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COMPARISON OF CIRCULATION ESTIMATES AND WINDS BASED ON SHIPBOARD AND SATELLITE-TRACKED BUOY DATA IN BRANSFIELD STRAIT, 9-14 MARCH, 1985 (PART III)

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14. Abstract/Notes

INPE's freely drifting prototype oceanographic buoy (System ARGOS) was launched successfully on 9 March at 19:31 GMT, for a several day test experiment. During the 9-14 March, 1985, interval, a set of 7 hydrographic stations was made in the Bransfield Strait to obtain information about temperature, salinity and density. In this report we present some results of the several day drifter trajectory, together with a comparison with geostrophic circulation, surface winds and air and sea temperatures. Mean drifter velocity was 27.0 cm s^{-1} toward 042^{o} and confirmed a predicted NE movement for the surface water layer. The surface geostrophic current was toward 020^{o} at 4 cm s^{-1}; at 10 m depth the current was toward 045^{o} at 5 cm s^{-1}. Best agreement was found between the drifter trajectory and the geostrophic current at 10 m depth. At the time of buoy launch and for about one day thereafter, winds were weak and toward 090^{o}; after another day, however, the surface winds changed and blew generally toward 250^{o} at speeds that gradually increased up to 16 kts, in opposition to the surface water motion. Air and water temperatures measured from the buoy are also discussed and compared with measurements made at the hydrographic stations.

15. Remarks *This work is being submitted to Revista Brasileira de Geofísica.*

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ABSTRACT

INPE's freely drifting prototype oceanographic buoy (System ARGOS) was launched successfully on 9 March at 19:31 GMT, for a several day test experiment. During the 9-14 March, 1985, interval, a set of 7 hydrographic stations was made in the Bransfield Strait to obtain information about temperature, salinity and density. In this report we present some results of the several day drifter trajectory, together with a comparison with geostrophic circulation, surface winds and air and sea temperatures. Mean drifter velocity was 27.0 cm s^{-1} toward 042^o and confirmed a predicted NE movement for the surface water layer. The surface geostrophic current was toward 020^o at 4 cm s^{-1}; at 10 m depth the current was toward 045^o at 5 cm s^{-1}. Best agreement was found between the drifter trajectory and the geostrophic current at 10 m depth. At the time of buoy launch and for about one day thereafter, winds were weak and toward 090^o; after another day, however, the surface winds changed and blew generally toward 250^o at speeds that gradually increased up to 16 kts, in opposition to the surface water motion. Air and water temperatures measured from the buoy are also discussed and compared with measurements made at the hydrographic stations.

COMPARAÇÃO DE ESTIMATIVAS DE CIRCULAÇÃO E VENTOS BASEADAS EM DADOS COLHIDOS A BORDO DE NAVIO E DADOS DE BÓIA REGISTRADOS POR SATÉLITE NO ESTREITO DE BRANSFIELD ENTRE 9 E 14 DE MARÇO DE 1985 (PART III)

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RESUMO

O protótipo da bóia oceanográfica de deriva do INPE (Sistema ARGOS) foi lançado com sucesso no dia 9 de março às 19:31 HMG, para um teste de vários dias. Durante o intervalo entre o dia 9 e 14 de março de 1985, um conjunto de 7 estações hidrográficas foi realizado no Estreito de Bransfield para obter dados de temperatura, salinidade e densidade. Neste relatório apresentam-se alguns resultados do teste de deriva da bóia que durou vários dias, junto com uma comparação com circulação geostrófica, ventos superficiais e temperaturas do mar e ar. A velocidade média da bóia foi de 27,0 cm s^{-1} para a direção 042^{o} e confirmou o movimento NE previsto para a camada superficial. A corrente geostrófica da superfície foi de 4 cm s^{-1} para 020^{o}, e de 5 cm s^{-1} para 045^{o} a 10 m de profundidade. A melhor concordância encontrada entre a trajetória do flutuador e a corrente geostrófico foi a 10 m. No horário do lançamento da bóia e um dia após, os ventos foram fracos e direcionados a 090^{o}; porém após mais um dia do lançamento os ventos mudaram de direção e sopraram generalmente em direção 250^{o} a uma velocidade de até 16 nós, em oposição ao movimento das águas de superfície. As temperaturas do ar e da água medidas pela bóia são também discutidas e comparadas com as medições feitas nas estações hidrográficas.

Introduction

This is the third of three reports on results from the first test and use of INPE's drifting oceanographic buoy in Antarctica. The first report (Stevenson and Alonso, 1985) describes the development of the drifting buoy; the second paper discusses variations in temperature, salinity and density based on shipboard measurements made during the buoy test (Stevenson et al., 1985).

INPE's prototype drifting oceanographic buoy was successfully launched on 9 March 1985, at 19:31 GMT, for a several day test. During the interval of 9-14 March, a set of 7 hydrographic stations was made in the Bransfield Strait to obtain temperature, salinity and density data. Results from the hydrographic data are being separately presented in this Meeting (Stevenson et al., 1985). In this report we will present some results of the drifting buoy, together with a comparison with geostrophic circulation, ship winds, and air and water temperatures.

Data and Methods

Positions of the drifting buoy are determined from the buoy's transmissions by the ARGOS center in Toulouse, France. The accuracy of each determination is affected by various factors, including the stability of the buoy transmitter. On the average, the buoy positions are considered known to within 300 m (0.003^o latitude, for example).

Water and air temperature readings were also made from the drifting buoy and were also received by NOAA-6 and NOAA-9 satellites passing overhead in their polar orbits. These data were later received at the ARGOS center in France, where geographic positions of the buoy were calculated. These data were subsequently received at INPE in São José dos Campos, Brazil.

Buoy position data from SERVICE ARGOS were also used to construct a map of the buoy trajectory. Because the subsurface sail or drag element of the buoy was 10 m below the buoy (11 m below the water surface), the trajectory represents water motion at about 10 m depth, since the surface buoy also exhibits some frictional drag in the uppermost meter of water. More technical details of the buoy construction are being given in a different report in this Meeting (Stevenson and Alonso, 1985).

Wind and air temperature measurements were made from the Oceanographic Support Vessel Barão de Teffé at the hydrographic stations. The Bendix aeronave wind sensor was located above the bridge, about 10 m above the water line of the ship.

Results

Progressive movement of the drifting buoy is seen in Figure 1. Based on previous studies of the area (Ikeda et al., 1985), a north-easterly water movement was predicted. The buoy launch position was therefore placed at the southern end of the set of hydrographic stations so that the buoy might move through the station grid. As seen from Figure 1, the buoy moved toward the northeast and passed through the southern set of stations. Mean buoy speed was 27 cm s^{-1} toward 042^{o} during the 58 hours of the buoy experiment.

Geostrophic circulation of 0 m and 10 m depth, referenced to 250 dbar, is shown in Figures 2 and 3. In the southern part of the Strait, surface geostrophic current was 4 cm s^{-1} toward 020^{o} and 5 cm s^{-1} toward 045^{o} at 10 m. Comparison of the buoy trajectory with the geostrophic circulation showed good agreement in terms of direction of water movement. The buoy speed was greater than that indicated by geostrophic calculations. Closest agreement was between geostrophic circulation at 10 m and the buoy trajectory. This is not surprising because the drag element (or window shade) of the drifter was set for 10 m below the buoy.

FIGS. 1, 2 and 3

Although some of this "excess velocity" may be attributed to wind drag on the buoy, resulting in a velocity greater than the water motion, it is our opinion that the actual water speed in the uppermost 10 m was greater than the geostrophic speed, due to wind friction on the water surface. Other reasons for the differences between the buoy trajectory and geostrophic currents include the selection of the depth of the reference level for the geostrophic current and the recognition that geostrophic currents are inherently average currents, with large time and space scales.

Wind speeds and directions measured at the oceanographic stations are shown in Figure 4. When the buoy was launched on 9 March and for one day thereafter, winds were 0-9 kts (0 - 4.5 m s^{-1}) toward 090^{o}. About one day later, the winds changed direction and blew toward 250^{o} at speeds that over the following two days increased up to 16 kts (8 m s^{-1}).

FIG. 4

The last 10 hours of the buoy trajectory (Figure 1) indicates that the near surface water velocity markedly decreased and exhibited little net displacement. In contrast, the geostrophic circulation continued to show flow toward the NE through 14 March. This difference indicates that the near surface current responded rather quickly to changes in wind stress (evidenced by the buoy trajectory), a change not noted by the geostrophic circulation. During the first two days of the experiment, the drifter estimates of the current indicated the flow to be to the left of the wind direction, consistent with Ekman drift.

During the buoy test, the ship proceeded to complete the set of oceanographic stations. The ship therefore was not close to the buoy for most of the buoy test. Considering this limitation, there is still value in comparing the dry bulb air temperatures made from the bridge of the ship with those from the buoy (Figure 5). There were

3 shipboard station observations made during the buoy test and these lie in close approximation to the linear regression curve shown in Figure 5. There are several reasons as to why there is an offset between the buoy air temperatures and those made from the ship. The air temperature sensor atop the buoy is about 1 m above the mean water line on the buoy, while the shipboard measurements were made more than 10 m above the sea surface. Various studies (for example Wu, 1985) have indicated that winds differ logarithmically in the lowest 20 m as compared to wind measurements at greater heights. By extension we can say that air temperatures and humidity in the lowest proximity to the sea surface differ from values at greater heights. The surface water temperature was 0.6 - 1.4^{o}C during the experiment, causing the air immediately above the sea surface to be more cold than the air at greater height above the surface. This explanation is supported by the fact that the warmer shipboard air temperatures corresponded to the larger ΔT's between the ship and buoy temperatures. In general, air/sea interactive processes, such as evaporation and the exchange of sensible heat from the ocean surface to the atmosphere, are considered responsible for at least a part of the observed temperature difference. Another reason for the temperature differences between the two data sets is that the buoy sensor may have gotten wet due to heavy wave action. The effect would be to reduce the sensor temperature from what it would be if perfectly dry. The replotting of the wet bulb with buoy air temperature data (not shown here) merely displaces the present curve downward about 1^{o}C.

FIG. 5

Another explanation for the offset in air temperatures is that an error was made in calibrating the buoy air sensor. From the small number of paired observations, it is not possible to determine the extent of such an error.

Water temperatures from the buoy may be compared in Figures 6 and 7. Although the oceanographic stations were not close to the buoy, the triangles in these two figures appear within 0.1 - 0.3^{o}C of the ship temperature data. Since the desired calibration was to be within 0.1^{o}C of actual water temperature, we consider the water sensors to have been accurately calibrated.

FIGS. 6 and 7

Conclusions

The following inferences or conclusions are drawn for this report:

1. Service ARGOS position fixes were received in sufficient numbers to determine the mean buoy trajectory to be 27 cm s^{-1} toward 042^{o}.

2. Closest agreement with geostrophic currents was at 10 m depth where the current was 5 cm s^{-1} toward 045^{o}.

3. The greater buoy speed is attributed to a combination of wind drag on the exposed part of the buoy and an actual water speed greater than the estimated geostrophic speed.

4. During 9-12 March, surface currents were in the direction of the wind but offset to the left, consistent with Ekman drift currents.

5. Comparison of the buoy air temperatures with the dry bulb measurements from the ship show the buoy temperatures to have been systematically cooler and of the form: $T_{ship} = 1.47\ T_{buoy} \pm 5.48$. That is, the temperature difference was greatest when the air temperature was warmest. Air/sea interactive processes may have been responsible for a part of the observed difference. Also, it is known that vertical

profiles of wind velocity, air temperature and humidity may show differences, due to heights of the measurements.

6. Comparison of buoy water temperatures with shipboard temperatures indicates the buoy temperatures to have been within 0.1 - 0.3°C of the shipboard temperatures.

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7 Figures

Figure Captions

Figure 1. Drifting buoy trajectory in Bransfield Strait during 9-12 March, 1985. Circles represent position fixes; triangles represent oceanographic stations.

Figure 2. Surface geostrophic circulation (in dynamic meters) referenced to 250 dbar surface, for 9-14 March, 1985.

Figure 3. Geostrophic circulation (in dynamic meters) for 10 m, referenced to 250 dbar surface, for 9-14 March, 1985.

Figure 4. Wind speed and direction measured from the Barão de Teffé during 9-14 March, 1985. Wind is blowing in the direction of the arrowheads.

Figure 5. Comparison of dry bulb air temperatures from ship and the buoy during 9-12 March, 1985. The equation defines the linear regression curve.

Figure 6. Mean water temperatures from the sensor 0.5 m below the buoy. B is the time of buoy launch while triangles and circle represent ship temperatures and isolated buoy temperature, respectively.

Figure 7. Mean water temperatures from the sensor 10 m below the buoy. B is the time of buoy launch while triangles and circle represent ship temperatures and isolated buoy temperature, respectively.

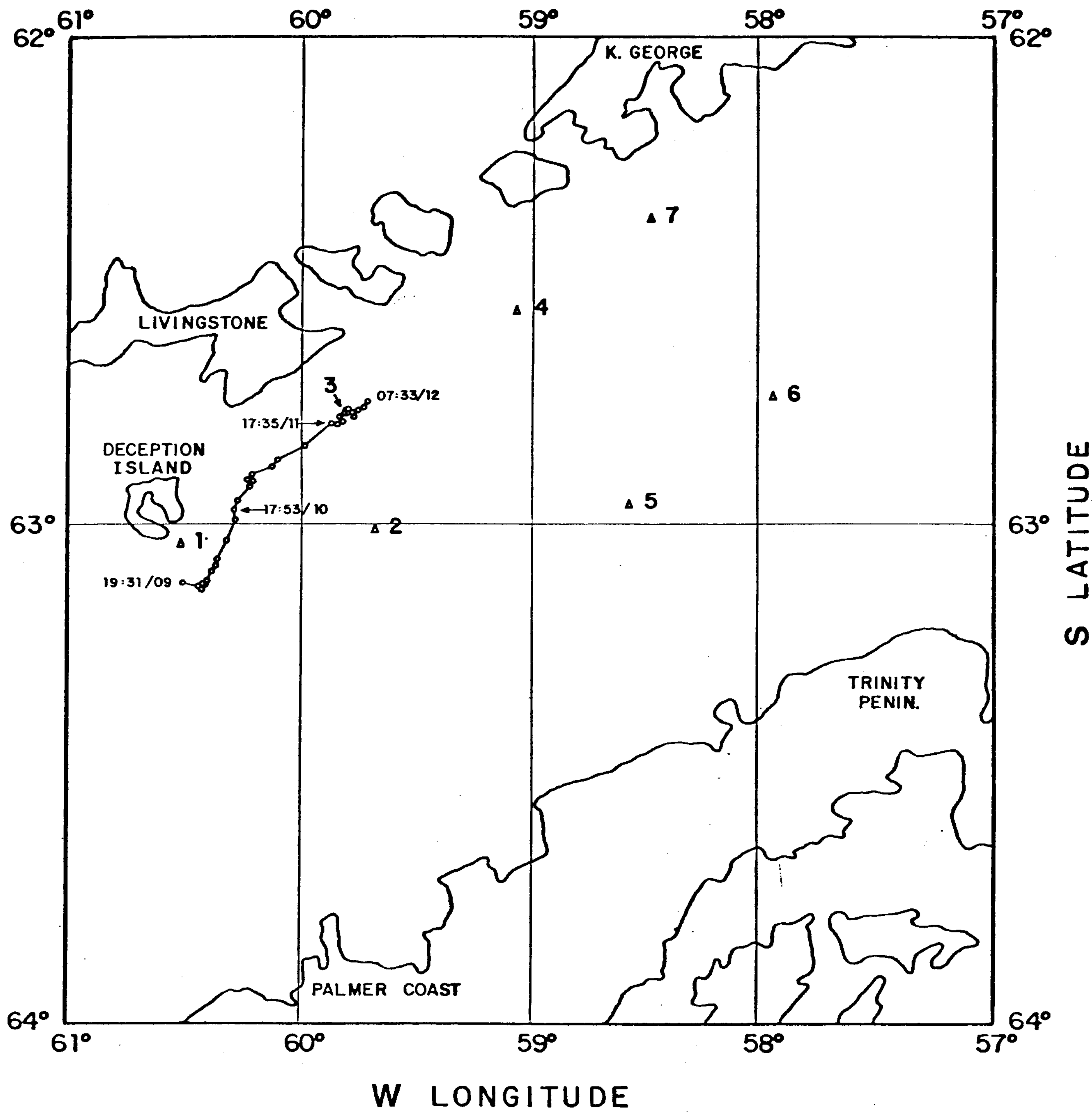
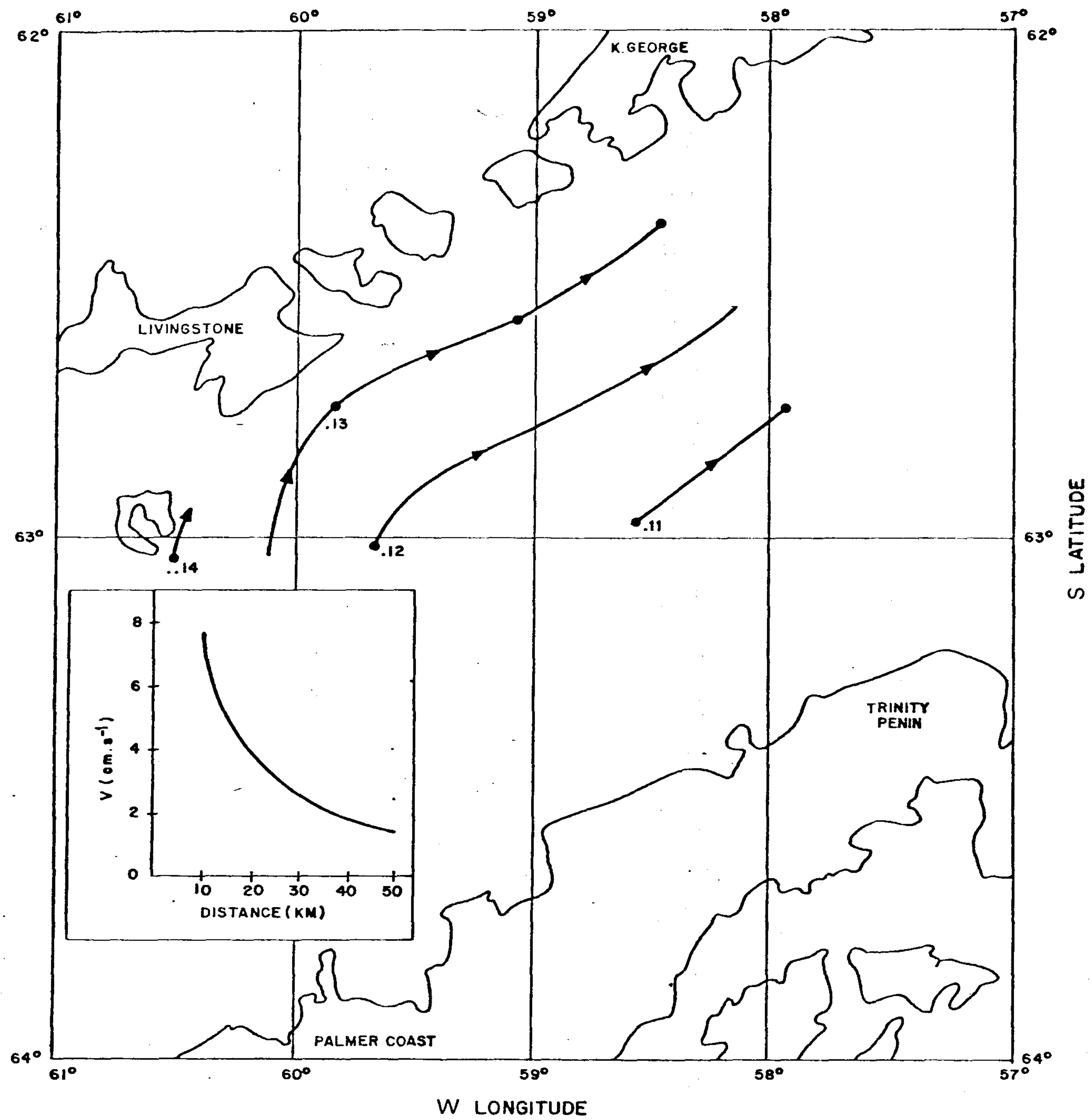

61°
60°
59°
58°
57°
62°
63°
64°
K. GEORGE
LIVINGSTONE
DECEPTION
ISLAND
TRINITY
PENIN.
PALMER COAST
1
2
3
4
5
6
7
07:33/12
17:35/11
17:53/10
19:31/09
W LONGITUDE
S LATITUDE

Figure 1



61°
60°
59°
58°
57°
62°
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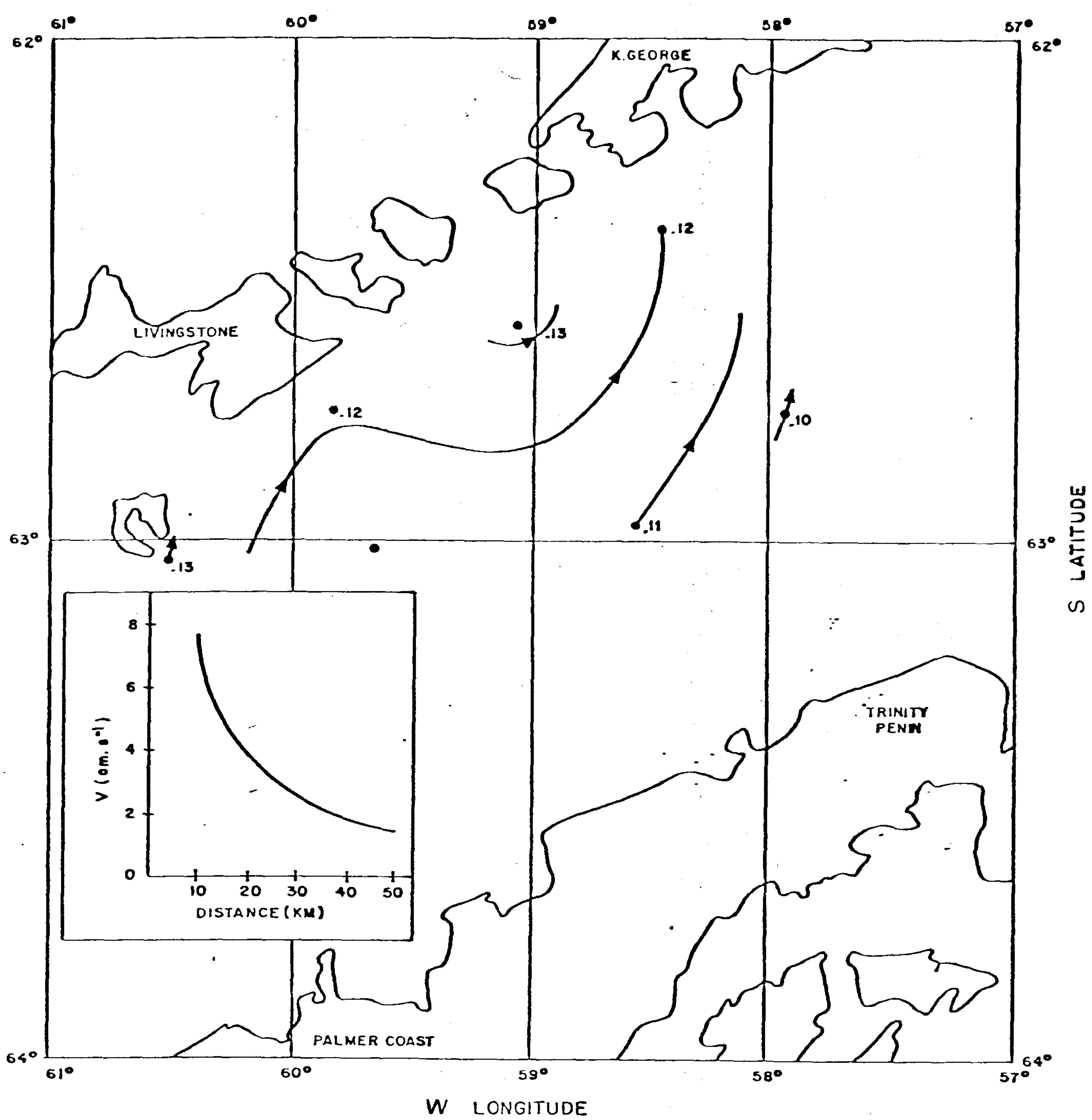
64°
K.GEORGE
LIVINGSTONE
.13
.14
.12
.11
TRINITY
PENIN
PALMER COAST
V (cm.s⁻¹)
DISTANCE (KM)
0
2
4
6
8
10
20
30
40
50
W LONGITUDE
S LATITUDE

Figure 2



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LIVINGSTONE
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TRINITY
PENIN
PALMER COAST
V (cm.s⁻¹)
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DISTANCE (KM)
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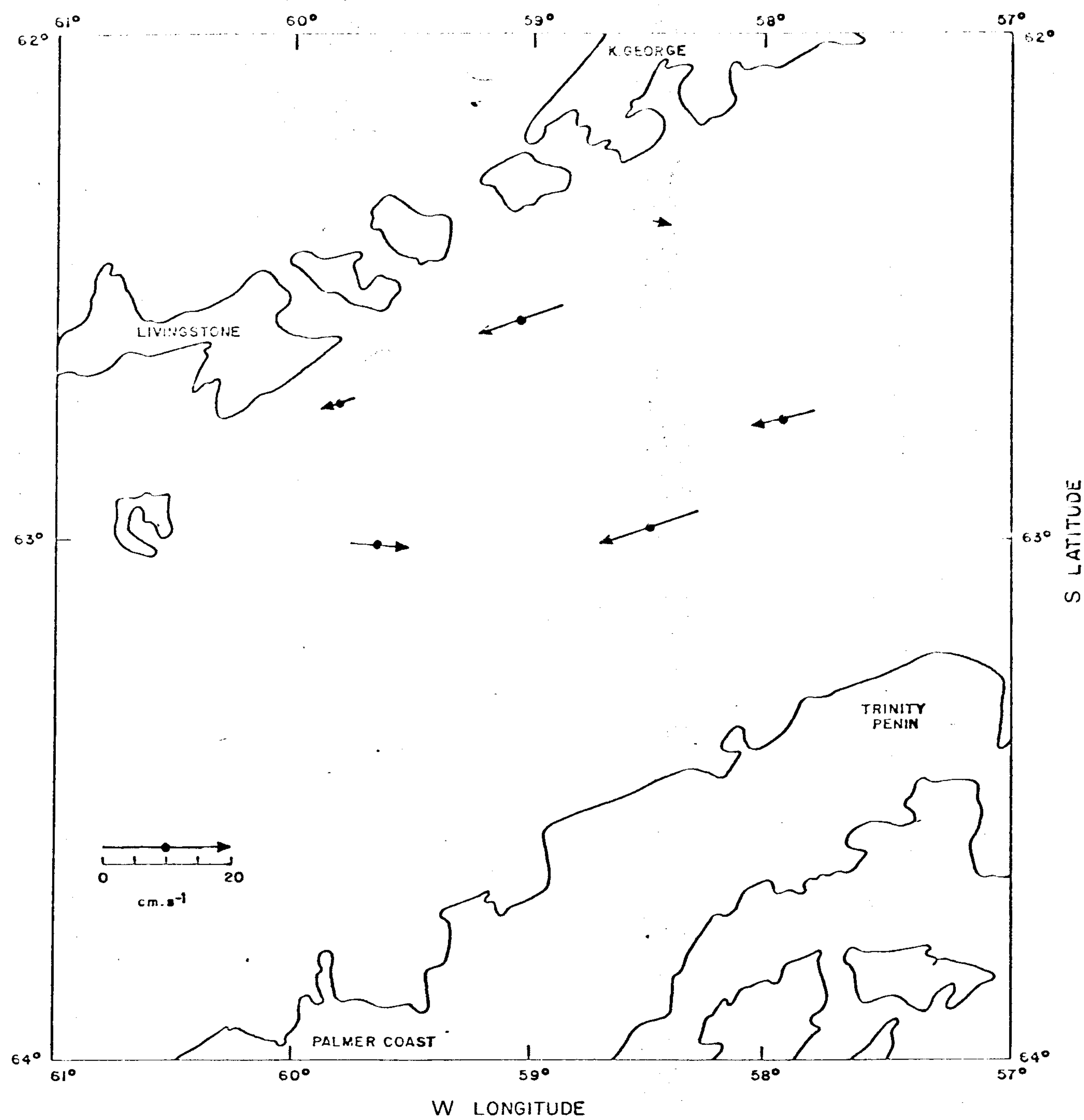
Figure 3



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60°
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S LATITUDE

Figure 4

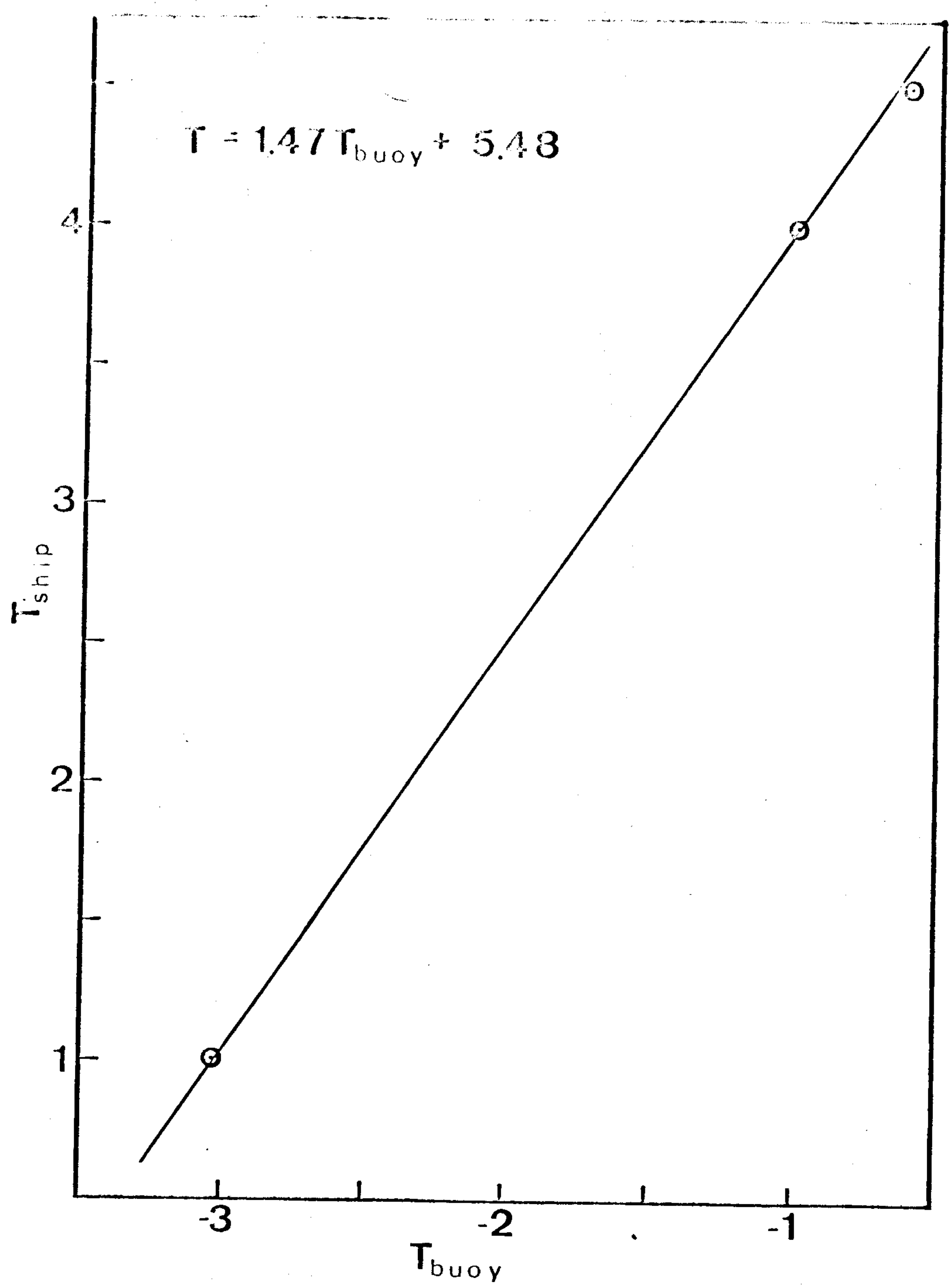
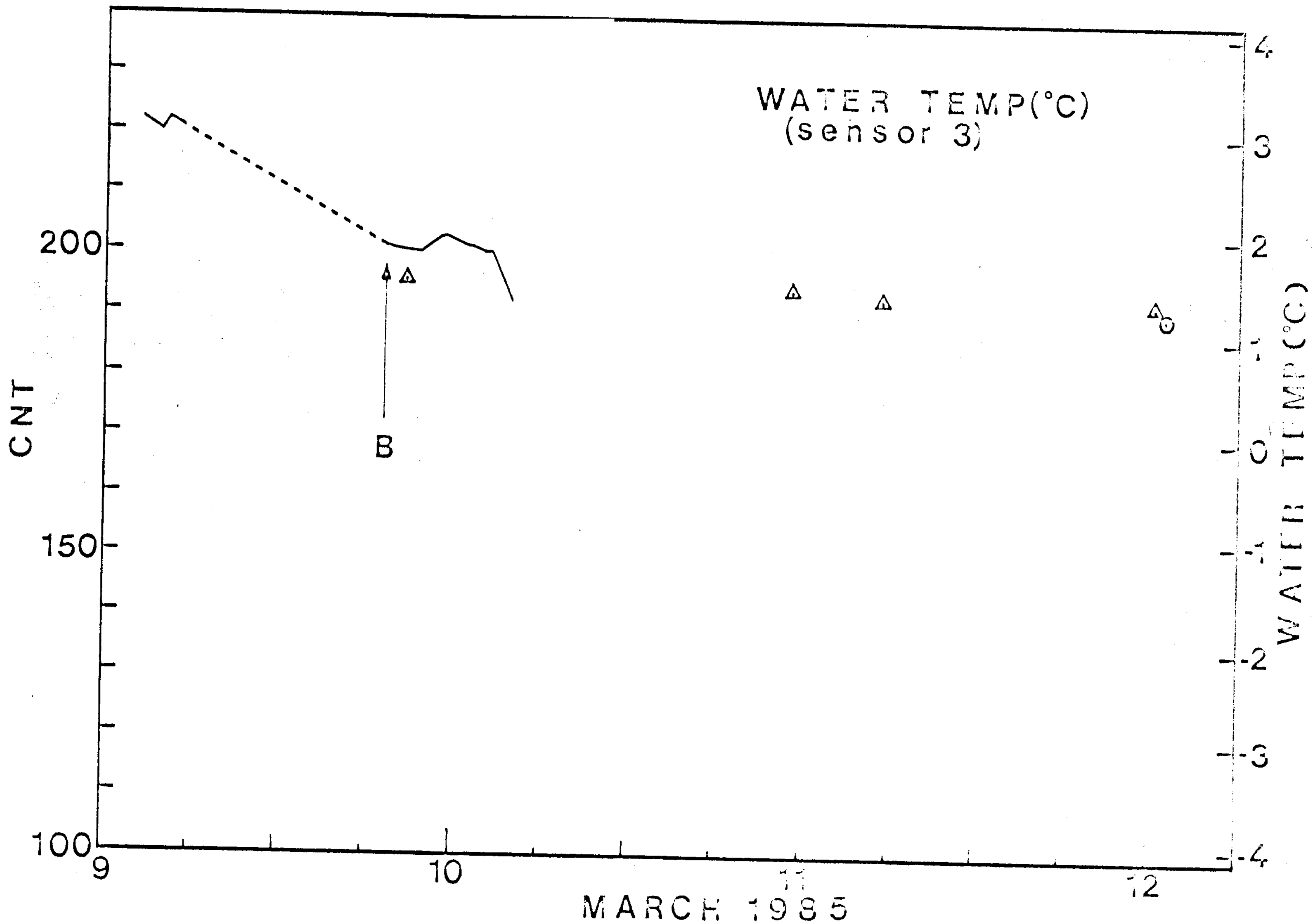


Figure 5


WATER TEMP(°C)
(sensor 3)
CNT
200
150
100
B
9
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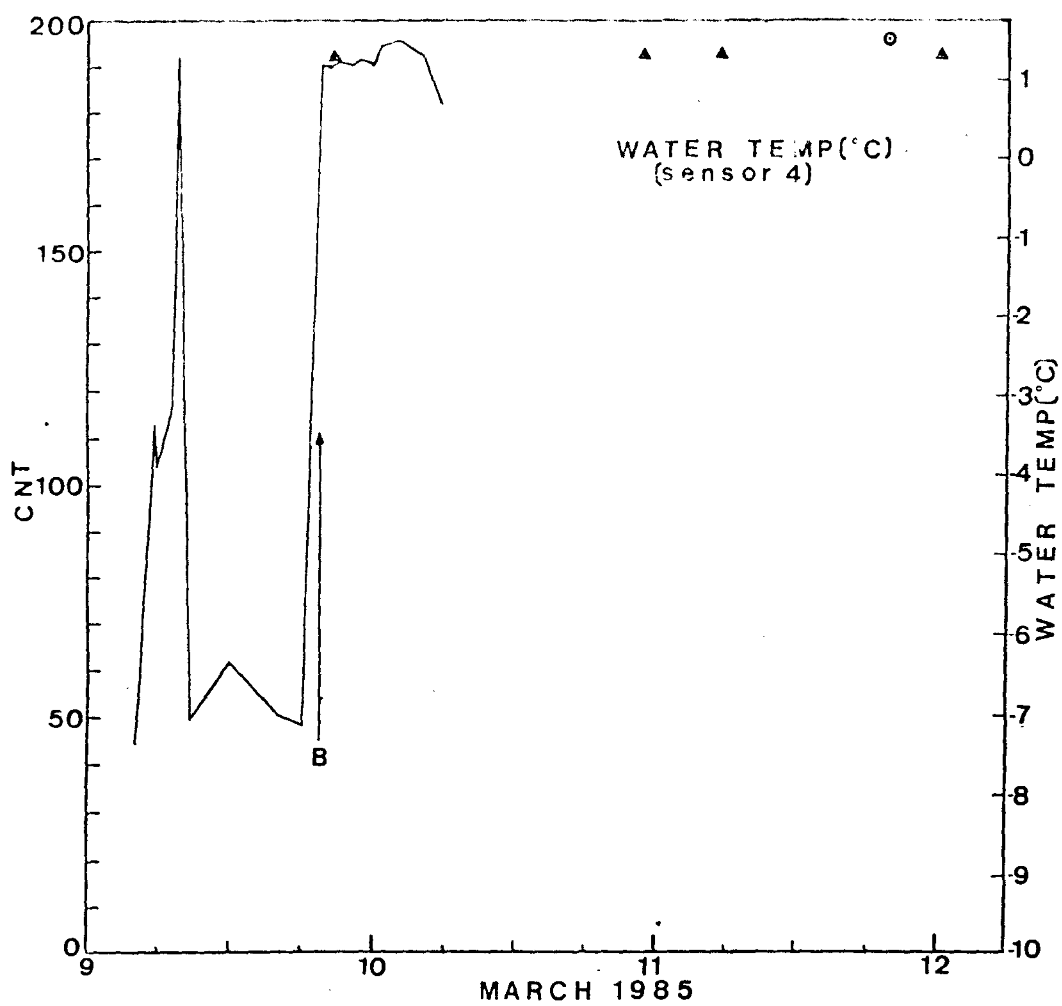
11
12
MARCH 1985
WATER TEMP (°C)
4
3
2
1
0
-1
-2
-3
-4

Figure 6



200
150
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MARCH 1985
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
WATER TEMP(°C)
WATER TEMP(°C)
(sensor 4)
B

Figure 7