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EXPERIMENTS TO DETERMINE THE FATE OF DEAD SEABIRDS OFF WOLLONGONG, NEW SOUTH WALES

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To simulate a seabird mortality incident, marked floats (total 375) were dropped in batches of five at 9 km, 35–45 km and 50–90 km east of Wollongong, New South Wales during each of 25 cruises from June 1985 to October 1987. Overall, 85 (22.7%) were recovered between Budgewoi (110 km N) and Bermagui (198 km S). Recovery rates for near-shore, mid-distance and furthest dropped batches were 29.6, 28 and 10.4 per cent respectively and the corresponding median recovery intervals were 4, 7 and 7 days. The reporting rates for floats presumed to have come ashore were 25.7 per cent from April to September (cool months) and 49.6 per cent from October to March (warm months). In a supplementary speed test, floats and Short-tailed Shearwater *Puffinus tenuirostris* corpses moved at five per cent and 3.1 per cent of wind speed respectively. It was concluded that the East Australian Current generally controls movement of floats parallel to the coast whereas wind controls east-west movement.

INTRODUCTION

Beach counts are used to determine seabird distribution (Blakers *et al.* 1984; Powlesland and Imber 1988) and seabird mortality due to weather (Stonehouse 1964; Underwood and Stowe 1984), pollution (Hope-Jones *et al.* 1970), disease (Coulson *et al.* 1968) and natural factors. The number of bodies that wash on to a beach depends on how many birds die at sea, where they die and on the factors that determine whether dead or dying birds drift ashore. These factors differ from site to site and it is often not known how far or for how long birds drift before being cast ashore. Estimates of total mortality are usually based on an assumed average recovery rate for the particular site.

In order to make accurate predictions of the place of death and the extent of mortality, it is necessary to understand the atmospheric and oceanographic influences on corpses at sea. The present study aimed to provide some understanding of these processes by a series of experiments on marked floats and dead Short-tailed Shearwaters *Puffinus tenuirostris*.

METHODS

Main Experiment

Fifteen floats were dropped east of Wollongong (Fig. 1) during each of 25 cruises from July 1985 to October 1987; five at 9 km east (A batches), five at 35–45 km east (B batches) and another five at 50–90 km east (C batches). The particular cruises (numbered 3–23 plus four additional cruises) and the study area are described in detail elsewhere (Wood 1990).

Floats were made from heavy duty clear plastic envelopes (140 × 200 mm). They contained c. 10 foam-plastic packing beads to enhance buoyancy and a notice displaying the unique number of the float as well as a request to advise finding place and date to a postal address or telephone number. When stapled and sealed with adhesive, the average weight was 32 gms (n = 13). Preliminary tests were performed on 12 floats of four prototypes anchored c. 3 km off shore. Small holes were found in all envelopes after 7–15 days, allowing ingress of seawater, but the inscribed notice in the chosen design was legible for 17–28 days. The puncture holes in all 12 floats appeared consistent with pecking by seabirds, a phenomena for which there is strong evidence (see Ryan 1987).

Wind records from Port Kembla were supplied by the Maritime Services Board in the form of 3-hourly mean strengths and directions to the nearest 22.5 degrees. Readings were added vectorially to investigate the effects of wind on the speed and direction of floats.

Bird and Float Speed Tests

These tests were performed at Berkley Marina, Lake Illawarra, on 10 and 11 December 1993 when wind was blowing steadily at about six knots. Negligible current was present at the test site (70 m × 34 m) which was enclosed on three sides. Fifteen Short-tailed Shearwaters that had been washed on Coniston Beach in the previous 16 hours were used for bird samples. In a series of tests, various numbers of floats and birds were tossed simultaneously into the water (max. = three of each) and timed with a stop-watch over measured distances. Birds and floats were allowed to lie in the water for at least three hours before the tests on the first day, and overnight before the last six tests. Wind speed was measured c. 1 m from

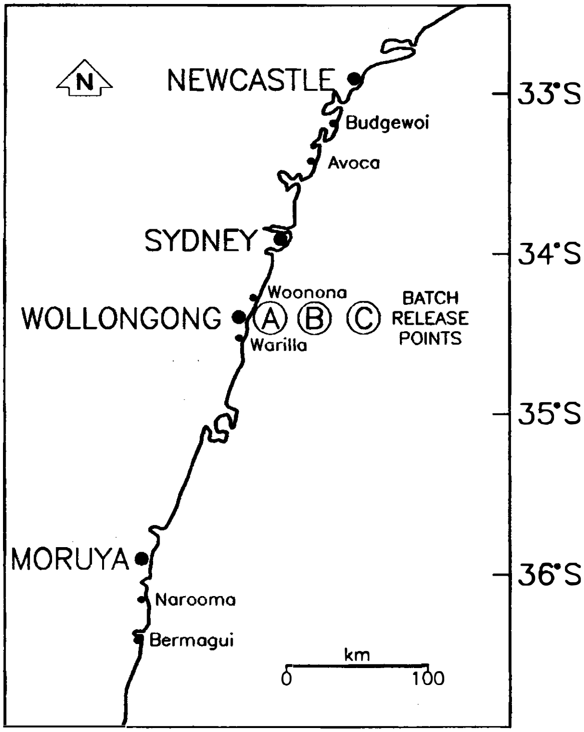

Figure 1. *Coastal New South Wales showing recovery range of floats released at sea off Wollongong between 1985 and 1987. Places mentioned in text are included.*

the surface with a Davis Instruments Electronic Turbometer and calculated for each test as the average of instantaneous readings every 8–10 seconds. All tests were completed in <10.6 minutes (mean = 6.3) over distances of <65 m (mean = 45 m).

Bird Deterioration Test

Sixteen Short-tailed Shearwaters were selected from beach-washed birds on Coniston Beach on 14 January 1989 and relocated to sand dunes c. 25 m from high water. Based on corpse appearance, corpse location on beach and a knowledge that numbers of wrecked birds peaked in late November-early December 1988 (pers. obs.), it is likely that the selected carcasses were washed up at least two weeks before 14 January 1989. The condition of carcasses was monitored during 11 inspections over the next 17 weeks.

RESULTS

A total of 85 floats (22.7%) was recovered along the coast from Budgewoi, 110 km north, to Bermagui, 195 km south. In the periods April to September and October to March, 18 and 67 floats were found with mean recovery rates of 10 and 34.4 per cent respectively (Table 1). A majority of recoveries (66%) were between latitudes 34°S and 35°S (Fig. 2). Recovery rates for A, B and C batches were 29.6, 28 and 10.4 per cent respectively.

Of all recoveries, 72 per cent were within 10 days, and the median recovery intervals for the A, B and C batches were four, seven and seven days respectively. Displacement speeds ranged

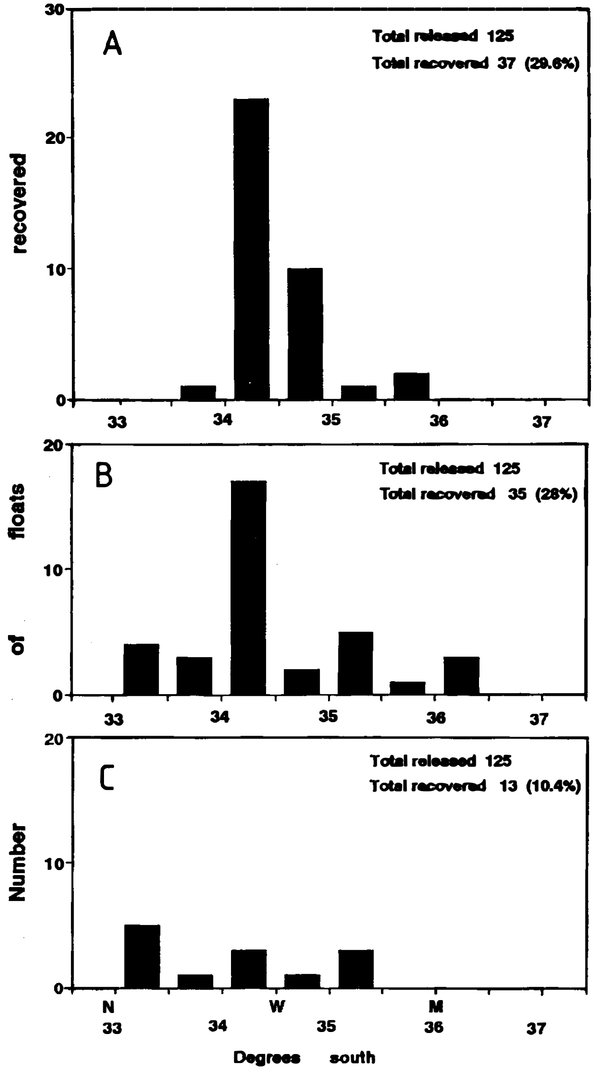

Figure 2. *Latitudinal distribution of floats recovered on the coast of New South Wales after release at sea off Wollongong; (A) 9 km east, (B) 35–45 km east and (C) 50–90 km east. The townships of Newcastle, Wollongong and Moruya are represented by the letters N, W and M respectively.*

TABLE 1

Comparison between reporting and recovery rates in the six month periods April–Septmeber and October–March.

Six month period	No. of batches dropped	Total no. of floats dropped	No. of batches which yielded recoveries	No. of floats probably beached*	No. of floats recovered	Mean reporting rate (%)	Mean recovery rate (%)
April to September	36	180	11	70	18	25.7	10
October to March	39	195	26	135	67	49.6	34.4

*Assumptions: (1) that all floats of a batch were beached if at least one of the same batch was recovered, and (2) that all floats of a batch were beached if at least one of another batch that was dropped further out to sea on the same cruise was recovered.

from 0.1 km/day to Port Kembla (batch 3B) to 37 km/day to Narooma (batch 10B). The median displacement speed for the first recovered floats from all batches was 11.7 km/day (Appendix 1).

All but six cruises yielded recoveries (Appendix 1). Cumulative wind vectors for these cruises over 16 days following each drop showed that only one batch (24A) could possibly have come ashore under the influence of wind. This possibility was doubtful however, as the resultant easterly component acting on batch 24A was weak and persisted for only two days. Assuming that no floats from these six cruises came ashore, together with the other assumptions mentioned in Table 1, it was estimated that only 205 floats drifted onto land. The overall public reporting rate was therefore 41.5 per cent, ranging from 49.6 per cent in warm months (October–March) to 25.7 per cent in cool months (April–September). The reporting pattern was typified by the returns of floats from the cruise on 27 September 1986 (Appendix 1) where it is almost certain that all 15 floats were beached along c. 10 km of coast but only seven were reported. It is most likely that some floats from this cruise landed on rocky headlands and shelfs. Variability in reporting was also typified in this batch group in that one of the furtherest dropped floats was reported in three days yet one from the closest drop was not reported until 35 days.

Speed tests at Berkley Marina showed considerable variation in the responses of particular floats, particular birds, and floats compared to birds. Floats travelled at an average of 4.97 per cent of wind speed (range 7.3–3.2%) whereas birds travelled at an average of 3.1 per cent (range 4.6–2.1%, Table 2). The average, maximum and minimum float speeds were consistently 1.5–1.6 times the corresponding bird speeds. Floats and birds moved at various directions from the drop point but all paths when pooled were within a sector of 30 degrees. Wings on birds that floated on their dorsums caused some specimens to obviously tack across wind but it was difficult to explain why floats responded with such directional variability.

TABLE 2

Results of speed tests at Berkeley Marina, Lake Illawarra, on 10 and 11 December 1993.

	n	Mean	Std dev.	Max	Min
Wind (mm/sec)	13	3 444	527	4 290	2 550
Floats (mm/sec)	10	162	32	226	126
Floats (% wind)	10	4.97	1.33	7.32	3.22
Shearwater corpses (mm/sec)	21	109	19	142	76
Shearwater corpses (% wind)	21	3.12	0.56	4.61	2.12

1 knot = 514 mm/sec.

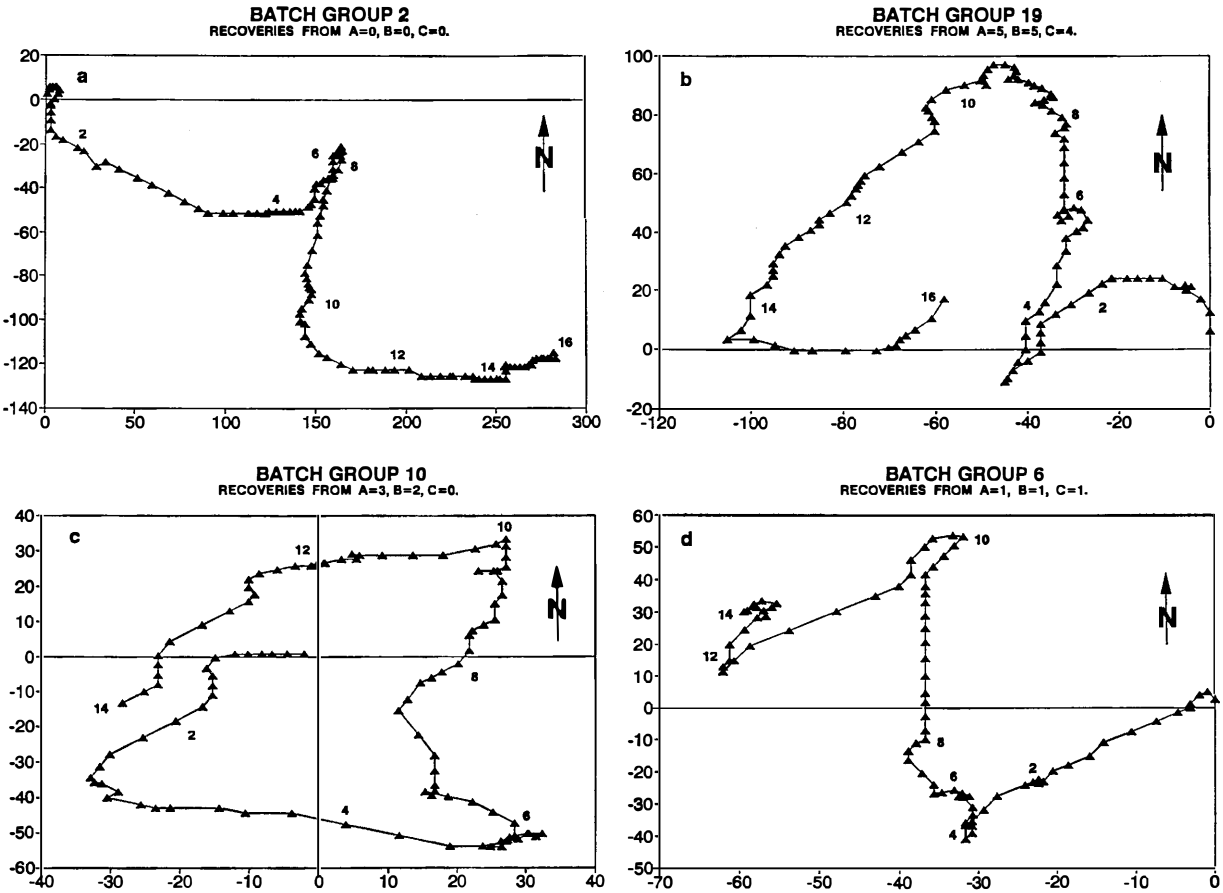

Figure 3. *Vector diagrams from four selected batch groups showing estimated movement of floats relative to the release point (0,0) under the influence of wind only. Float speed is assumed to be five per cent of wind speed at Port Kembla. All scales are kilometres and numbers refer to the mid-day position at two day intervals after the day of release. For recovery details see Appendix 1. Resultant effects of wind and current are given in text.*

The effect of wind alone is shown in Figure 3. As expected, no floats were recovered from batch group 2 and all but one float was recovered from batch group 19. For batch group 10, three of the A floats were found at Warilla and two of the B batch near Narooma. In batch group 6, one each of the A, B and C floats were found at Woonona, Avoca and Ulladulla respectively (see Appendix 1).

Table 3 provides an indication of the rate of decomposition of beach-washed corpses. The respective mean daily temperatures in February, March and April were 25.8°C, 20.2°C and 18.1°C. Rainfall at the University of Wollongong (5 km NW) in January, February, March, April and May 1989 was 217 mm, 82 mm, 148 mm, 435 mm and 240 mm respectively during a combined total of 99 wet days. Total rainfall over these five months was 38 per cent more than the corresponding 16-year mean.

DISCUSSION

The precise position of floats (or birds) off Wollongong cannot be determined from the wind vector alone. Indeed, these experiments have shown that a wind of 20 knots exerts the same force on drifting floats as a current of only one knot. The East Australian Current is well known as a major system (Hamon 1965) and speeds off central New South Wales have been estimated at 2–5 knots southwards (van Tets and Fullagar

TABLE 3

Results of deterioration tests of 16 Short-tailed Shearwater corpses at Coniston Beach from January to May 1989. Dead specimens were relocated to exposed dunes about 25 m from high water.

Time since found beached (weeks)	Condition of corpses
3	All able to be identified.* Only one partly broken into pieces.
8	Eleven identifiable, mostly intact. Five with tails not found.
12	Seven identifiable, just intact. Four with tails not found. Five recognized only from wing and skeletal remains.
17	One with wings, head and tail still intact and identifiable. Eleven recognized only from wing and skeletal remains.

*Identification based only on length of tail relative to straightened leg.

1978; Creswell 1987). More recently, Freeland *et al.* (1985) showed that the current vector ranged widely from about two knots north to about five knots south. Within a 190-day period the current changed direction, north to south and vise versa, about 17 times. A steadily flowing southern current of only 0.8 knots would explain the drift of two 10B floats to Narooma in five days (Appendix 1, Fig. 3c). Moreover, a relatively small northwards current for a few days followed by a current reversal to southwards for about a week would account for the recovery of batch 6A, 6B and 6C floats at Woonona, Avoca and Ulladulla respectively (Appendix 1, Fig. 3d).

These experiments provide information which will assist in the interpretation of beached seabird counts and allow a better understanding of where and when birds have died at sea. The results could also be used to determine the extent of a mortality incident off New South Wales. Unlike previous studies in the Irish Sea (Bibby and Lloyd 1977) and North Sea (Bibby 1981) where wind was the major controlling influence, the East Australian Current and the wind in combination control the movement of corpses off New South Wales. In general, the current controls movement along the coast; the wind controls east-west movement. A resultant easterly component is usually necessary to force birds to shore. An average rate of drift of 3.1 per cent of wind speed is in close agreement with previous estimates of 2.2 per cent (Hope-Jones *et al.* 1970), 2.55 per cent (Bibby and Lloyd 1977) and 4 per cent (Bibby 1981). In all these studies, wind speed was measured at coastal stations but it is important to appreciate that the speed and direction of wind at sea can be significantly different to that on land (P. Tate, pers. comm.). Bibby (1981) stated that winds in the North Sea during his study were likely to be three times that measured at a coastal station.

In the present study, there were substantial differences between the recovery and reporting rates because westerly winds blew some floats away from land, but in making the following comparisons with other studies, reporting rates are used because all test specimens in previous studies were directed towards land and would have beached unless they sank. At 41.5 per cent overall, ranging from 25.7 per cent (cool months) to 49.6 per cent (warm months), the reporting rates off Wollongong compare favourably with 20 per cent for gulls marked with bill tags in the North Sea (Bibby 1981), 25 per cent for shags in north-east England (Coulson *et al.* 1968) and 11–58 per cent for gulls dropped in the Irish Sea (Bibby and Lloyd 1977). Recovery rates off Wollongong were considerably higher in warm months than cool months, a manifestation of the predominant wind direction during these periods. In winter, 64 per cent of winds are from the west, south-west or north-west whereas in summer only 29 per cent of winds are from those directions. Only cruises between May and September, when winds often contained a western component, provided no recoveries. As in other similar studies, reporting rates off New South Wales appear to be closely linked to season of year. Reporting rates are also dependent on bird species or type of test specimen and publicity (see Bibby and Lloyd 1977; Bibby 1981).

This study provides new information on rates of seabird decomposition on beaches in New South Wales. Rainfall at any site will reduce dessication rates due to solar radiation and although the rainfall at Wollongong was somewhat above average during the test period, the decomposition rates obtained for Coniston Beach were considered typical because the time since the specimens were initially beached was likely to be 2–3 weeks more than that shown in Table 3 (refer methods). Scavengers also increase rates of decay and, as fresh holes made by Ghost Crabs (Ocypodidae) were often seen within a few metres of the test specimens, it is almost certain that these crustaceans fed on the carcasses at night and accelerated the process of decomposition at the test site. Decomposition rates at sea, however, are still unclear. Tests on five Short-tailed Shearwaters corpses in a floating cage in Lake Illawarra in December 1986 (water temperature 20.2°C) resulted in disarticulation of carcasses in 7–10 days (Wood, unpubl. data). Scavengers in this brackish estuary are from a different invertebrate family than those at sea but if carcasses remain in tact off the New South Wales' coast for even one week, a steady current of only one knot could cause a displacement of 300 km north or south of the point of death. Cox (1976) considered that sea lice (Crustacea) were rapid disposers of flesh and that beach-derelicts found in good condition off South Australia 'probably died (at sea) shortly before reaching land'. Conversely, Bibby and Lloyd (1977) thought it unlikely for Herring Gull *Larus argentatus* corpses in the Irish Sea to become disarticulated in less than a week. Previous studies by Hope-Jones *et al.* (1970) and Bibby (1981) showed that larid and alcid corpses remained identifiable for 35–170 days and up to 120 days respectively from the date of death at sea to the date of reporting, although these periods include the time at sea and on the beach. From circumstantial evidence, Hope-Jones *et al.* (1970) concluded that 50 per cent of 410 alcids tested at sea sank to the bottom within 11 days. The above studies suggest that further investigation is needed to determine decomposition rates of dead seabirds in various marine environments around Australia and other countries.

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APPENDIX 1

Recoveries of floats released off Wollongong during 25 cruises between June 1985 and October 1987. Fifteen floats were dropped on each cruise; five at 9 km east (A batch), five at 35–45 km east (B batch) and five at the turning point (C batch, refer column 3).

Batch group No.	Cruise date	Release point of C batches (km east)	No. of recoveries from batches			Movement of the first float recovered				
			A	B	C	Batch	Days elapsed	Destination	Displacement (km)	Displacement speed (km/day)
1	29 June 85	90	1	0	1	A	13	Kiama	26	2
						C	14	Jervis Bay	120	8.6
2	27 July 85	51.9	0	0	0			No recoveries		
3	24 Aug. 85	68.5	0	1	0	B	725	Pt Kembla	37	0.1
4	21 Sept. 85	50	0	0	0			No recoveries		
5	27 Oct. 85	53.7	4	3	0	A	1	Woonoona	12	12
						B	8	Currarong	65	8.1
6	3 Nov. 85	74.1	1	1	1	A	9	Woonoona	12	1.3
						B	9	Avoca	89	9.9
						C	17	Ulladulla	125	7.4
7	23 Nov. 85	79.6	0	2	0	B	8	Pt Kembla	37	4.6
8	13 Jan. 86	77.8	3	2	0	A	1	Royal N. Park	23	23
						B	28	Bermagui	198	7.1
9	25 Jan. 86	64.8	3	2	1	A	2	Bellambi	12	6
						B	4	Jervis Bay	80	20
						C	4	Vincentia	94	23.5
10	15 Feb. 86	64.8	3	2	0	A	2	Warilla	15	7.5
						B	5	Narooma	185	37
11	22 Mar. 85	72.2	2	0	0	A	2	Kiama	26	13
12	26 Apr. 86	63	1	1	0	A	8	Kurnell	40	5
						B	157	Royal N. Park	37	0.2
13	24 May 86	63	0	0	0			No recoveries		
14	28 June 86	50	0	0	0			No recoveries		
15	26 July 86	66.7	1	0	0	A	1	Pt Kembla	12	12
16	24 Aug. 86	59.3	0	0	0			No recoveries		
17	27 Sept. 86	64.8	2	3	2	A	35	Pt Kembla	12	0.3
						B	3	Pt Kembla	37	12.3
						C	3	Coniston	65	21.7
18	25 Oct. 86	55.6	2	2	0	A	8	Stanwell Park	18	2.3
						B	4	Wanda Beach	43	10.8
19	23 Nov. 86	66.7	5	5	4	A	1	Fairy Meadow	12	12
						B	2	Wombarra	39	19.5
						C	7	Wamberal	114	16.3
20	13 Dec. 86	75.9	1	0	0	A	10	Durras	117	11.7
21	25 Jan. 87	64.8	3	0	0	A	3	Culburra	45	15
22	21 Mar. 87	64.8	3	3	0	A	2	Royal N. Park	26	13
						B	2	Wanda Beach	43	21.5
23	25 Apr. 87	74.1	0	4	1	B	13	The Entrance	102	7.8
						C	14	The Entrance	107	7.5
24	26 July 87	51.9	0	0	0			No recoveries		
25	25 Oct. 87	50	2	4	3	A	2	Cronulla	35	17.5
						B	2	Royal N. Park	38	19
						C	2	Wanda Beach	49	24.5