POLYMODE NEWS

No. 6

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In this issue:

FIRST CRUISE TO THE NARES ABYSSAL PLAIN

by Tom Rossby and Howard Freeland

On 28 February 1976, we left San Juan, Puerto Rico on board the University of Miami's R/V Gillis, equipped with five SOFAR floats, one current meter mooring with two vector-averaging current meters (at 1500 and 2000 m) and two film-type current meters (at 4000 m and 4800 m), and 200 T-7 XBT's. The floats were outfitted with a pressure/temperature sensor and telemetry subsystem, and a semi-active ballasting system to maintain constant depth. It was our intent to locate a significant baroclinic perturbation in the Nares Abyssal Plains region, and to launch all instrumentation in the center of the eddy after an initial survey. The survey work was to be continued before returning to Miami.

The initial search was facilitated by Claes Rooth's earlier passage through the area, in which he found a significant cold perturbation. The first two days were accordingly used to conduct a broad survey of this feature and to locate its center. Originally we had planned to use the remaining time to launch the five floats at a slow and watchful pace. In fact, things went so smoothly that all equipment was launched in five days. The remaining 2.5 days were then used for a systematic XBT survey.

The general oceanographic picture at 24°N, 62°W shows, according to the Fuglister Atlas (1960),

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PERFORMANCE OF THE GATE TWO-LEGGED MOORING

by Gerold Siedler, Eberhard Gerlach, Rolf Käse, and Walter Zenk

The GATE C-Scale Experiment's internal wave project required that a horizontal array of sensors be placed in the upper thermocline (Philander, et al, 1974). Instrument separations from a few meters to a few hundred meters were needed to obtain the coherence scales of high-frequency internal waves. A two-legged mooring was designed which incorporated a horizontal line of nine current meters at approximately 60 m depth and ten current meters vertically spaced on one leg of the mooring. Two thermistor chains were suspended vertically along the other leg (Figure 8). Coated steel cables were used for the mooring near the surface, and synthetic rope was used in the deep water. The mooring had two toroid surface buoys, one carrying a wind recorder. Bottom depth was 4900 m. The mooring (GATE mooring F-1) was placed in the tropical Atlantic at 8°50'N, 22°53'W for three weeks in August-September, 1974.

As in the deployment of the Internal Wave Experiment tri-mooring, a special problem was posed in obtaining the appropriate anchor distance. Since an acoustic positioning system was not available in this case, deployment of the second anchor was to be controlled by monitoring cable tension at two critical points on the mooring (Figure 8). Unfortunately, the radio transmitter telemetering the tension

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NOTES *from the Editor*

Events of interest to POLYMODE scientists often pass by, noted by a few, but not widely made know. Thus it was, perhaps, that a few months ago the third report of SCOR Working Group 21 on the intercomparison of current meters was published as Technical Paper No. 23 in Marine Science by UNESCO. This is the third of three such reports comparing the performance of current meters used internationally. SCOR Working Group 21, under the chairmanship of John Swallow, that carried out the work, has now been disbanded.

The third report compares Alexaev (U.S.S.R.), Geodyne Model 850 (U.S.A.), LSK (G.D.R.), and VACM (U.S.A.) instruments. One example of each instrument was placed on adjacent surface and sub-surface moorings. The work was performed at Site D (39°10'N, 70°W) in August-September, 1972. The report includes time series figures, spectral intercomparisons, and numerous speed-speed diagrams for current meter pairs. Some recommendations are included.

Copies of the report are available. To obtain a copy, a request on letterhead stationary should be addressed to:

Division of Marine Sciences
UNESCO
Place de Fontenoy
75700-PARIS France

The three reports in the series are:

UNESCO Technical Papers in Marine Science

No. 11 (1969) An intercomparison of some current meters, Report on an experiment at W.H.O.I. Mooring Site "D", 16-24 July 1967 by the working group on Continuous Current Velocity Measurements.

No. 17 (1974) An intercomparison of some current meters. Report on an experiment of Research Vessel Akademik Kurchatov, March-April 1970, by the working group on Current Velocity Measurements.

No. 23 (1975) An intercomparison of some current meters, III. Report on an experiment carried out from the Research Vessel Atlantis II, August-September, 1972, by the Working Group on Continuous Velocity Measurements.

Copies of No. 17 may still be available, but No. 11 is now reported as out of print.

-- F. W.

POLYMODE OFFICE NOTES

Joint POLYMODE Organizing Committee meetings will be held in Moscow in April to discuss mutual scientific, logistical, and technical questions. The U. S. delegation will arrive in Moscow on 23 April and depart on or about 28 April.

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Quarterly reports for the period 1 January-1 April are due at the IDOE office of the National Science Foundation (NSF) on 1 May, 1976. In the past, individual reports were forwarded separately to NSF. This year, the Executive Office will produce an integrated POLYMODE Quarterly Report. To reduce the amount of paper work for investigators, Bob Heinmiller will provide a uniform format for material and will also accept information over the telephone. This material will be prepared for the final report and will be checked with the investigator before being transmitted to NSF. It should be noted that this method of collecting the information will be used only when the investigator desires it. Anyone who prefers to write and forward a quarterly report individually may do so. Graphic illustrations are welcomed and encouraged in both cases.

We hope to make the reporting process easier by using this approach, while providing an adequate amount of information for NSF to evaluate the progress of both individual projects and POLYMODE as an overall program.

Principal investigators of active NSF POLYMODE grants will be contacted soon with details.

ACKNOWLEDGEMENT

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FIRST CRUISE TO THE NARES ABYSSAL PLAIN (continued)

a N/S gradient in the main thermocline of about 2°C/1000 km, increasing somewhat southward of ∿25°N, and decreasing to the north. This N/S gradient gives rise to a mean baroclinic shear of approximately 4 cm/sec per km. Similar values were obtained from an XBT section from Bermuda to Puerto Rico by Claes Rooth a week before our arrival (see Figure 5).

Antarctic Intermediate Water is found beneath the main thermocline between 900-1100 m. The Mediterranean Salt Tongue lies below. At 700 m, the intended depth for two shallow floats, the average temperature for the area was about 10.75°C, slightly less than the 11.5°C expected from the Fuglister Atlas. Of course, neither of these are significant estimates of the true mean.

The ocean bottom in the operating area is generally flat at 5825 m with occasional seamounts (one not charted?) extending more than 1000 m above the seabed. A preliminary chart (prepared by Scott McDowell) is shown in Figure 1.

Preliminary charts of the temperature field at 200, 450, and 700 m (Figures 2, 3 and 4) have been prepared for the periods 1-3 March (with some points from 4-5 March) and 7-9 March, an uninterrupted survey. The first set of charts is noticeably "noisier" than the second one, due to the irregular sampling grid necessitated by daytime launching requirements. Nonetheless, a cold central feature is evident at the two lower levels, whereas the 200 m patterns are different and change more rapidly in time. This cold eddy is clearly displaced to the west in the second survey. A west-northwest phase pattern velocity of 3-5 cm/sec is evident. In Figure 5, temperature perturbations were plotted at 450 m at three separate times: 23-24 February, 1-2 March, and 7-9 March and are representative of the pattern displacement at both 450 m and 700 m. Note that this velocity agrees with the mean baroclinic shear referred to above.

At 200 m, the picture is more confused due to rapid changes in the pattern itself. Although major isotherm features are displaced westward, it is also evident that the closed contours of the first survey give way in time to a simpler east-west gradient structure.

The complex structure revealed by the first survey is at least partially artificial due to the different times at which nearby points were sampled; a similar problem exists at 450 m and 700 m. An additional problem arises at depth due to the internal tide perturbations of the main thermocline. The contour intervals are 0.3°C apart, which corresponds to ∿15 m vertical displacement, a number comparable to observed internal tides. This suggests that additional resolution might be obtained by using a few inverted echo sounders to de-tide the survey data.

The spatial and temporal variability of $\partial T/\partial Z$ has been averaged between 550 and 750 m. This is a measure of expansion or compaction of isotherms about a mean state. One might expect these variations to reflect changes in the horizontal mass distribution, i.e., the horizontal divergence. We have plotted ΔT between 550 and 750 m (in which ΔT is obtained by a visual "least squares fit" directly on the XBT trace) for the two survey periods, as shown in Figures 6a and 6b. A value of 4°C corresponds to $\overline{\partial T/\partial Z}=0.02$°C/m, a typical value for the main thermocline. We call attention to the 10 percent departures from this mean in both surveys. There is a distinct similarity of pattern being displaced approximately 20 km to the west. This pattern

(continued page 5, left column)

PERFORMANCE OF THE GATE·TWO-LEGGED MOORING (continued)

data from the buoy to the ship failed during deployment. However, computations made of the mooring structure before the experiment and measurements of the separations between the vessel and the two surface buoys, along with a navigational buoy, permitted us to determine the mooring configuration.

The mooring was set by placing a navigational buoy with a radar reflector and a light in the area. The left (westward) leg of the bimooring was set with an auxiliary surface buoy to the point just below the lower thermistor chain, using the buoy-first technique. The auxiliary buoy was removed, and the remainder of the westward side of the mooring and the left-hand end of the horizontal leg were attached. The instruments were then installed on the horizontal leg as the line was paid out. The upper portion of the eastward mooring was attached at the right-hand end of the horizontal leg. The right-hand buoy was removed as instruments were added to the line. Once this operation was complete, the lower leg of the mooring was connected and the instruments were attached. The anchor was attached to the end of the eastward leg and, using an acoustic release, to the end of the ship's deep-sea cable. The winch lowered the anchor to the bottom.

The plan was to fire the acoustic release on the cable when the anchor was above its intended position. During the lowering, the winch failed, and the eastward leg of the mooring broke. The array was anchored successfully the following day. However, a longer line had to be used for the replacement due to a lack of spare acoustic releases for recovery, resulting in an asymmetry of the mooring. During recovery, the acoustic release in the horizontal line was fired first, and the two separate parts of the mooring could then be taken onboard with the usual techniques.

The mooring's probable behavior was computed before the experiment. For determining the configuration for given velocity profiles with varying current direction, a program based on that of Skop and O'Hara (1969) was developed. The horizontal and four vertical lines were divided into a finite number of elements. An assumed configuration was used to start, and a balance of forces was obtained using an iteration technique.

The aim of the calculation was to determine the length of each leg and the distance from the anchor in such a way that sufficient horizontal forces at the branch points would prevent excessive sagging of the horizontal line; however, the tension was not to exceed 1000-1200 kilopounds. Part of the tension was reduced by adding glass floats. Since the exact depth at the deployment site was not known, several configurations had to be examined. Forces were brought to appropriate levels by changing the anchor separation without varying the cable lengths. The hydrodynamic forces were calculated by using an expected shape of the current profile; later evaluation showed the expected profile to be sufficiently realistic. The program simulated the pre-release phase of the second anchor positioning. The asymmetry introduced in the mooring configuration during launch reduced the cable tension and increased the sagging of the horizontal line by 3-6 m. An example of a computed configuration is shown in Figure 9.

The actual performance was checked after the experiment by using pressure and temperature data from the moored instruments. Appar-

(continued page 6, left column)

FIRST CRUISE TO THE NARES ABYSSAL PLAIN (continued)

has possibly changed less than the temperature fields themselves.

The difference between these two yields an Eulerian time rate of change. In order to see how this relates to the horizontal divergence, we integrate the divergence equation between two material surfaces to obtain:

$$\left(\frac{\overline{\partial u}}{\partial x} + \frac{\overline{\partial v}}{\partial y} \right) = - \frac{1}{H} \frac{dH}{dt} \quad .$$

H can be expressed in terms of the plotted quantity ΔT since the vertical gradient is remarkably constant over this depth range:

$$\frac{\partial \overline{T}}{\partial z} = 1/\frac{\Delta H}{\Delta T} = \beta \quad .$$

Thus, H between two material surfaces is $(\delta T/\beta)$ where δT is a prescribed temperature difference. Thus,

$$\left(\frac{\overline{\partial u}}{\partial x} + \frac{\overline{\partial v}}{\partial y} \right) = - \frac{\beta}{\delta t} \frac{d(\delta T/\beta)}{dt} = \frac{1}{\beta} \frac{d\beta}{dt} \quad ..$$

The dashed lines in Figure 7 correspond to

$$\frac{1}{H} \frac{\partial H}{\partial t} \approx 1.4 \times 10^{-6} \sec^{-1}$$

or a little more than 1 percent of the Coriolis parameter. It is important to recognize that the time difference plot shows only the Eulerian changes; thus, it does not include the terms $u(\partial H/\partial x)$, $v(\partial H/\partial y)$, which is comparable to the local time derivative.

It is possible to obtain an estimate of the total time derivative by examining the rate of change in H along the float tracks. We have not plotted these yet, but we do know that the two shallow floats which were launched within a few miles of 24°N, 62°W moved almost due north at 5 cm/sec between the two surveys. Along this path, H (ΔT) has changed very little (see Figure 6a and 6b). These float tracks will appear in a future issue of the POLYMODE News.

Reference

Fuglister, F. C. (1960) Atlantic Ocean Atlas of Temperature and Salinity Profiles and Data from the International Geophysical Year of 1957-1958. Woods Hole Oceanographic Institution Atlas Series, I, Woods Hole, Mass.

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PERFORMANCE OF THE GATE TWO-LEGGED MOORING (continued)

ently, the mooring was first aligned with the axis of the equatorial countercurrent (Figure 10a), but later, the current turned to the east. The pressure record from instrument no. 07 (Figure 10b) near the center of the horizontal line, displays instrument depth variations of 1-2 m, with bursts of semi-diurnal tidal oscillations on some days. The absolute accuracy of the high pressure sensors is not sufficiently high to determine the shape of the horizontal line, but another method can be applied for this purpose. Differences in mean temperatures measured by the moored instruments were converted to depth differences by using a mean vertical temperature gradient obtained from repeated CTD soundings. The result is shown in Figure 11a. The maximum depth obtained from computations based on actually measured currents results in an agreement of ±2 m.

Finally, the vertical mooring motion obtained from the pressure measurements of instrument no. 07 can be compared with the vertical water displacement computed from temperature time series and scaled with the mean vertical temperature gradient. The spectra in Figure 11b indicate that spectral levels of the instrument displacement are one to two orders of magnitude below the spectral level of water displacement in the internal gravity wave range. The mooring was thus sufficiently stable for the experiment.

References

Philander, G., M. Mikaye, Y. Tarbeev, & T. de la Morinière (1974) The oceanographic sub-programme for GATE. GATE Report No. 8, ICSU and WMO, Geneva.

Skop, R. A. and G. J. O'Hara (1969) The static equilibrium, configuration of cable arrays by the use of the method of imaginary reactions. N.R.L. Report 6819, Naval Research Laboratory, Washington DC.

POLYMODE HISTORICAL AND ETYMOLOGICAL NOTES

by Sir Tinley Wright

NARES, (nârz), Sir George Strong (1831-1915), admiral and Arctic explorer; great-grandson of Sir George Nares [(1716-1786), barrister, M. P., justice of the common pleas]; entered Navy, 1845; captain of H.M.S. Challenger, dispatched by the British government to explore southern oceans, 1872-1874; led government Artic expedition in Alert and Discovery, 1875-1876; F.R.S., 1875; K.C.B., 1876; Rear-Admiral, 1887; Vice-Admiral, 1892.

nares (nâr´ēz) pl.n. The openings in the nasal cavities in vertebrates; nostrils.

The POLYMODE* News is produced at the Woods Hole Oceanographic Institution. It is edited by Ferris Webster and Leigh Stoecker.

If you have material of interest for this newsletter, please get in touch with either of the above at the Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, Telephone (617) 548-1400.

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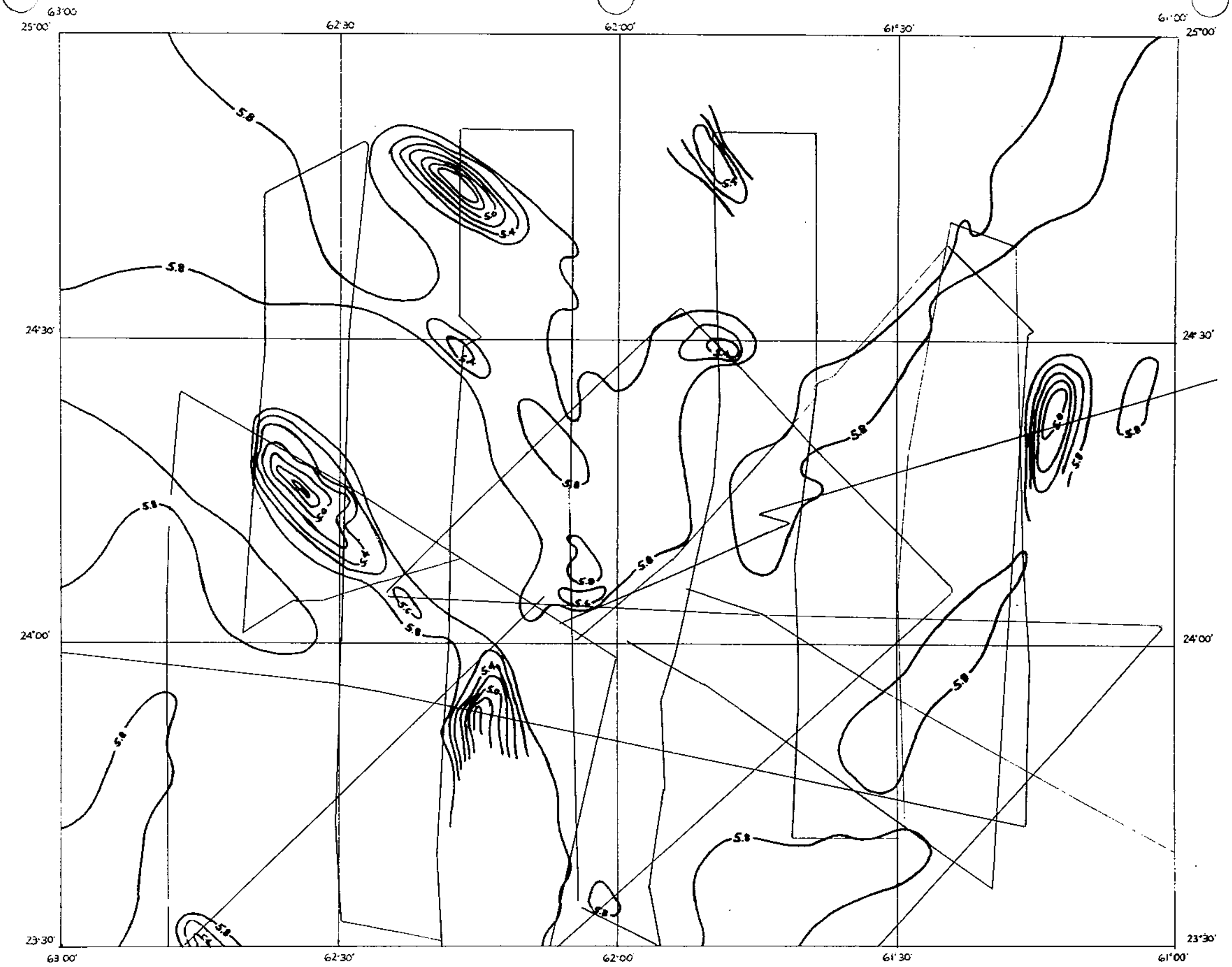
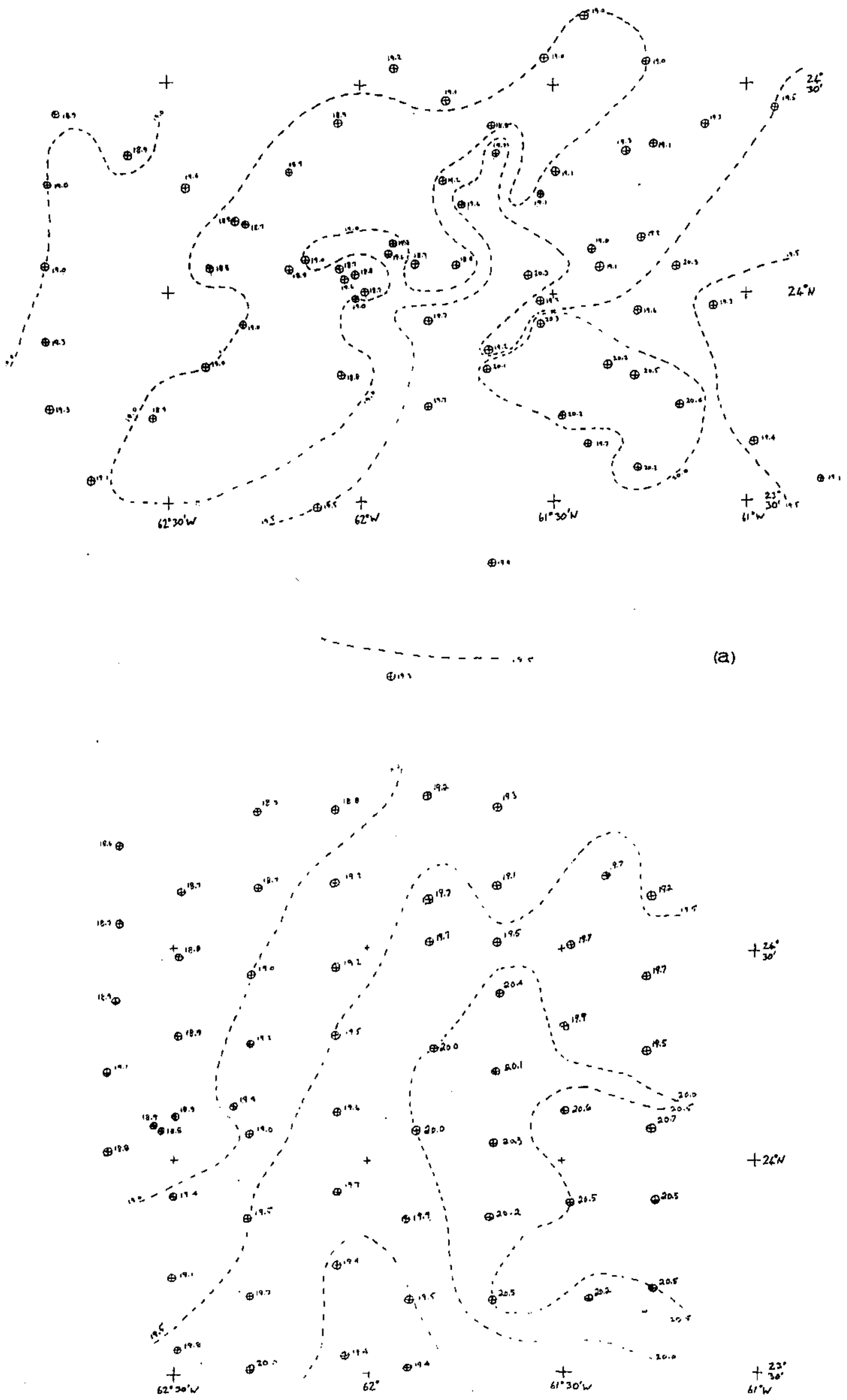
*POLYMODE is derived from the names of the U.S.S.R. POLYGON experiments and the Mid-Ocean Dynamics Experiment (MODE).



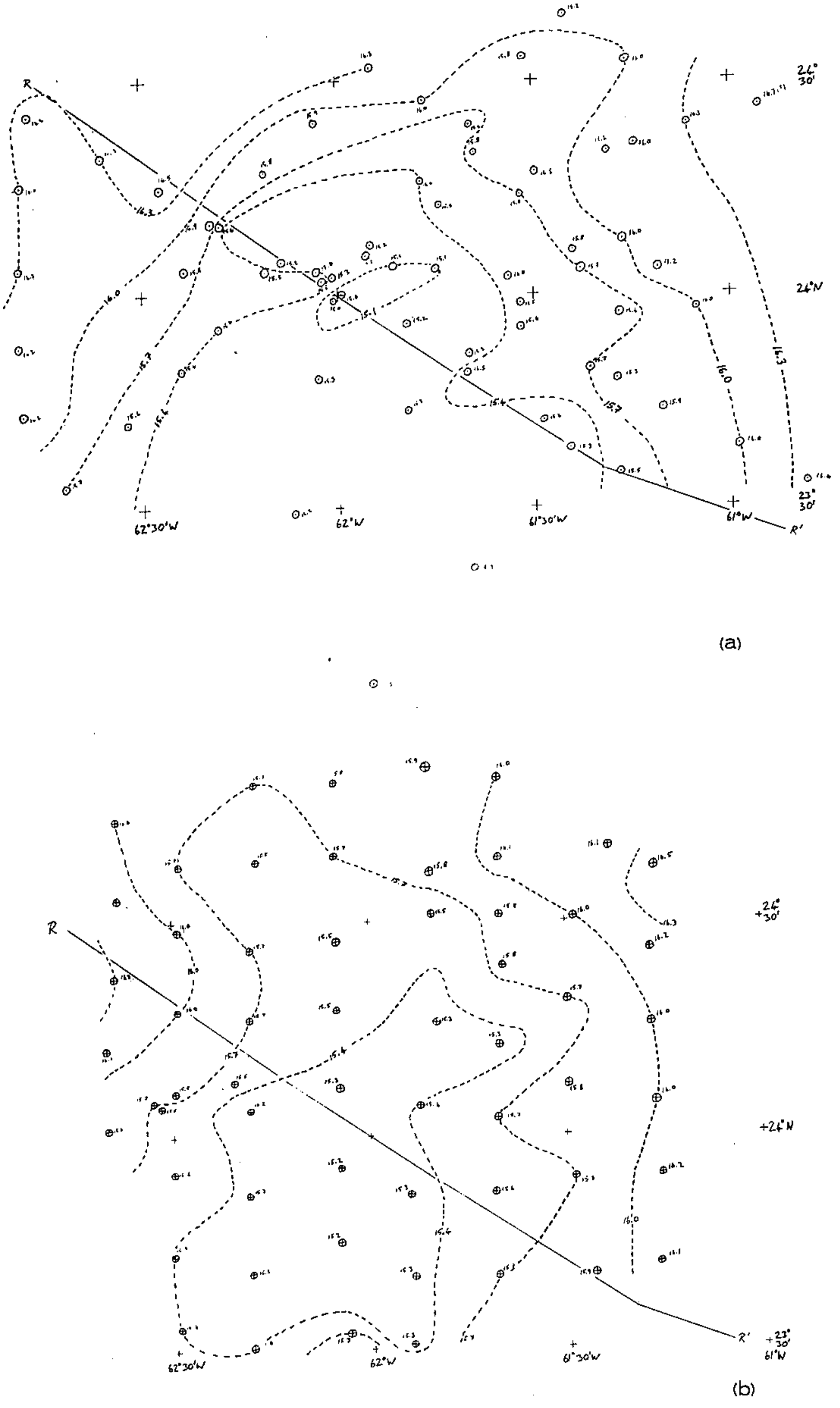
Bottom topography and cruise tracks in the Nares Abyssal Plains Region.

Figure 1 (Rossby and Freeland)



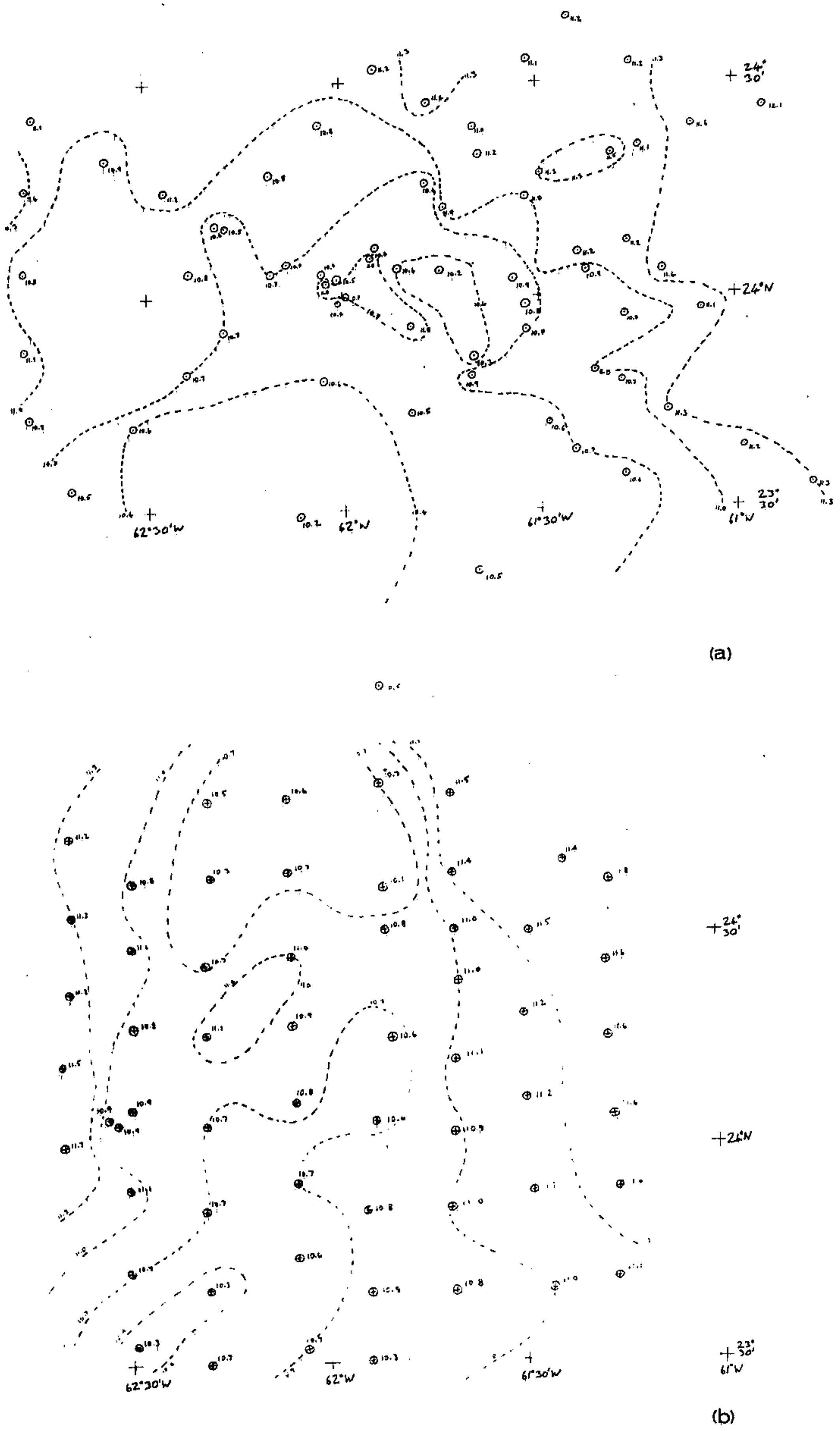
Temperature field at 200 m (preliminary).
(a) 1-3 March; (b) 7-9 March

Figure 2 (Rossby and Freeland)



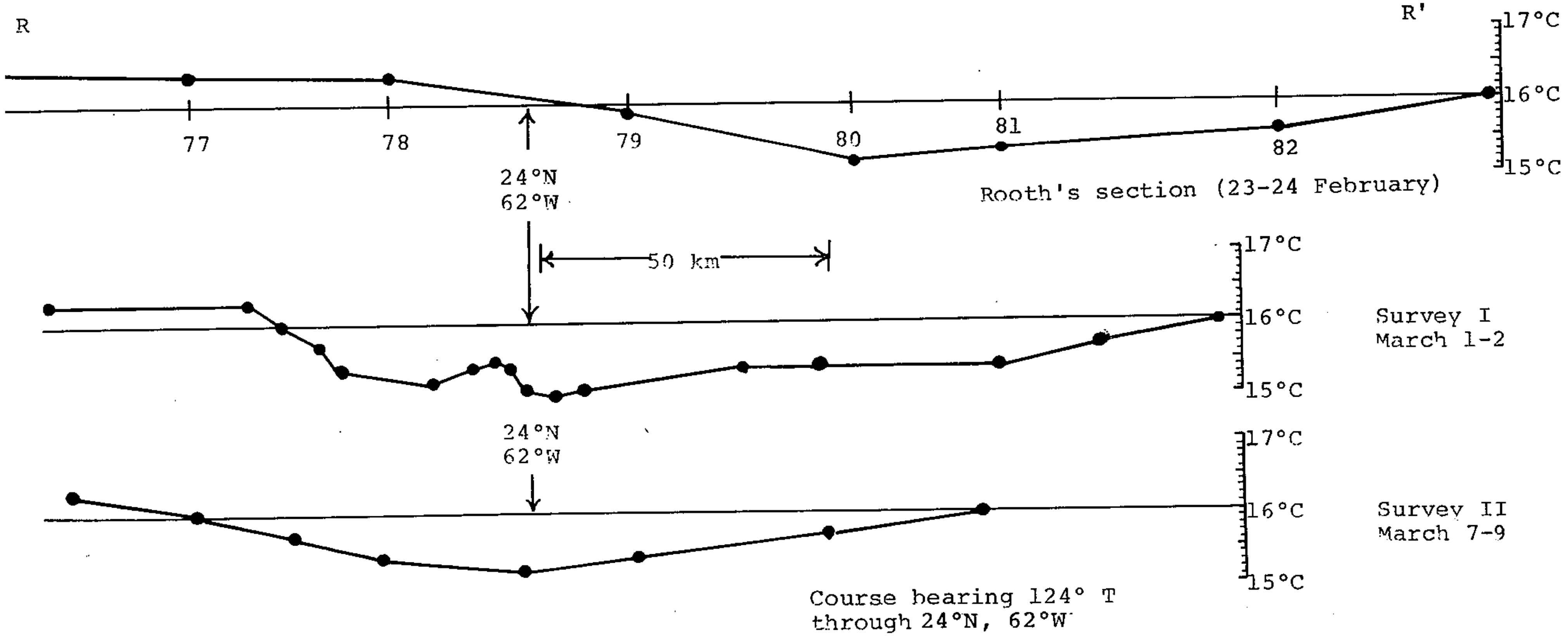
Temperature field at 450 m (preliminary). The line marked RR' indicates Rooth's cruise track. (a) 1-3 March; (b) 7-9 March

Figure 3 (Rossby and Freeland)



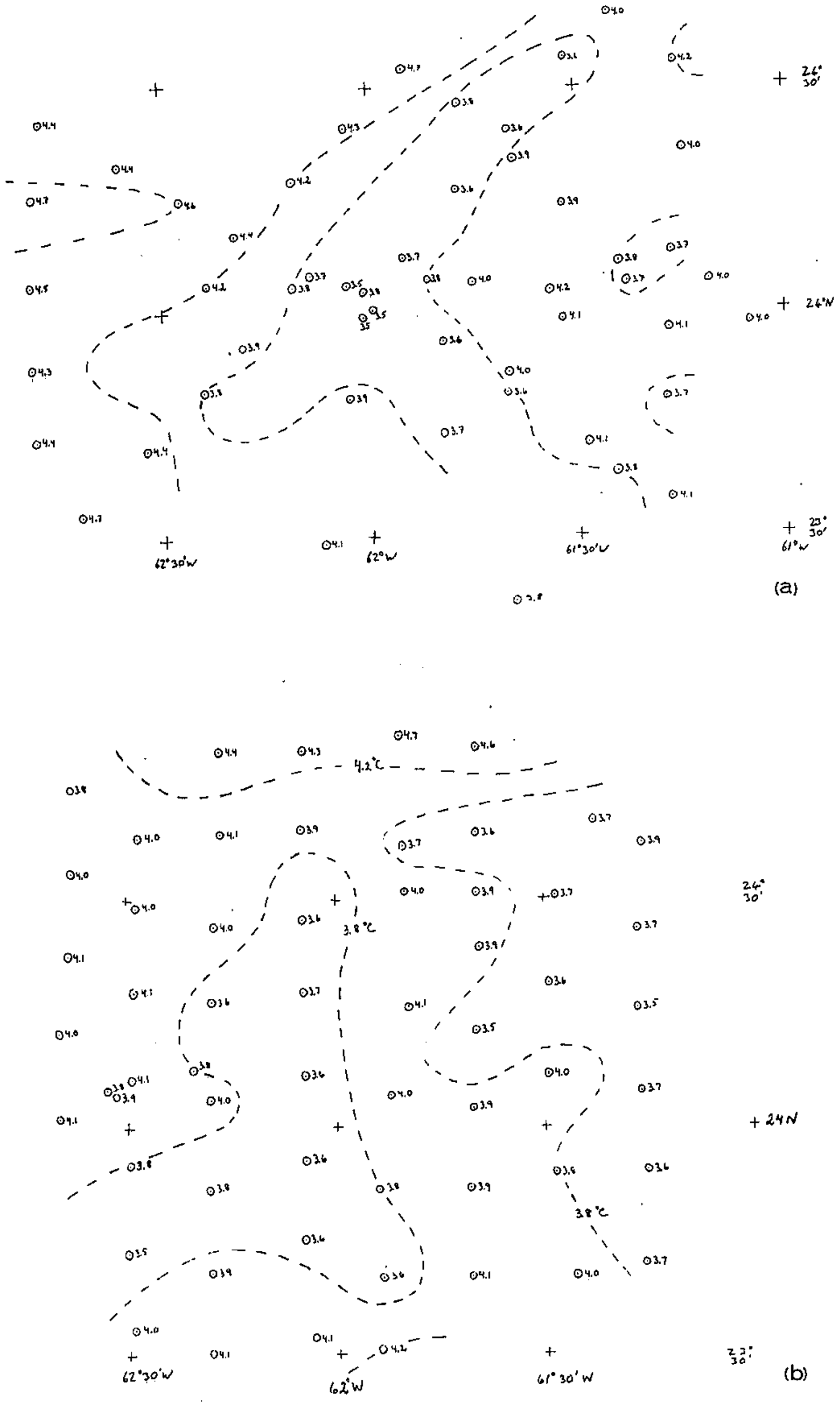
Temperature field at 700 m (preliminary).
(a) 1-3 March; (b) 7-9 March

Figure 4 (Rossby and Freeland)



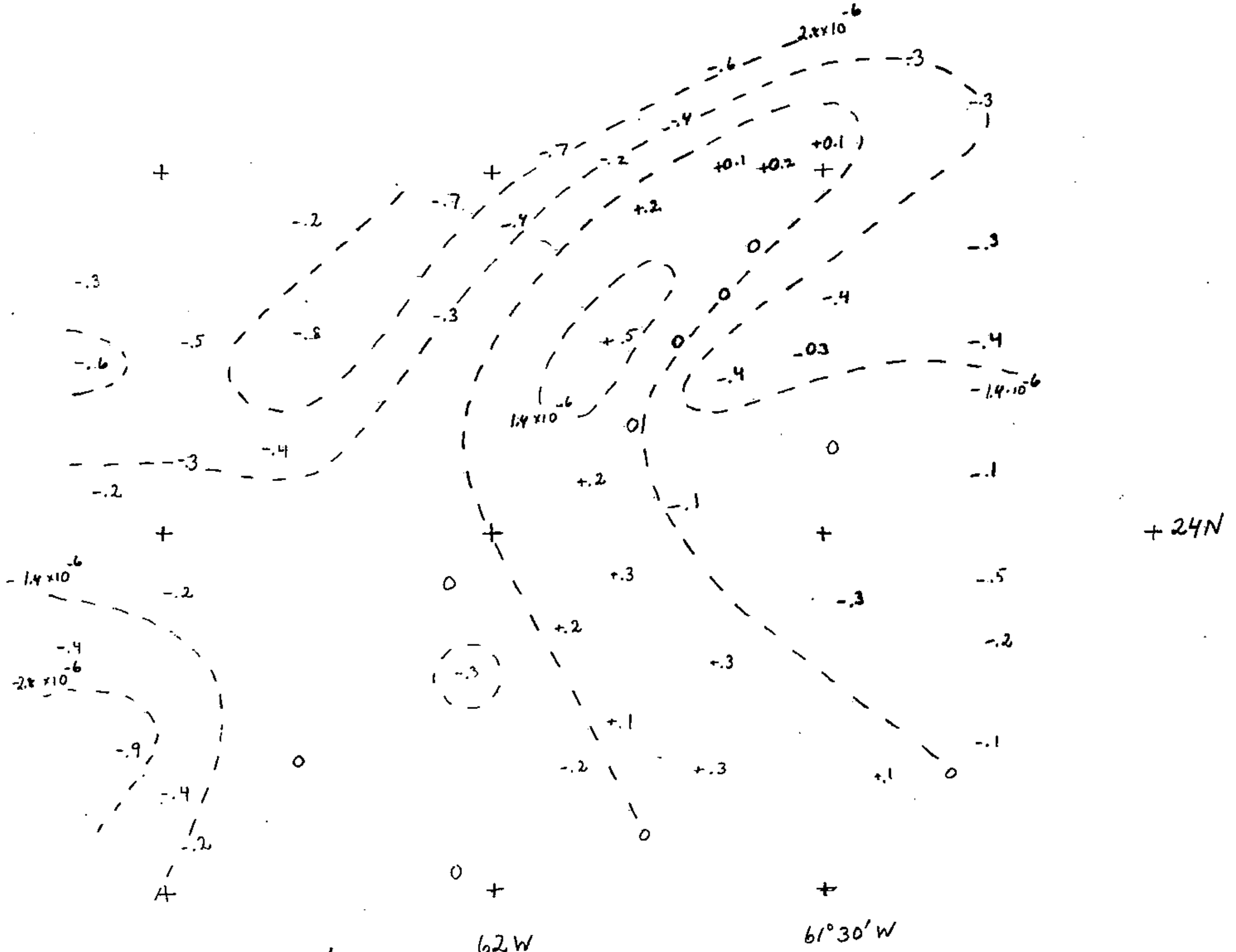
Temperature profiles at 450 m in the Nares Abyssal Plain region. The top profile was made by Claus Rooth about one week before the other two profiles shown.

Figure 5 (Rossby and Freeland)



Temperature difference between 550 m and 750 m (ΔT) for the two survey periods: (a) 1-3 March; (b) 7-9 March.

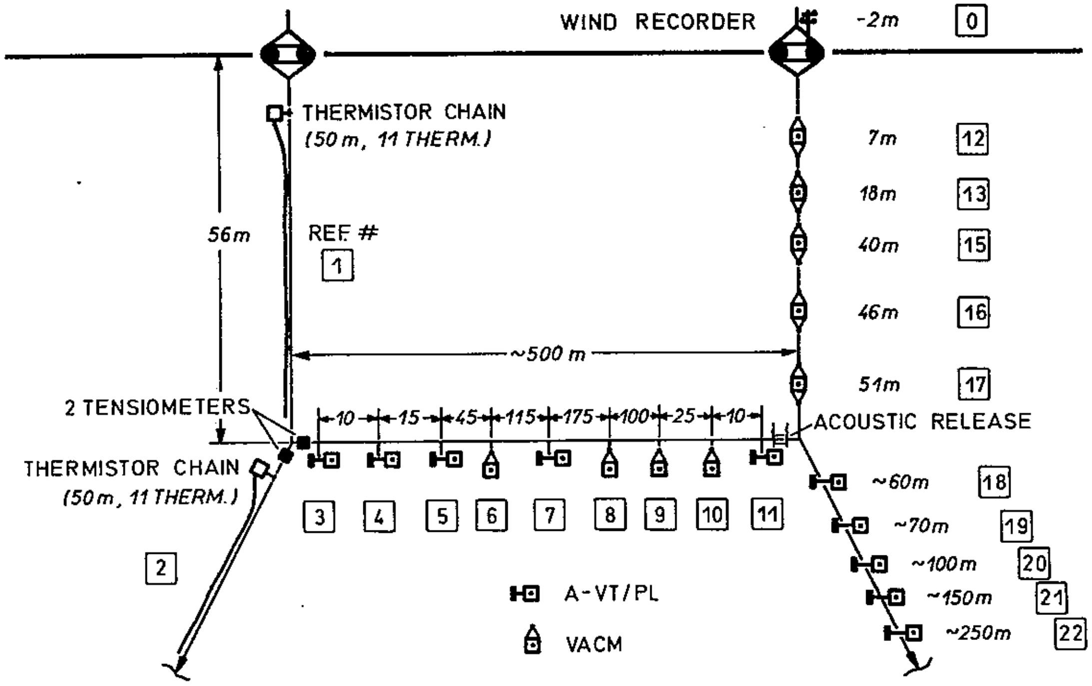
Figure 6 (Rossby and Freeland)



Contour interval: 1.4×10^{-6} sec^{-1}

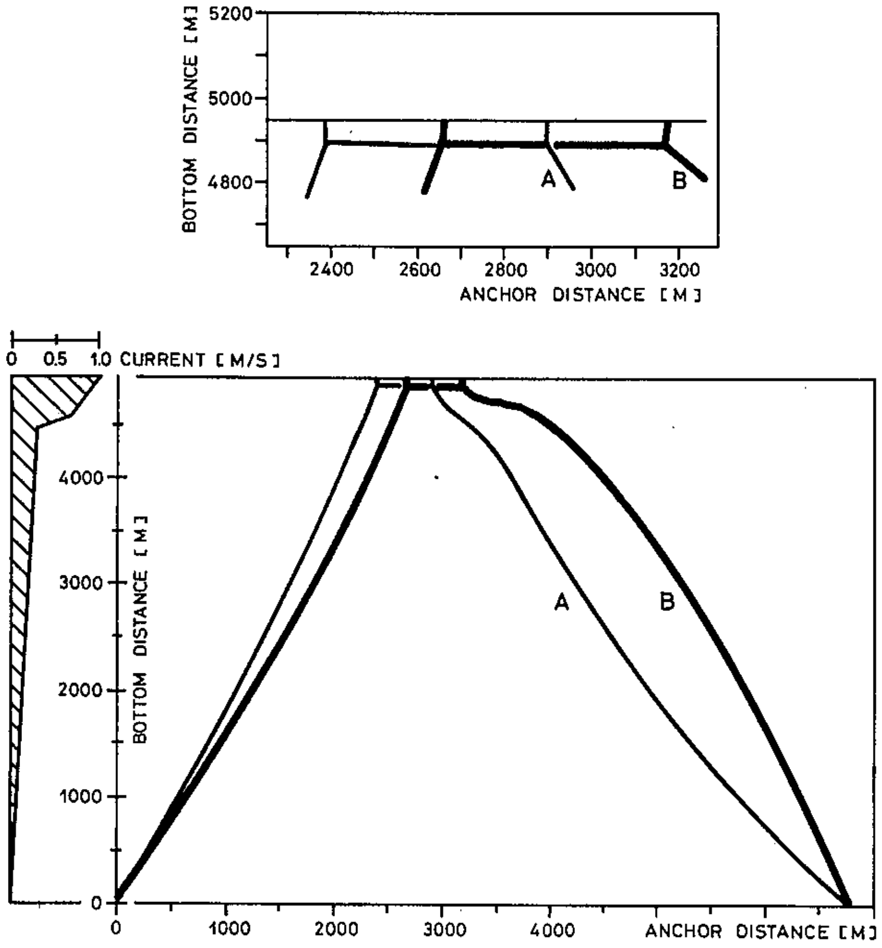
Contours of Eulerian time rate of change, $\frac{1}{H}\frac{\partial H}{\partial t} \approx 1.4 \times 10^{-6}\text{sec}^{-1}$. This figure is derived from the difference in the two periods shown in Figure 6 (a) and (b).

Figure 7 (Rossby and Freeland)



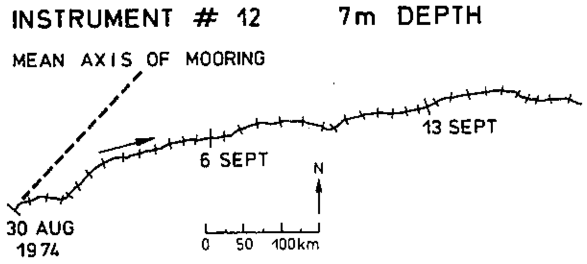
Upper part of GATE two-legged mooring (not to scale). A-VT/PL indicates Aanderaa current/temperature meter, some of which included pressure and/or conductivity sensors. VACM indicates vector-averaging current meter.

Figure 8 (Siedler, *et al*)



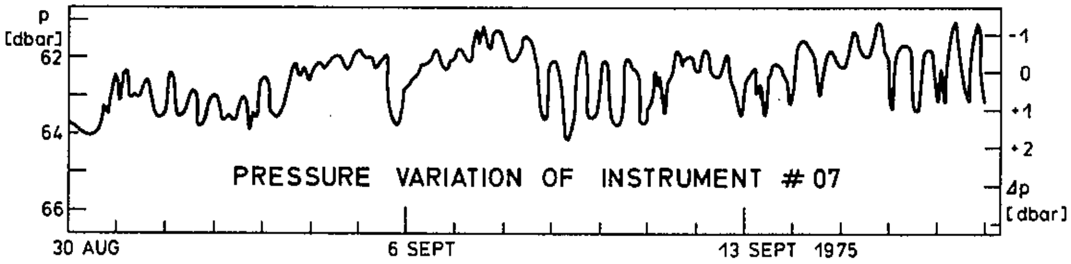
Example of computed mooring configuration for no current (A) and for current along the mean axis as indicated on the left.

Figure 9 (Siedler, et al)



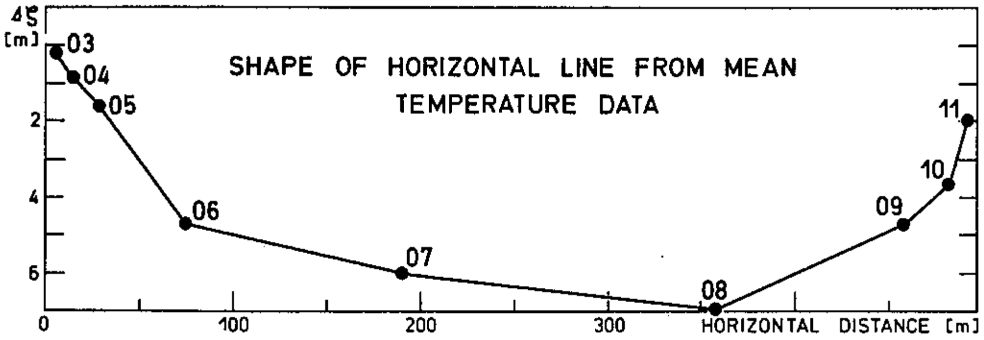
Progressive-vector diagram obtained from instrument no. 12, with the direction of the mooring axis indicated by the dotted line.

Figure 10a



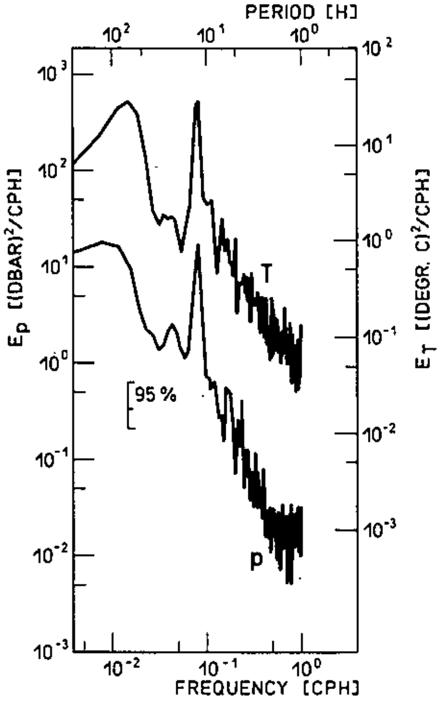
Pressure recorded by instrument no. 7 near the center of the horizontal line.

Figure 10b
(Siedler, et al)



Shape of mooring line as calculated from mean temperatures recorded by moored instruments and from the mean vertical temperature gradient, recorded by CTD.

Figure 11a



Auto-spectrum of pressure fluctuations due to the vertical displacement of instrument no. 7 (p) and auto-spectrum of temperature fluctuations measured by the same instrument (T). In the case of the T-spectrum, the scale to the right corresponds to temperature variance, while those to the left correspond to displacement variance.

Figure 11b
(Siedler, et al)