CSIRO
Division of Fisheries and Oceanography

REPORT 115

The Response of Drogued and Undrogued Drifting Buoys to Eddies and the Wind

G. R. Cresswell and J. Garrett

1980

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION
DIVISION OF FISHERIES AND OCEANOGRAPHY
P.O. BOX 21, CRONULLA NSW 2230

Reprint 1080

National Library of Australia Cataloguing-in-Publication Entry

Cresswell, G.R.
The response of drogued and undrogued drifting buoys to eddies and the wind

(Division of Fisheries and Oceanography report; no. 115)
Bibliography
ISBN 0 643 02514 6

1. Oceanographic buoys. 2. Ocean currents. 3. Winds.
I. Garrett, J. joint author. II. Title. (Series: Commonwealth Scientific and Industrial Research Organization. Division of Fisheries and Oceanography. Report; no. 115)

551.47

Printed by CSIRO, Melbourne

79.561-600

THE RESPONSE OF DROGUED AND UNDROGUED DRIFTING BUOYS TO EDDIES AND THE WIND

G.R. Cresswell and J. Garrett†*

*CSIRO Division of Fisheries and Oceanography
P.O. Box 21, Cronulla, N.S.W. 2230 Australia

†Institute of Ocean Sciences
P.O. Box 6000, Sidney, B.C. V8L 4B2 Canada

CSIRO Aust. Div. Fish. Oceanogr. Rep. 115 (1980)

Abstract

Drifting buoys released into an anticyclonic eddy in the western Tasman Sea showed the effects of both current and wind. The buoys used included prototypes for the Australian and Canadian buoys for the Global Weather Experiment. Relative to the Australian buoys the Canadian buoys drifted downwind at 4.5 ± 1% of the wind speed.

INTRODUCTION

During the Global Weather Experiment (GWE) in 1979 a variety of satellite-tracked buoys with and without drogues have been distributed over the oceans of the southern hemisphere. The resulting station grid is unprecedented in meteorology and is likely to have important consequences for oceanography. For the latter it would be desirable to have some indication of the relative responses of the different buoys to winds and currents. An experiment for this purpose began in March 1977 when four Australian CSIRO and four Canadian buoys were released in pairs into an anticyclonic eddy (eddy A) off south east Australia. This report examines the tracks of these and two other buoys in relation to available current and wind data. Unfortunately, the complexity of the ocean circulation and the wind field served to make the findings less quantitative than we would have wished.

THE BUOYS

The identification numbers of the Australian and Canadian buoys are prefixed with A and C respectively. They were as follows:

A1570 - 2 m long horizontally-floating 'torpedo' buoy (Cresswell *et al.*, in press) with a 200 m long 5 mm diameter stainless steel tether cable to a 4.5 m diameter parachute.

A1054, A1352, A1364, A1546 - 4.5 m long vertically-floating 'spar' buoys with 20 m long 12 mm diameter polyethylene tether rope to a 4.5 m diameter parachute. These buoys and drogues closely resemble the Australian GWE ones.

A1234 - 'torpedo' with 20 m rope tether to a parachute.

C640, C676, C1361, C1543 - 2 m 'spars' without drogues of the type to be used for the Canadian GWE buoys (World Meteorological Organization 1977).

All buoys carried sea surface temperature sensors with the Canadian buoys functioning perfectly throughout their lives which exceeded one year. Of the Australian buoys A1054 gave no temperature information, A1546's temperatures as presented in a data report (Cresswell and Wood 1977) seem too high, and A1364 had battery problems and was not heard on enough satellite passes to be included here.

RESULTS

The experiment was conducted against a background of considerable spatial and temporal ocean current complexity. HMAS 'Kimbla' was used to locate eddy A by means of an Expendable Bathythermograph (XBT) survey (Nilsson and Cresswell, unpublished manuscript) and the buoys were released into it on day 63 (4 March 1977) as follows: A1546, A1570, C640, and C1543 at the centre of eddy A; A1364 and C1361 10 km east of the eddy centre; and A1054 and C676 ~70 km south west of the centre.

To the north of eddy A the formation of eddy B through the pinch-off of the East Australian Current was indicated by both the track of A1234 and a subsequent 'Kimbla' XBT survey. Buoy A1352 was released into eddy B on day 87 (28 March) during this survey.

Restricting, for the moment, our examination to the Australian buoys (Fig. 1a.) we see that A1054, which was released 70 km south west of eddy A's centre, described 1½ loops before escaping to the north, turning cyclonically, and drifting eastward between eddies A and B. Buoys A1546 and A1570 stayed with eddy A as it moved 300 km at 5 km day^{-1} SSE between March and May. These two buoys described a number of very small loops suggesting, perhaps, that they were frequently near the eddy centre. The difference between the two buoys — A1546 a spar with a 20 m tether to a parachute, A1570 a torpedo with a 200 m tether to a parachute — does not seem to have affected their relative long term responses to the eddy. Eddy B, in the meantime, had formed and it kept buoys A1234 and A1352 trapped until June.

By comparison, the two eddies did not constitute such a trap for the Canadian buoys (Fig. 1b.): C676 escaped after 3 days, C640 and C1543 after 8-9 days, and C1361 after 10 days, thence to approximately travel the path of A1054. C676 entered eddy B on day 75 and then described a loop very similar to that of A1234, which it lead by 3 days. It remained trapped in eddy B until day 100 (10 April) when it escaped to the north.

The wind data available were the four-hourly Beaufort scale wind vectors logged aboard HMAS 'Kimbla' while in the latitude range 35°-41°S and surface wind vectors calculated from daily atmospheric pressure charts. Sea surface temperatures measured by the Canadian buoys appear in Fig. 2.

The relative effects of the wind on buoys A1054 and C676 during their first few days after release can be seen in Fig. 3 where wind vectors are plotted at interpolated positions on the track of C676. For the first day the wind acted at right angles to the current thereby tending to move C676 away from the eddy centre. At 1133Z on day 64 (5 March) it was 44 km south of A1054. The wind during this time was ~12 m s^{-1} which means that C676 moved relative to A1054 at 4.5% of the wind speed with an uncertainty of 1% related to the two position fix uncertainties of ± 5 km. The direction of the wind through until day 66 was such to move the buoy away from the eddy centre; it escaped from the eddy on day 66 (7 March) and indicated an increase in sea surface temperature from 21.1°C to 21.8°C.

The next example detailing the differences between drogued and undrogued buoys is given in Fig. 4 and it illustrates the difficulties of interpretation in a complex region. The 'Kimbla' wind vectors are plotted at interpolated positions on the track of C1361. Buoys C1361, C640 and C1543 were all driven northeast under the combined effects of current and wind on days 70 and 71 (11 and 12 March). They all travelled at 1.2 m s^{-1}, but C1361 was nearest the eddy centre, and therefore in the weakest current, while C640 and C1543 spent part of this time at the fast edge of the eddy; they escaped from the eddy sometime prior to the day 71 fixes because their sea surface temperature readings decreased from 21.5°C to 20.8°C and 21.5°C to 20.6°C respectively between days 70 and 71. Thus their distances travelled received an unknown contribution from the eddy current. A1054 travelled along their path at 1.5 m s^{-1} between the fixes on days 71 and 72.

An example of a buoy leaving eddy A, re-entering and then leaving again is also given in Fig. 4: buoy C1361 was carried outside A1054's track on day 72 (13 March) during which the sea surface temperature that it measured decreased from 21.1°C to 20.4°C. (Note that C676 registered a temperature *increase* from 21.1°C to 21.8°C when it left the eddy in this area on day 66.). By 0440 on the next day, after it had been carried back into the eddy its temperature had returned to 21.1°C. During day 74 (15 March) its temperature started to decrease and by day 75 it was down to 20.1°C. From the wind vectors plotted at interpolated positions on the track of C1361 the buoy motion can be seen in a qualitative way to have responded to wind forcing. Calculations of the wind effect carrying C1361 from and into eddy A can be made: C1361 left the eddy as a result of being displaced outward 21 km at 0.45 m s^{-1} across the path of A1054 between 1344 on day 71 and 0250 on day 72. A representative value for the wind during this time is 6 m s^{-1} perpendicular to the current and this leads to a value of 7.5% of the wind speed for the effect on C1361 relative to A1054. The errors will be large due to uncertainties in position fixing, the onset time for the westerly winds and measurements made relative to the path of A1054, since it did not reach the area until another day had passed. C1361 was carried back into the eddy as a result of being displaced 22 km inward at 0.28 m s^{-1} across the path of A1054 between 1449 on day 72 and 1227 on day 73. Winds during this time were mainly perpendicular to the path of A1054 at 5-12 m s^{-1} with 8 m s^{-1} being representative. This leads to a wind effect of 3.5% for C1361 relative to A1054. Once again, the errors will be large.

The tracks of buoys A1054 and C1361 from days 76 to 84 (17-25 March) show C1361 being carried to the north of A1054 between days 76 and 79. For part of this time, day 77/78, it entered warmer water ranging up to 22.7°C; by day 79 the temperature was down to 20.1°C.

The final example to be discussed here is that of buoy C676 entering eddy B: between the second fix on day 74 (15 March) and the first fix on day 75 it entered the stream of warm northern water which carried A1234 into the newly forming eddy B. In so doing it encountered a sea surface temperature increase from 21.5°C to 23.1°C. It kept in water of 22.9-23.1°C until it escaped from eddy B to the north after day 100. It later demonstrated its response to the wind on day 123 (3 May) by drifting into, and running aground in, Sydney Harbour during a storm.

CONCLUSIONS

From an examination of the tracks of drogued and undrogued buoys it has been possible to qualitatively interpret their differences. The one measurement that could be made on the responses of the buoys to the wind with any degree of confidence suggested that the undrogued Canadian GWE buoys could drift downwind at 4.5 ± 1% of the wind speed relative to the Australian GWE buoys with drogues.

Ideally an experiment such as this would need to be done in an area free of the complexities of eddies and rapidly changing winds: an example is the South Equatorial Current in the Central Indian Ocean where Australian buoys have drifted westward with only slight deviations (Cresswell and Golding 1979).

Acknowledgments

We thank the data processing staff at NASA, the crew of HMAS 'Kimbla' and Dr Carl Nilsson.

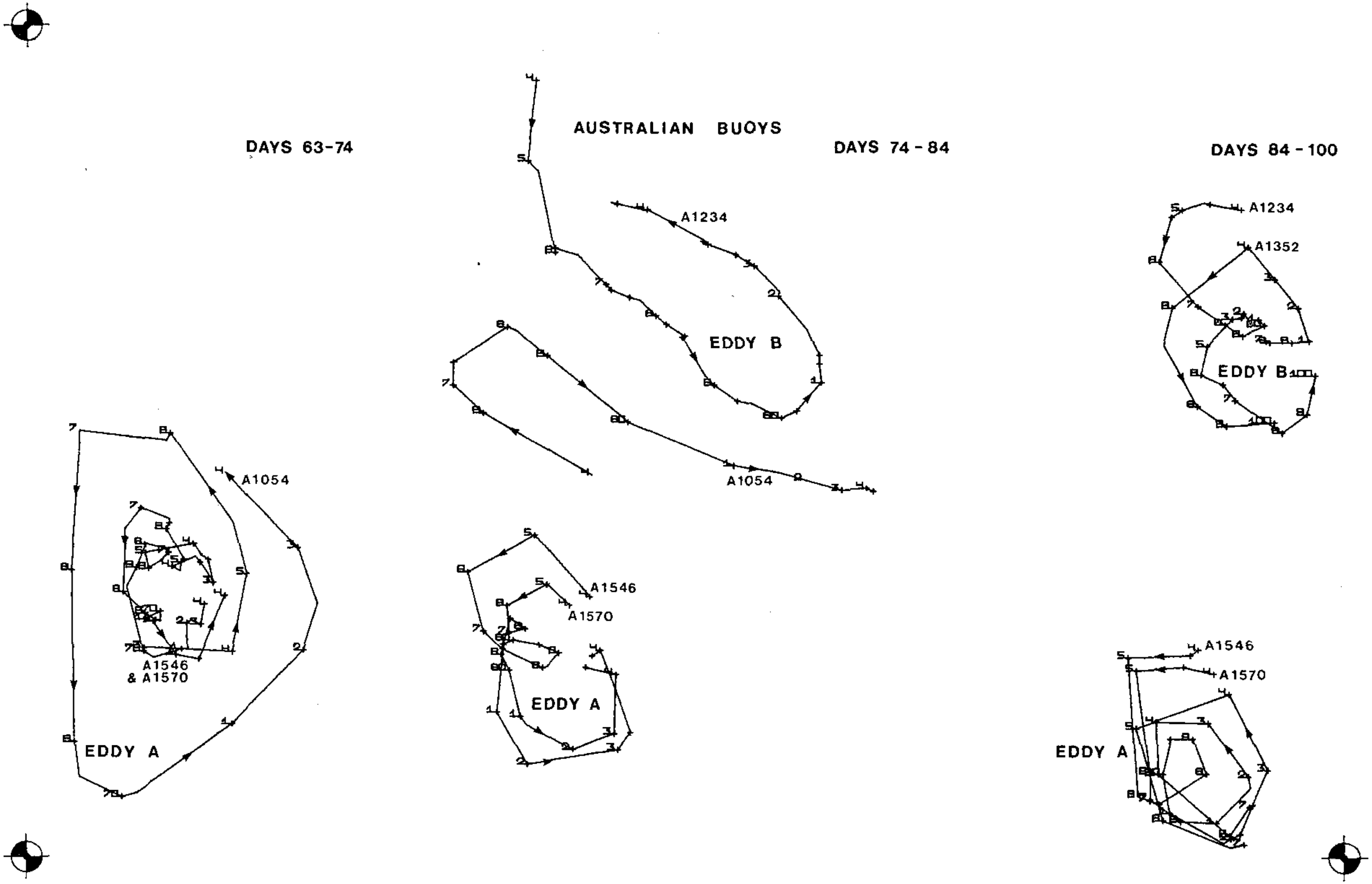
REFERENCES

Cresswell, G.R., and Wood, J.E.(1977). Satellite-tracked buoy data report II. Tasman Sea releases November 1976-July 1977. CSIRO Aust. Div. Fish.Oceanogr. Rep.91.

Cresswell, G.R., and Golding, T.J. (1979). Satellite-tracked buoy data report III. Indian Ocean 1977. Tasman Sea July-December 1977. CSIRO Aust. Div. Fish. Oceanogr. Rep. 101.

Cresswell, G.R., Richardson, G.T., Wood, J.E., and Watts, R. The satellite-tracked 'torpedo' buoy. CSIRO Aust. Div. Fish. Oceanogr. Rep. 82 (In press).

World Meteorological Organization (1977). First GARP Global Experiment. The southern hemisphere drifting buoy system. Garp Newsletter No. 31.



AUSTRALIAN BUOYS
DAYS 63-74
DAYS 74 - 84
DAYS 84 - 100
A1054
A1546
& A1570
EDDY A
A1234
EDDY B
A1054
A1546
A1570
EDDY A
A1234
A1352
EDDY B
A1546
A1570
EDDY A

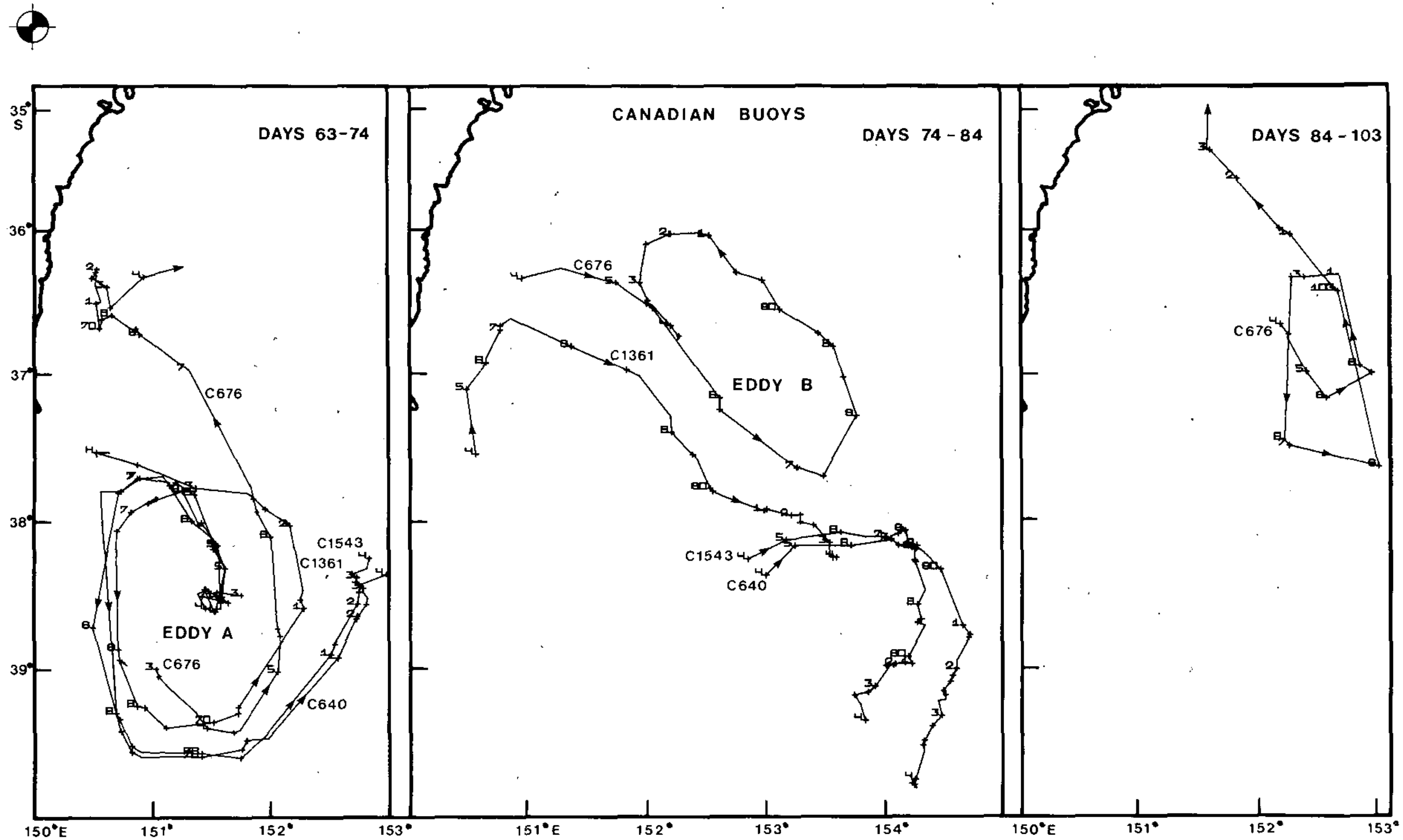


Fig. 1. Tracks of the Australian (a) and Canadian (b) buoys in the vicinity of eddies A and B.

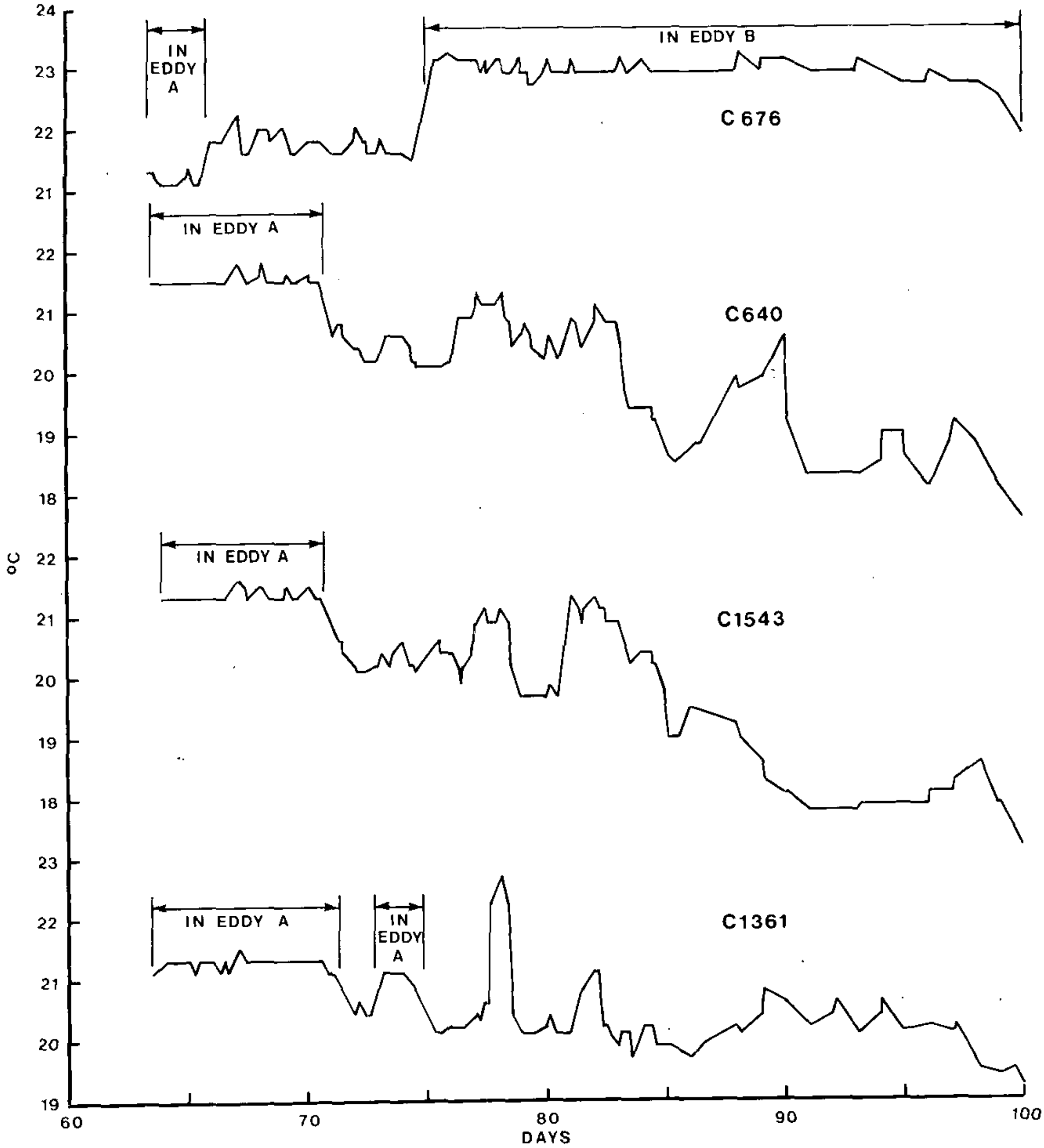


Fig. 2. Sea surface temperatures measured by the Canadian buoys.

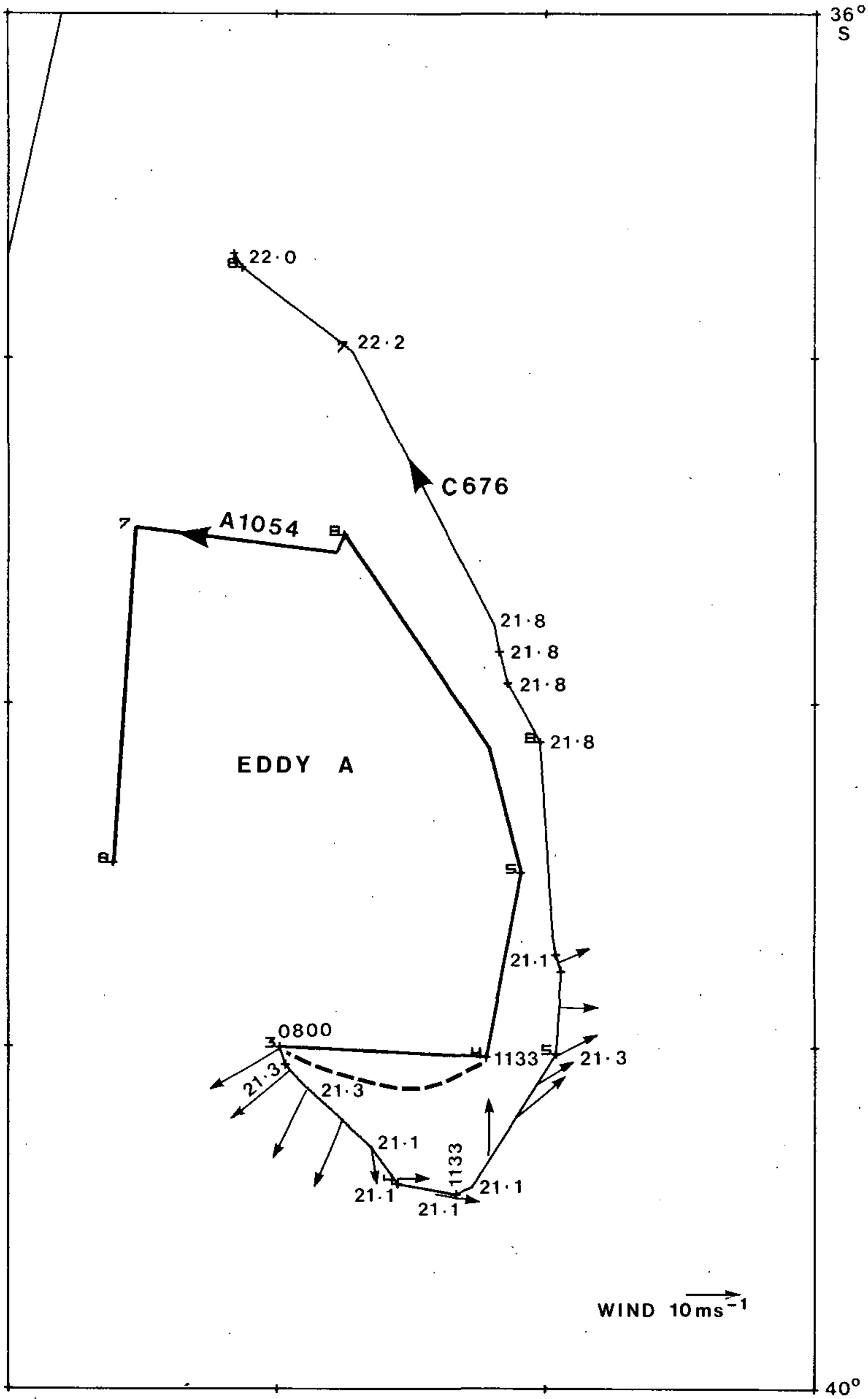


Fig. 3. The tracks of the Australian buoy A1054 and the Canadian buoy C676 for the 5 days following their release. Wind vectors logged on H.M.A.S. "Kimbla" are plotted at interpolated positions on the track of C676. Sea surface temperatures measured by C676 and times referred to in the text are shown.

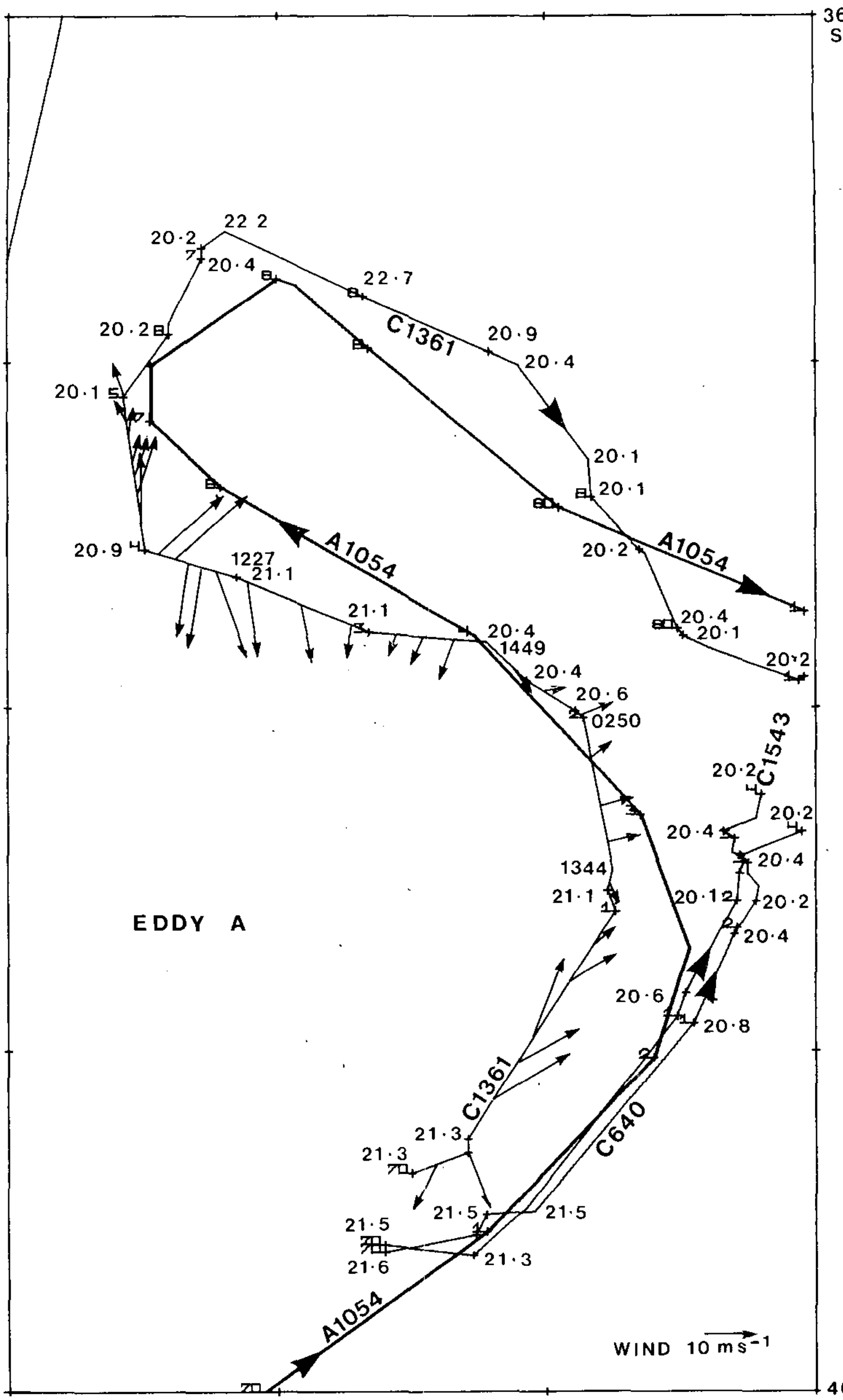


Fig. 4. The tracks of A1054, C640, C1361 and C1543 from day 70. Wind vectors logged on H.M.A.S. "Kimbla" are plotted at interpolated positions on the track of C676. Sea surface temperatures measured by the Canadian buoys and times referred to in the text are shown.

CSIRO
Division of Fisheries and Oceanography

HEADQUARTERS
202 Nicholson Parade, Cronulla, NSW
P.O. Box 21, Cronulla, NSW 2230

NORTHEASTERN REGIONAL LABORATORY
233 Middle Street, Cleveland, Qld
P.O. Box 120, Cleveland, Qld 4163

WESTERN REGIONAL LABORATORY
Leach Street, Marmion, WA 6020
P.O. Box 20, North Beach, WA 6020