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# A TIME SERIES STATION OFF NORTH WEST AUSTRALIA

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# A TIME SERIES STATION OFF NORTH WEST AUSTRALIA

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*Abstract*

The results from 10 hours of half-hourly observations of temperature and salinity as functions of depth are reported. The observations were made at 13°27'S, 122°08'E in August 1976. Changes in isotherm depth as rapid as 27 m in 1 hour were found. There were many isothermal and isohaline layers below the main thermocline. The observations give limited information on time and space scales of these layers.

## INTRODUCTION

The observations reported below were made towards the end of "Sprightly" Cruise 24/76. The set of observations occupied 10 hours, during which the vessel was kept "on station" as nearly as possible by using the results obtained from the satellite navigation equipment. The main purpose of the exercise was to test the use of the bathysonde, together with satellite navigation, to observe changes in vertical temperature and salinity structure at one position as a function of time. It was realised that no serious study of internal waves could be carried out in the short time available (10 hours).

The site chosen for the experiment was one that had been occupied earlier in the cruise, and had shown interesting mixed layers and sudden temperature changes as a function of depth. The station position was 13°27'S 122°08'E, and was approximately 14 km north of Seringapatam Reef. The water depth was 530 m.

## INSTRUMENTAL

The bathysonde is a continuous-recording instrument for temperature, salinity and depth. It uses an acoustic telemetering link between an underwater sensing unit and a shipboard recording unit. It is a development of an earlier instrument (Lockwood 1970), and was designed and built in this Division. The bathysonde as used at the time series station differed from the earlier instrument in having a depth range of only 350 m, and in transmitting all three frequency-modulated signals simultaneously, instead of sequentially.

Lowering speeds were in the range 25-60 m/min. No automatic compensation was provided in the circuitry for Doppler shift of the frequency modulated signals. No correction for the Doppler shift was made in processing the records. All observations reported below were made when the instrument was being lowered, so that only the variation in lowering speed should enter into the differences between observations. The computed effect of neglecting the Doppler shift was less than 0.1°C in temperature, approximately 0.01‰ in salinity, and less than 1 m in depth.

The output for each lowering of the instrument was recorded on a separate chart on a 2-pen Leeds and Northrup recorder. One pen recorded temperature as a function of depth, while the other recorded salinity as a function of depth.

## OBSERVATIONS

Observations were taken in the period 2200 hours 20th August 1976 to 0800 hours 21st August 1976. The first 3 records were spaced one hour apart, but after that the lowerings were made at each half hour, except that the lowering at 0300 hours was missed as the ship was being repositioned following a satellite fix.

Table 1 shows the times of satellite fixes (marked with *), and the displacement of the ship. The ship was repositioned twice during the observation period. The first repositioning was at 0255 hours when the ship was steamed 2.7 km towards 050°. The second repositioning was at 0545 hours when the ship was steamed 3.0 km towards 057°.

There was no wind. The small wire angles when the bathysonde was at maximum depth (angles of order 5-10°) indicated some vertical shear in the current. Since the current estimated from the ship's drift was practically unidirectional over a period of 10 hours, it was probably not a tidal current. Note that the mean drift (1.25 kn towards 235°) is very similar to GEK currents found at neighbouring stations earlier in the cruise. This observation tends to support the idea that the current was not predominantly a tidal current.

## RESULTS

Figure 1 is a reproduction of a typical record, with temperature, salinity and depth scales added. The temperature trace shows an apparently mixed layer to a depth of approximately 75 m, below which the trace has a markedly stepwise structure. The salinity trace shows that the "mixed" layer is not homogeneous; there is a discontinuity at about 35 m depth. Below the "mixed" layer, the salinity trace shows numerous spikes towards lower salinity. These are associated with the steps in the temperature trace, and are due to mis-match between the time constants of the conductivity cell and the thermistor used for compensating the effect of temperature on conductivity. Note that, due to mechanical design of the two-pen recorder, the salinity trace is displaced upwards relative to the temperature trace by about 2.5 mm. Salinity is approximately independent of depth below about 150 m. The apparent increase in salinity with depth below 150 m is almost exactly accounted for by the effect of pressure on conductivity. This effect may be regarded as almost linear, for the depth and temperature ranges of interest here.

Figure 2 shows the 18 temperature profiles that were obtained between 2200/20 and 0800/21 hours. The temperature profiles have been displaced sideways by amounts proportional to the time intervals between them. The figure shows that many of the features of an individual profile can be recognised on neighbouring profiles, but that none of the features (except the bottom of the mixed layer) can be confidently identified throughout all 18 profiles. The times of repositioning the ship are indicated by arrows at the top of Fig. 2. There is no obvious discontinuity in the shapes of the profiles made just before and just after the repositioning. This may be taken to indicate that the "features" visible in the temperature profiles probably have horizontal extent greater than 3 km.

Figures 3a and b show respectively the envelopes of the 18 temperature and salinity profiles. Figure 3a shows that the width of the envelope is least in the mixed layer (approximately 0.4°C) and maximum (about 2.5°C) just below the mixed layer. The spread decreases again to about 0.6°C near maximum depth. In Fig. 3b, the width of the envelope is again maximum just below the mixed layer (approximately 0.34‰), compared with about 0.1‰ in the mixed layer and at greater depths. Note however that since no check samples were taken, we cannot be sure how much of the spread in Fig. 3b is due to instrumental drift. It should also be noted that the envelope shown in Fig. 3b was drawn after rather subjective smoothing of the spikes in the salinity profiles.

Attempts were made to plot the depths of various features of either the temperature or salinity profiles as functions of time, but it was considered there was too much subjectivity in identifying features from one profile to the next. It was decided that the best way of showing the variation as a function of time was to measure the depths of three isotherms on each profile, and plot these depths as functions of time. The positions of the isotherms (24.4°C, 18.4°C, 14.4°C) are shown on Fig. 3a. They were chosen to be just beneath the mixed layer, through one of the main temperature step features, and at an arbitrarily chosen lower temperature. Figure 4 shows the depths of these isotherms as functions of time. The depths alter by the order of 30-40 m. The most rapid change was the deepening of the 14.4°C isotherm by about 27 m in one hour. The figure suggests that the mixed layer depth and the depth of the 14.4°C isotherm may vary in opposite directions, but the record is too short for a firm conclusion on this point. The figure does indicate however, that appreciable changes in the depths of the isotherms can be found in this way, and suggests that a longer series might give interesting results.

It is interesting to compare the widths of the envelope of the time series temperature and salinity profiles in Figs 3a and b with the spread of profiles at 3 adjacent stations (stations 929, 932 and 936) which had been occupied earlier in the cruise. These profiles are shown in Figs 5a and 5b. Station 932 was at the same latitude and longitude as the time series station, 929 was 29 km offshore from 932, and station 936 was 67 km inshore from 932. Except for salinities above about 120 m depth, the spread found at one station over a period of 10 hours appears to be slightly greater than the differences in the profiles over a distance as great as 96 km in the onshore-offshore direction. (These latter differences, of course, are not true spatial differences, since the three stations were not occupied at the same time.).

DISCUSSION

The results obtained on "Sprightly" may be compared with the results reported by Stommel and Federov (1967), who investigated microstructure near 13°28'S 120°13'E, i.e. approximately 2° west of our position. They found a mixed layer about 135 m deep, which was deeper than found by "Sprightly". Stommel and Federov also found a marked temperature inversion, of about 0.6°C, in the depth range 135-145 m. This temperature inversion was associated with a then salinity maximum. No inversion or salinity maximum of this type was found by "Sprightly".

Our data are not extensive enough to check on any of the other interesting features found by Stommel and Federov.

A rough estimate of the effect of the time changes on density and on dynamic height was made. The estimate was based only on the changes in the depth range 70 m to 120 m, i.e. the range that includes the bottom mixed layer. The observed changes in a 10 hour period would alter the computed surface height by about 1 dyn cm. This should have little effect on interpretation of the dynamic height pattern, although the dynamic height relief in this area (15 dyn cm of the whole of Cruise Sp24/76, for surface dynamic height relative to 1300 decibars) is small compared to that found in higher latitudes.

REFERENCES

Lockwood, D.L. (1970). A temperature-salinity-depth recorder with an acoustic link. *Deep-Sea Res.* **17**, 379-384.

Stommel, H., and Fedorov, K.N. (1967). Small scale structure in temperature and salinity near Timor and Mindanao. *Tellus*, **19**, 306-325.

Table 1

Times of satellite fixes (*) and of ship repositioning and the resulting estimates of ship's drift

| Time | Drift (n.mi) | Drift Speed (kn) |
|---|---|---|
| *2226/20 | | |
| | 255° 0.8 | 1.8 |
| *2252/20 | | |
| | 229° 3.1 | 1.2 |
| *0230/21 | | |
| 0310/21 | | |
| | 241° 1.1 | 1.0 |
| *0414/21 | | |
| | 230° 1.1 | 1.1 |
| *0514/21 | | |
| 0600/21 | | |
| | 245° 1.4 | 1.6 |
| *0652/21 | | |

Mean drift : 1.25 kn towards 235°

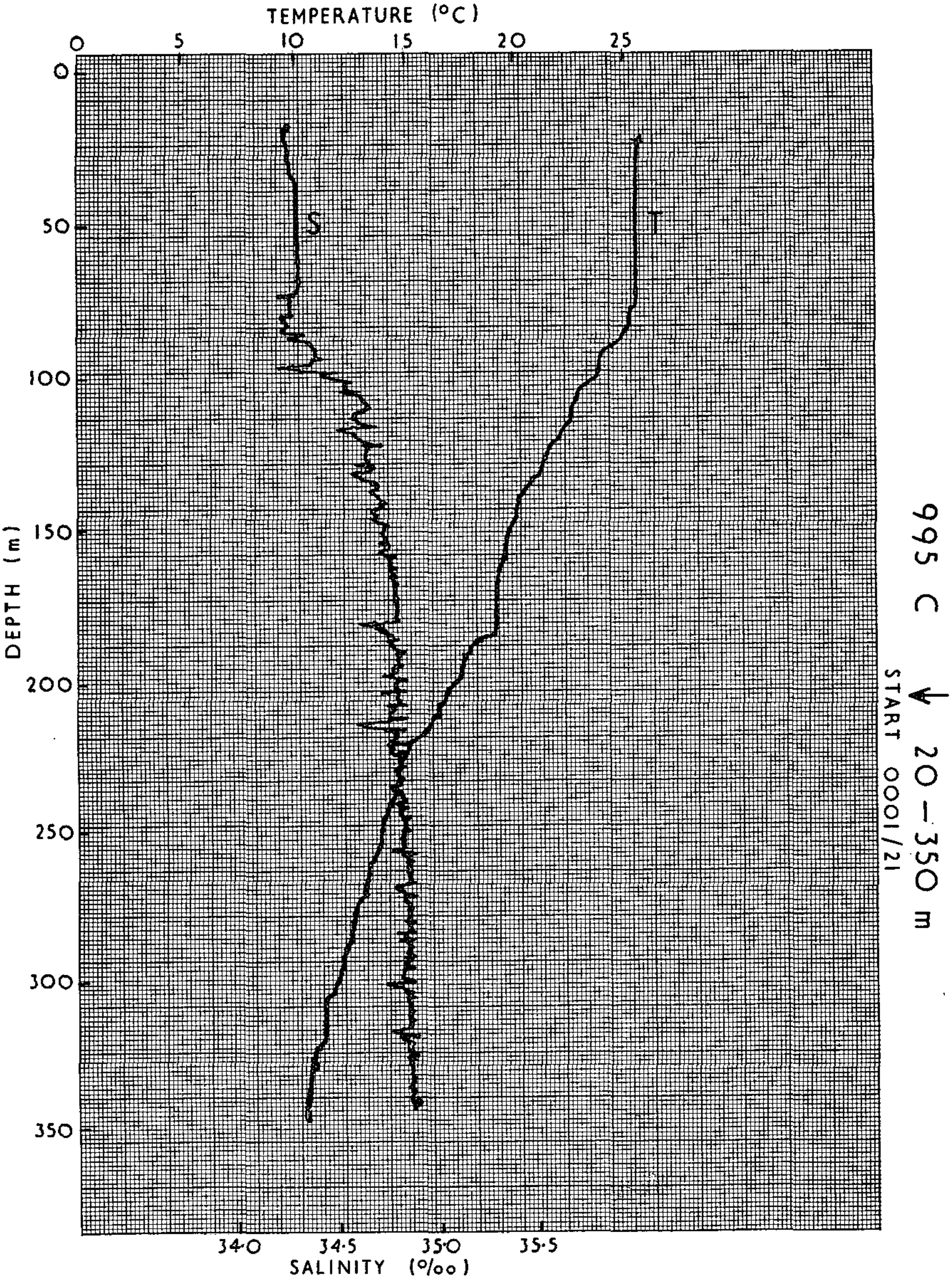


Fig. 1. Photograph of a typical record, with scales added.

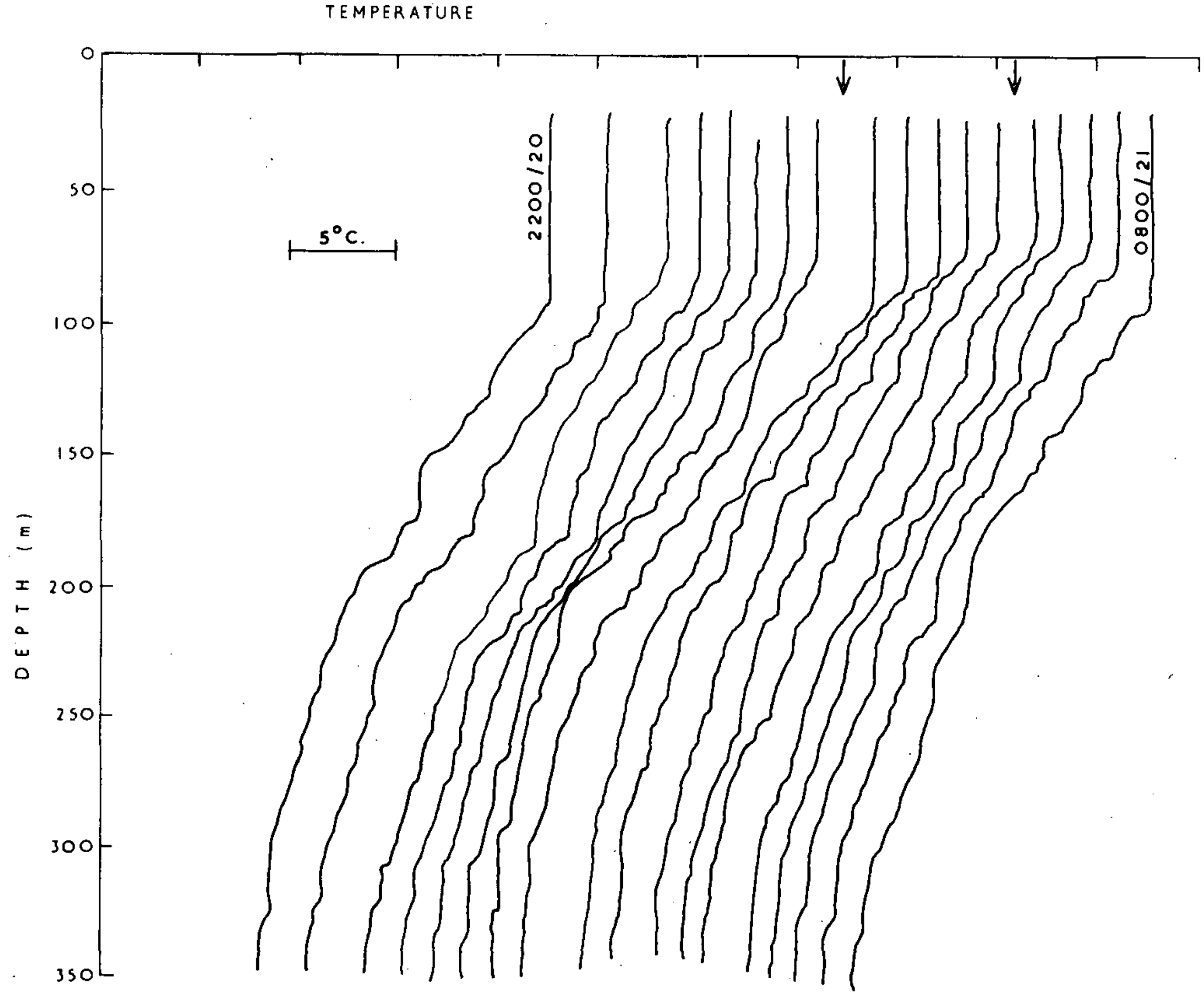


Fig. 2. The 18 temperature profiles, 2200/20 to 0800/21. The profiles have been displaced sideways by amounts proportional to the time intervals between them. The arrows indicate times when the ship was repositioned.

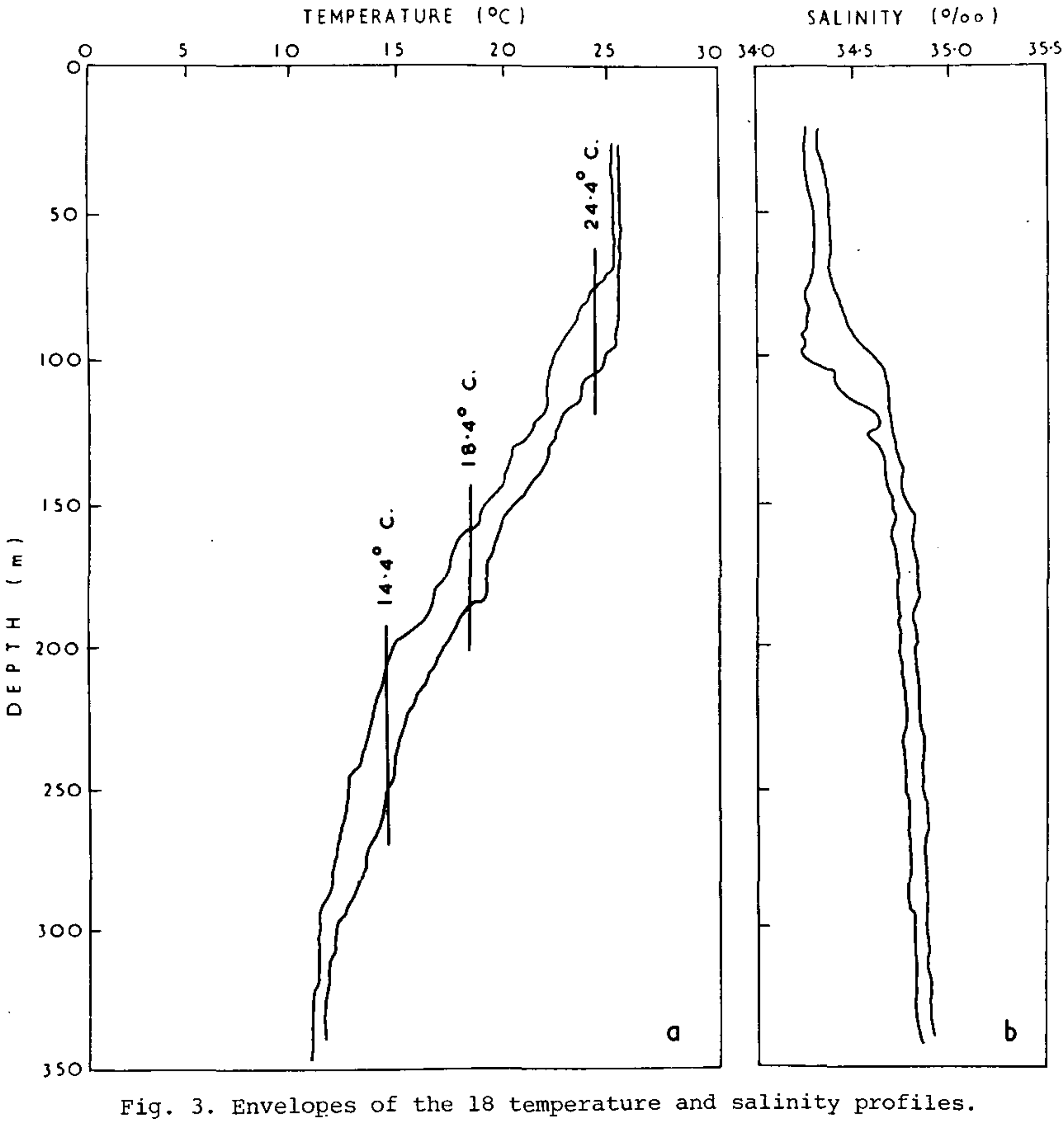


Fig. 3. Envelopes of the 18 temperature and salinity profiles.

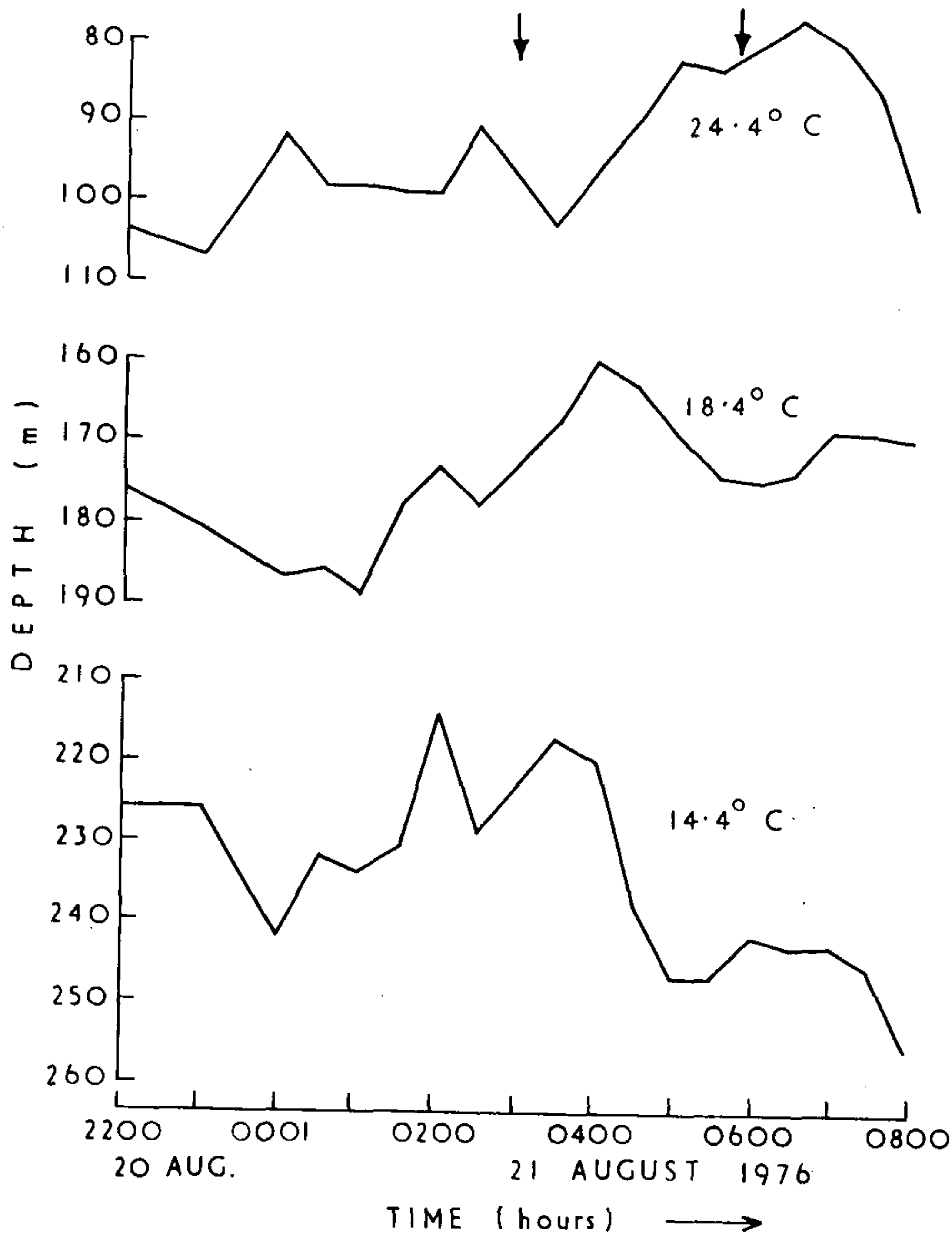


Fig. 4. Depths of isotherms as functions of time The arrows show the times when the ship was repositioned.

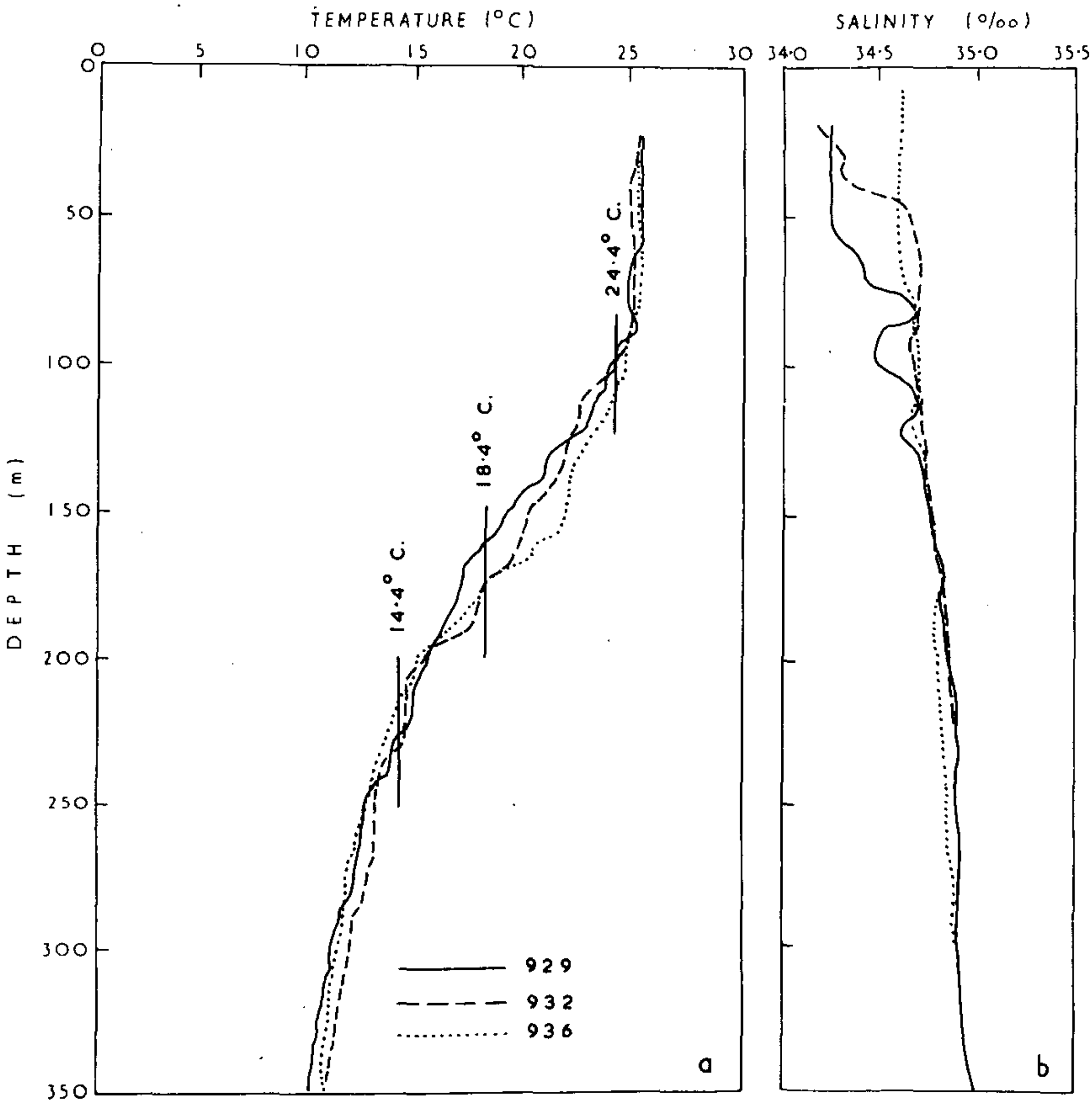


Fig. 5. Temperature and salinity profiles at stations 929, 932, and 936. These stations were occupied between 1320 and 2238 on 17th August. Station 932 was at the same position as the time series station.