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THE BATHURST BAY HURRICANE AND ASSOCIATED STORM SURGE

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Abstract: A review of the hurricane which passed over Bathurst Bay, North Queensland, in March 1899 - the worst ever experienced in Queensland from the point of view of loss of life and shipping.

1. INTRODUCTION

There are many reasons for a closer examination of the Bathurst Bay hurricane of 5 March 1899; among them we may list the following:

(i) It was perhaps the most intense cyclone ever to cross the Queensland coast, a central pressure of 27 inches of mercury (914 mb) being recorded.

(ii) It destroyed a pearling fleet with the loss of over 300 lives.

(iii) Observations indicate that the eye of the storm passed directly over the anchored pearling fleet.

(iv) A storm surge of over 40 ft height accompanied the landfall of the cyclone. This may well be an Australian record.

(v) An erroneous popular explanation as to the origin of the cyclone is in vogue, and is quoted from time to time in the press. The legend is to the effect that two cyclones clashed over Bathurst Bay and caused the disaster.

(vi) The cyclone was preceded and accompanied by intense electrical activity.

2. GENERAL

This cyclone has been briefly discussed in Results of Rainfall Observations made in Queensland (1914) and by Visher and Hodge (1925) and its track mapped. It originated in the north-west Coral Sea. In the suddenness of its development and the lack of heralding strong winds on the Queensland coast it bears a striking similarity to the Bowen cyclone of 1958. The cyclone was preceded and accompanied by intense electrical activity, and sferics, had it been known in 1899, would have probably provided a useful forecasting aid.

It was unfortunate that the cyclone struck on a Saturday night, since in those days no Sunday weather chart was drawn. It was also unfortunate that barometers on New Caledonia were out of order prior to the event. In any case, no radio or other communication with the pearling fleet was possible in the Peninsula in those days, even had a warning been available.

The author has had access to the following sources of information in addition to those quoted above:

(i) Original rainfall and climatological returns.

(ii) 9 a.m. weather charts prepared by the Queensland Government Meteorologist (C.L.Wragge).

(iii) The Outridge Booklet.

The Outridge Booklet, so called for want of a better name, was published by the Outridge Printing Company as a memorial to those lost in the disaster, in particular Alfred and Harold Outridge, owners of part of the pearling fleet, who both perished. The booklet is a veritable mine of information and contains, inter alia, chapters on the pearling industry, tabulated statement of vessels wrecked and lives lost, weather reports and charts, description of the hurricane, experiences of the different schooners, some statements of survivors, etc.

The present day reader should bear in mind that in 1899 weather reports were limited to 9 a.m. reports only from the Australian mainland and New Caledonia. No reports were available from the Indies, New Guinea, the Solomons, Norfolk Island, Lord Howe Island or the New Hebrides, and Willis Island was unknown.

3. THE ANTECEDENT WEATHER AND THE DISPOSITION OF THE PEARLING FLEET

On 4 March 1899, the following were anchored at the north west end of Princess Charlotte Bay - see Figs 1 and 2:

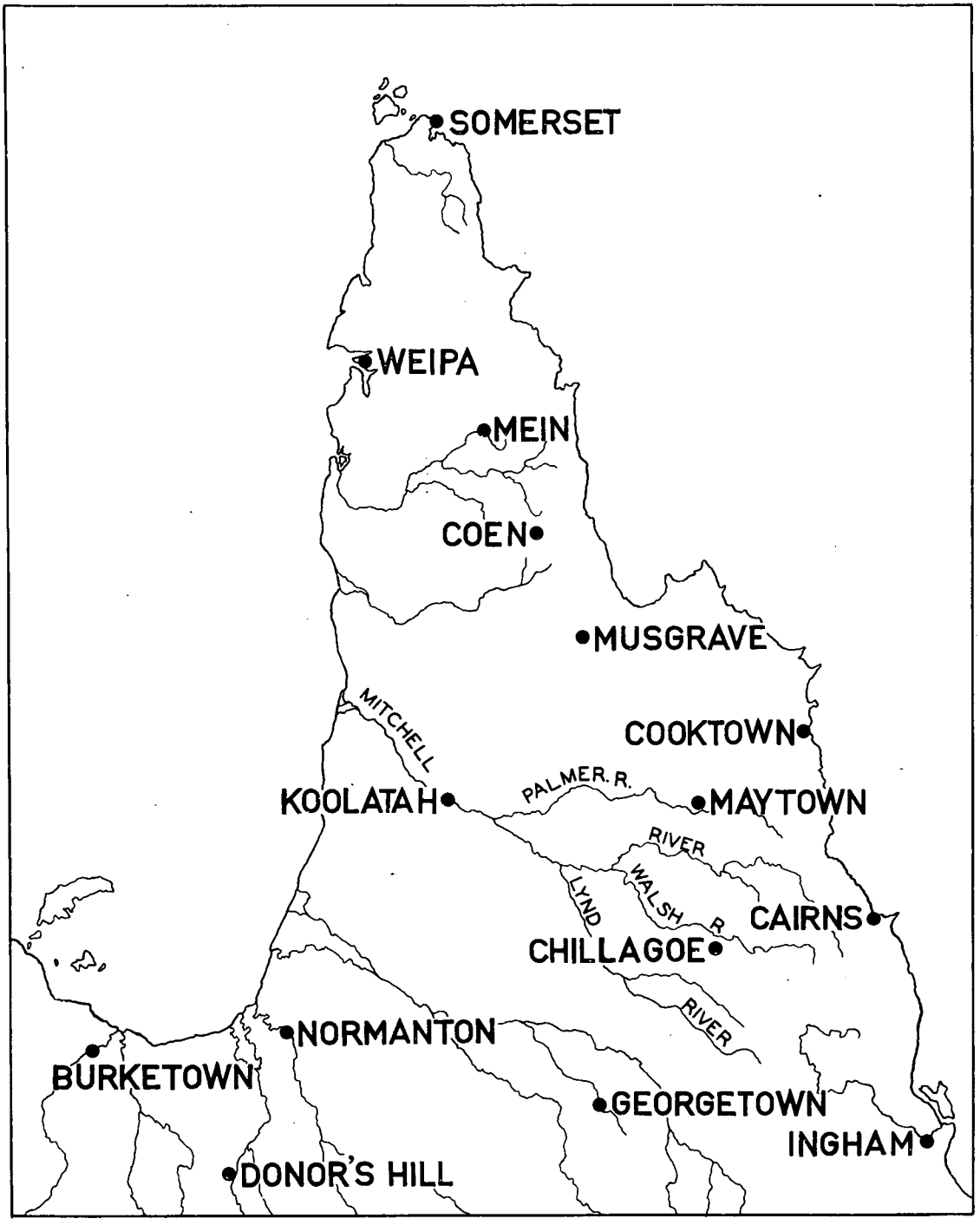

Fig 1. Location Map.

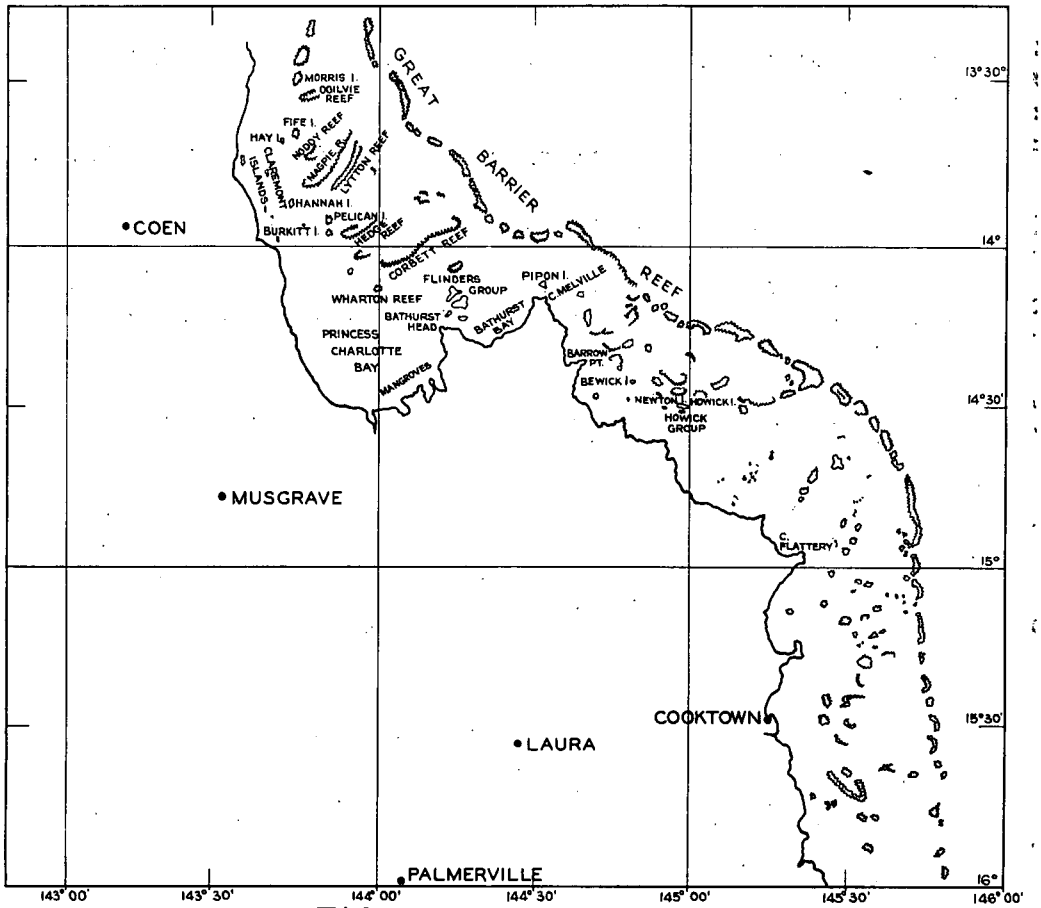

FIG. 2 LOCATION MAP.

(a) The schooner "Tarawa", 142 tons, with the tender "Wai Weer" and 18 luggers.

(b) The schooner "Meg Merrilees", 143 tons, with 14 luggers.

(c) The schooner "Olive", 92 tons, with 14 luggers.

(d) The schooner "Aladdin", 102 tons, with 14 luggers.

In Bathurst Bay, 45 miles away, the following were at anchor:

(a) The schooner "Sagitta", 84 tons, with 9 luggers.

(b) The schooner "Silvery Wave", 98 tons, with 15 luggers.

(c) The schooner "Crest of the Wave", 112 tons, with 13 luggers.

(d) The small schooner, "Admiral", 25 tons.

About 2 miles north-west of Cape Melville was anchored the Channel Rock Lightship.

At Noble Island near Barron Point was the lugger "North Wales".

Near the Howick Islands were anchored 6 cutters.

Other cutters were anchored at various places in the hurricane area. The schooner "Wanetta", with 11 luggers, was further north and escaped the storm.

The Outridge Booklet says: "The 4th of March was a Saturday, and as usual on this day the luggers had collected near their respective schooners for the purpose of renewing stores, getting water and fuel, repairing damaged gear, delivering shell, and for the divers to report to the managers of their success, and to receive orders for the ensuing week. It was a time of joviality, rest and companionship. The prevailing wind for the previous three weeks had been from the south-east and consequently most of the vessels, especially those in Bathurst Bay, were close in to the land for shelter, and for convenience in getting wood and water."

A study of the 9 a.m. synoptic charts prepared by Wragge confirms the above statement. The intertropic convergence zone had been north of Cape York since 9 February, (except for 20 February), with chiefly south-easterly winds along the coast of the Peninsula, associated with a high pressure ridge along the Queensland coast and a broad equatorial trough over the Coral Sea. From time to time this equatorial trough would appear to deepen and Wragge would then label it disturbance "so-and-so" and issue warnings. Thus on 4 March he called the disturbance "Mahina". No newspaper was published on the 5th, it being a Sunday, but Wragge used to attempt 3 day forecasts. Thus, on 3 March, he wrote: "Conditions are again becoming suspicious between the Louisiades and the north of New Caledonia, and although no danger yet threatens the Queensland coast, we must needs keep a bright lookout."

At this stage (3rd) pressures had not commenced to fall along the Peninsula.

The following extract from the Outridge Booklet is therefore all the more interesting:

"Mr. H.P.Beach, Postmaster at Thursday Island, and an amateur meteorologist of considerable ability writes:-

I remember the nights of the 2nd and 3rd of March very well. They were uncommonly hot and generally oppressive. The eastern part of the horizon was terribly lit up with distant lightning, which disclosed a black, leaden, fierce-looking sky or background. The lightning was singularly severe, and an

almost continuous electrical discharge, although not the slightest sound of thunder reached the ear. The next night I remarked a similar uncanny appearance of the previous evenings. I re-moored my boat which was riding quietly on an almost dead calm sea. I returned to the verandah, and admired the beautiful display of the distant lightning, similar to that of the two previous nights, but certainly nearer on this occasion. The night was even closer, and more oppressive than on the 2nd and 3rd, and a monotonously quiet night it was. At about midnight I turned in - the night still beautifully calm, hot and illuminated to the eastward. Next morning, the 5th, a strong south-easterly wind set in, and at 9 a.m. Cape York reported, 'No communication south of the Coen'. I am convinced that the terrific display of lightning on the 2nd, 3rd and 4th March had something to do with or bore some near relation to the approach of the cyclone."

(In regard to the south-easterly wind on the 5th, this cannot be substantiated, although accepted and commented on by the Outridge Booklet. Cape York at 9 a.m. 5th reported north-west Beaufort force 5 and Proudfoot Lightship, at 10°32'40"S and 141°27'E, west north-west Beaufort force 5. It is to be inferred that the wind was north-west.)

In order to avoid a plethora of charts, the 24 hourly pressure tendencies have been tabulated in Table 1.

It can be seen from Table 1 that the pressure tendencies gave some indication of development as early as 9 a.m. on the 4th, the region of greatest fall being located in the Musgrave-Cooktown region.

Unfortunately the observer at Musgrave had been in the habit of setting the barometer at 9 p.m. and reading it next day. "In the confusion of the tempest" he forgot to do so on the morning of the 5th and was subsequently absent for a fortnight on line duty. Valuable information was thereby lost.

Winds had been south-easterly all along the coast on the 3rd. However, at 9 a.m. on the 4th Cape York reported north-westerly, with calms at Moreton and Mein, and south-easterlies from Coen southwards. The south-easterly had reached Beaufort force 4 at Cairns and Cooktown (previously force 2).

Rainfalls also were somewhat indicative of development. Rainfalls to 9 a.m. are listed in Table 2.

The two inch rainfalls at Cape York and Somerset on the 3rd accompanied the southward movement of the intertropic convergence zone. The one to two inch falls on the North Coast on the 4th are in agreement with strengthening south-east winds.

Table 1 - 24 Hourly Pressure Tendencies (mb) at Tropical Stations - March 1899

Station	9 am 2nd	9 am 3rd	9 am 4th	3 pm 4th	9 pm 4th	9 am 5th	3 pm 5th	9 pm 5th	9 am 6th	3 pm 6th	9 pm 6th	9 am 7th	9 am 8th	9 am 9th	9 am 10th
Cape York	-0.4	-0.4	-0.8	-1.1	--	-4.0	--	--	+1.4	--	+0.9	+0.3	+1.6	-0.5	+2.0
Mein	-1.6	+0.4	-1.0	-2.5	-2.1	-6.7	-3.8	-3.1	+2.3	+1.6	+0.9	+0.5	-0.2	+1.9	+1.6
Musgrave	--	-0.3	-0.9	-3.0	--	--	--	--	--	--	--	--	--	--	--
Cooktown	-0.5	-0.7	-1.9	-3.6	-4.5	-7.8	--	+0.4	+4.2	--	+4.3	+0.8	-1.8	-1.1	+2.3
Cairns	-0.4	0.0	-2.1	-2.2	--	-2.4	-0.5	--	+1.1	--	--	+0.3	-3.1	-0.1	+2.3
Cardwell	-0.1	+0.3	-1.7	--	--	-1.9	--	-0.6	+0.2	--	+0.3	-1.3	-2.5	-1.2	+2.8
Croydon	+0.3	+0.2	-0.5	--	--	-4.2	--	-1.0	-1.1	--	-1.6	+1.0	-2.2	-0.5	+3.1
Normanton	-0.8	+1.0	-0.6	+1.4	+0.3	-4.6	-4.7	-6.3	-0.4	--	-2.0	-2.3	-1.8	+0.1	+4.4
Karumba	--	--	--	-1.3	-2.4	--	--	-4.1	--	-4.3	-1.8	-0.7	-1.3	+0.7	+5.2
Burketown	-0.5	+0.7	-0.5	-1.2	-2.5	-4.0	-5.2	-2.9	-4.2	-2.7	-3.9	-2.3	-1.1	+3.4	+5.0

Table 2 - 24 Hourly Rainfalls to 9 a.m. March 1899

Station	9 am 2nd	9 am 3rd	9 am 4th	9 am 5th	9 am 6th	9 am 7th	9 am 8th	9 am 9th	9 am 10th
Proudfoot Lightship	55	15	1	110	245	165	133	70	15
Cape York	87	226	46	150	184	73	133	121	43
Somerset	9	230	2	89	281	91	124	184	--
Moreton	15	32	75	75	62	25	182	—	152
Mein	--	24	7	9	15	50	66	116	67
Coen	—	--	10	220	115	20	145	74	16
Musgrave	104	42	4	626 to 3 pm	--	--	--	--	—
Laura	7	--	24	94	724	28	114	109	110
Maytown	--	10	12	(	404)	102	120	166	—
Cooktown	4	95	66	275	640	781	93	86	30
Port Douglas	--	69	152	200	600	925	583	—	—
Cairns	--	187	104	198	480	646	919	78	134
Kuranda	—	178	178	(	861)	1412	1017	97	—
Cardwell	6	73	238	(	516)	526	540	364	13
Walsh	—	18	2	80	238	72	205	238	60
Croydon	62	29	--	20	18	53	10	110	26
Normanton	4	432	--	(	28)	243	155	240	22
Karumba	—	108	—	(	15)	455	245	213	38
Burketown	--	1	—	--	278	278	658	559	—
Miranda Downs	---	32	18	13	102	48	35	147	93

4. THE LANDFALL OF THE HURRICANE

The Outridge Booklet states: "On the 4th and 5th of March 1899, the east coast of Queensland, in the neighbourhood of Princess Charlotte Bay, between 13°30' and 14°30'S was visited by a terrific hurricane, which destroyed vegetation on the shore, wrecked a lightship, schooners, and caused the loss of over 300 lives." It then proceeds to summarise the landfall of the cyclone as follows: "At 7 p.m. there was a moderate breeze from the east south-east, and it gradually increased in force till about 11 p.m., when it suddenly changed, blowing with hurricane force from the south-west, and working round to west and then north-west, it finally died away about 10 a.m. on Sunday morning. It was accompanied by torrents of rain, vivid lightning, reverberating thunder, which could scarcely be heard amidst the noise of the wind, the swish of the spray, the dashing of the waves against the doomed vessels, the groaning of the planks and the straining of the cordage and spars. Between the hours of 3 to 5 a.m. a tidal wave swept along the coast, in many instances completing the ruin the hurricane had begun."

The area of devastation is clearly indicated, extending from Bewick Island to Hannah Island (Fig. 2). At Newton Island, south of Bewick Island, the vegetation was untouched, but between Bewick and Hannah the trees and grass were swept clean. The distance between these two islands is 83 statute miles. The Outridge Booklet states: "Approaching Bathurst Bay from the northward, Flinders Island and Bathurst Head are passed. On the former, the trees were all stripped of leaves and branches, and were, in many places, torn up by the roots; and to the southward of Bathurst Head, along the shores of Princess Charlotte Bay, some square miles of mangroves have been destroyed. This is a serious calamity for the natives, the fruit of the mangrove being their principal food."

5. ACCOUNTS OF EYE WITNESSES WITH RECONSTRUCTED TIME SECTIONS ACROSS THE CYCLONE

(i) The Outridge Booklet provides eye witnesses' accounts from points to the north, centre and south of the storm. Probably no Australian cyclone has been so well documented. Not only did the centre of the cyclone pass over the pearling fleet described above, but it also passed very close to a land party at Barrow Point. The following account is by Constable J.M.Kenny, who was in charge of the Eight-mile Police Station, Cooktown:-

> "Left the Eight-mile on 28th February, with four native troopers and ten horses. Proceeded to the Munburra goldfield, on the Starcke River, and then struck the coast and went searching for the mate of a South Sea Islander. These two islanders (the

survivor said) landed in a dinghy near Barrow Point (supposed to have deserted from the pearl fleet). The blacks speared his mate, and he escaped, reaching the Munburra in an exhausted state. Kenny reached Barrow Point on Saturday, 4th March, and camped about 6 p.m., on a ridge fully 40 ft above sea level, and about half-a-mile from the beach, with scrub and a high sand ridge between the camp and beach. On Saturday afternoon a light south-east breeze prevailed, with a drizzling rain. About half-past 11 p.m. it came on to blow very stiff from the south south-east, increasing every minute. At 12 p.m. the troopers' tent was carried away, and they came into Kenny's tent; and about ten minutes after this was demolished by a limb falling right across it, and smashing through Kenny's hammock. Luckily he had left his hammock, as the rain was pouring on it, caused by a tent peg pulling up. When the tent collapsed, all hands made for the biggest open space near, guided by very rapid lightning which occurred at intervals. Here it was necessary to cover up face and hands in a blanket to keep off the pelting rain, which seemed to hit as hard as hail. About 2 a.m. the wind veered a couple of points, and blew with hurricane force. At 5 a.m. it shifted to north-east, and, if possible, blew harder than ever, with torrents of rain. Shortly after the wind shifted to the north-east an immense tidal wave swept in shore, and reached waist deep on the ridge with the camp on it, completing the misery of the constable and troopers, also spoiling Kenny's watch. Here the wave stretched between two and three miles inland. Judging from the appearance of the sun, it was not properly daylight till about 10 a.m. on Sunday morning, the 5th. Spent Sunday looking round and picking up fragments of camp gear, and putting same in a place of safety, as it was found impossible to travel with the horses on account of the rivers. On mustering the horses, four were found to have been killed by trees. On Monday morning a start was made for Munburra on foot. Saw no boats, and very little wreckage, but saw a dinghy on the beach. Dead fish of all kinds were piled up, including porpoises, sharks, dugong, sea-snakes, also sea birds, land birds, and wallabies. When these animals and fish began to decay the stench was pretty considerable. Reached Munburra on Friday, 10th March, having only native tucker (including yams, wallabies, iguana, carpet snake and sugar-bag) for four days. Horses were procured at Munburra, and Eight-mile was reached on Monday, after an experience that Constable Kenny says he would not like to have repeated. The force of wind was so terrific that the trees had leaves, twigs, branches, and bark stripped clean off, and the country presents a brown and desolate appearance. On Monday the party had to swim thirteen rivers, creeks, and gullies, next day six, next two, and next four, swims which in themselves were a pretty tidy day's work."

A reconstruction of the probable time section for Barrow Point is given in Fig. 3. It can be deduced that the eye passed just to the north of Barrow Point.

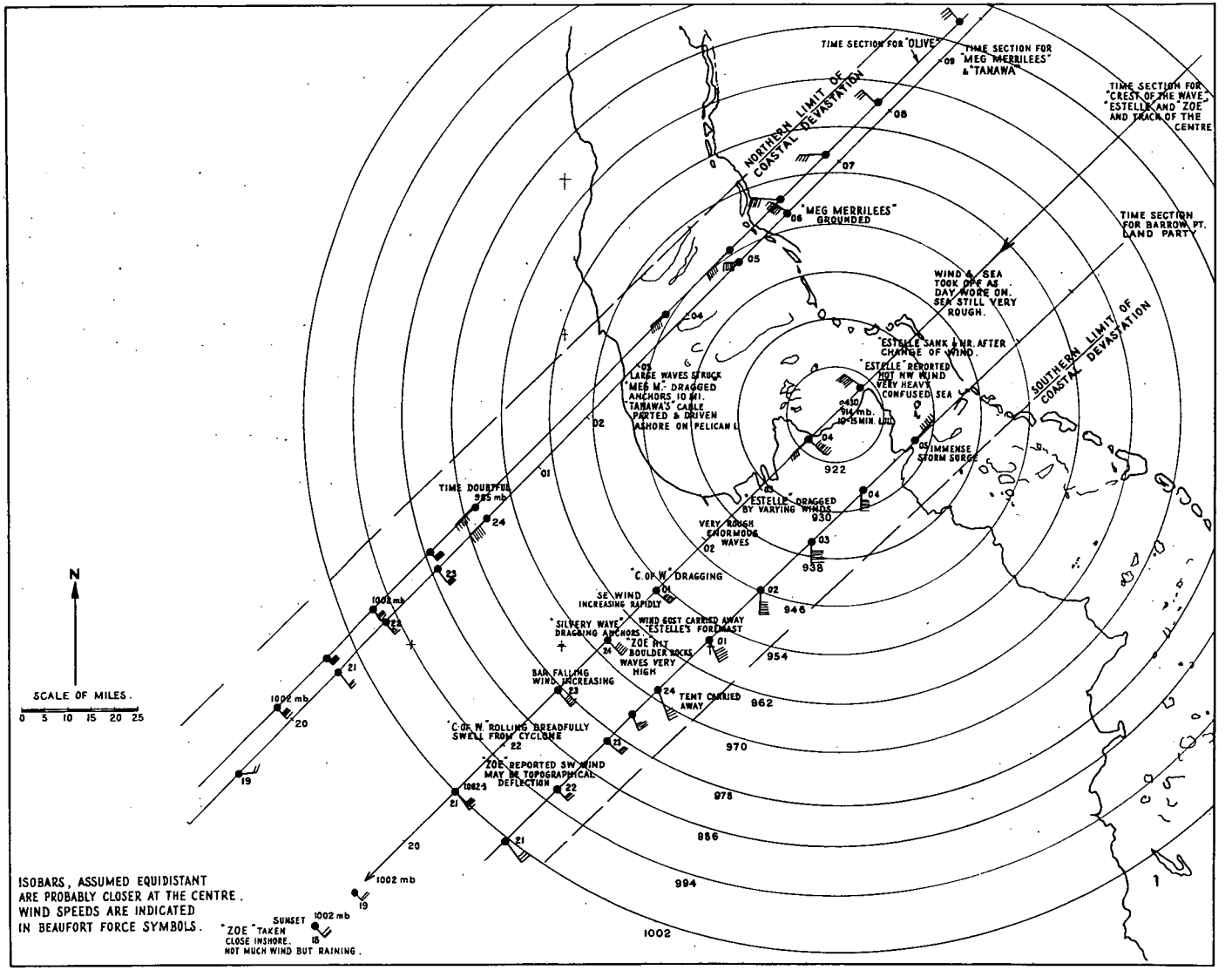

FIG. 3. RECONSTRUCTED TIME SECTIONS FROM SHIP REPORTS & BARROW POINT LANDING PARTY.

(ii) The "Tarawa" was anchored 1½ miles east of Pelican Island. Her reconstructed time section is shown in Fig. 3. About 3 a.m. several large waves washed away her whale-boat. She dragged her anchors for 10 miles and the masts were cut away to try to save her, but she still dragged on as if she had no anchors down. She grounded on a high reef at 6 a.m. and filled. Five of her luggers were lost and 9 men drowned.

The small schooner "Wai Weer" of the "Tarawa" fleet was wrecked close by.

From a study of the time section it is evident that the centre passed to the southwards.

(iii) The "Olive" was anchored to the north of Burkitt Island. The gale started from the south-east. At 10 p.m. the barometer was 29.60 inches (1002.3 mb) and fell rapidly to 29.10 (985.4). The wind then changed and blew with hurricane force from the south-west, and at daylight veered round to the west, still blowing stiffly, and finally died away at 10 a.m. from the north-west. The schooner dragged with both anchors down right round to the south-east of the island. Her time section indicates a cyclone passing to the southwards.

The "Olive" had no boats totally wrecked, although the "Waratah" drifted down onto a companion boat, the "Edith" and was sunk. A large hole was knocked in the "Waratah", her counter being almost entirely carried away. The "Edith" rescued the crew of the "Waratah", and managed to survive the storm.

(iv) The "Aladdin" was anchored near the "Olive". She dragged towards the reef but slipped her chains and missed the island. She then dropped another anchor. Only one lugger from her fleet was lost.

(v) The "Admiral" had very fine lines, was of deep draft, with several tons of lead on the outside of her keel. She had just arrived with a full cargo and a number of passengers, who, with her crew of five, were all lost.

(vi) The "Silvery Wave" was a brigantine of 98 tons, well built of hardwood and particularly strong. She was anchored in Bathurst Bay. Her excellent ground tackle caused her loss. Had she drifted with the south or south-west winds into deep water she would have been saved. As it was, when the wind changed north-west, with a fetch over 20 miles of sea, the waves greatly increased in size. Anchored in three fathoms she was overwhelmed, and probably bumped herself to pieces on the bottom.

The only survivor was a sick Japanese sailor. He stated that about midnight another anchor was dropped as the schooner was dragging with the gale. About 7.30 a.m. he went on deck as the schooner was

filling fast and he expected her to sink at any moment. He saw some of the crew, but the masts had gone and the bulwarks were all broken. A big sea washed him overboard and the schooner filled and sank.

The diver who later examined the wreck found no signs of the masts having been cut. They must have been carried away by the gale.

(vii) The "Sagitta" sank in deep water with her crew of nearly twenty. Probably she collided with the "Silvery Wave".

(viii) The Channel Rock Lightship was last seen at 11 p.m. She was probably overwhelmed by the enormous waves and sank at her moorings, all on board being drowned. Opinions differ as to the direct cause of her loss. She was particularly well found, her hull alone costing £2,000. Some say the wind got under her wooden awnings and threw her on her beam ends; others assert that she was riding with too little chain, was overwhelmed and could not recover. Her loss emphasises the terrific force of the wind.

Today her place is taken by a lighthouse on Pipon Island.

(ix) The "Crest of the Wave" was anchored on the lee side of Cape Melville, with the schooners "Sagitta", "Silvery Wave" and "Admiral" anchored nearby, and some forty luggers nearer the shore. The barometer at sunset read 29.60 inches (1002.3 mb).

"Between 11 and 12 p.m. the wind began to increase, and the barometer to fall. So powerful was the wind that the 'Silvery Wave' dragged her anchors and drifted down close to the 'Sagitta'. It was difficult to see the positions of the different schooners on account of the intense darkness, only lightened by the occasional flashes of lightning, and there was very great danger of collisions, so gun shots were interchanged to give some idea of their relative situations. The 'Silvery Wave' still continuing to drag, the 'Sagitta' moved, it is believed slipping her cable to do so, and took up a position nearer the Cape, Captain Jefferson on the 'Silvery Wave' letting go another anchor about the same time. The wind continuing rapidly to increase in force from the south-east, the 'Crest of the Wave's' anchor began to drag. The full length of chain was given out, still she dragged, drifting out into the open channel. When six fathoms of water was reached, the lead being kept going, the other anchor was let go, but even with all the ground tackle out the vessel continued to drive before the increasing gale. The intense darkness and driving rain prevented anything being seen of the other boats or the land. The sea by this time was very rough and enormous waves broke time after time on board. The stern dinghy and port whale boat went over the side, and the bulwarks were washed away. The glass continued to fall until 4.30 a.m. on Sunday, the 5th March, when it reached 27 inches; then there was a lull for about ten

or fifteen minutes, when the wind suddenly came from the north-west with such terrific force that the schooner was thrown on her beam ends and almost buried in the raging sea. The cabin windows were smashed in, and the cabins began to fill with water. To prevent the vessel foundering the masts were cut away, a matter of no small difficulty as she was lying on her beam ends, and with enormous waves washing over her. She then righted, losing the starboard whale boat, which left the schooner without a boat. It was noticed that the vessel was getting deep in the water, which was but six inches below the deck, so the pump was set going, and two gangs of men were also told off to bail out with buckets, while others searched for the leak. The water was found coming in from the rudder trunk, and the leak was soon stopped up with blankets, bags of flour and other things that came handy. Pumping and bailing were continued until the vessel was out of immediate danger. The wind and sea took off as the day went on, although it was still very rough, and the exhausted men were able to get some food of which they stood much in need after battling against such fearful odds for some ten or twelve hours.

"At 7 p.m. on the same day (Sunday), the 'Duke of Norfolk', from London, rounded up alongside in answer to the signals of distress, and sent a boat. Mrs. Porter and child were taken on board the steamer, where they were well cared for and made comfortable. Captain Jenkins very kindly lent Captain Porter a boat, and anchored near him all night. So far nothing had been seen of the other vessels or luggers, and it was also noticed that the lightship had disappeared. The days that followed were sad ones. Thirty men were picked up off the beach; these had saved their lives by swimming. Thirty-two bodies had been buried, and others were seen floating in the sea. Mr. Alf Outridge's body was buried and two white men from the lightship. In all about eighty bodies were accounted for out of 280 men drowned. All the luggers were sunk, as well as the schooners 'Sagitta', 'Silvery Wave' and 'Admiral'."

The account of the Captain's wife tending her seasick baby in a cabin full of water, and having her at one stage washed from her arms, makes touching reading.

It is evident from her time section that "Crest of the Wave" experienced the eye of the cyclone itself. The 4.30 a.m. barometer reading of 27 inches is the lowest ever recorded in Australia.

Reference to Fig. 4 shows the way the "Crest of the Wave" drifted from her original anchorage to a position $2\frac{1}{2}$ miles north west of Channel Rock. The Outridge Booklet considers that "Sagitta", "Silvery Wave", and "Admiral" might also have been saved had their ground tackle not held, thus preventing their drift into deeper water.

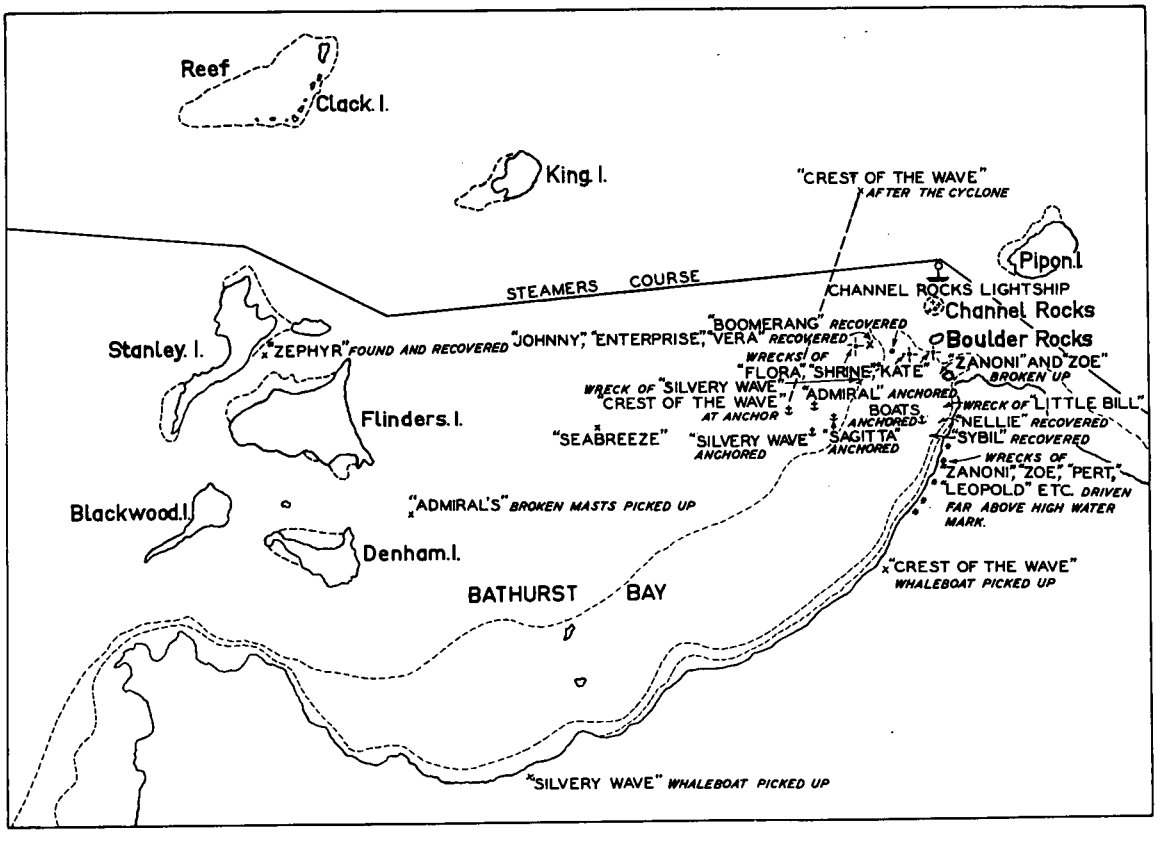

Fig 4. Details from ship reports of effect of cyclone.

(x) The lugger "Zoe" anchored near the "Sagitta", about 1½ miles from the watering place at Cape Melville. About 6 p.m. the diver ordered the boat close in to shore; there was not much wind, but it was raining. About 9 or 10 p.m. a south west wind came. They allowed the boat to drift hoping to clear the rocks, but at about 12 o'clock she hit Boulder Rocks, close to the point.

(xi) The lugger "Zanoni" was wrecked close to Boulder Rocks, Cape Melville. During the storm the crew shut the hatches but one was incomplete and the waves breaking over the boat swamped her. She sank in three fathoms about 3.30 a.m., the mainmast breaking at the time.

(xii) The account of the lugger "Estelle" is of exceptional interest, as she reported not only the eye of the storm, but also the warm core.

"Seto was a Japanese diver of the 'Estelle'. He reports that about midnight on Saturday an extra strong gust of wind struck his boat, and the foremast went over the side. No sail was set at the time, the wind was fierce and powerful enough to blow the mast away. The boat dragged her anchor, and was drifted about in different directions, according to the varying winds. The diver steered all through the dreadful night, endeavouring to keep the boat's head to the big seas that frequently broke aboard and threatened to overwhelm her. The boat was in a sinking condition, when between 5 and 6 o'clock there was about ten minutes' calm, advantage of which was taken to pump out the water. Then the wind started from north-west, the opposite direction, blowing directly on shore, and appeared quite hot. It was much stronger than when from the south-east or south-west, and caused a very heavy confused sea. The boat sank in about half an hour after the change of wind."

(xiii) The Outridge Booklet gives a further indication of the terrific strength of the wind.

"Some aboriginals from a camp near Cape Melville were assisting shipwrecked men out of the water. A change of wind or a sudden gust swept round the hills and blew the natives into the water. They struggled hard, but were unable to reach land again, and were driven out to sea and drowned."

Describing salvage operations the Outridge Booklet states:

"All the boats recovered close to the shore had their masts carried away just above the decks. From this it would appear that the boats had been rolled over and over along the bottom. Other evidences are visible which tend to strengthen this belief. The force of the waves must have been tremendous to turn the boats over and over, and it is fortunate that the bottom of the sea was, at that place, composed of mud, otherwise the boats would all have been chafed to pieces."

Referring to the wreckage: "About 2 miles from the Cape, wreckage is most plentiful, and in some places it is a quarter of a mile inland from the seashore." This confirms Kenny's account of the storm surge.

Summary of damage to shipping.

In all 5 large vessels were totally lost,
2 " " wrecked but refloated,
1 " " dismasted,
54 luggers were totally lost,
12 " were wrecked but refloated.

The death roll reached 307.

6. A RECONSTRUCTION OF THE HURRICANE AS AT 0430 HRS 5 MARCH 1899

In Fig. 3 are shown plotted the time sections for the various boats and the land party at Barrow Point. We know that the eye passed over the "Crest of the Wave" between 0430-0500 hr, 5 March 1899, this being supported by the "Estelle's" "between 5 and 6 a.m."; as the "Estelle" was by this time in a sinking condition, niceties of timing could not be expected. The writer has plotted the 9 a.m. position of the cyclone from all available observations (no chart was prepared by Wragge on 5 March, it being a Sunday). The position of the centre so obtained is half way between Coen and Laura, which stations were reporting north-west force 9 and south-east 9 respectively. The distance from Bathurst Bay to this position is about 65 statute miles which makes the speed of movement of the cyclone approximately 15-16 mph in a direction from north-east to south-west.

If now we plot the time sections along a line from south-west to north-east and at hourly intervals on a scale of 16 miles between hours, and centring the 0430 hr position over Bathurst Bay, we are, in effect, moving the stations relative to a stationary cyclone. The time sections thus plotted become, in effect, equivalent to a space cross-section as at 0430 hr. The assumptions made include (a) no change in shape or intensity of the storm during the period under consideration, and (b) no diurnal variations. We also assume the correctness of the barometer readings from the "Crest of the Wave" and the "Olive". The latter gave no time for the reported 29.10 inches reading, but as it was said to accompany the south-west change, which the nearby "Meg Merrilees" reported as occurring at midnight, it has been inferred that it applies also to about midnight.

Fig. 3 therefore represents a reconstruction of the cyclone as at approximately 0430-0500 hr 5 March 1899. The pressure gradient amounts to 88 mb in 104 nautical miles. Winds described as "hurricane force"

have been plotted as Beaufort force 12, which in those days was the limit of the Beaufort scale. However, the winds experienced were most probably well in excess of force 12. The present day Beaufort scale has been extended up to force 17 (109-118 kt); forces 12 to 17 are all described as "hurricane". From the evidence it appears certain that winds exceeded 100 kt.

7. THE STORM SURGE

We are now in a much better position to examine the fantastically high storm surge which Constable Kenny's party experienced at Barrow Point. From the position and track of the cyclone (Fig. 3), we should not expect any storm surge from Princess Charlotte Bay northwards. However, from Bathurst Bay to Cape Flattery we notice hurricane force onshore winds, and furthermore we notice that in this area the Barrier Reef is at its closest to the Queensland coastline, from Cape Melville to the outer edge of the reef being only 12 nautical miles. There is thus a sudden transition from deep to shallow water, with the coastline only 12 miles away.

Lee Harris (1956) has listed the main effects contributing to the formation of a storm surge. Most of them are found to be in operation in this instance.

(a) The effects of atmospheric pressure

The 88 mb pressure deficiency would account for an inverted water barometer effect of 28 ft. However, we have no means of checking the accuracy of the reported 27 in. barometer reading. Nevertheless, dynamic amplification occurs in a moving storm due to a term involving $(1 - V^2/gH)$, where V is the speed of the cyclone, g is the acceleration due to gravity, and H the equilibrium depth of the field. Harris (1956) has found that the amplification due to this term may increase the amplitude of the water level disturbance in a lake by a factor of five.

(b) Wind set-up

The piling up of water by the wind is called the set-up. An important point mentioned by Harris is that the set-up is inversely proportional to the undisturbed depth of the water. Hence a given wind stress will produce a greater disturbance in sea level if it occurs at low tide. This must be considered in areas in which the tidal range is a substantial fraction of the mean depth of the water.

In our case the area under consideration is strewn with coral reefs, the upward limit of whose growth is determined by the mean height of low water. The mean range of tide at Pipon Island and Howick Islands is as follows:-

Mean Range of Tide

	at springs	at neaps
Pipon Island	5.2 ft	1.0 ft
Howick Island	5.8 ft	1.4 ft

The predicted time of occurrence of high water on 5.3.1899 was 0311 hr at Townsville. At Pipon and Howick Islands the tide occurs 11 and 6 minutes later respectively. The phase of the moon on 5.3.1899 was last quarter, which means that the neap tidal range should be used.

We infer, then, that the storm surge occurred about 2 hours after high water, when the level would have fallen only a matter of some inches. At Pipon Island the mean high water neaps is 6.7 ft above datum, and is 5.3 ft above at the Howick Islands. Mean tide levels at Pipon and Howick Islands are 6.2 and 4.6 ft respectively.

The inference is that at the time of the storm surge the water at Barrow Point would have stood nearly at mean tide level in the absence of the surge.

The coastline from Cape Melville to Cape Flattery lies approximately north-west to south-east, i.e. normal to the hurricane winds.

(c) The shoaling effect

The amplitude of a wave tends to increase as the wave moves into a region of decreasing depth. Green's Law states that

$$h_s/h_d = (H_d/H_s)^{\frac{1}{4}}$$

where h_s and h_d are the amplitudes of the wave near the shore and in deep water respectively, and H_s and H_d are the equilibrium depths of the water. Harris mentions a 2 ft tsunami being amplified to from 10 to 25 ft on the island of Hilo, Hawaii.

Summarizing these factors it can be said that conditions were entirely favourable for a storm surge. Mackey and Whittingham (1956) describe another storm surge which occurred on this same section of coast (at Low Islets). The orientation of the coastline and the proximity of the Great Barrier Reef were probably important factors.

Kenny was camped "on a ridge fully 40 ft above sea level, and about half a mile from the beach". The water reached waist deep on the ridge. We may thus infer that the storm surge had a height of 43 ft above mean sea level. Kenny states that it extended 2 - 3 miles inland. Wreckage at Cape Melville was found ¼ mile inland.

Lee Harris (1956) says: "The storm surge should not be confused with the ordinary and more visible wind driven waves and swells. The waves and swell, with a frequency normally greater than 5 to 12 per minute may reach amplitudes much greater than that of the storm surge, and may do tremendous damage near the shoreline, but they have a relatively short wavelength and cannot extend very far inland. However, the storm surge has a period measured in hours and rarely goes through more than two or three significant cycles with a single storm. Normally one cycle is present. This disturbance has a wavelength of many miles and in low lying and swampy land it may penetrate several miles beyond the normal shoreline."

In this case we have the evidence of the party on the ridge which was itself half a mile from the shore; the wave extended 2 - 3 miles inland; and the Outridge Booklet says "between the hours of 3 to 5 a.m. a tidal wave swept along the coast". All this evidence points to a true storm surge.

Conner, Kraft and Lee Harris (1957) have given empirical formulae for the prediction of storm surges in the U.S.A. They are:

$$h_{max} = 0.867\ (1005-p_o)^{0.618} \quad \text{and}$$

$$h_{max} = 0.154\ (1019-p_o), \quad \text{where } p_o \text{ is the central pressure of the storm.}$$

Applied to this case they indicate a surge of approximately 15 ft above mean sea level. This is not surprising as the surges from which they are derived reach only up to the order of this height.

Indirectly this fortifies the assumption that the 27 in (914 mb) barometer reading may be correct. If so it is approaching the lowest ever recorded in the U.S.A. which was the 892 mb of the Labor Day hurricane of 1935.

8. THE FURTHER TRACK OF THE CYCLONE

Using Wragge's charts as a guide but with further reference to monthly returns not available to Wragge until over a month after the event, the writer has reconstructed the synoptic charts and has produced the track map shown in Fig. 5. It differs from the tracks shown by Visher and Hodge (1925) and the Queensland Rainfall Volume. It should be remembered that at this period of synoptic analysis it was the custom to correct the barometer for temperature and altitude but not for gravity. Thus a further .06 to .07 in (2-2½ mb) should be subtracted from Wragge's barometer readings and isobars to compare with modern practice.

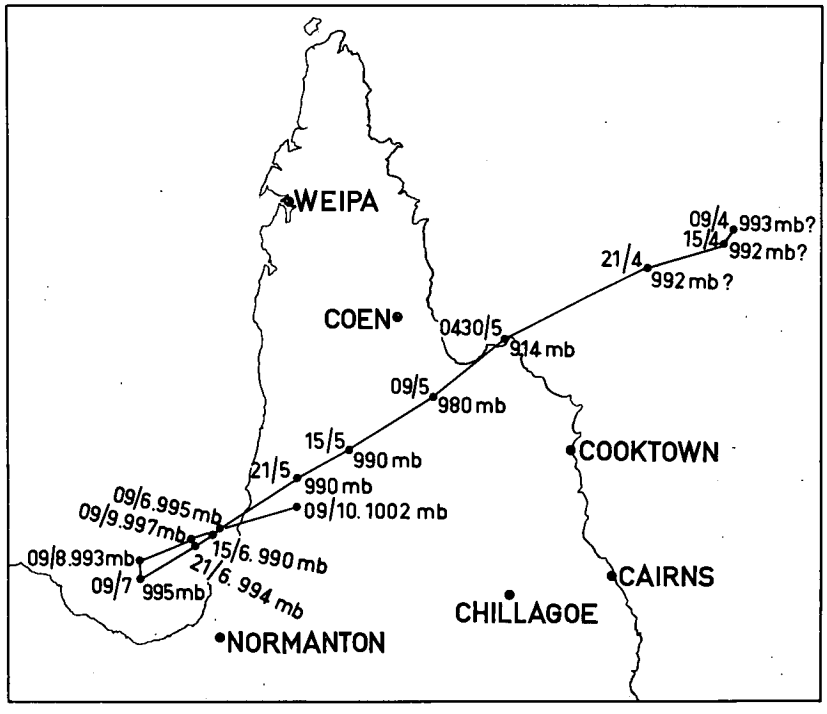

Fig 5.
Track of the Bathurst Bay hurricane of 4th – 10th March 1899.

It was found necessary to draw intermediate charts (3 p.m. and 9 p.m.) in order to obtain the most accurate determination of the track. If we accept the 27 in barometer reading from the "Crest of the Wave", it is seen that considerable deepening occurred after 9 p.m. on 4 March (992 to 914 mb). Following its landfall considerable filling occurred to 9 a.m. on the 5th (980 mb). The cyclone then followed an essentially straight track to its position in the southern Gulf of Carpentaria on the 7th. Some slight rejuvenation appears to have taken place as the centre passed from land to sea over the Gulf, winds of south-east force 11 being reported from Burketown on the 7th. However, after 9 a.m. on the 8th, the cyclone doubled back on its tracks towards the east north-east and crossed the coast again on the 10th, with rapid filling, and Karumba reported "clear, fine, decided break for fine weather".

During the period of the cyclone the equatorial trough in which it bred remained more or less stationary around 15S, 155E with an anti-cyclonic ridge along the Queensland coast. The schooner "Moonta" was wrecked near Gatcombe Head (near Gladstone) on the 8th, but this had nothing to do with the cyclone.

9. AN ERRONEOUS POPULAR EXPLANATION OF THE HURRICANE

From time to time the writer had been puzzled in the past by references to two storms clashing over Bathurst Bay. This perennial re-appears with every press article on past Queensland cyclones. The legend has apparently grown out of a statement made by Wragge on 10.3.1899: "The extreme western edge of 'Mahina' it was, when the centre was nearer the Louisiades, that evidently caused the diaster off our north eastern coast, and the eastern side of the monsoon 'Nachon' was also a factor. Much indeed do we regret that we have no means of advising the lightships and pearling fleets of the approach of storms between Cooktown and Torres Straits".

The Outridge Booklet has a note as follows:- "Reference to the Chart (kindly supplied by the Meteorological Department) will enable readers to better understand the above remarks". This chart is reproduced in Fig. 6. It is incredible that Wragge should have produced such a chart (if indeed he did) since his 9 a.m. charts do not support it in any way. There is no evidence of a storm moving in from Timor. His equatorial trough "Mahina" bred the cyclone in its north-west area, and the cyclone became his "Monsoon Nachon" in the Gulf of Carpentaria. There is not the slightest shred of evidence for the cyclone moving south east and out to sea near Rockhampton. The wreck of the "Moonta" near Gladstone on the 8th may have been associated in the mind of the public with the disaster at Bathurst Bay.

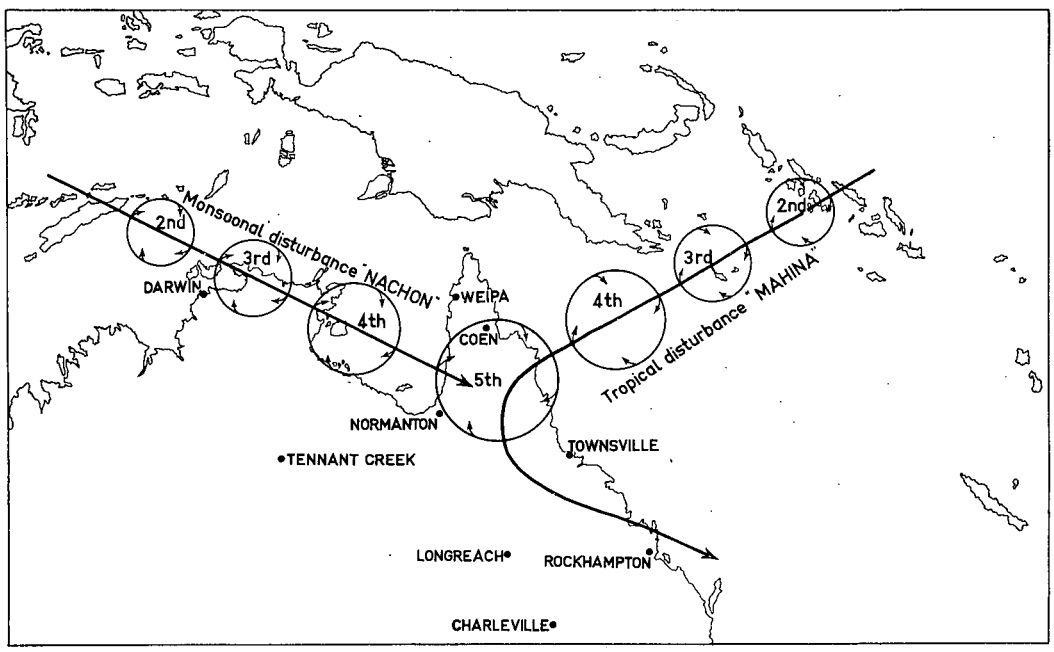

Fig 6. Tracks of the storms Nachon and Mahina the combined influence of which caused the disaster on 5th. March 1899.

10. RAINFALL AND FLOODING

Reference to Table 2 indicates that rainfalls were heaviest in the North Coast Barron district, Kuranda receiving 24 inches in two days on the 7th and 8th. This was whilst the cyclone was in the southern Gulf. However, the central parts of the storm produced flooding along its track across the peninsula. Heavy flooding was reported in the Palmer and Walsh Rivers. On the 5th and 6th Maytown reported a high state of flood. "The river rose during the night - a banker". On the 8th Walsh reported very big floods and on the 11th stated that the river was 15 ft above its highest stage for the previous 20 years.

11. ACKNOWLEDGMENT

Grateful thanks are due to Mr. J.Zillman of this Bureau who discovered the Outridge Booklet and brought it to the attention of the writer, and who subsequently rendered valuable assistance with the charts.

References

Bureau of Meteorology	1914	Results of Rainfall Observations made in Queensland
Conner, W.C., Kraft, R.H. and Harris, D.Lee	1957	Mon. Whr. Review, V.85 N.4 Apl. 1957
Harris, D. Lee	1956	Trop. Cyc. Sym. Paper 24, Brisbane, December 1956
Mackey, G.W. and Whittingham, H.E.	1956	Trop. Cyc. Sym. Paper 25, Brisbane, December 1956
Outridge Printing Co.	--	"The Outridge Booklet"
Visher, S.S. and Hodge, D.	1925	Australian Hurricanes and Related Storms, Bull. 16, C.M.B., Melbourne