fig 1.
As the tornado advanced towards the Manual Science Block, (b) in Fig. 2, a student endeavou ring to close a northeastern window was sprayed with salt water and struck on the face by a piece of seaweed. Aluminium roofing, twisted beyond recognition, was later retrieved from as far as a mile away, and a section of aluminium roofing found in ti-tree swamp beyond the western limit of Fig. 1, if it came from the High School - as seems almost certain - was carried for a distance of more than three miles.

From the Burrawan Motel, (c) in Fig. 1 (see also Fig. 3), the proprietress, Mrs. K. Mason, heard a loud roar and saw a huge pillar of rain or spray coming in from the sea and advancing towards Burrawan Street. She recognised countless seabirds being carried around and upwards before the entire scene was blotted out by torrential rain and salt spray. The windows of the motel were later found to be coated with salt and numerous injured seabirds were found on the lawn.

As the tornado moved downhill across Owen Street the severity of the damage decreased somewhat, but severe damage was again apparent in Lord Street where two houses were severely damaged and a garage demolished completely. Residents in this area agreed that the arrival of tornadic winds followed the clap of thunder within a matter of seconds. This is indicative of fairly rapid movement in from the coast. The photograph, Plate 1, taken looking southwestwards from behind the second house, is typical of the fate which befell much of the stripped roofing iron.

After crossing a swamp area where, although reeds lay downstream, there was little evidence of its passage, the tornado worked uphill towards Searview Avenue.Apparently regaining destructive power it shifted a house on its stumps and removed all but the foundations of a garage. Beyond the crest of the hill, there was however, little evidence of the passage of a tornado apart from a few missing roof tiles and broken T.V. antennae. One resident in this area described a relatively harmless whirl which stripped lantana flowers and scattered them on the lawn but did little more. It would appear that this point marked the end of surface activity of Tornado I, although there is evidence that debris which it lifted was carried northwesterly to and beyond Hindman Street, preceding the arrival of Tornado II in that area by a minute or less.

Tornado II

There is no definite evidence to indicate the exact location at which this tornado crossed the coast but residents in the area who had observed it as a waterspout were of the opinion that it was moving southwest towards Flynn's Beach before turning and moving across the coast from the eastsoutheast near the eastern end of Hill Street.

After felling a television mast and a palm tree (see (g) in Fig. 1, and on a larger scale Fig. 4) it carved a narrow track of devastation diagonally towards Cross Street. A garage was completely demolished behind one house (Plate 2 shows what remained of the concrete foundations) and the side fence was flattened with sections falling in opposite directions, but the building itself remained virtually undamaged.

The northeast corner of the adjoining house (which was unoccupied at the time) appears to have been lifted a short way and dropped heavily. Most of the stump caps had shifted and concrete footpaths adjacent to the building had cracked in several places. This is illustrated by Plate 3. Plate 4 shows the distortion of the initially straight fence between the two houses following the tornado passage. Causing less extensive damage as it moved downhill between two houses in Cross Street (Plate 5), the tornado moved almost due westward to King Street where three men were working inside a partly completed house. As it passed almost directly overhead, the building lifted, turned almost 30 degrees in an anticlockwise direction and collapsed. The result can be seen in Plate 6. The occupants suffered only minor injuries. Continuing on a westerly heading from Owen to Lord Street, it unroofed the buildings in its path and tore the limbs from a huge weeping fig tree. Eye witnesses from the western end of Burrawan Street observed the tornado to approach from the south before veering away to the west. A number of houses along Gray Street, which appear to have been directly in the path of the tornado, escaped undamaged. This could be due to the effect of "skipping" or "zig-zagging" of the path. Several residents who were questioned were unable to say which actually occurred, and since most of the small scale damage had been repaired the explanation for this behaviour must remain open.
The tornado left little or no evidence of its passage across the swamp area between Lake Road and the Historic Cemetery, but from there to Horton Street it left a wide trail of devastation as it crossed Kooloonbung Creek via the traffic bridge and then moved west between Bridge and Gordon Streets.

Within a few minutes of hearing a loud clap of thunder, an eye-witness at the Service Station (a) in Fig. 1 heard a loud roar as an eastward-facing window collapsed and numerous motor car tyres were blown towards Kooloonbung Creek. A motorist turning into Gordon Street from Horton Street tried to stop but the car was carried on to the bridge by the force of the wind. A pine tree of 6 ft girth was torn from the ground and collapsed beside the road. Branches from trees on the southern side of the bridge fouled telephone lines and large limbs fell across the road. Trees up to 2 ft in girth beside the bridge were snapped off at eye-level.

An eye-witness at (r) in Fig. 1 heard a heavy clap of thunder followed within minutes by a roaring wind and he watched as television antennae began to collapse on the opposite side of Gordon Street. The top and one side of a petrol bowser at (r) in Fig. 1 (see also Fig. 5) were blown off and carried back towards the bridge. The glass top of the bowser hit the roadway and shattered. Roofs of houses in the block diagonally opposite (r) were seen to begin to lift and loose sheets of iron were torn off. One roof was seen to rise slowly to the base of the cloud (estimated by an ex-Air Force Pilot to be at a few hundred feet), beginning to rotate as it rose and eventually flying to pieces, with debris showering in all directions. Heavy rain was falling and in the words of another eye-witness "the sky seemed to be filled with trees and branches and bits of houses".

No clear picture emerges of the passage of the tornado from Hollingsworth to Hindman Streets. The majority of buildings in the two blocks suffered some structural damage but the apparent random pattern of major destruction must be attributed to some factor other than the structural weakness of certain buildings. In the opinion of the author the description by one eye-witness who claimed that he could see the tornado zig-zagging violently may well be accurate. This possibility has an important bearing on establishing the sense of rotation of the storm, to be discussed briefly in Section 3.

Along this section of the track numerous windows were shattered and garages and other outbuildings were razed.

Nearing the western end of Gordon Street the tornado added three lives to its toll. A partially completed two-storey building collapsed as the tornado struck and the men died in the wreckage which is shown in Plate 8. Westward across Hindman Street a brick home was severely damaged and trees on either side were snapped off at roof top level. Mud was splattered inside the house as windows shattered. The adjoining building on the left was untouched. Major damage continued to the crest of the ridge and numerous trees broke off at a height of about 20 to 25 feet from the ground (See Plate 9). Thence the tornado moved downhill across a partly-treed area but the only evidence of its passage was a trail of debris from the shattered buildings.

Half a mile further west a fresh trail of damage resulted as the tornado snapped off a 40 ft tree and twisted a partially completed house in an anticlockwise direction (see Plate 10). Fifty yards further on, in Hudson Street, a garage was demolished and a home partially unroofed. This was the last evidence that could be found of the direct effect of tornadic winds. A mile further west at Port Macquarie aerodrome shortly before an East-West Airlines aircraft was due to arrive, sheets of roofing iron and other debris were seen floating westward like pieces of newspaper high in the sky, but there was no evidence of a tornadic circulation. As a precautionary measure the approaching aircraft was radioed to bypass Port Macquarie.

3. SENSE OF ROTATION OF THE TORNADOES

There is little doubt that Tornado 1 possessed normal cyclonic rotation. As already discussed, the most severe damage occurred in a narrow strip to the left of the track. Fine branches carried back across the road on the extreme right of the path at (a) provide further evidence of cyclonic rotation. It was noted that branches of comparable size were carried less than a quarter of the distance backward that those on the left hand side were carried forward.
Assuming the damage on the left side to be the effect of a 90 kt wind, this would give a circulating wind component of 60 kt, and a speed of movement of about 30 kt. This is admittedly a crude estimate of the speed of translation of the tornado, but the figures appear reasonable.

The distribution of damage to the High School is consistent with cyclonic rotation, and further evidence is provided by the distribution of the damage in the vicinity of the Burrawan Motel as sketched in Fig. 3.

Much more surprising is the distribution of damage and the disposition of debris along the track of Tornado II. Fig. 4 shows the assumed track and the layout of damage in the Hill Street area. The severity of damage is most evident on the right hand side of the affected area. This, of course, is not by itself proof of anticyclonic rotation, for almost the same pattern of damage could be produced by (say) a 50 kt cyclonic circulation being translated at 50 kt. What is significant is the fact that on the left hand side of the track there is also definite evidence, in the form of a flattened paling fence and a fallen pipe, of a strong westerly wind.

Confirmatory evidence of a similar nature is provided by the behaviour of the petrol bowser at point (r) as sketched in Fig. 5. The anticlockwise rotation imparted to the building in King Street, and particularly also in the case of the twisted building at West Port near St. Clare's caravan park, is regarded as definitely indicative of anticyclonic rotation but is nevertheless far from conclusive.

Contrary evidence is found in the Gordon Street area where a large motel sign (Plate 7), on the left hand side of the path of damage, leans in a westerly direction. This would be consistent with anticlockwise spin if, and only if, the tornado had passed to the south of it. There is reason to believe that the tornado was in fact zigzagging in this area, but a survey of the damage provided insufficient justification for sketching such a track.

In summary it may be stated that all evidence points to the cyclonic rotation of Tornado I, while in the case of Tornado II, although there is a certain amount of apparently conflicting evidence, there are strong grounds for supposing it to have rotated anticyclonically.

4. THE SYNOPTIC SITUATION

It is of value for the purposes of compilation of a tornado climatology to study the broadscale synoptic properties of the atmosphere in the region where a tornado occurs. However, since the tornado is a phenomenon whose initiating cause is not to be found on the scale of the synoptic chart, it is generally not possible to attribute its development at the particular place and time to any specific cause beyond the local enhancement of a state of considerable instability by, and in conjunction with, some mechanism unknown.

The U.S. investigations of Fawbush and Miller have produced a set of criteria by which the macrostate of the atmosphere can be judged as favourable or otherwise to tornadic development. The applicability of these criteria to the Australian region has been discussed by Southern (1960).

The synoptic situation of 9 July was not one which would on first appearances be expected to produce violent storms. However, a closer study reveals the presence, though not in any marked degree, of most of the prime requirements for the possible release of violent instability and hence, other micro-scale factors being favourable, the development of tornadoes and waterspouts.

During the period 3 to 7 July an intense high pressure system had moved slowly from the western Bight to the vicinity of southeast New South Wales. At the same time a rather complex upper cold trough had moved eastward from Western Australia and on the morning of 7 July the 500 mb trough lay southeast to northwest across southern Queensland with a cold pool lying back over northern New South Wales. The surface 'high' subsequently moved out to the Tasman Sea and built up a ridge to the southwest. By the morning of 9 July the main centre of the 'high' was located south of Tasmania and pressures were falling along the northern New South Wales coast as a trough in the easterlies developed southwards from the Coral Sea. Fig. 6 shows the surface chart for 0900 hr 9 July. A closed upper cyclonic circulation and a pool of cold air lay over northern New South Wales.
Fig. 7  Shear Hodograph, Williamtown 0900 EST 9 July 1962.
Examination of the upper contour and isotherm patterns and the shear hodographs for Eagle Farm and for Williamtown (Fig. 7) gives no indication of increasing instability over the northern New South Wales coast. The Showalter thunderstorm indices for Williamtown, Eagle Farm and Lord Howe Island were respectively +1, +5 and +3.

However, inspection of the 2300 GMT (0900 EST) soundings for Williamtown and Lord Howe Island (Fig. 8) reveals the presence of a moist layer near the surface, surmounted by a deep layer of drier air with a vertical temperature distribution such that the composite layer was convectively unstable. The decrease with height of the potential adiabatic wet bulb temperature to about the 10,000 foot level indicates that if this layer were subjected to broadscale lifting violent convection could be released. This is quoted as one of the prime requirements of an incipient tornado situation. On its own, however, it is not sufficient. Some lifting mechanism is necessary to release the instability. The synoptic situation of 9 July provides a possible mechanism to produce the required broadscale ascent in the form of convergence in the trough lying just off the coast.

It thus seems likely that considerable instability in the air mass which lay over Fort Macquarie at 13 hr on 9 July was released by this mechanism. Other subsidiary synoptic requirements, if present, were not strongly in evidence and are not discussed.

Assuming the deductions concerning sense of rotation of the two vortices to be correct, it would be interesting to speculate on their respective paths in relation to the "steering" wind, against the background of theories which predict such a configuration (notably that of Wagener (1928), which in principle is the same as that currently in favour in the Russian literature). This is not done here.

5. NOTEWORTHY FEATURES OF THE FORT MACQUARIE TORNADOES

(i) Rain

Torrential rain, described by some eye-witnesses in the path of the tornadoes as the heaviest they had ever seen, appears to have been confined to a fairly narrow belt along the paths, but no actual registrations were available apart from the Port Macquarie Pilot Station which recorded 45 points in the 3 hour period from noon to 3 p.m.

(ii) Hail

Reports of hail were confined to a small area about a quarter of a mile to the right of Tornado II to the west of the town.

(iii) Thunder and Lightning

The majority of residents reported a single clap of thunder before the tornado struck, but a minority mentioned a continuous rumble for some minutes. Reports of a fireball are interesting. Workers in the U.S.A. have found a number of unusual electrical effects associated with tornadoes and a sferics method of tornado tracking has been devised. At 1300 hr on 9 July, the Queensland sferics network made a first class fix on a point about 50 miles east of Port Macquarie.

(iv) Sound

All persons in the immediate path of the tornadoes reported a deafening roar, but on the other hand the author spoke with a number of persons, who were working (indoors) within a quarter of a mile of Tornado II and knew nothing of the event.

(v) Appearance

While over the sea the appearance seems to have been typical of the waterspouts which are not infrequently observed off the coast. From a selection of photographs of tornadoes and waterspouts shown to eye-witnesses, a number of persons chose as most nearly resembling the Port Macquarie phenomenon photograph DW D18 of a film strip series entitled "Storms", produced by Diana Wyllie Ltd., London.
Fig. 8 Aerological diagram for Williamtown and Lord Howe Is. for 0900 EST 9 July 1962.
Wind Speed Involved

It is the impression of the author that wind speeds within about 10 feet of the ground probably reached the order of 100 knots but may have doubled this value above the surface. These are semi-quantitative estimates from the shape and size of objects damaged or carried along by the wind. The situation illustrated in Plate 7 would provide an excellent opportunity to deduce an order of magnitude for the wind speed at the 10 ft level. The calculation awaits the receipt of usable data on the strength of the steel posts supporting the motel sign.

Speed of Translation

No reliable figures are available, but it seems from the sequence of events and the estimates of persons who watched Tornado II, as it moved perpendicular to their line of sight, that it was of the order of 30 to 40 mi/hr.

Pressure Reduction

There was no evidence of "exploding houses" although a number of windows of buildings directly in the path shattered outwards.

Updraught

Numerous objects were observed to be carried upwards within the tornado and the sea birds observed from the Burrawan Motel appear to have been carried upwards in a path spiralling around the periphery of the "core".

The body of a dog, allegedly possessed of a "stay-at-home" nature, was found in the destroyed building in Gordon Street, three-quarters of a mile from his home at (k) in Fig. 1. It seems quite possible that he was lifted from the ground in the vicinity of his home and carried aloft, to be deposited moments later in the Gordon Street area.

Downdraught

Although no conclusive evidence was found for the existence of a central downdraught, it seems reasonable to attribute the bodily injury to the seabirds to their being carried into a strong downward current in the core of the tornado and hurled onto the ground.

Severity of Damage in Relation to Topography

With a few exceptions, the most severe damage occurred on those parts of the track where the tornado was working uphill and there appeared to be a "damage shadow" just beyond the crests of the hills.

Associated Seismic Effects

The shattered concrete paths, as illustrated in Plate 3, could have been the result of the sudden jarring which would have been produced had the house dropped heavily back onto its stumps; or they could have been the work of minor ground movements which have frequently been found to accompany tornadic passages in the U.S.A. One resident nearby mentioned experiencing the sensation of an earth tremor.

6. CONCLUSIONS

As stated earlier, the investigation was to a certain extent deprived of valuable details by the rapidity with which the residents of Fora Macquarie went about restoring the town to its former picturesque state. The individual eye-witnesses' accounts, if it had been possible to record all the details, would have filled an interesting book. In summarising the major features of these reports in Section 5, the author has leaned more heavily on the general impression gained in conversing with residents than on any compiled tabulation of characteristics.
ACKNOWLEDGMENTS

The co-operation and assistance of the people of Port Macquarie is gratefully acknowledged, with special mention of the assistance given by Sergeant Clifford of the Fort Macquarie Police and Dr. N. E. McClaren of Hindman Street who lost sections of the roof of his brick home and a number of out-buildings and who gained, in addition to the experience of the passage of a tornado, a number of sheets of green roofing iron, a pair of workman's overalls and an assortment of bath towels.

REFERENCES


Wagener, A. 1928 Zeitschrift Fur Met. 45.