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## Hydroblack 91

## Report of the CTD Intercalibration Workshop

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D.G. Aubrey, T. Oguz, E. Demirev, V. Ivanov, T. McSherry,
V. Diaconu, and E. Nikolaenko

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Funding was provided by the National Science Foundation through Grant No. OCE-9121788, the Vetlesen Foundation, the Andrew W. Mellon Foundation, the Mobil Foundation, Inc. and the Regional Environmental Center for Central & Eastern Europe (Budapest).





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Woods Hole, Massachusetts 02543

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**Technical Report**

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**Approved for Distribution:**

**G. Michael Purdy**
Department of Geology and Geophysics

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## ABSTRACT

An Intercalibration Workshop was held at the Woods Hole Oceanographic Institution (W.H.O.I.) from 1-10 December, 1991, for the CTD data acquired during HYDROBLACK '91. This intercalibration exercise was a prelude to an interdisciplinary HYDROBLACK '91 intercalibration to be held in Crimea, Ukraine, in February, 1992, incorporating the full suite of physical, biological, and chemical measurements acquired during the cruise.

HYDROBLACK '91 acquired for the first time a complete hydrographic, biological, and chemical data set for the entire Black Sea, to 2000 m water depth, with the participation of all Black Sea riparian countries as well as the U.S. Nearly 300 hydrographic stations were occupied to full water depth; biological and chemical measurements were made at 100 of these stations. This quasi-synoptic survey was accomplished using five ships during an interval of approximately three weeks.

Results show some disparities between CTD's from the different regions, but the intercalibrated results show a consistent and high resolution detail of the dynamic topography and other physical characteristics of the entire Black Sea basin. The intercalibrated data set is now available within each country and from W.H.O.I., and will form the basis for studies on ocean physics as well as interdisciplinary issues such as oxygen depletion within the basin and hydrogen sulfide distribution. This effort provides an intercalibrated, spatially-dense baseline against which all future and past measurements can be compared.

In spite of significant economic pressures arising from the changes in the eastern European countries, and the inadequate scientific exchange with the west during the past two decades, HYDROBLACK '91 is considered a success and a model for future international scientific and monitoring efforts throughout the Black Sea. Similar efforts are anticipated twice-yearly in the framework of the new Cooperative Marine Science Program for the Black Sea.

## GOALS OF WORKSHOP

The goals of the Intercalibration Meeting include:

- Assess quality of HYDROBLACK 1991 data
- Intercalibrate the HYDROBLACK 1991 data sets using intercalibration stations and bottle sample results.
- Discuss scientific results of HYDROBLACK 1991: compare with known results of earlier cruises to Black Sea.
- Outline scientific paper(s) that will result from hydrographic results
- Complete Technical Report on Intercalibration Exercise
- Outline agenda for February, 1992, meeting in Sevastopol for HYDROBLACK 1991.
- Discuss goals of future Hydrographic work in Black Sea; prepare additional recommendations, if necessary, to VARNA meeting results.

The agenda for the intercalibration workshop is presented as Appendix I.

## CRUISE DESCRIPTION

Five ships participated in HYDROBLACK 1991 (Table 1). These ships all provided data from several different brands of CTD's, using to the extent possible similar procedures as outlined in the HYDROBLACK 1991 cruise plan (Erdemli, Turkey, July 1991: Appendix II).

HYDROBLACK 91 accomplished nearly 300 hydrographic stations, using ships from three different Black Sea riparian countries. Two Ukrainian vessels (Kolesnikov and Parshin), two Turkish ships (Bilim and Piri Reis), and one Bulgarian vessel (Akademik) participated, occupying for the first time stations quasi-synoptically over the entire Black Sea within a period of three weeks. Station spacing was approximately 20 nm.

## TABLE 1

## SHIP AND CTD INVENTORY

## HYDROBLACK 1991

| Vessel | Country | CTD* | Dates | Number of Stations |
|---|---|---|---|---|
| R/V Akademik | Bulgaria | Sea Bird SBE-9 | 2 - 12 Sept 91 | 53 |
| R/V Bilim | Turkey | Sea Bird SBE-9 | 5 - 23 Sept 91 | 104 |
| R/V Prof. Kolesnikov | Ukraine | Istok V | 9 - 29 Sept 91 | 94 |
| R/V Parshin | Ukraine | Hydrozond | 8 - 12 Sept 91 | 40 |
| R/V Piri Reis | Turkey | Sea Bird SBE-9 | 7 - 17 Sept 91 | 16 |
| | | | TOTAL | 307 |

* Details on CTD's contained in Appendix 3 and Table 2

## TABLE 2
## CTD DATA SPECIFICATIONS
## HYDROBLACK 1991

| CTD MODEL | PRESSURE (DB) | CONDUCTIVITY (S/m) | TEMPERATURE (°C) | SAMPLE FREQUENCY (hz) |
|---|---|---|---|---|
| SEA BIRD SBE-9 | +/- 2% (0-6000 m) | +/- 0.0004 S/m | +/- 0.003 °C | 24 |
| SEA BIRD SBE-19 | | | | 2 |
| ISTOK V | 0.025% (0-60 MPa) | +/- 0.00025 S/m | 0.025°C | 4 |
| HYDROZOND | 0.04 - 0.6 MPa | +/- 0.0035 S/m | +/- 0.03°C | 3 |

## DATA ASSESSMENT

Data from all ships were loaded into a SUN Sparcstation II at the Woods Hole Oceanographic Institution. These data consisted of 1-decibar (db) bin-averaged data, as provided in Varna by the individual host countries following HYDROBLACK 1991. The data consisted of ascii files of pressure (decibars), temperature (in situ, °C), salinity (psu), and density (sigma-t). In order to implement filtering and spike removal, data were converted to conductivity using the routine of Fofonoff and Millard (1983).

Instruments: The Akademik, Bilim, and Piri Reis used the same model of CTD: a Sea Bird SBE-9. The Kolesnikov used an Istok V CTD; the Parshin had available both a Sea Bird SBE-19 (for shallow stations) and a Hydrozond. Table 2 and Appendix 3 provide details on the different CTD's used.

Data quality: Data from intercalibration stations were examined first to determine the quality of the data. An assessment of the data follows. The data examined were limited to deep stations (greater than 1000 db), since the spatial and temporal variability at these depths is less than elsewhere, and the dynamic range is more limited. The deep data were the best available to examine for drift and noise problems with the instruments.

- Akademik: These data are of high quality. Drift of the temperature sensor was small (Figure 1), with the drift being within the dynamic upper layer, and not within the deeper bottom mixed-layer. The drift likely represents dynamics within this deeper water (spatial variability). Differences in salinity reflect the differences in temperature (Figure 2): the largest differences are above the bottom mixed layer (bml), with less than 0.005 psu difference within the bml.

  Occasionally, spikes occurred in salinity in the deeper waters. Spikes also occurred near the seasonal thermocline. The shallow spikes occurred because of ship heave due to heavy seas, combined with the slow lowering speed in the upper 100 meters (Figure 3). The lowering speed of 0.5 m/sec was modulated by surface waves, resulting in contaminated data within the strong gradients of the seasonal thermocline. In deeper waters, spikes (Figure 2) appeared that were linked with missing data (the modulo count on the Sea Bird was higher than 24). This resulted in both positive and negative spikes in conductivity and temperature, and hence in salinity. The cause of this spiking appears to be cable-related, either due to slip-ring problems or other cable problems.

- Bilim: These data appear to be of high quality. Temperature and salinity both appeared uniformly varying and noise-free. Long-term drift is small (less than 0.005 degrees C and 0.005 psu within the bml during the entire cruise: Figures 4 and 5). Convergence within the bml suggests the drift is due to spatial variability or dynamical changes. No spiking was observed in these data.

- Kolesnikov: These data were of high quality, but were noisier than the Bilim and Akademik data. The temperature signal taken at deep stations throughout the three weeks of sampling show several features (Figure 6):

  - Discontinuities in temperature, due to coarse discretization (reporting to 0.00x degrees C instead of 0.000x degrees C).
  - Staircases, where temperature "stuck" at a uniform value for more than 25 meters. For instance, one staircase occurred at 9.015°C throughout the cruise.
  - Space/time variability, with a spread of about 0.02 degrees C throughout the cruise. Since the temperatures shown are actual temperatures (not potential), the bml cannot be observed in temperature as a uniform layer, but these same 0.02°C differences persist in the bml itself at 1800 db levels and deeper. Since the bml is so uniform horizontally and vertically, this disparity represents a drift in the sensor.

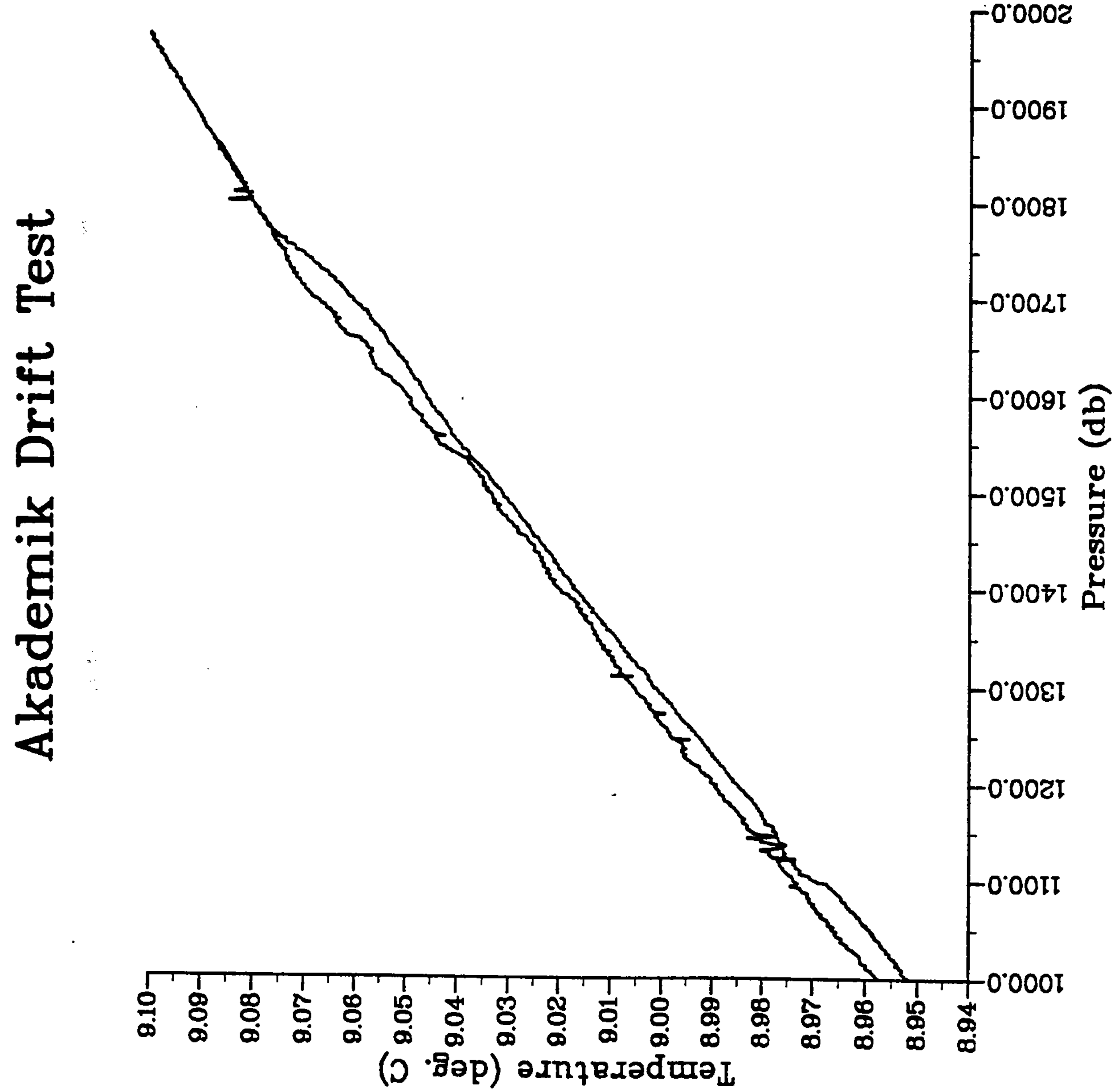


Figure 1: Temperature versus depth from the Akademik, during HYDROBLACK '91. Agreement of actual temperature within the bottom mixed layer shows no appreciable temperature drift through time. Spikes in the temperature signal appear to result from cable weakness, slip-ring noise, or perhaps a bad connector.

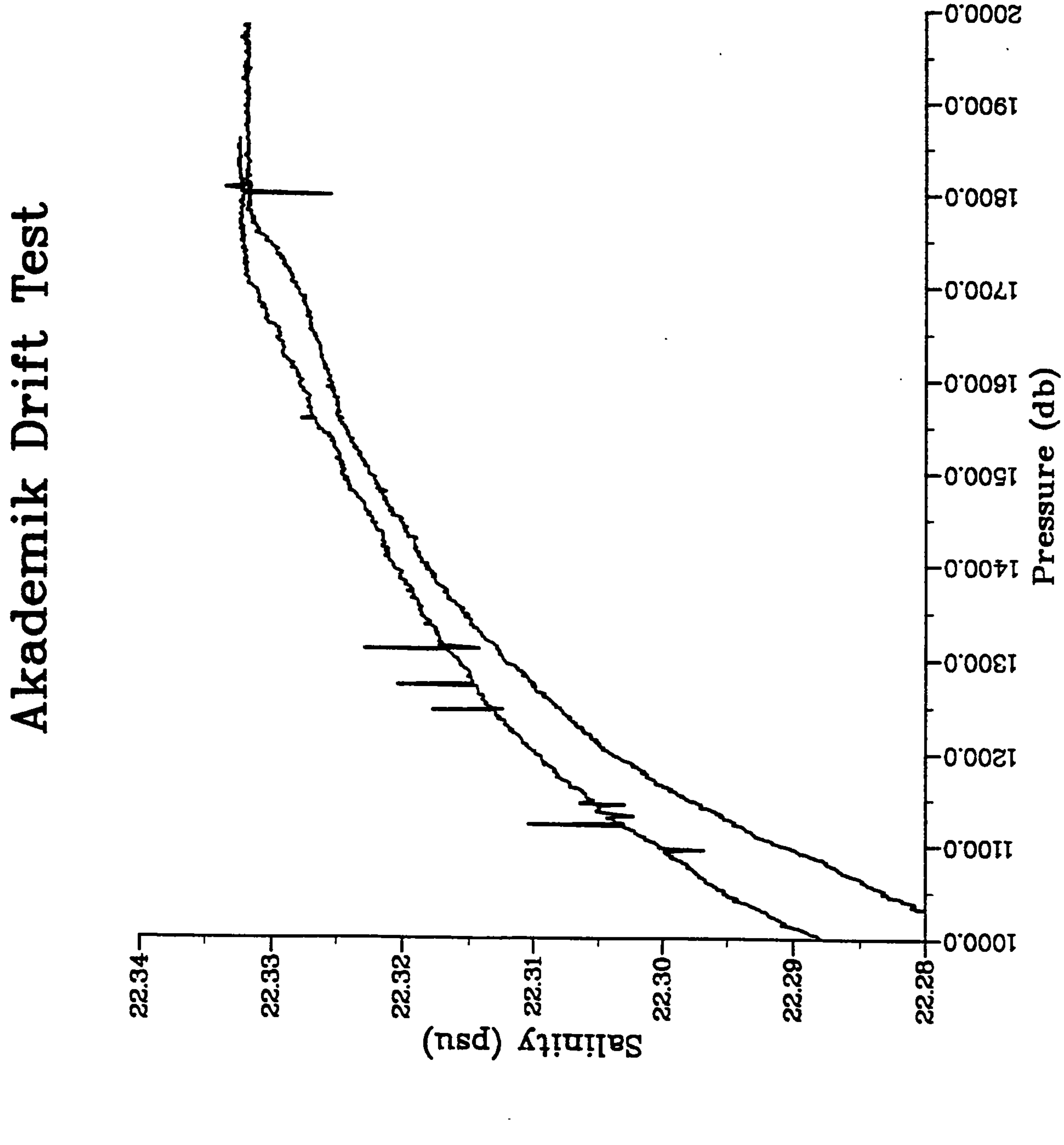


Figure 2: Salinity versus depth calculated for the Akademik casts of Fig. 1. The temperature spikes show up as marked salinity spikes. Salinity in the bottom mixed layer agrees well for the two casts.

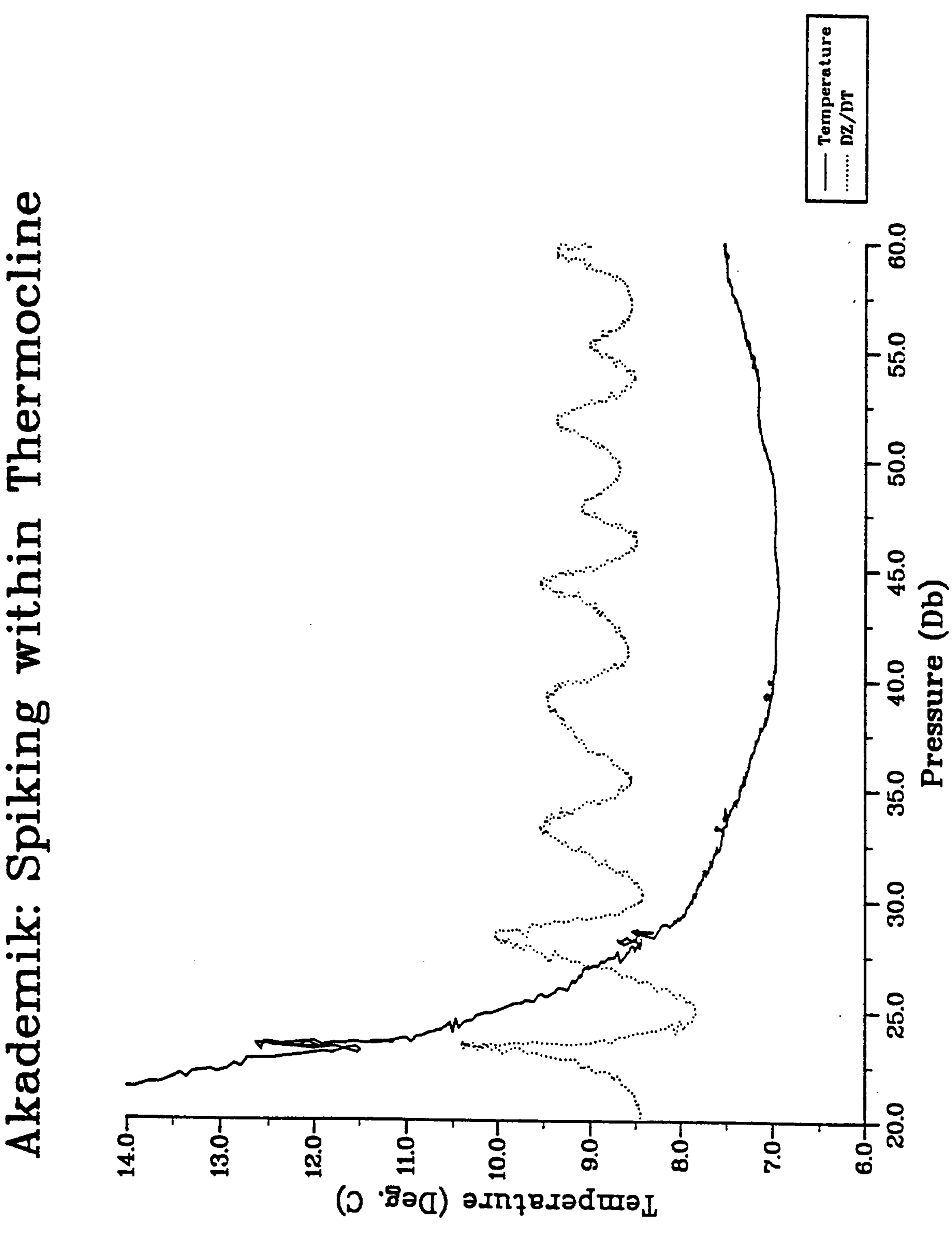


Figure 3: Temperature versus depth in the upper 60 db for the Akademik at one station. The solid line is the temperature from the CTD. The dashed line shows low-pass filtered vertical CTD velocity. Spikes in temperature within the thermocline occur when the vertical velocity changes rapidly, most likely due to ship motion caused by surface waves. The spike cannot be removed by simple filtering, and was exacerbated by too slow a lowering speed through the thermocline.

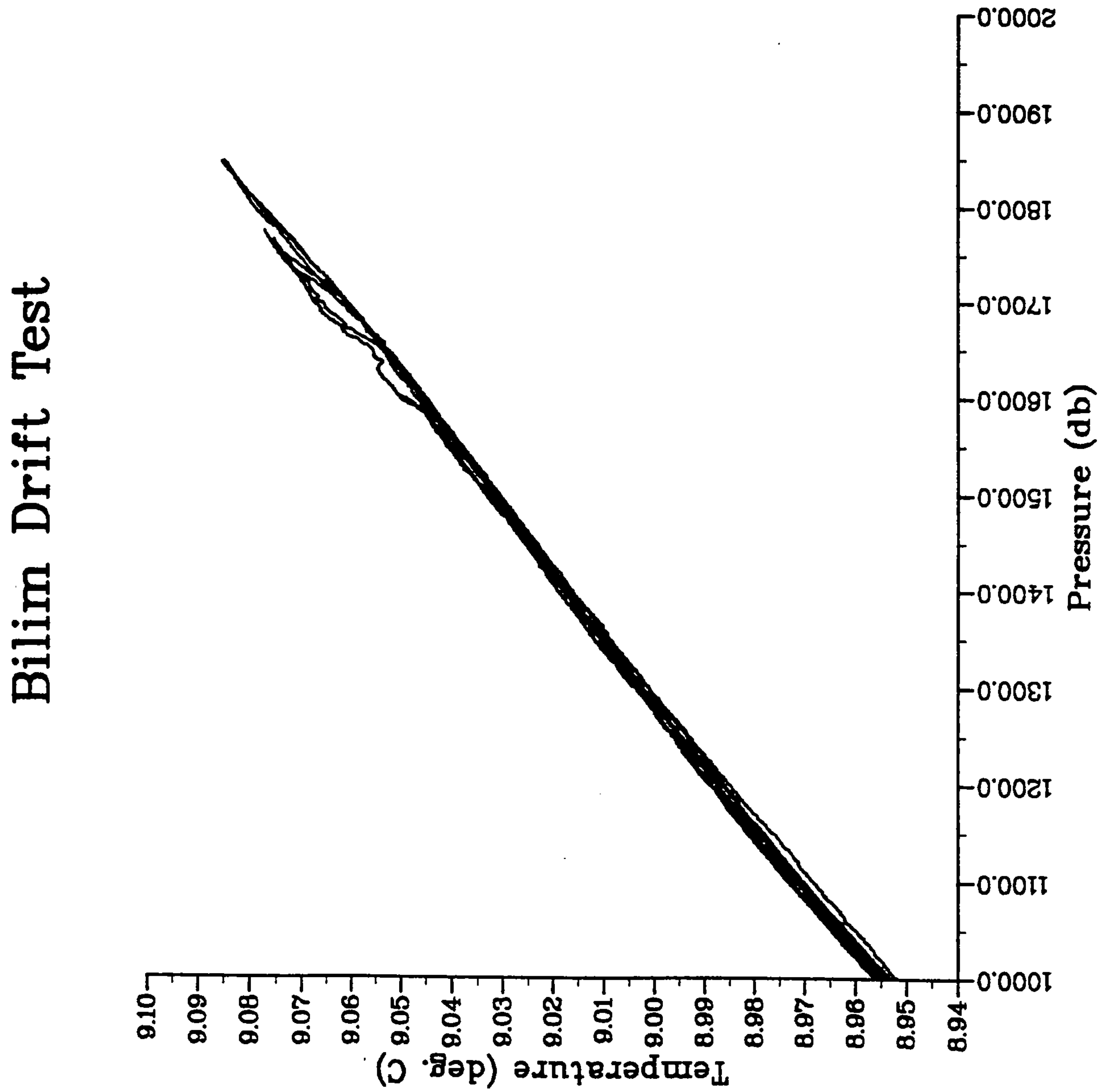


Figure 4: Temperature versus depth from the Bilim, during HYDROBLACK '91. Agreement of temperatures throughout most of the water column over the entire southern Black Sea during a period of two weeks indicates stability of the thermistor in the Bilim CTD. Wire length restrictions prevented the Bilim CTD from entering far into the bottom mixed layer.

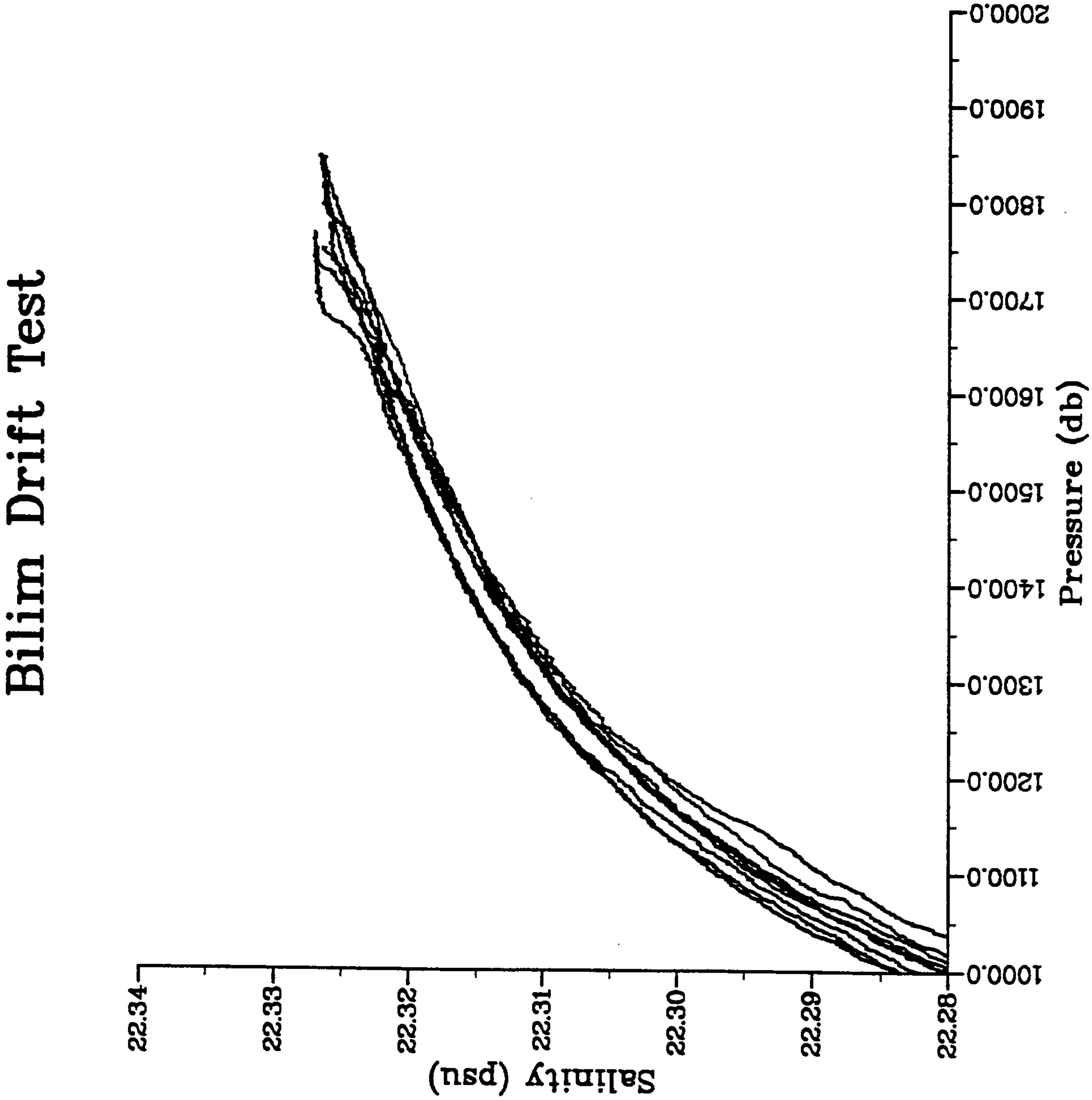


Figure 5: Salinity versus depth calculated for the Bilim casts of Fig. 4. As for temperature, the salinity data for the different casts are similar, especially near the bottom where they converge to a value of approximately 22.325 psu.

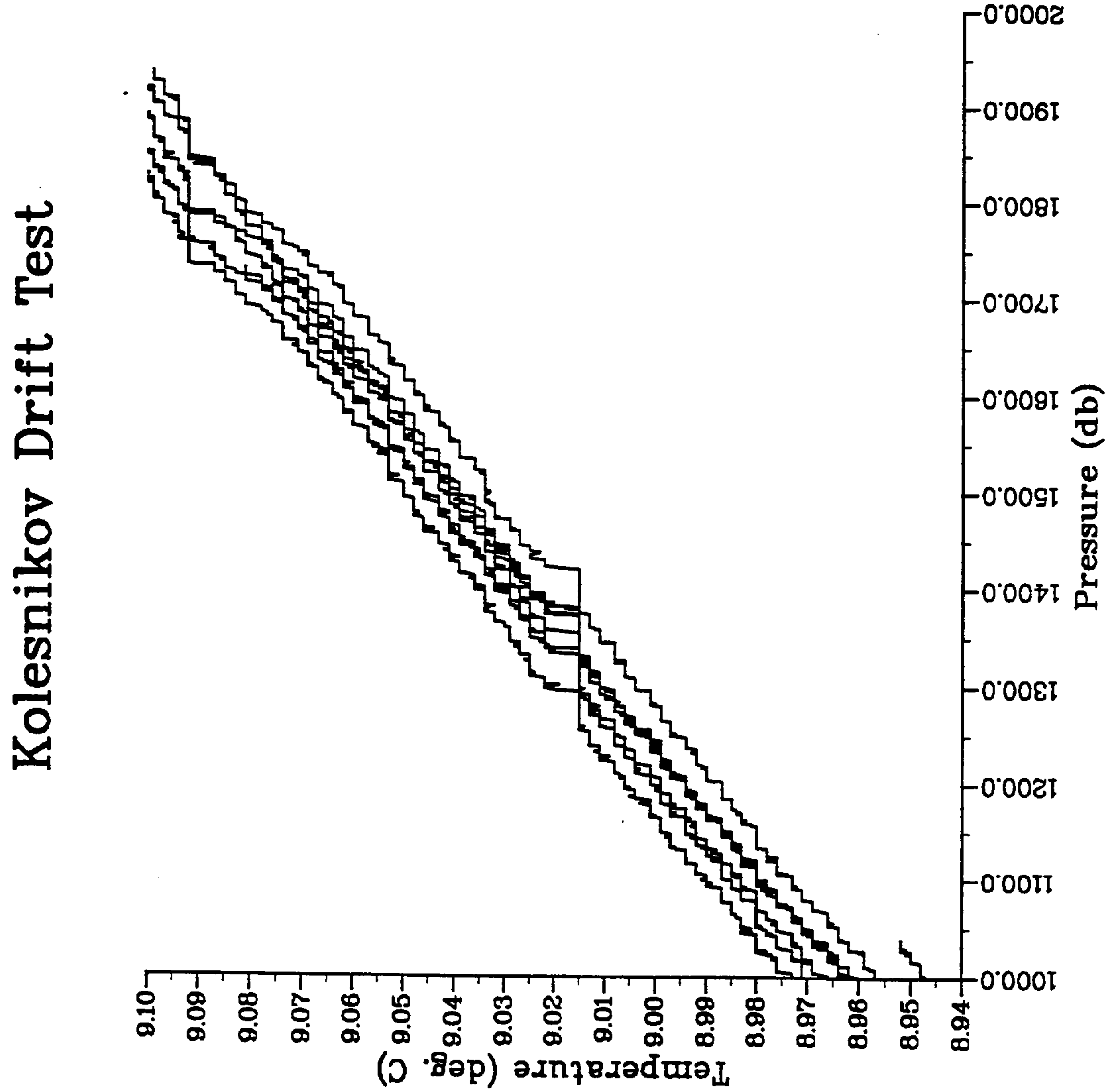


Figure 6: Temperature versus depth from the Kolesnikov, during HYDROBLACK '91. Temperature had several problems: the discretization interval is apparent in the graph by the jagged changes. Also, there is considerable drift in temperature (by about 0.02°C) during the course of the experiment. Finally, temperature sticks at certain levels (e.g., 9.015°C) for tens of meters water depth.

The temperature drift was investigated through time, to see if the difference were linear as reported in a 1990 joint Soviet-Turkish Black Sea hydrographic experiment. Unfortunately, this drift was not linear (Figure 7).

The conductivity was uniform throughout the cruise, showing no drift. Salinity, however, reflects the temperature drift by showing large scatter in salinities (0.01 psu and greater) throughout the cruise Figure 8).

- Parshin: These data were taken with a coarse-resolution instrument (Hydrozond), and some data were taken also by a SeaBird SBE-19, before this latter instrument's pressure sensor failed halfway through the cruise (operator error). The SBE-19 data were of high quality, showing little spiking or other anomalies. The Hydrozond data, however, had greater difficulties. The Hydrozond's conductivity cell stopped working, so the sampling procedure consisted of lowering the thermistor and pressure sensors, examining the data, and then taking bottle samples analyzed on board for salinity. The result was a coarse resolution varying from a few meters to hundreds of meters in the deep stations. The accuracy of the instruments also is poor compared to the Sea Birds or Istok, so the deeper Parshin data were discarded. Only the shallow water data were used in this analysis.

- Piri Reis: Only a few stations were run by the Piri Reis. These data appeared of similar quality as the Bilim and Akademik data. Temperature variability (Figure 9) was near zero in the bml, but showed a little structure above the bml. In salinity (Figure 10), the same variability shown by temperature exists, but the salinity in the bml is always uniform. The drift is small (less than 0.02 psu).

- Knorr 1988: Although not part of this cruise, the KNORR 1988 data were examined for time and space variability. These data (reported by Murray et al. 1989 and several others) were high quality observations against which the present data could be compared. Two sets of profiles were examined in detail, consisting only of deep stations (to about 2000 db). The first set of profiles consists of stations throughout the Turkish part of the Black Sea (Figure 11), which would be indicative of spatial variability. The second set is taken from a single station, occupied repeatedly throughout the four-month duration of the Knorr cruise in the Black Sea.

Space variability in temperature is relatively small, with negligible variability within the bml (Figure 12). Variability between 1000 m and 2000 m was approximately 0.05 °C. Space variability in conductivity similarly was small, and negligible within the bml (Figure 13). Variability within the 1000-1800 db levels was approximately 0.002 S/m). Finally, spatial variability in salinity arising from the conductivity and temperature variability (Figure 14) is of the order of 0.005 psu in the bml. Variability is greater between 1000 and 2000 db levels.

Time variability in the Knorr data is similar as the spatial variability. The time variability in temperature (Figure 15) is of the order of 0.005 °C. Time variability in conductivity (Figure 16) is similar, with one higher measurement which might represent a different instrument. The variability in temperature and conductivity translate to a variability in salinity (Figure 17) of about 0.003 psu, with the exception of the one measurement having a high conductivity, which has a salinity within the bml higher by about 0.008 psu.

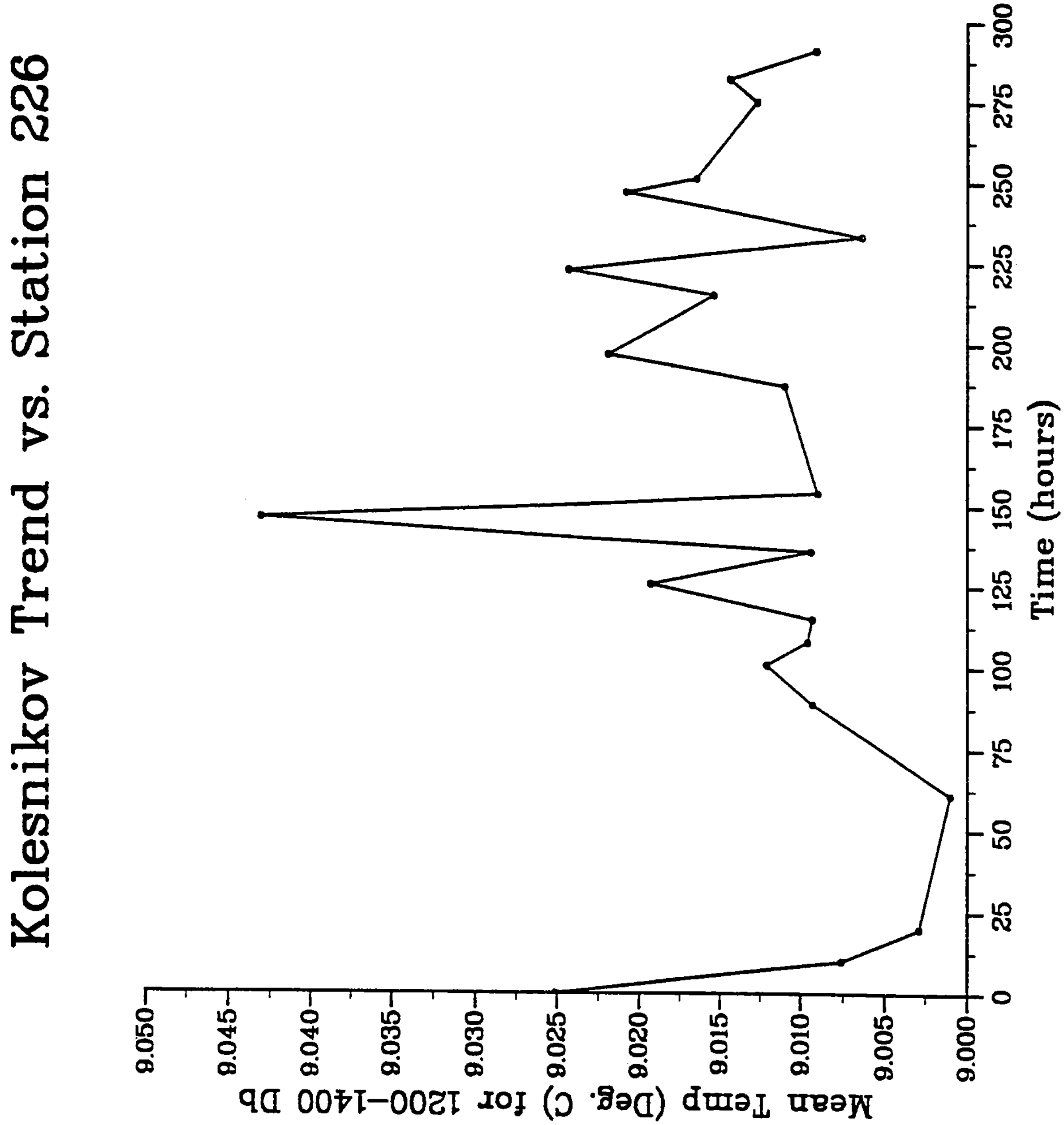


Figure 7: Mean temperature for the pressure levels of 1200-1400 db for the Kolesnikov. Horizontal axis is time from the first hydrographic cast of the Kolesnikov. The variability in temperature through time shows that a simple time-dependent temperature correction was not appropriate for the Kolesnikov data.

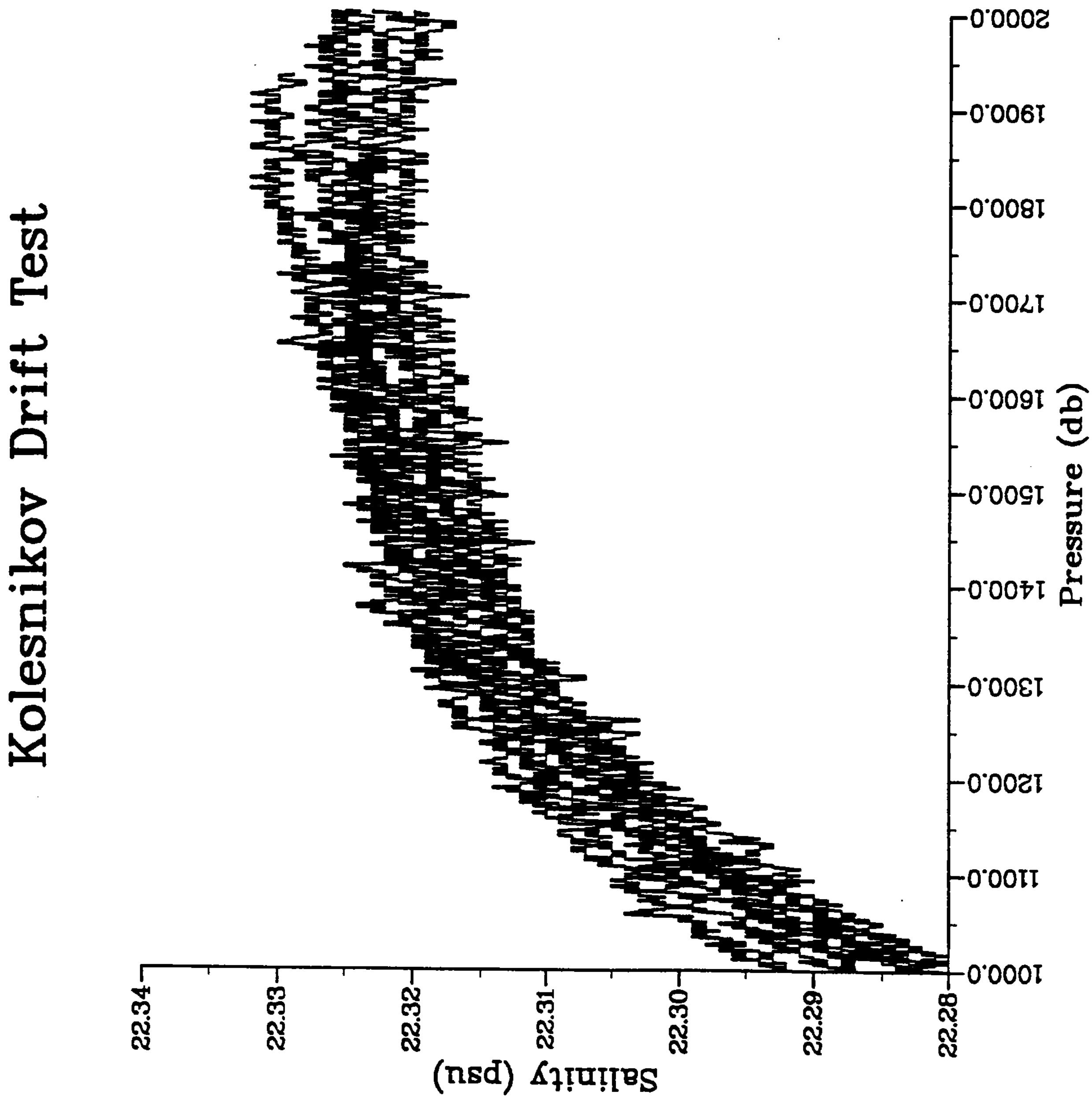


Figure 8: Salinity versus depth calculated for the Kolesnikov casts of Fig. 6. Salinity drift indicates several features: There is a notch-structure resulting from the coarse resolution of the thermistor. Salinity remains constant in several regions due to the sticking of the temperature at certain levels. Finally, there is strong curvature in the deeper waters, which result from a depth-dependent over-correction made to the conductivity measurement. This correction has the effect of artificially flattening salinity at greater depths.

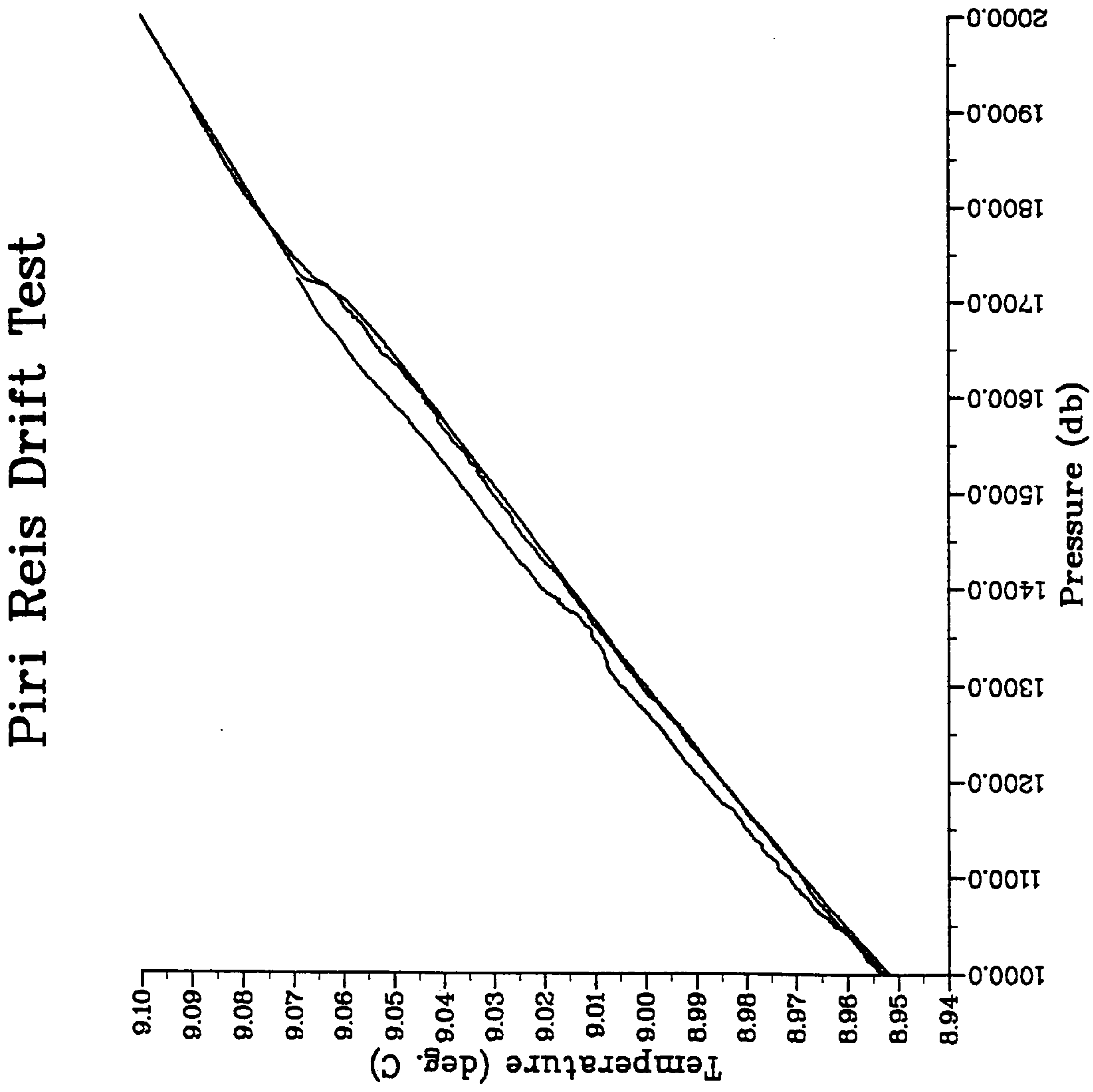


Figure 9: Temperature versus depth from the Piri Reis, during HYDROBLACK '91. Agreement of temperatures throughout most of the water column over the western Black Sea during a period of two weeks indicates stability of the thermistor in the Piri Reis CTD. In particular, actual temperature in the bottom mixed layer is nearly identical (to better than 0.001°C).

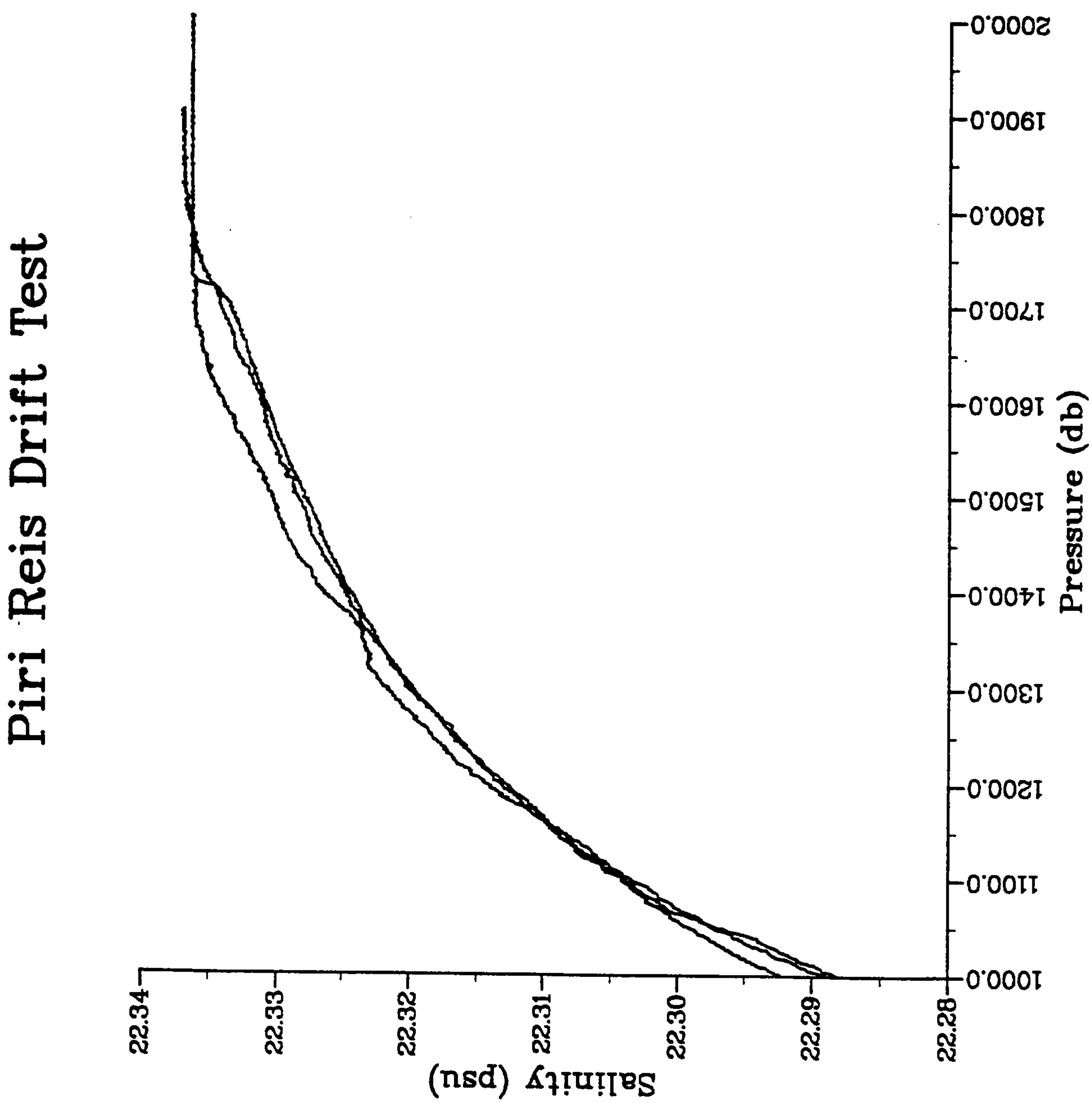


Figure 10: Salinity versus depth calculated for the Piri Reis casts of Fig. 9. As for temperature, the salinity data for the different casts are similar, especially near the bottom where they converge to a value of approximately 22.335 psu. This convergent value is higher by about 0.01 psu than the equivalent values for the Bilim.

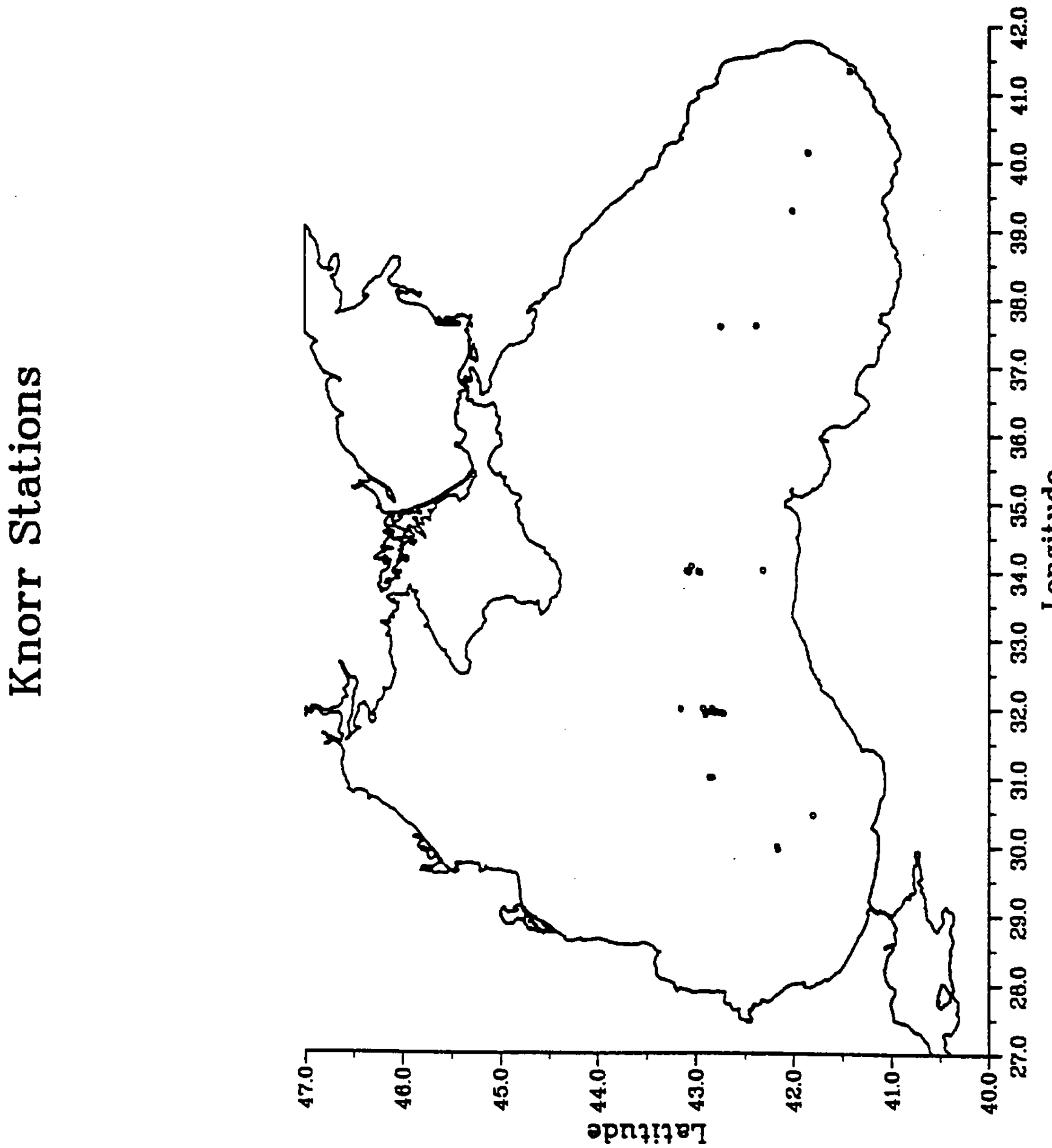


Figure 11: Positions of Knorr hydrographic stations from 1988.

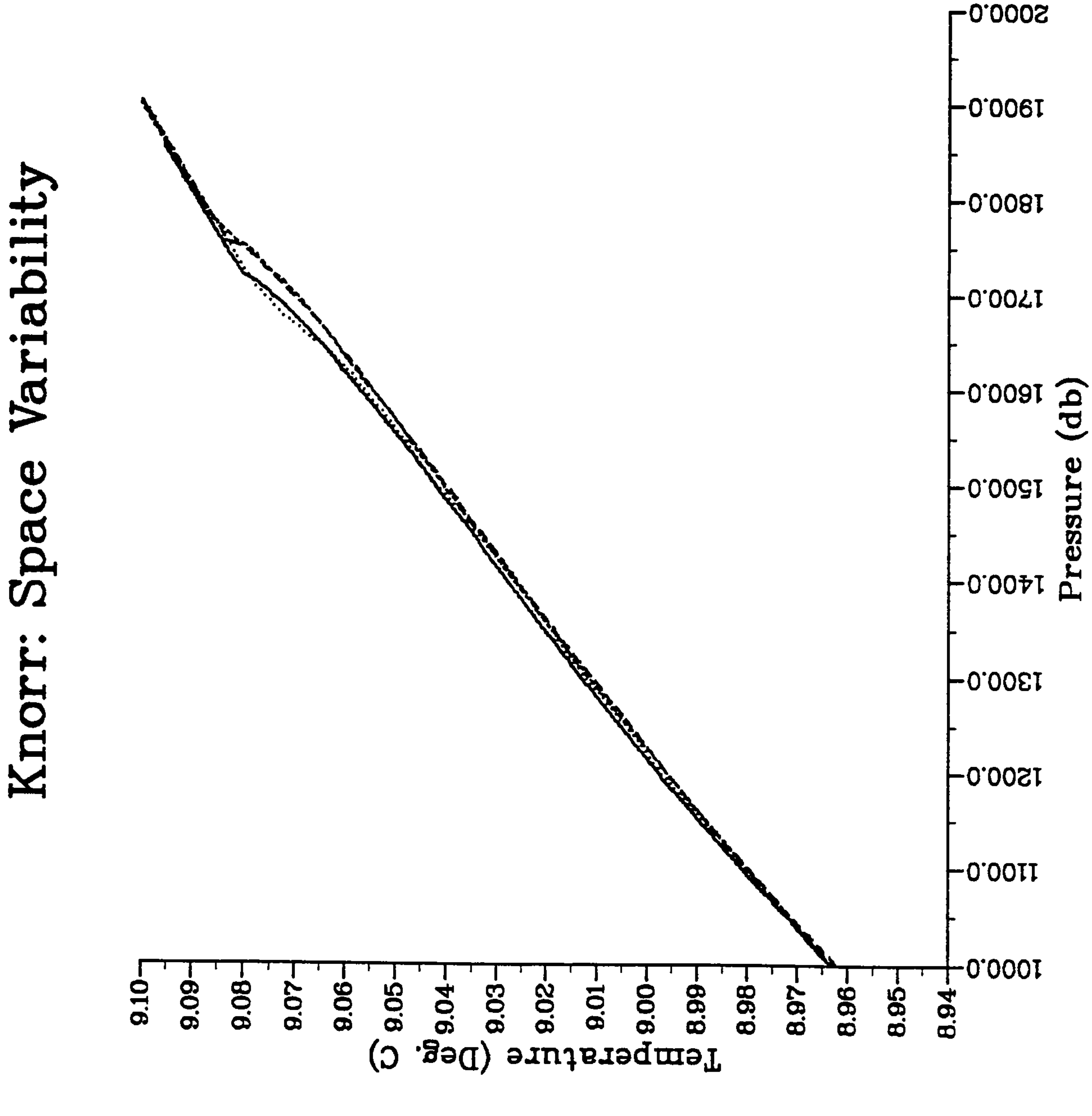


Figure 12: Temperature versus depth from the Knorr, for 1988, for some deep stations. Agreement of temperatures throughout most of the water column over the entire southern Black Sea during a period of several months indicates stability of the thermistor in the Knorr CTD. In particular, actual temperature in the bottom mixed layer is nearly identical (to less than 0.001°C).

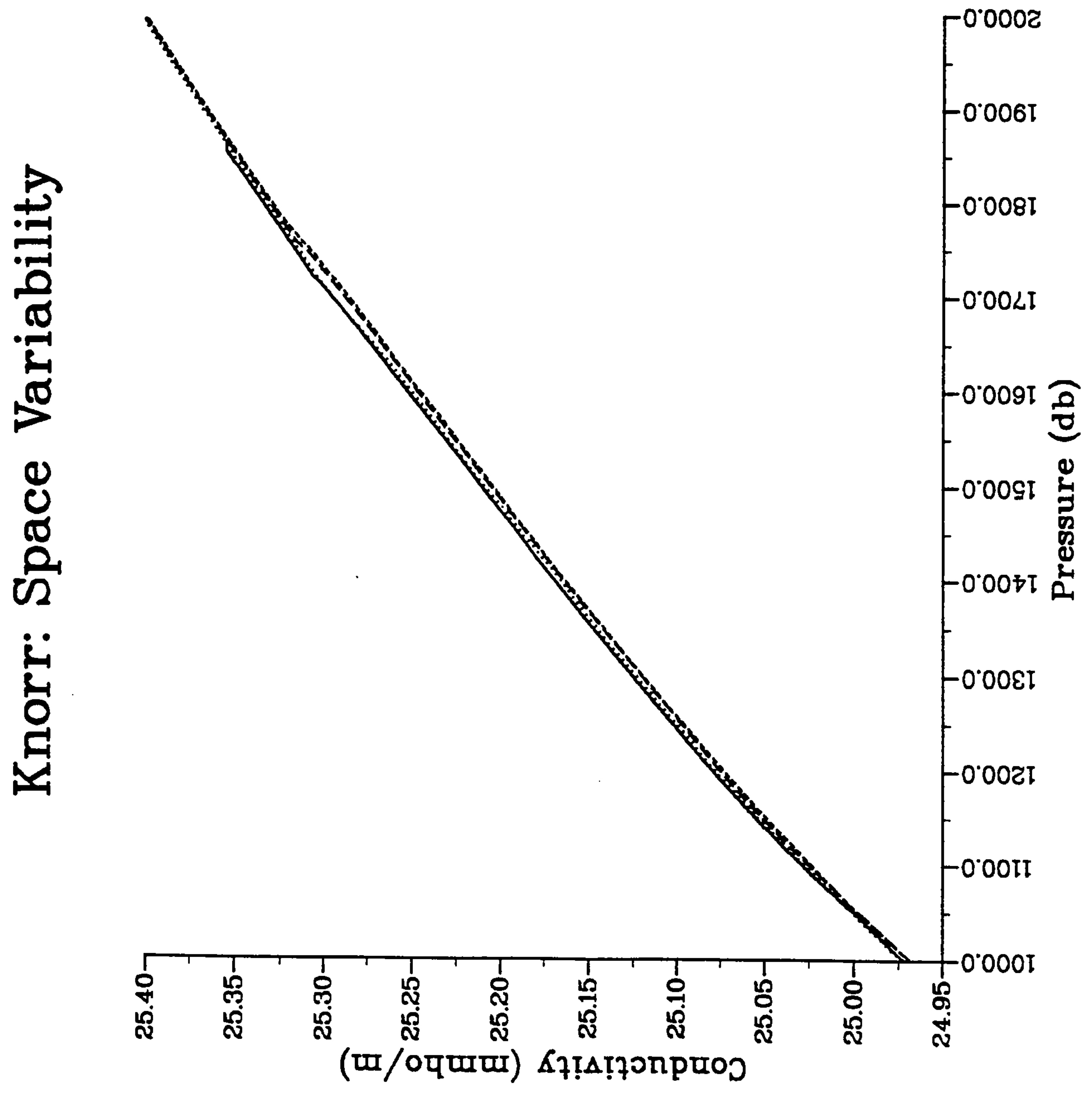


Figure 13: Conductivity versus depth from the Knorr, for 1988. Agreement of conductivity throughout most of the water column over the entire southern Black Sea during a period of several months indicates repeatability of the conductivity cell in the Knorr CTD, especially in the bottom mixed layer.

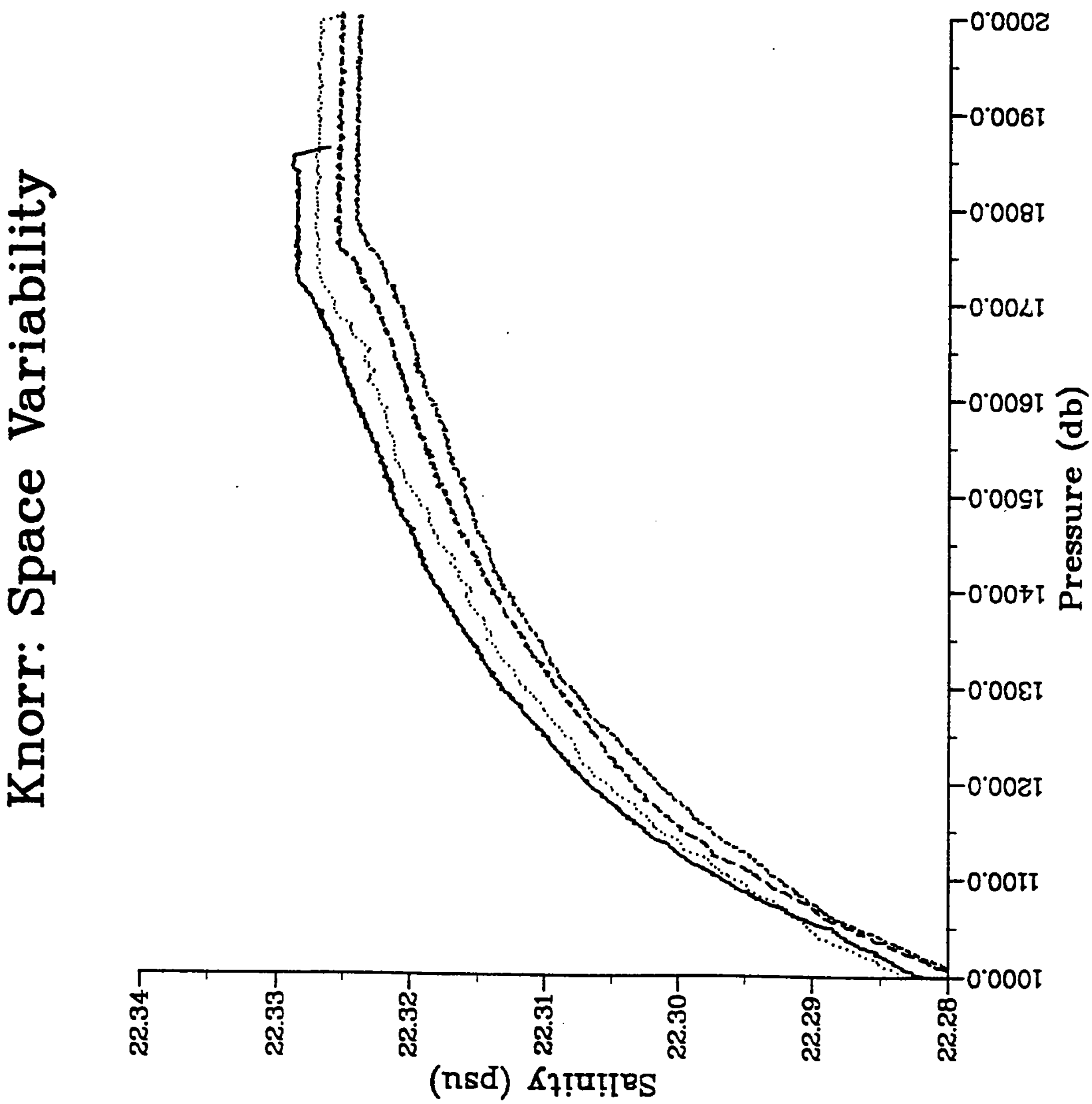


Figure 14: Salinity versus depth from the Knorr, for 1988, for some deep stations. Agreement of salinity throughout most of the water column over the entire southern Black Sea during a period of several months indicates good performance of the Knorr CTD, especially in the bottom mixed layer. Differences in the bottom mixed layer are about 0.005 psu.

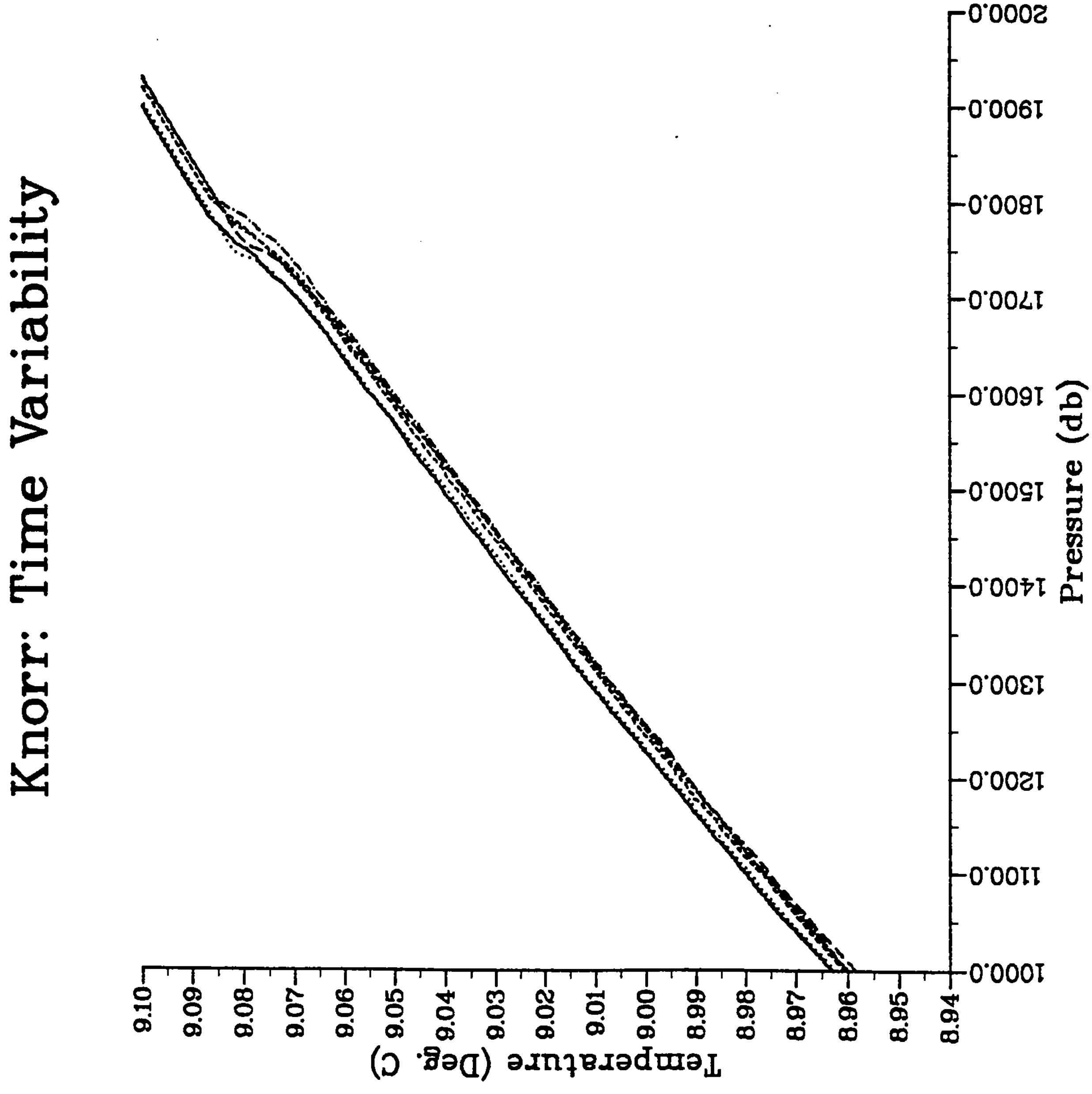


Figure 15: Temperature versus depth from the Knorr, for 1988, for a single deep station occupied repeatedly during a period of several months. Agreement of temperatures throughout most of the water column during a period of several months indicates stability of the thermistor in the Knorr CTD. In particular, actual temperature in the bottom mixed layer is nearly identical (to better than 0.005°C).

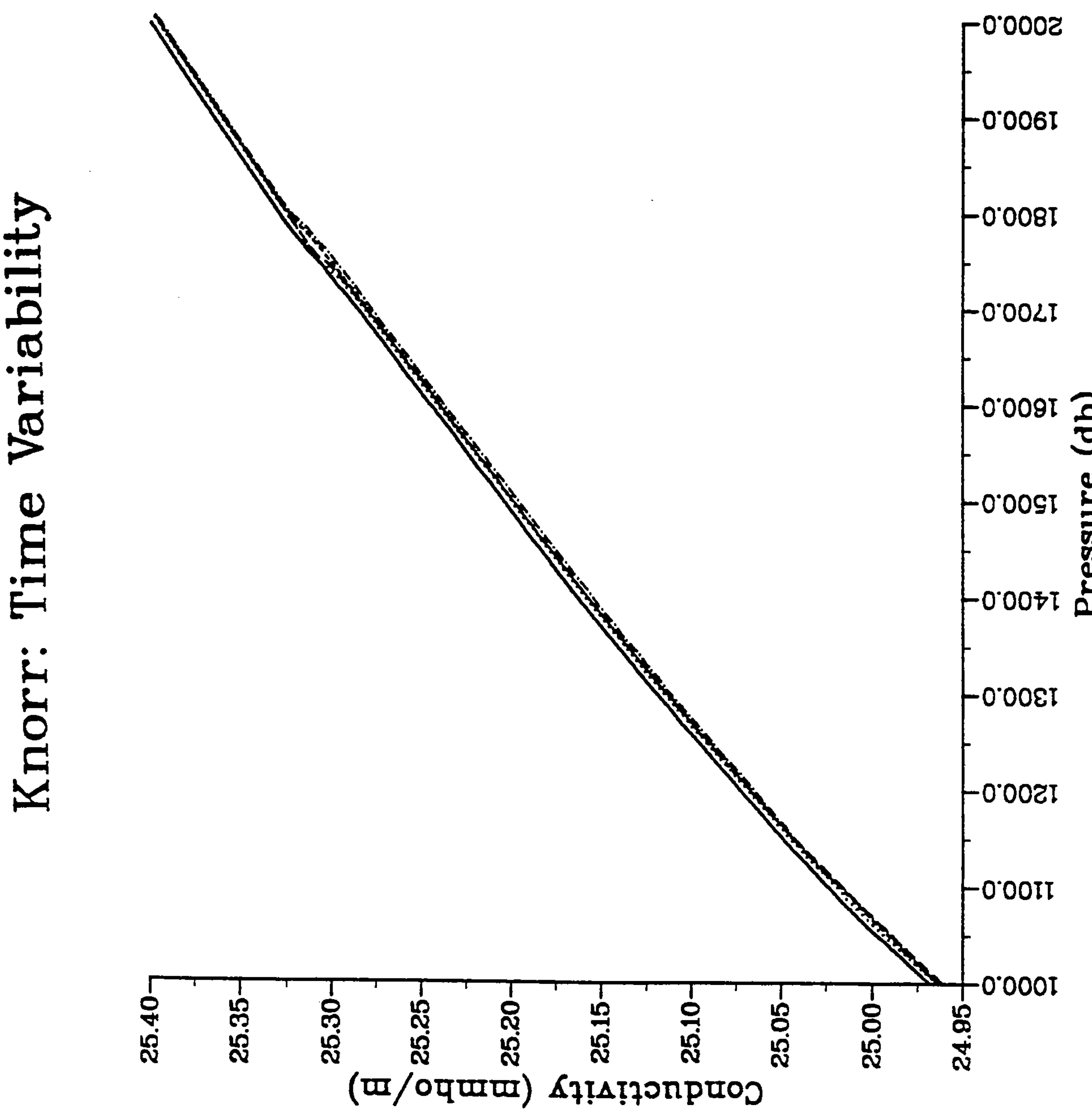


Figure 16: Conductivity versus depth from the Knorr, for 1988, for a single station during a period of several months. Agreement of conductivity throughout most of the water column during a period of several months indicates stability of the conductivity cell in the Knorr CTD, especially in the bottom mixed layer, where differences are on the order of 0.002 S/m.

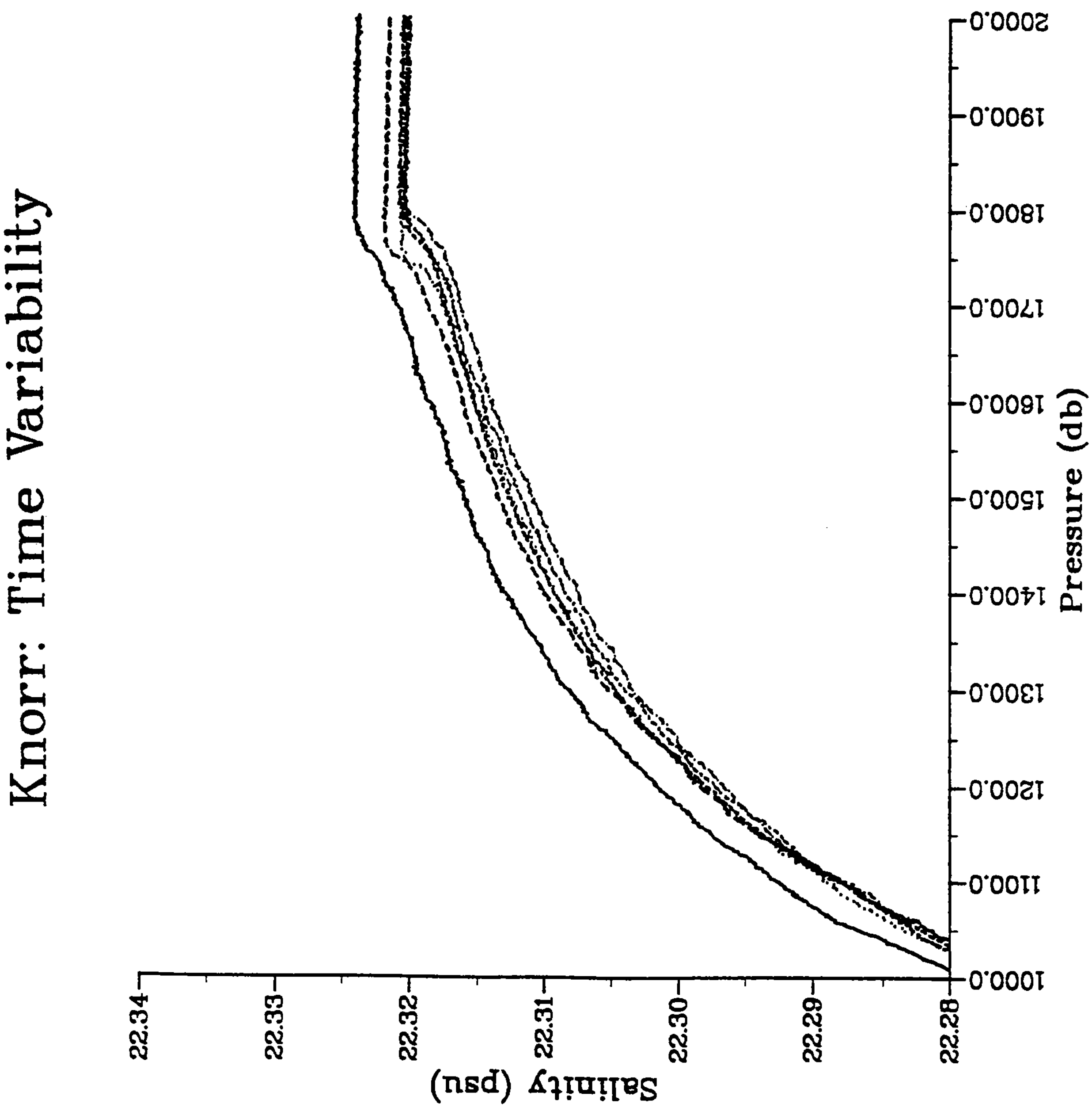


Figure 17: Salinity versus depth from the Knorr, for 1988, for a single deep station taking data during a period of several months. Agreement of salinity throughout most of the water column during a period of several months indicates good performance of the Knorr CTD, especially in the bottom mixed layer. Differences in the bottom mixed layer salinity are about 0.005 psu, the same level as the spatial variability described in Fig. 14.

## DATA INTERCALIBRATION

The intercalibration was accomplished on two bases: comparison of results from common stations, and the use of bottle samples to measure salinity. The two intercomparisons are described below here.

**Intercalibration stations**: The HYDROBLACK 91 cruise plan (Appendix II) laid out a series of intercalibration stations for the cruise (Figure 18), at which at least two ships would acquire measurements to the full water depth or to 2000 db, whichever was less. The two ships were to occupy these stations as synoptically as possible, but rough weather, poor communications at times, and instrument difficulties prevented some simultaneous measurements. On one occasion however, two ships (Akademik and Parshin) met for a simultaneous cast, even sharing a meal!

The goal of the intercalibration station was to provide in situ measurements of instrument performance, so the data could be compared and, if necessary, shifted for grouped analysis. The intercalibration was performed on temperature and conductivity, with comparisons made for salinity. Two intercalibration stations are presented for illustration. Station N30N45 (see Table 3 for a listing of station identification, analysis code, time and date of sampling, water depth, etc.) was occupied by the Akademik, Bilim, and Kolesnikov (Figure 19), and illustrates come of the difficulties in the sampling. The Bilim salinities are below those of the other two CTD's, except in deepest water where the Kolesnikov salinity intercepted the Bilim salinity. The Kolesnikov salinity also is noisy. The Akademik data are uniformly above the Bilim salinities, and are much less noisy except for the cable noise described above. For comparison, this station can be compared with Knorr data added (Figure 20), comparing now at greater depths (deeper than 1400 db). Here, two Knorr stations (one in the east and one in the west), superimpose close to the Bilim data. The Kolesnikov suffers apparently from a depth dependency (discussed later), and the Akademik salinities are uniformly high.

**Spike removal and filtering**: Analysis of the data indicate that some filtering and spike removal was required. For all stations, filtering and spike removal was limited to levels greater than 500 db, to avoid filtering in the region of greatest gradients where such filtering could alter the structure of the profiles. Also, the filtering required is much less than the dynamic signature within these shallower regions, so filtering was not performed shallower than this level.

The filter used in all analyses was a tenth order Butterworth filter with a cutoff at 0.05 per meter. This filter was selected because of its lack of stopband and passband ripple. Although other filters could have been used, these one gave good performance without altering the shape of the profiles. In order to avoid phase shifts, the filtering was performed both forwards and backwards. However, this procedure gave unacceptable loss of data near the greater depths where the intercalibration occurred. To avoid this, the filter was run only in a forwards direction, and then shifted linearly to account for the filter loss at the end (40 db of data lost). Although the phase error is not linear with frequency for this filter, the narrow frequencies left in the data could be represented accurately by a simple frequency-independent shift. This was verified by repeated analysis both one way and forwards-and-backwards, and comparing the differences. The filter is described, for instance, in Oppenheim and Schafer (1975).

Only conductivity and temperature were filtered. Both were filtered with identical filters. The specific signal conditioning applied to each data set is described below.

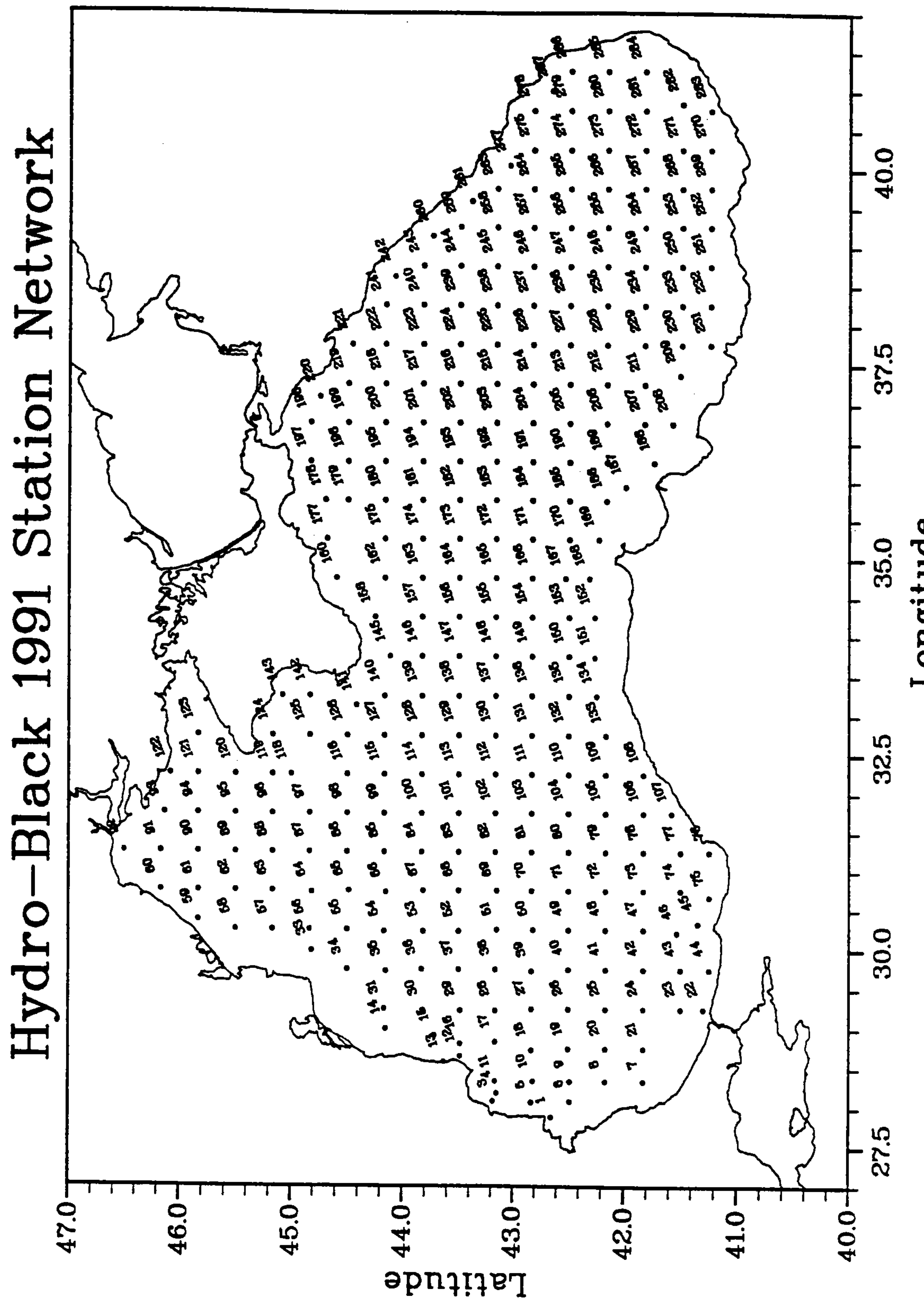


Figure 18: Station numbers and locations for HYDROBLACK '91 hydrographic casts.

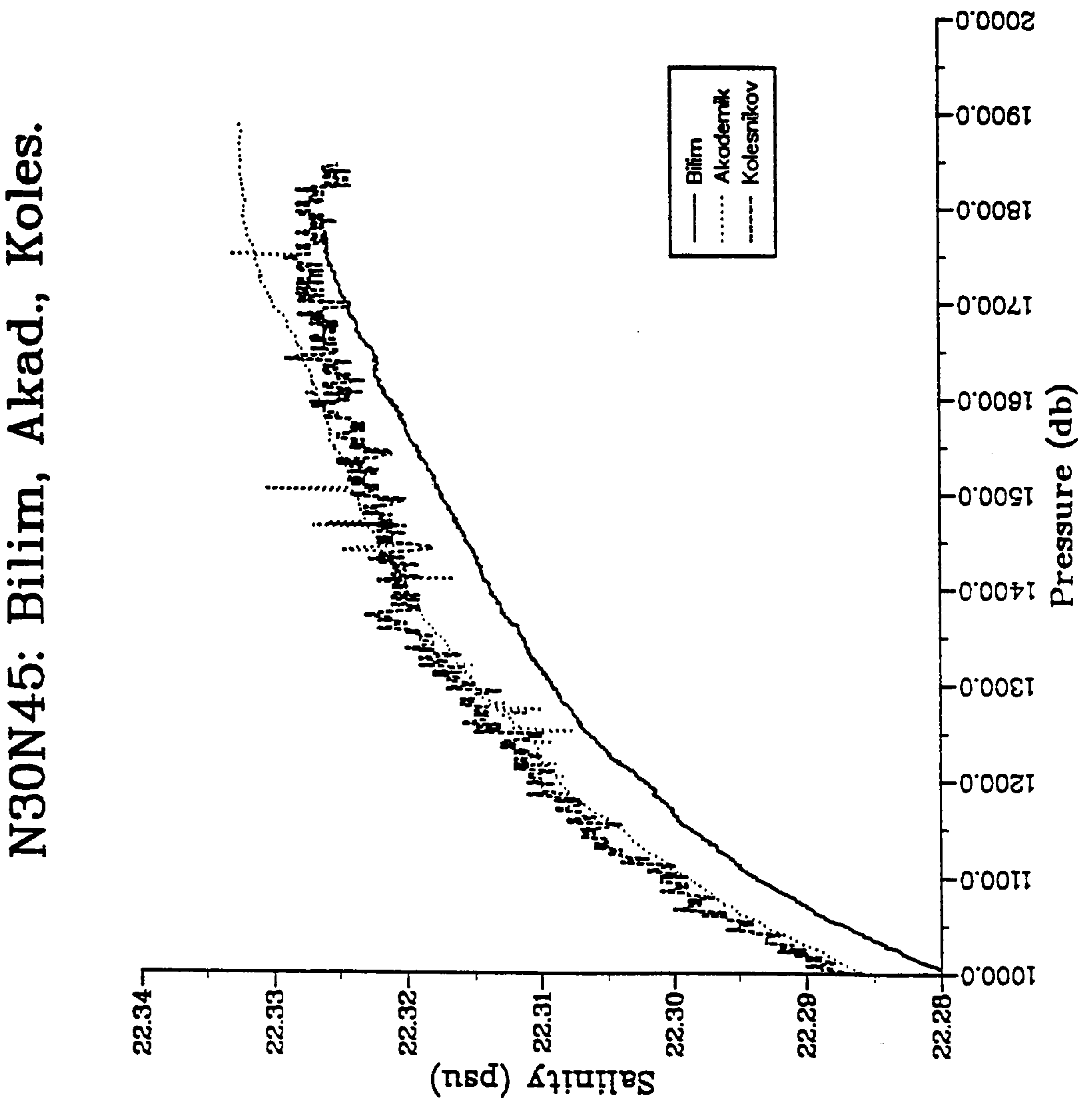


Figure 19: Comparison of non-intercalibrated salinity measurements at Station N30N45 for the Bilim, Akademik, and Kolesnikov. The overcorrection of the Kolesnikov data is depicted in the straightening of the salinity signal with depth, and crossing of the other two CTD's.

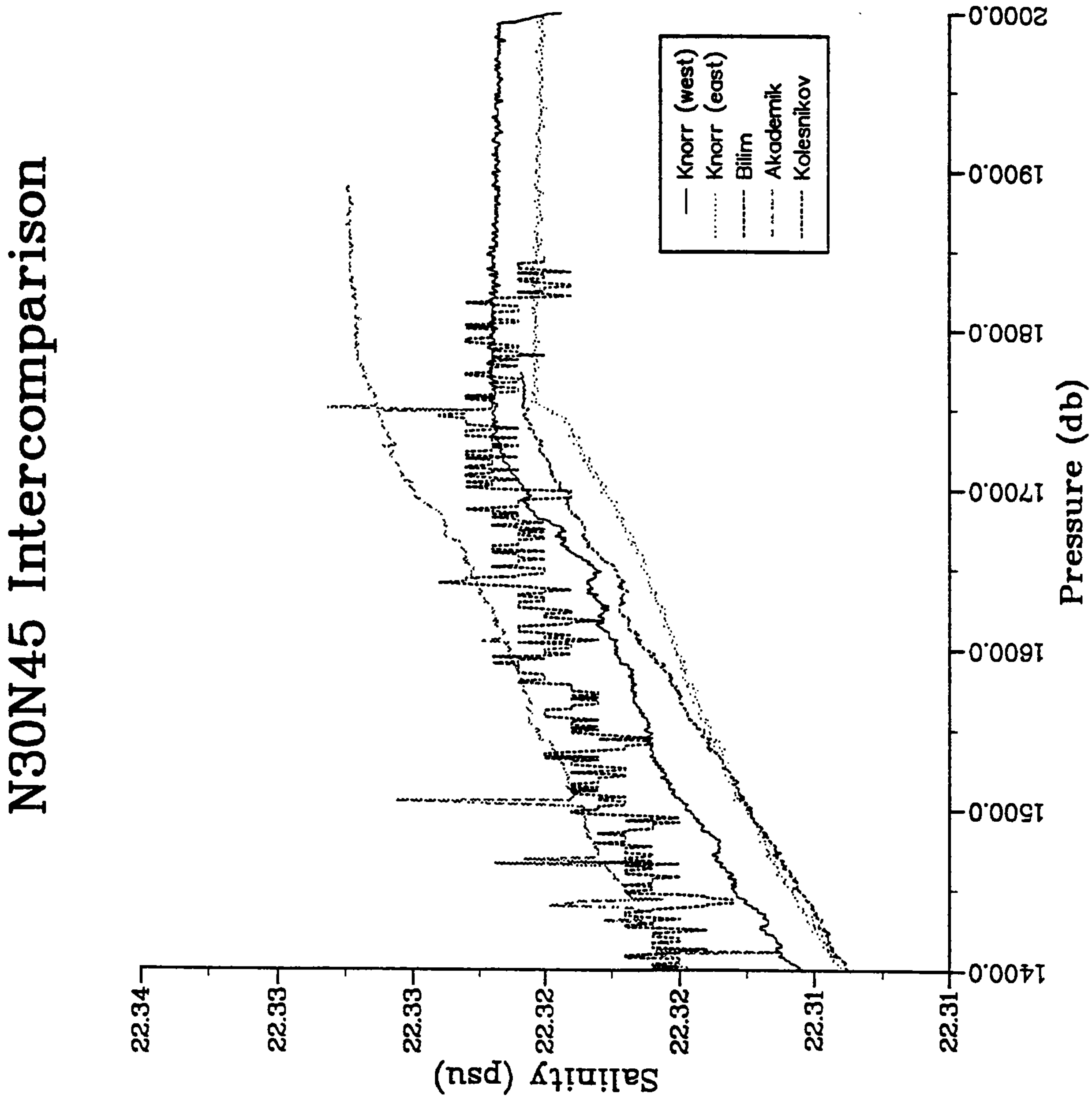


Figure 20: Same data as for Fig. 19, except for a more limited depth range (1400 to 2000 db), and adding the Knorr data. The Bilim data are the closest to the Knorr results; the Akademik CTD data are offset by about 0.01 psu higher compared to the Knorr and Bilim data.

TABLE 3

STATION CODES AND LOCATIONS

**HYDROBLACK 1991 BLACK SEA CRUISE**

**R/V BILIM STATIONS**

| station | code | lat | long | depth (m) | date | time (GMT) |
|---|---|---|---|---|---|---|
| L50L45 | 42 | 41 50 00 | 29 45 00 | 2000 | 09-05-1991 | 14 10 |
| M10M15 | 48 | 42 10 00 | 30 15 00 | 2000 | 09-05-1991 | 19 35 |
| M50M45 | 70b | 42 50 00 | 30 45 00 | 2100 | 09-06-1991 | 02 20 |
| N10N15 | 82b | 43 10 00 | 31 15 00 | 1800 | 09-06-1991 | 06 05 |
| N30N45 | 101b | 43 30 00 | 31 45 00 | 1925 | 09-06-1991 | 10 50 |
| N10P45 | 130 | 43 10 00 | 32 45 00 | 2180 | 09-06-1991 | 16 20 |
| N10Q15 | 137 | 43 10 00 | 33 15 00 | 2100 | 09-06-1991 | 21 45 |
| M16Q44 | 151 | 42 16 00 | 33 44 00 | 0900 | 09-07-1991 | 17 50 |
| M15Q15 | 134 | 42 15 00 | 33 15 00 | 1900 | 09-07-1991 | 21 25 |
| M30Q15 | 135 | 42 30 00 | 33 15 00 | 2100 | 09-07-1991 | 23 55 |
| M50Q15 | 136 | 42 50 00 | 33 15 00 | 2100 | 09-08-1991 | 03 30 |
| N10Q45 | 148b | 43 10 00 | 33 45 00 | 2100 | 09-08-1991 | 07 30 |
| M50Q45 | 149 | 42 50 00 | 33 45 00 | 2100 | 09-08-1991 | 11 00 |
| M30Q45 | 150 | 42 30 00 | 33 45 00 | 2000 | 09-08-1991 | 14 10 |
| M30R15 | 153 | 42 30 00 | 34 15 00 | 2100 | 09-08-1991 | 17 30 |
| M16R15 | 152 | 42 16 00 | 34 15 00 | 0450 | 09-08-1991 | 20 10 |
| M19R45 | 168 | 42 19 00 | 34 45 00 | 1200 | 09-08-1991 | 23 00 |
| M14S15 | 169 | 42 14 00 | 35 15 00 | 2000 | 09-09-1991 | 11 00 |
| M30S15 | 170 | 42 30 00 | 35 15 00 | 2000 | 09-09-1991 | 14 20 |
| M32R45 | 167 | 42 32 00 | 34 45 00 | 2000 | 09-09-1991 | 17 40 |
| M50R45 | 166 | 42 50 00 | 34 45 00 | 2100 | 09-09-1991 | 21 30 |
| M50R15 | 154 | 42 50 00 | 34 15 00 | 2100 | 09-10-1991 | 01 20 |
| N10R15 | 155b | 43 10 00 | 34 15 00 | 2100 | 09-10-1991 | 04 35 |
| N10R45 | 165 | 43 10 00 | 34 45 00 | 2100 | 09-10-1991 | 09 30 |
| N10S15 | 172 | 43 10 00 | 35 15 00 | 2100 | 09-10-1991 | 14 05 |
| N10S45 | 183 | 43 10 00 | 35 45 00 | 2100 | 09-10-1991 | 17 35 |
| N10T15 | 192 | 43 10 00 | 36 15 00 | 2100 | 09-10-1991 | 22 30 |
| N10T45 | 203 | 43 10 00 | 36 45 00 | 2100 | 09-11-1991 | 01 55 |
| M50T45 | 204 | 42 50 00 | 36 45 00 | 2100 | 09-11-1991 | 05 30 |
| M50T15 | 191 | 42 50 00 | 36 15 00 | 2100 | 09-11-1991 | 10 05 |
| M50S45 | 184 | 42 50 00 | 35 45 00 | 2100 | 09-11-1991 | 13 40 |
| M50S15 | 171 | 42 50 00 | 35 15 00 | 2100 | 09-11-1991 | 16 50 |
| M30S45 | 185 | 42 30 00 | 35 15 00 | 2100 | 09-11-1991 | 22 00 |
| M10S45 | 186 | 42 10 00 | 35 45 00 | 1765 | 09-12-1991 | 01 30 |
| M00S56 | 187 | 42 00 00 | 35 56 00 | 1420 | 09-12-1991 | 04 05 |
| M10T15 | 189 | 42 10 00 | 36 15 00 | 1400 | 09-12-1991 | 06 45 |
| M30T15 | 190 | 42 30 00 | 36 15 00 | 2080 | 09-12-1991 | 09 50 |
| M30T45 | 205 | 42 30 00 | 36 45 00 | 2090 | 09-12-1991 | 14 10 |
| M30V15 | 213 | 42 30 00 | 37 15 00 | 2100 | 09-12-1991 | 17 50 |
| M50V15 | 214 | 42 50 00 | 37 15 00 | 2100 | 09-12-1991 | 21 15 |
| M50V45 | 226b | 42 50 00 | 37 45 00 | 2100 | 09-13-1991 | 00 45 |
| M30W15 | 236 | 42 30 00 | 38 15 00 | 2100 | 09-13-1991 | 06 30 |
| M30V45 | 227 | 42 30 00 | 37 45 00 | 2100 | 09-13-1991 | 09 45 |
| M10V45 | 228 | 42 10 00 | 37 45 00 | 2100 | 09-13-1991 | 13 10 |
| M10V15 | 212 | 42 10 00 | 37 45 00 | 2000 | 09-13-1991 | 16 30 |
| M10T45 | 206 | 42 10 00 | 36 45 00 | 1800 | 09-13-1991 | 21 00 |
| L50T45 | 207 | 41 50 00 | 36 45 00 | 0560 | 09-13-1991 | 23 45 |
| L50V15 | 211 | 41 50 00 | 37 15 00 | 1930 | 09-14-1991 | 02 30 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L50V45 | 229 | 41 | 50 | 00 | 37 | 45 | 00 | 1900 | 09-14-1991 | 06 | 05 |
| L30V45 | 230 | 41 | 30 | 00 | 37 | 45 | 00 | 1850 | 09-14-1991 | 09 | 50 |
| L30W15 | 233 | 41 | 30 | 00 | 38 | 15 | 00 | 1960 | 09-14-1991 | 13 | 45 |
| L50W15 | 234 | 41 | 50 | 00 | 38 | 20 | 00 | 2000 | 09-14-1991 | 17 | 35 |
| M10W15 | 235 | 42 | 10 | 00 | 38 | 15 | 00 | 2100 | 09-14-1991 | 20 | 35 |
| M10W45 | 248 | 42 | 10 | 00 | 38 | 45 | 00 | 2100 | 09-14-1991 | 23 | 50 |
| L50W45 | 249 | 41 | 50 | 00 | 38 | 45 | 00 | 2050 | 09-15-1991 | 03 | 35 |
| L30W45 | 250 | 41 | 30 | 00 | 38 | 45 | 00 | 1950 | 09-15-1991 | 06 | 20 |
| L30X15 | 253 | 41 | 30 | 00 | 39 | 15 | 00 | 2000 | 09-15-1991 | 10 | 00 |
| L50X15 | 254 | 41 | 50 | 00 | 39 | 15 | 00 | 2020 | 09-15-1991 | 13 | 05 |
| M10X15 | 255 | 42 | 10 | 00 | 39 | 15 | 00 | 2050 | 09-15-1991 | 16 | 45 |
| M10X45 | 266b | 42 | 10 | 00 | 39 | 45 | 00 | 2050 | 09-15-1991 | 19 | 50 |
| L50X45 | 267 | 41 | 50 | 00 | 39 | 45 | 00 | 1960 | 09-16-1991 | 00 | 15 |
| L30X45 | 268 | 41 | 30 | 00 | 39 | 45 | 00 | 1950 | 09-16-1991 | 03 | 10 |
| L30Y15 | 271 | 41 | 30 | 00 | 40 | 15 | 00 | 1770 | 09-16-1991 | 07 | 50 |
| L50Y15 | 272 | 41 | 50 | 00 | 40 | 15 | 00 | 1850 | 09-16-1991 | 11 | 30 |
| L50Y45 | 281 | 41 | 50 | 00 | 40 | 15 | 00 | 1650 | 09-16-1991 | 15 | 50 |
| L30Y50 | 282 | 41 | 30 | 00 | 40 | 50 | 00 | 1660 | 09-16-1991 | 18 | 35 |
| L15Y45 | 283 | 41 | 15 | 00 | 40 | 45 | 00 | 1380 | 09-16-1991 | 22 | 15 |
| L15Y15 | 270 | 41 | 15 | 00 | 40 | 15 | 00 | 1630 | 09-17-1991 | 01 | 25 |
| L15X45 | 269 | 41 | 15 | 00 | 39 | 45 | 00 | 1780 | 09-17-1991 | 05 | 35 |
| L15X15 | 252 | 41 | 15 | 00 | 39 | 15 | 00 | 1460 | 09-17-1991 | 08 | 40 |
| L15W45 | 251 | 41 | 15 | 00 | 38 | 45 | 00 | 1660 | 09-17-1991 | 12 | 20 |
| L15W15 | 232 | 41 | 15 | 00 | 38 | 15 | 00 | 1460 | 09-17-1991 | 15 | 40 |
| L15V45 | 231 | 41 | 15 | 00 | 37 | 45 | 00 | 1470 | 09-17-1991 | 18 | 50 |
| L31V22 | 209 | 41 | 31 | 00 | 37 | 22 | 00 | 1580 | 09-17-1991 | 21 | 05 |
| L35T45 | 208 | 41 | 35 | 00 | 36 | 45 | 00 | 0500 | 09-18-1991 | 02 | 45 |
| L45T15 | 188 | 41 | 45 | 00 | 36 | 15 | 00 | 0920 | 09-18-1991 | 05 | 40 |
| M10P45 | 133 | 42 | 10 | 00 | 32 | 45 | 00 | 2100 | 09-19-1991 | 10 | 00 |
| M30P45 | 132 | 42 | 30 | 00 | 32 | 45 | 00 | 2100 | 09-19-1991 | 13 | 00 |
| M50P45 | 131 | 42 | 50 | 00 | 32 | 45 | 00 | 2100 | 09-19-1991 | 16 | 00 |
| M50P15 | 111 | 42 | 50 | 00 | 32 | 15 | 00 | 2100 | 09-19-1991 | 19 | 30 |
| N10P15 | 112 | 43 | 10 | 00 | 32 | 15 | 00 | 2100 | 09-19-1991 | 22 | 20 |
| N10N45 | 102 | 43 | 10 | 00 | 31 | 45 | 00 | 2100 | 09-20-1991 | 01 | 40 |
| M50N45 | 103 | 42 | 50 | 00 | 31 | 45 | 00 | 2100 | 09-20-1991 | 04 | 30 |
| M30N45 | 104 | 42 | 30 | 00 | 31 | 45 | 00 | 2100 | 09-20-1991 | 08 | 20 |
| M30P15 | 110 | 42 | 30 | 00 | 32 | 15 | 00 | 2100 | 09-20-1991 | 11 | 45 |
| M10P15 | 109 | 42 | 10 | 00 | 32 | 15 | 00 | 2100 | 09-20-1991 | 14 | 40 |
| M10N45 | 105 | 42 | 10 | 00 | 31 | 45 | 00 | 2100 | 09-20-1991 | 18 | 50 |
| L50N45 | 106 | 41 | 50 | 00 | 31 | 45 | 00 | 1630 | 09-20-1991 | 21 | 40 |
| L50N15 | 78 | 41 | 50 | 00 | 31 | 15 | 00 | 2030 | 09-21-1991 | 01 | 25 |
| M10N15 | 79 | 42 | 10 | 00 | 31 | 15 | 00 | 2100 | 09-21-1991 | 05 | 10 |
| M30N15 | 80 | 42 | 30 | 00 | 31 | 15 | 00 | 2100 | 09-21-1991 | 08 | 35 |
| M30M45 | 71 | 42 | 30 | 00 | 30 | 45 | 00 | 2100 | 09-21-1991 | 12 | 30 |
| M10M45 | 72 | 42 | 10 | 00 | 30 | 45 | 00 | 2100 | 09-21-1991 | 15 | 50 |
| L50M45 | 73 | 41 | 50 | 00 | 30 | 45 | 00 | 1900 | 09-21-1991 | 19 | 35 |
| L30N15 | 77 | 41 | 30 | 00 | 31 | 15 | 00 | 1450 | 09-21-1991 | 23 | 45 |
| L30M45 | 74 | 41 | 30 | 00 | 30 | 45 | 00 | 1400 | 09-22-1991 | 03 | 15 |
| L15M40 | 75 | 41 | 15 | 00 | 30 | 40 | 00 | 1100 | 09-22-1991 | 05 | 30 |
| L21M20 | 45 | 41 | 21 | 00 | 30 | 20 | 00 | 0100 | 09-22-1991 | 08 | 10 |
| L32M13 | 46 | 41 | 32 | 00 | 30 | 13 | 00 | 1000 | 09-22-1991 | 09 | 30 |
| L50M15 | 47 | 41 | 50 | 00 | 30 | 15 | 00 | 1980 | 09-22-1991 | 12 | 10 |
| M10L45 | 41 | 42 | 10 | 00 | 29 | 45 | 00 | 2150 | 09-22-1991 | 17 | 25 |
| L50L45 | 42 | 41 | 50 | 00 | 29 | 45 | 00 | 2000 | 09-22-1991 | 20 | 55 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L30L45 | 43 | 41 | 30 | 00 | 29 | 45 | 00 | 1500 | 09-23-1991 | 00 50 |
| L25L30 | 44 | 41 | 25 | 00 | 29 | 30 | 00 | 0600 | 09-23-1991 | 03 00 |

## R/V K. PIRI REIS STATIONS

| station | code | lat | | | long | | | depth | date | time |
|---|---|---|---|---|---|---|---|---|---|---|
| L18L15 | 22 | 41 | 18 | 00 | 29 | 15 | 00 | 0080 | 09-07-1991 | 10 10 |
| L30L15 | 23 | 41 | 30 | 00 | 29 | 15 | 00 | 0365 | 09-07-1991 | 14 00 |
| L50K20 | 7 | 41 | 50 | 00 | 28 | 20 | 00 | 0070 | 09-07-1991 | 17 00 |
| M10K20 | 8r | 42 | 10 | 00 | 28 | 20 | 00 | 0100 | 09-07-1991 | 21 00 |
| M10K45 | 20 | 42 | 10 | 00 | 28 | 45 | 00 | 0600 | 09-07-1991 | 23 30 |
| L50K45 | 21 | 41 | 50 | 00 | 28 | 45 | 00 | 0400 | 09-08-1991 | 02 30 |
| L50L15 | 24 | 41 | 50 | 00 | 29 | 15 | 00 | 1748 | 09-12-1991 | 14 15 |
| M10L15 | 25 | 42 | 10 | 00 | 29 | 15 | 00 | 1924 | 09-12-1991 | 19 15 |
| M30L15 | 26r | 42 | 30 | 00 | 29 | 15 | 00 | 1976 | 09-12-1991 | 23 55 |
| M30L45 | 40r | 42 | 30 | 00 | 29 | 45 | 00 | 2106 | 09-13-1991 | 05 15 |
| M30M15 | 49 | 42 | 30 | 00 | 30 | 15 | 00 | 2109 | 09-13-1991 | 11 15 |
| M50M15 | 50r | 42 | 50 | 00 | 30 | 15 | 00 | 2097 | 09-13-1991 | 14 45 |
| M50N15 | 81 | 42 | 50 | 00 | 31 | 15 | 00 | 2094 | 09-13-1991 | 23 35 |
| L15N15 | 76 | 41 | 15 | 00 | 31 | 15 | 00 | 0088 | 09-15-1991 | 11 45 |
| L35N45 | 107 | 41 | 35 | 00 | 31 | 45 | 00 | 2000 | 09-16-1991 | 09 20 |
| L50P15 | 108 | 41 | 50 | 00 | 32 | 15 | 00 | 2000 | 09-17-1991 | 13 35 |

## R/V KOLESNIKOV STATIONS

| station | code | lat | | | long | | | depth | date | time |
|---|---|---|---|---|---|---|---|---|---|---|
| M50V45 | 226k | 42 | 50 | 00 | 37 | 45 | 00 | 2150 | 09-09-1991 | 15 30 |
| M50W15 | 237 | 42 | 50 | 00 | 38 | 15 | 00 | 2135 | 09-09-1991 | 19 15 |
| M50W45 | 246 | 42 | 50 | 00 | 38 | 45 | 00 | 2110 | 09-09-1991 | 22 15 |
| M30W45 | 247 | 42 | 30 | 00 | 38 | 45 | 00 | 2100 | 09-10-1991 | 02 00 |
| M30X15 | 256 | 42 | 30 | 00 | 39 | 15 | 00 | 2050 | 09-10-1991 | 05 40 |
| M30X45 | 265 | 42 | 30 | 00 | 39 | 45 | 00 | 1950 | 09-10-1991 | 08 55 |
| M10X45 | 266k | 42 | 10 | 00 | 39 | 45 | 00 | 1970 | 09-10-1991 | 12 30 |
| M10Y15 | 273 | 42 | 10 | 00 | 40 | 15 | 00 | 1870 | 09-10-1991 | 15 40 |
| M10Y45 | 280 | 42 | 10 | 00 | 40 | 45 | 00 | 1565 | 09-10-1991 | 18 35 |
| L50Z15 | 284 | 41 | 50 | 00 | 41 | 15 | 00 | 1180 | 09-10-1991 | 22 55 |
| M10Z15 | 285 | 42 | 10 | 00 | 41 | 15 | 00 | 1185 | 09-11-1991 | 01 40 |
| M30Z15 | 286 | 42 | 30 | 00 | 41 | 15 | 00 | 0700 | 09-11-1991 | 04 40 |
| M40Z00 | 287 | 42 | 40 | 00 | 41 | 00 | 00 | 1275 | 09-11-1991 | 07 10 |
| M30Y45 | 279 | 42 | 30 | 00 | 40 | 45 | 00 | 1600 | 09-11-1991 | 09 25 |
| M30Y15 | 274 | 42 | 30 | 00 | 40 | 15 | 00 | 1590 | 09-11-1991 | 13 05 |
| M50Y45 | 278 | 42 | 50 | 00 | 40 | 45 | 00 | 1040 | 09-11-1991 | 18 00 |
| M50Y15 | 275 | 42 | 50 | 00 | 40 | 15 | 00 | 0995 | 09-11-1991 | 20 45 |
| N03Y03 | 277 | 43 | 03 | 00 | 40 | 03 | 00 | 1400 | 09-11-1991 | 23 05 |
| N10X45 | 263 | 43 | 10 | 00 | 39 | 45 | 00 | 1530 | 09-12-1991 | 01 20 |
| M50X45 | 264 | 42 | 50 | 00 | 39 | 45 | 00 | 1880 | 09-12-1991 | 05 25 |
| M50X15 | 257 | 42 | 50 | 00 | 39 | 15 | 00 | 2000 | 09-12-1991 | 09 10 |
| N10X15 | 258 | 43 | 10 | 00 | 39 | 15 | 00 | 1900 | 09-12-1991 | 11 45 |
| N24X35 | 261 | 43 | 24 | 00 | 39 | 35 | 00 | 1370 | 09-12-1991 | 15 25 |
| N30X15 | 259 | 43 | 30 | 00 | 39 | 15 | 00 | 1840 | 09-12-1991 | 18 50 |
| N45X08 | 260 | 43 | 45 | 00 | 39 | 08 | 00 | 1050 | 09-12-1991 | 21 00 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N30W45 | 244 | 43 | 30 | 00 | 38 | 45 | 00 | 2120 | 09-13-1991 | 00 | 20 |
| N50W45 | 243 | 43 | 50 | 00 | 38 | 45 | 00 | 1740 | 09-13-1991 | 03 | 30 |
| P05W37 | 242 | 44 | 05 | 00 | 38 | 37 | 00 | 1225 | 09-13-1991 | 06 | 00 |
| P10W15 | 241 | 44 | 10 | 00 | 38 | 15 | 00 | 1790 | 09-13-1991 | 09 | 10 |
| N50W15 | 240 | 43 | 50 | 00 | 38 | 15 | 00 | 2130 | 09-13-1991 | 12 | 25 |
| N30W15 | 239 | 43 | 30 | 00 | 38 | 15 | 00 | 2144 | 09-13-1991 | 16 | 10 |
| N10W45 | 245 | 43 | 10 | 00 | 38 | 45 | 00 | 2120 | 09-13-1991 | 21 | 25 |
| N10W15 | 238 | 43 | 10 | 00 | 38 | 15 | 00 | 2140 | 09-14-1991 | 00 | 10 |
| N30V45 | 224 | 43 | 30 | 00 | 37 | 45 | 00 | 2150 | 09-14-1991 | 04 | 30 |
| N10V45 | 225 | 43 | 10 | 00 | 37 | 45 | 00 | 2160 | 09-14-1991 | 07 | 35 |
| N10V15 | 215 | 43 | 10 | 00 | 37 | 15 | 00 | 2170 | 09-14-1991 | 11 | 15 |
| N30V15 | 216 | 43 | 30 | 00 | 37 | 15 | 00 | 2165 | 09-14-1991 | 15 | 00 |
| N50V45 | 223 | 43 | 50 | 00 | 37 | 45 | 00 | 2140 | 09-14-1991 | 18 | 30 |
| N50V15 | 217 | 43 | 50 | 00 | 37 | 15 | 00 | 2130 | 09-14-1991 | 22 | 00 |
| N50T45 | 201 | 43 | 50 | 00 | 36 | 45 | 00 | 0214 | 09-15-1991 | 01 | 10 |
| N30T45 | 202 | 43 | 30 | 00 | 36 | 45 | 00 | 2175 | 09-15-1991 | 04 | 35 |
| N30T15 | 193 | 43 | 30 | 00 | 36 | 15 | 00 | 2000 | 09-15-1991 | 08 | 50 |
| N50T15 | 194 | 43 | 50 | 00 | 36 | 15 | 00 | 2000 | 09-15-1991 | 12 | 30 |
| P10T45 | 200 | 44 | 10 | 00 | 36 | 45 | 00 | 1965 | 09-15-1991 | 19 | 25 |
| P10V15 | 218 | 44 | 10 | 00 | 37 | 15 | 00 | 2000 | 09-15-1991 | 23 | 40 |
| P10V45 | 222 | 44 | 10 | 00 | 37 | 45 | 00 | 0920 | 09-16-1991 | 03 | 40 |
| P28V45 | 221 | 44 | 28 | 00 | 37 | 45 | 00 | 1780 | 09-16-1991 | 06 | 50 |
| P30V15 | 219 | 44 | 30 | 00 | 37 | 15 | 00 | 1150 | 09-16-1991 | 09 | 45 |
| P45V05 | 220 | 44 | 45 | 00 | 37 | 05 | 00 | 0810 | 09-16-1991 | 12 | 50 |
| P50T45 | 198 | 44 | 50 | 00 | 36 | 45 | 00 | 0062 | 09-16-1991 | 14 | 45 |
| P30T45 | 199 | 44 | 30 | 00 | 36 | 45 | 00 | 0990 | 09-16-1991 | 18 | 05 |
| P10T15 | 195 | 44 | 10 | 00 | 36 | 15 | 00 | 1700 | 09-16-1991 | 21 | 50 |
| P30T15 | 196 | 44 | 30 | 00 | 36 | 15 | 00 | 0750 | 09-17-1991 | 01 | 15 |
| P50T15 | 197 | 44 | 50 | 00 | 36 | 15 | 00 | 0080 | 09-17-1991 | 04 | 05 |
| P42S45 | 178 | 44 | 42 | 00 | 35 | 45 | 00 | 0600 | 09-17-1991 | 06 | 55 |
| P30S45 | 179 | 44 | 30 | 00 | 35 | 45 | 00 | 1300 | 09-17-1991 | 09 | 20 |
| P10S45 | 180 | 44 | 10 | 00 | 35 | 45 | 00 | 1890 | 09-17-1991 | 12 | 45 |
| N50S45 | 181 | 43 | 50 | 00 | 35 | 45 | 00 | 2100 | 09-17-1991 | 15 | 15 |
| N30S45 | 182 | 43 | 30 | 00 | 35 | 45 | 00 | 2200 | 09-17-1991 | 19 | 00 |
| N30S15 | 173 | 43 | 30 | 00 | 35 | 15 | 00 | 2200 | 09-17-1991 | 22 | 25 |
| N50S15 | 174 | 43 | 50 | 00 | 35 | 15 | 00 | 2200 | 09-18-1991 | 01 | 30 |
| P10S15 | 175 | 44 | 10 | 00 | 35 | 15 | 00 | 2100 | 09-18-1991 | 04 | 10 |
| P41S15 | 177 | 44 | 41 | 00 | 35 | 15 | 00 | 0730 | 09-18-1991 | 09 | 05 |
| P36R45 | 160 | 44 | 36 | 00 | 34 | 45 | 00 | 1360 | 09-18-1991 | 12 | 00 |
| P10R45 | 162 | 44 | 10 | 00 | 34 | 45 | 00 | 2160 | 09-18-1991 | 16 | 00 |
| P15R15 | 158 | 44 | 15 | 00 | 34 | 15 | 00 | 1270 | 09-18-1991 | 20 | 10 |
| N50R15 | 157 | 43 | 50 | 00 | 34 | 15 | 00 | 2140 | 09-19-1991 | 00 | 05 |
| N50R45 | 164 | 43 | 50 | 00 | 34 | 45 | 00 | 2205 | 09-19-1991 | 03 | 10 |
| N30R45 | 163 | 43 | 30 | 00 | 34 | 45 | 00 | 2210 | 09-19-1991 | 06 | 20 |
| N10R15 | 155k | 43 | 10 | 00 | 34 | 15 | 00 | 2215 | 09-19-1991 | 10 | 35 |
| N10Q45 | 148k | 43 | 10 | 00 | 33 | 45 | 00 | 2220 | 09-19-1991 | 13 | 55 |
| N30R15 | 156 | 43 | 30 | 00 | 34 | 15 | 00 | 2220 | 09-19-1991 | 18 | 00 |
| N30Q45 | 147 | 43 | 30 | 00 | 33 | 45 | 00 | 2190 | 09-19-1991 | 21 | 30 |
| N50Q45 | 146 | 43 | 50 | 00 | 33 | 45 | 00 | 2100 | 09-20-1991 | 00 | 30 |
| N50Q15 | 139 | 43 | 50 | 00 | 33 | 15 | 00 | 2000 | 09-20-1991 | 04 | 00 |
| P10Q15 | 140 | 44 | 10 | 00 | 33 | 15 | 00 | 1890 | 09-20-1991 | 07 | 00 |
| P25Q08 | 141 | 44 | 25 | 00 | 33 | 08 | 00 | 0670 | 09-20-1991 | 10 | 00 |
| P07Q45 | 145 | 44 | 07 | 00 | 33 | 45 | 00 | 0955 | 09-20-1991 | 17 | 40 |
| N30Q15 | 138 | 43 | 30 | 00 | 33 | 15 | 00 | 2180 | 09-20-1991 | 21 | 25 |

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|---|---|---|---|---|---|---|
| N30P45 | 129 | 43 30 00 | 32 45 00 | 2130 | 09-21-1991 | 04 00 |
| N50P45 | 128 | 43 50 00 | 32 45 00 | 1925 | 09-21-1991 | 07 40 |
| N50P15 | 114 | 43 50 00 | 32 15 00 | 1800 | 09-21-1991 | 11 15 |
| N30P15 | 113 | 43 30 00 | 32 15 00 | 2000 | 09-21-1991 | 14 30 |
| N30N45 | 101k | 43 30 00 | 31 45 00 | 1915 | 09-21-1991 | 18 00 |
| N50N45 | 100k | 43 50 00 | 31 45 00 | 1635 | 09-21-1991 | 20 40 |
| N50N15 | 84k | 43 50 00 | 31 15 00 | 1660 | 09-21-1991 | 23 45 |
| N30N15 | 83k | 43 30 00 | 31 15 00 | 1615 | 09-22-1991 | 03 10 |
| P30P45 | 126k | 44 30 00 | 32 45 00 | 1500 | 09-28-1991 | 21 30 |
| P10P45 | 127 | 44 10 00 | 32 45 00 | 1750 | 09-29-1991 | 01 00 |
| P10P15 | 115 | 44 10 00 | 32 15 00 | 1595 | 09-29-1991 | 03 40 |
| P30P15 | 116k | 44 30 00 | 32 15 00 | 1415 | 09-29-1991 | 07 00 |
| P30N45 | 98k | 44 30 00 | 31 45 00 | 1190 | 09-29-1991 | 10 00 |
| P10N45 | 99k | 44 10 00 | 31 45 00 | 1200 | 09-29-1991 | 13 15 |
| P10N15 | 85k | 44 10 00 | 31 15 00 | 0750 | 09-29-1991 | 16 40 |

## R/V AKADEMIK STATIONS

| station | code | lat | long | depth | date | time |
|---|---|---|---|---|---|---|
| N10K05 | 3 | 43 45 00 | 28 05 00 | 0020 | 09-03-1991 | 13 00 |
| N10K20 | 11 | 43 10 00 | 28 20 00 | 0040 | 09-03-1991 | 16 26 |
| N10K50 | 17 | 43 10 00 | 28 50 00 | 0325 | 09-03-1991 | 21 10 |
| N10L15 | 28 | 43 10 00 | 29 15 00 | 1640 | 09-04-1991 | 02 12 |
| N10L45 | 38 | 43 10 00 | 29 45 00 | 1600 | 09-04-1991 | 06 45 |
| N10M15 | 51 | 43 10 00 | 30 15 00 | 1743 | 09-04-1991 | 10 50 |
| N10M45 | 69 | 43 10 00 | 30 45 00 | 1945 | 09-04-1991 | 15 05 |
| N10N15 | 82a | 43 10 00 | 31 15 00 | 1804 | 09-04-1991 | 19 05 |
| N30N45 | 101a | 43 30 00 | 31 45 00 | 1927 | 09-05-1991 | 01 55 |
| N30N15 | 83a | 43 30 00 | 31 15 00 | 1600 | 09-05-1991 | 06 30 |
| N30M45 | 68 | 43 30 00 | 30 45 00 | 1400 | 09-05-1991 | 11 30 |
| N30M15 | 52 | 43 30 00 | 30 15 00 | 1300 | 09-05-1991 | 15 50 |
| N30L45 | 37 | 43 30 00 | 29 45 00 | 0820 | 09-05-1991 | 20 50 |
| N30L15 | 29 | 43 30 00 | 29 15 00 | 0091 | 09-06-1991 | 02 00 |
| N30K50 | 16 | 43 30 00 | 28 50 00 | 0074 | 09-06-1991 | 06 10 |
| N30K40 | 12 | 43 30 00 | 28 40 00 | 0065 | 09-06-1991 | 10 50 |
| M50K20 | 10 | 42 50 00 | 28 20 00 | 0092 | 09-06-1991 | 19 00 |
| M40J50 | 1 | 42 40 00 | 27 50 00 | 0022 | 09-06-1991 | 22 03 |
| M30K05 | 6 | 42 30 00 | 28 05 00 | 0066 | 09-07-1991 | 01 15 |
| M50K05 | 5 | 42 50 00 | 28 05 00 | 0037 | 09-07-1991 | 05 35 |
| M10K20 | 8a | 42 10 00 | 28 20 00 | 0105 | 09-07-1991 | 11 30 |
| M30K20 | 9 | 42 30 00 | 28 20 00 | 0098 | 09-07-1991 | 15 45 |
| M30K45 | 19 | 42 30 00 | 28 45 00 | 1390 | 09-07-1990 | 18 50 |
| M50K45 | 18 | 42 50 00 | 28 45 00 | 1160 | 09-07-1990 | 23 45 |
| M50L15 | 27 | 42 50 00 | 29 15 00 | 2036 | 09-08-1991 | 03 20 |
| M30L15 | 26a | 42 30 00 | 29 15 00 | 2020 | 09-08-1991 | 06 50 |
| M30L45 | 40a | 42 30 00 | 29 45 00 | 2160 | 09-08-1991 | 12 00 |
| M50L45 | 39 | 42 50 00 | 29 45 00 | 2110 | 09-08-1991 | 15 10 |
| M50M15 | 50a | 42 50 00 | 30 15 00 | 2150 | 09-08-1991 | 20 35 |
| M50M45 | 70a | 42 50 00 | 30 45 00 | 2160 | 09-09-1991 | 00 15 |
| N50N15 | 84a | 43 50 00 | 31 15 00 | 1590 | 09-09-1991 | 09 35 |
| P10N15 | 85a | 44 10 00 | 31 15 00 | 0721 | 09-09-1991 | 16 15 |
| P30N15 | 86a | 44 30 00 | 31 15 00 | 0600 | 09-09-1991 | 22 10 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P50N15 | 87a | 44 | 50 | 00 | 31 | 15 | 00 | 0066 | 09-10-1991 | 02 | 45 |
| P50M45 | 64a | 44 | 50 | 00 | 30 | 45 | 00 | 0066 | 09-10-1991 | 05 | 30 |
| P30M45 | 65 | 44 | 30 | 00 | 30 | 45 | 00 | 0097 | 09-10-1991 | 07 | 50 |
| P10M45 | 66 | 44 | 10 | 00 | 30 | 45 | 00 | 0126 | 09-10-1991 | 11 | 30 |
| N50M45 | 67 | 43 | 50 | 00 | 30 | 45 | 00 | 1020 | 09-10-1991 | 14 | 50 |
| N50M15 | 53 | 43 | 50 | 00 | 30 | 15 | 00 | 0116 | 09-10-1991 | 18 | 45 |
| P10M15 | 54 | 44 | 10 | 00 | 30 | 15 | 00 | 0094 | 09-10-1991 | 20 | 00 |
| P30M15 | 55 | 44 | 30 | 00 | 30 | 15 | 00 | 0072 | 09-10-1991 | 22 | 45 |
| P50M15 | 56a | 44 | 50 | 00 | 30 | 15 | 00 | 0050 | 09-11-1991 | 03 | 15 |
| P50M00 | 33 | 44 | 50 | 00 | 30 | 00 | 00 | 0044 | 09-11-1991 | 05 | 25 |
| P30L45 | 34 | 44 | 30 | 00 | 29 | 45 | 00 | 0059 | 09-11-1991 | 07 | 50 |
| P10L00 | 14 | 44 | 10 | 00 | 29 | 00 | 00 | 0042 | 09-11-1991 | 13 | 00 |
| P10L15 | 31 | 44 | 10 | 00 | 29 | 15 | 00 | 0051 | 09-11-1991 | 15 | 35 |
| P10L45 | 35 | 44 | 10 | 00 | 29 | 45 | 00 | 0063 | 09-11-1991 | 19 | 00 |
| N50L45 | 36 | 43 | 50 | 00 | 29 | 45 | 00 | 0074 | 09-11-1991 | 21 | 50 |
| N50L15 | 30 | 43 | 50 | 00 | 29 | 15 | 00 | 0064 | 09-12-1991 | 00 | 05 |
| N40K55 | 15 | 43 | 40 | 00 | 28 | 55 | 00 | 0058 | 09-12-1991 | 03 | 35 |
| N39K36 | 13 | 43 | 39 | 00 | 28 | 36 | 00 | 0012 | 09-12-1991 | 06 | 25 |
| N10K12 | 4 | 43 | 10 | 00 | 28 | 12 | 00 | 0025 | 09-12-1991 | 13 | 30 |
| N10K02 | 2 | 43 | 10 | 00 | 28 | 02 | 00 | 0015 | 09-12-1991 | 15 | 05 |

## R/V PARSHIN STATIONS

| station | code | lat | | | long | | | depth | date | time | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R30N15 | 92 | 46 | 30 | 00 | 31 | 15 | 00 | 0008 | 09-08-1991 | 21 | 10 |
| R10M45 | 60 | 46 | 10 | 00 | 30 | 45 | 00 | 0020 | 09-08-1991 | 00 | 10 |
| Q50M22 | 59 | 45 | 50 | 00 | 30 | 22 | 00 | 0017 | 09-08-1991 | 03 | 20 |
| Q30M15 | 58 | 45 | 30 | 00 | 30 | 15 | 00 | 0025 | 09-08-1991 | 05 | 39 |
| Q10M15 | 57 | 45 | 10 | 00 | 30 | 15 | 00 | 0024 | 09-08-1991 | 07 | 50 |
| P50M15 | 56p | 44 | 50 | 00 | 30 | 15 | 00 | 0045 | 09-08-1991 | 10 | 15 |
| P50M15 | 64p | 44 | 50 | 00 | 30 | 15 | 00 | 0062 | 09-08-1991 | 12 | 45 |
| Q10M45 | 63 | 45 | 10 | 00 | 30 | 45 | 00 | 0040 | 09-08-1991 | 15 | 20 |
| Q30M45 | 62 | 45 | 30 | 00 | 30 | 45 | 00 | 0037 | 09-08-1991 | 17 | 40 |
| Q50M45 | 61 | 45 | 50 | 00 | 30 | 45 | 00 | 0016 | 09-08-1991 | 20 | 16 |
| R10N15 | 91 | 46 | 10 | 00 | 31 | 15 | 00 | 0024 | 09-08-1991 | 23 | 10 |
| Q50N15 | 90 | 45 | 50 | 00 | 31 | 15 | 00 | 0021 | 09-09-1991 | 01 | 10 |
| Q30N15 | 89 | 45 | 30 | 00 | 31 | 15 | 00 | 0041 | 09-09-1991 | 03 | 20 |
| Q10N15 | 88 | 45 | 10 | 00 | 31 | 15 | 00 | 0052 | 09-09-1991 | 05 | 40 |
| P50N15 | 87p | 44 | 50 | 00 | 31 | 14 | 00 | 0063 | 09-09-1991 | 07 | 45 |
| P30N15 | 86p | 44 | 30 | 00 | 31 | 15 | 00 | 0620 | 09-09-1991 | 10 | 10 |
| P10N15 | 85p | 44 | 10 | 00 | 31 | 15 | 00 | 0760 | 09-09-1991 | 18 | 00 |
| N50N15 | 84p | 43 | 50 | 00 | 31 | 15 | 00 | 1470 | 09-09-1991 | 22 | 10 |
| N30N15 | 83p | 43 | 30 | 00 | 31 | 15 | 00 | 1600 | 09-10-1991 | 02 | 40 |
| N30N45 | 101p | 43 | 30 | 00 | 31 | 45 | 00 | 1926 | 09-10-1991 | 08 | 35 |
| N52N40 | 100p | 43 | 52 | 00 | 31 | 40 | 00 | 1500 | 09-10-1991 | 15 | 00 |
| P12N44 | 99p | 44 | 12 | 00 | 31 | 44 | 00 | 1220 | 09-10-1991 | 22 | 00 |
| P30N45 | 98p | 44 | 30 | 00 | 31 | 45 | 00 | 1090 | 09-11-1991 | 02 | 55 |
| P49N44 | 97 | 44 | 49 | 00 | 31 | 44 | 00 | 0059 | 09-11-1991 | 06 | 45 |
| Q10N45 | 96 | 45 | 10 | 00 | 31 | 45 | 00 | 0051 | 09-11-1991 | 09 | 00 |
| Q30N45 | 95 | 45 | 30 | 00 | 31 | 45 | 00 | 0044 | 09-11-1991 | 11 | 15 |
| Q50N46 | 94 | 45 | 50 | 00 | 31 | 46 | 00 | 0027 | 09-11-1001 | 13 | 30 |
| R08N45 | 93 | 46 | 08 | 00 | 31 | 45 | 00 | 0009 | 09-11-1991 | 15 | 30 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R05P16 | 122 | 46 | 05 | 00 | 32 | 16 | 00 | 0008 | 09-11-1991 | 17 | 45 |
| Q50P45 | 123 | 45 | 50 | 00 | 32 | 45 | 00 | 0022 | 09-11-1991 | 20 | 15 |
| Q49P15 | 121 | 45 | 49 | 00 | 32 | 15 | 00 | 0026 | 09-11-1991 | 22 | 15 |
| Q30P15 | 120 | 45 | 30 | 00 | 32 | 15 | 00 | 0035 | 09-12-1991 | 00 | 19 |
| Q10P15 | 119 | 45 | 10 | 00 | 32 | 15 | 00 | 0048 | 09-12-1991 | 02 | 30 |
| Q00P16 | 118 | 44 | 00 | 00 | 32 | 16 | 00 | 0075 | 09-12-1991 | 03 | 50 |
| P30P15 | 116p | 44 | 30 | 00 | 32 | 15 | 00 | 1380 | 09-12-1991 | 06 | 45 |
| P31P45 | 126p | 44 | 31 | 00 | 32 | 45 | 00 | 0780 | 09-12-1991 | 11 | 10 |
| P50P45 | 125 | 44 | 50 | 00 | 32 | 45 | 00 | 0130 | 09-12-1991 | 13 | 40 |
| P49Q16 | 142 | 44 | 49 | 00 | 33 | 16 | 00 | 0092 | 09-12-1991 | 16 | 05 |
| Q05Q15 | 143 | 45 | 05 | 00 | 33 | 15 | 00 | 0022 | 09-12-1991 | 17 | 55 |
| Q10P45 | 124 | 45 | 10 | 00 | 32 | 45 | 00 | 0070 | 09-12-1991 | 20 | 15 |

Akademik data: The Akademik data were in good condition, except for some spikes noted at greater depths due to cable noise. These data were filtered in both temperature and conductivity. Although instead of filtering, the data could have been corrected by examining the modulo count and discarding any count increments greater than 24, the latter procedure would have been too time consuming for the small amplitude of spikes experienced. Butterworth filtering was effective at removing the spikes.

The shallow water spikes arising from ship motions influencing the seasonal thermocline were not removed. Their removal requires analysis of raw data, which was too time-consuming. These spikes will have to be removed at a later date.

Bilim data: These data were essentially noise-free, and hence were not filtered.

Kolesnikov data: These data were much noisier than the Akademik and Bilim data. Several types of filtering and corrections were made to these data.

The temperature data were examined in detail, and found to have large staircases (temperature sticking at a single value for up to 50 db). Although double-diffusion might provide similar ramps, they would not be expected to be of the same vertical scale, and would be seen in the other data (SBE-9), where they were absent. This staircase therefore was judged to be a faulty thermistor. To correct this error, the most prominent ramps (the largest at 9.015 degrees) were filtered by applying a linear correction over the length of this ramp. To filter out other staircases and to smooth out the discretization ramps, the temperature data were subjected below 500 db to a tenth order low-pass Butterworth filter, with a cutoff frequency at 0.05 per meter.

The conductivity data were fairly smooth, except for ripples having spatial scales of about 20-50 m, and amplitudes of about 0.01 mhos/m. Though smooth, the same filter was applied to these data to match that applied to the temperature data. In addition, the conductivity data also flattened out a great depths, compared to the Akademik and Bilim data (e.g., Figure 19). To correct for this effect, the depth-dependent correction that the Kolesnikov scientists applied to the data was removed, using the formula:

$$C_n = C_m/(1+C_{kp}*p)$$

where the subscript n refers to the adjusted value, C is conductivity, m is the measured value, $C_{kp}$ is the conductivity depth coefficient, and p is pressure in db. The Kolesnikov used a value of $5x10^{-5}$ for $C_{kp}$. To investigate the effect of $C_{kp}$ on the slope of the conductivity data at depth, various values of $C_{kp}$ were applied to the conductivity data after the correction was removed ($C_{kp}=0$). The values for $C_{kp}$ used were $1.5x10^{-5}$, $2.5x10^{-5}$, and $3.5x10^{-5}$. Using several intercalibration stations with the Kolesnikov (including M10X45 and N30N45), the least error at depth occurred for values of about $1.5x10^{-5}$ for $C_{kp}$ (Figures 21 and 22). This empirical depth dependency was derived for shallower water, but apparently was not optimized in deeper waters where the effect is greatest and where the intercalibration took place.

Parshin: No corrections or filtering were made to the Parshin data, because there were inadequate data with which to intercompare quantitatively. Intercomparison at one intercalibration station (Figure 23) shows the coarseness of the Parshin sampling, making detailed comparison impossible. Since the Parshin data are used only in shallow water where dynamic range is great, the lack of intercalibration is not limiting.

Piri Reis: The Piri Reis data were similar to the Bilim's, and required no filtering or spike removal.

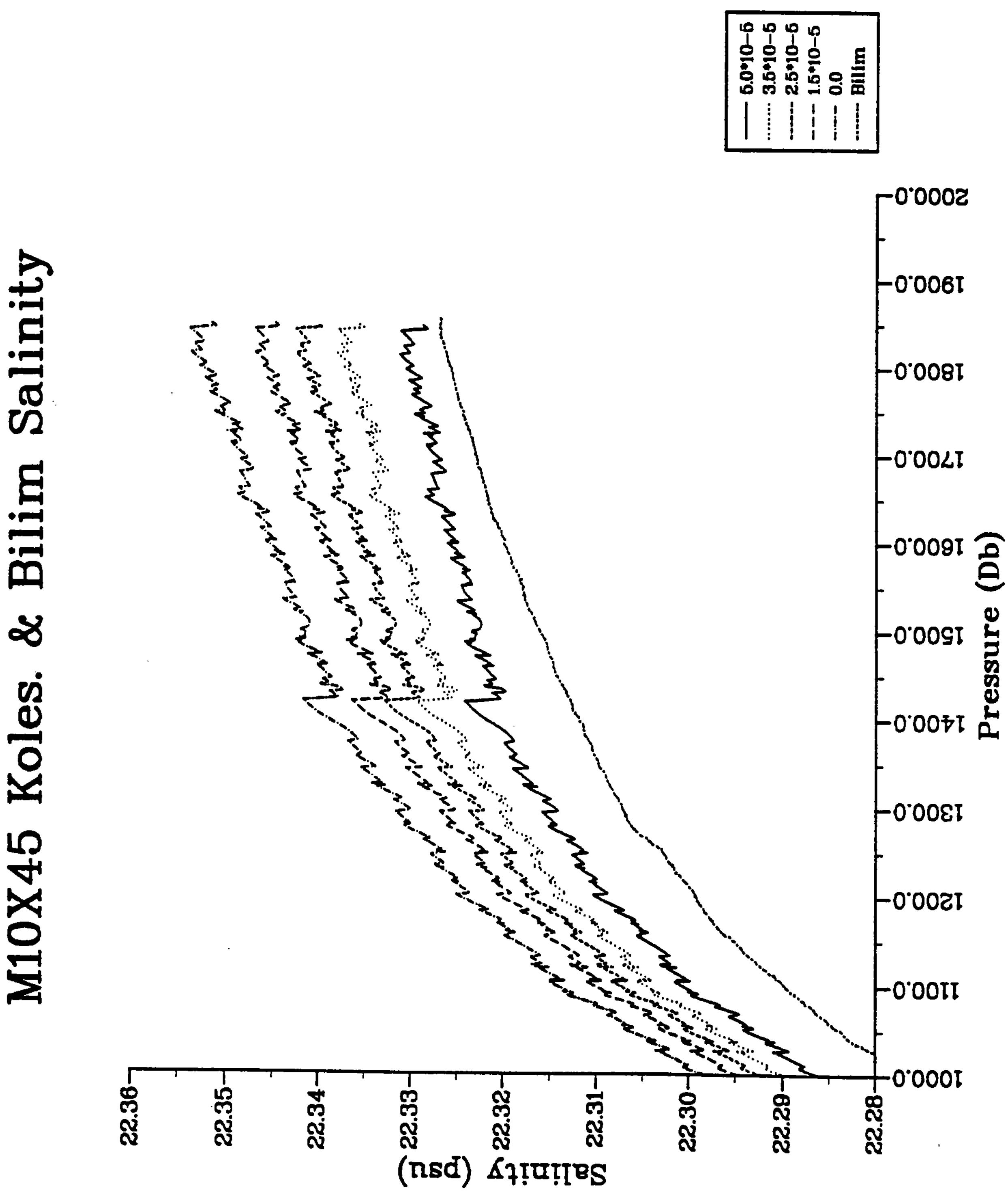



Figure 21: Comparison of salinity for the Kolesnikov and Bilim at station M10X45, varying the depth-dependent conductivity correction for the Kolesnikov CTD. The effect of the correction on the flattening of the salinity data at depth is shown.

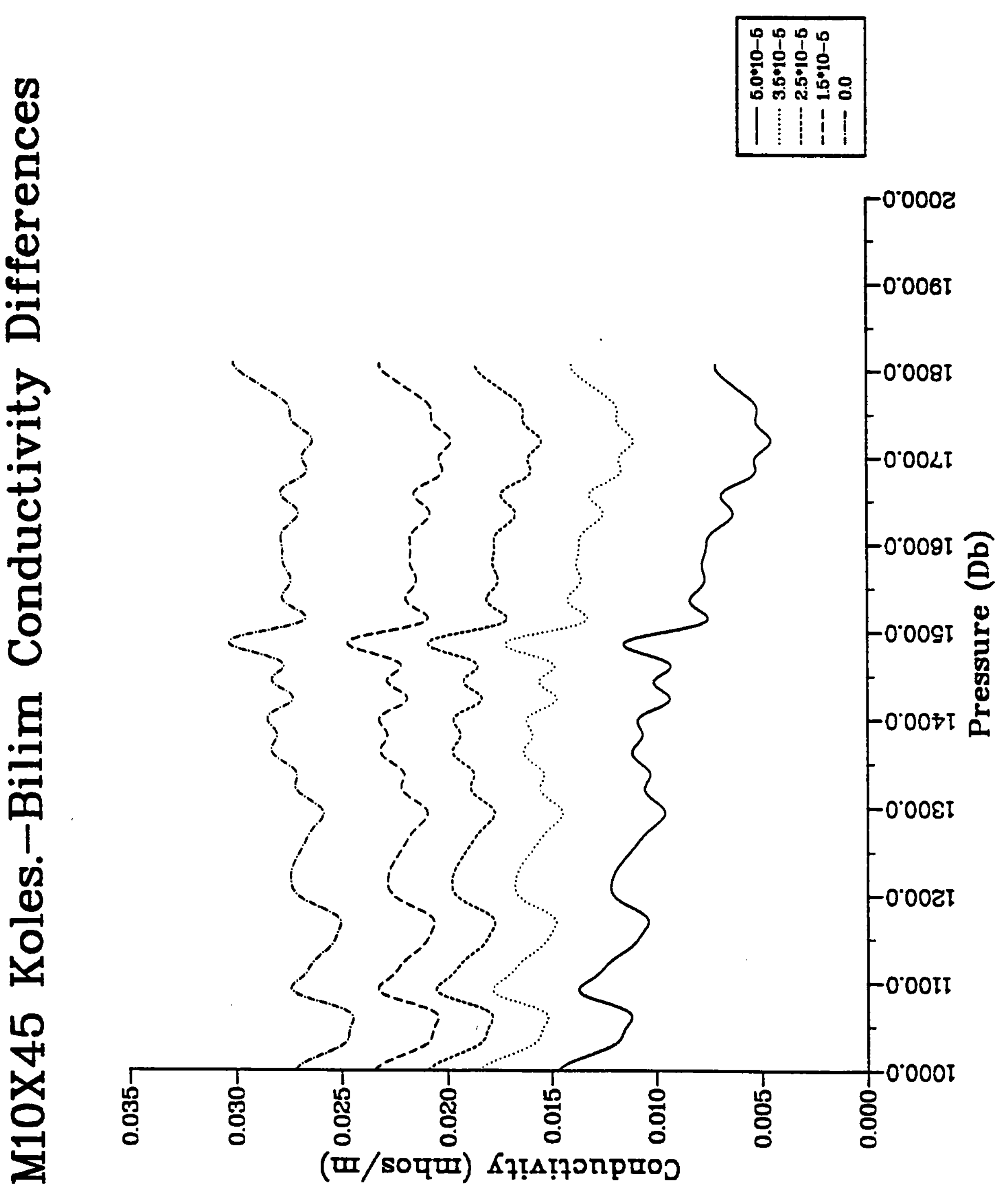



Figure 22: Differences in conductivities for the Kolesnikov and the Bilim at station M10X45, varying the depth-dependent conductivity correction for the Kolesnikov CTD. Although offsets are found in all sets, the error has no depth dependence for the case of the smallest depth correction.

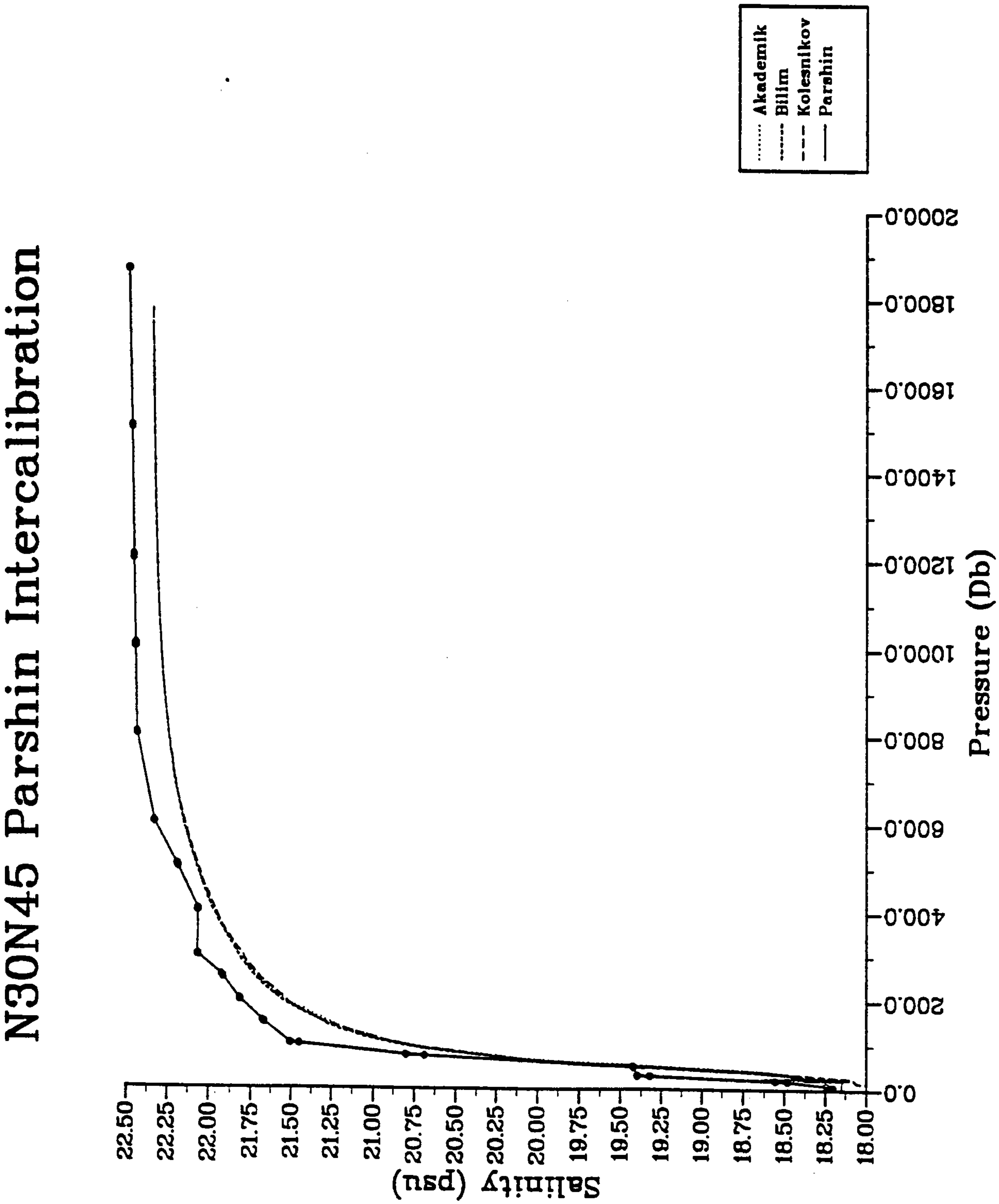



Figure 23: Intercomparison of the Parshin salinity data with Akademik, Bilim, and Kolesnikov data at station N30N45. Data points for the Parshin are shown as circles, indicating the coarseness of the sampling. Data points for other CTD's are not shown, since the sampling interval was too small. The coarseness of the Parshin data indicates that detailed intercalibration is impossible. Note that at this coarse depth scale, the three other ships produced data that are indistinguishable. Since most of the Parshin data are from shallow stations, this coarse sampling is less damaging.

**TEMPERATURE CORRECTIONS:** The filtered and de-spiked data were compared then compared to provide intercalibration offsets for all instruments for temperature. For temperature, corrections were derived from comparison at numerous intercalibration stations (Table 4). Based on these comparisons, the Bilim, Piri Reis, and Akademik temperatures were kept constant. The Kolesnikov temperature was reduced by 0.01°C, although the scatter about this value is about 0.005 °C. Lack of a clear time variation in temperature offset precluded more accurate correction.

**CONDUCTIVITY CORRECTIONS:** The filtered and de-spiked data were then compared to provide intercalibration offsets for all instruments. Offsets were applied only to bin-averaged temperature and conductivity, not to salinity. For conductivity, the corrections were made after comparisons shown in Table 5. Since Bilim and Akademik conductivities were nearly equal (within approximately 0.005 S/m of each other), the other gauges were intercalibrated to these. The Kolesnikov conductivity was reduced by 0.023 S/m to provide best agreement and the Piri Reis was reduced by 0.01 S/m. The Akademik conductivity was reduced by 0.006 S/m, which is close to the accuracy of the present data.

**INTERCALIBRATED DATA:** After application of the conductivity and temperature filtering and offsets, the new salinity was computed. Also computed were potential temperature ($\Theta$) and potential density ($\sigma_\theta$). Some examples of the intercomparisons of conductivity and salinity following these corrections are presented as Figures 24 through 35. For many of the intercalibration stations, the difference in intercalibrated temperatures is of the order of 0.005°C, and the salinity is 0.003 psu (e.g., Figures 24 and 25). For other stations, some difference in structure is apparent (e.g., Figure 26 of potential temperature), which is due to slight differences of position of the ships which in turn measure different thickness of bml. Other differences in temperature are as high as 0.005°C, such as in Figure 28. Finally, the greatest differences occur in intercomparisons with the Kolesnikov, which experienced significant drift in temperature (plus or minus 0.01°C). Comparisons between the Kolesnikov data and the Bilim or Akademik data show little consistency, with Kolesnikov salinity either above or below that at the other ships, depending on the date and location. Since no simple time variability to temperature changes was noted, no better correction could be added. Hence, the uncertainty in the measurements for the Kolesnikov is about 0.01°C. However, at some stations, the Akademik, Kolesnikov, and Bilim agree well, such as at Station N30N45 (Figures 34 and 35). Here, the agreement in temperature is better than 0.005°C, and the agreement in salinity is within 0.004 psu in general.

**SALINITY BOTTLE SAMPLES FOR TITRATION:** Water samples were obtained at each cast aboard the ships. These bottle samples were intended for intercalibration purposes. However, the sampling procedure was flawed in that the cruise plan did not specify the type of bottle to be used, nor the depths at which samples were to be taken. Consequently, the data from the Turkish ships and the Bulgarian ship had to be discarded. The bottles used were made of plastic, and evaporation occurred in the bottles before their analysis at Woods Hole.

The samples taken aboard the Parshin and the Kolesnikov were made with standard glass bottles, and hence were of high quality except when the sampling rosette leaked. However, the Parshin samples were taken at shallow depths where variability is high, and hence were of no use in intercalibration between ships. The Kolesnikov data were the best of the group (Table 6). In general, the bottle samples disagreed with the Kolesnikov conductivity measured by the Istok CTD by about 0.025 S/m. This value is about 0.008 S/m less than that applied based on intercomparison of the profiles at intercalibration stations. This difference is consistent with the uncertainty resulting from the temperature drift.

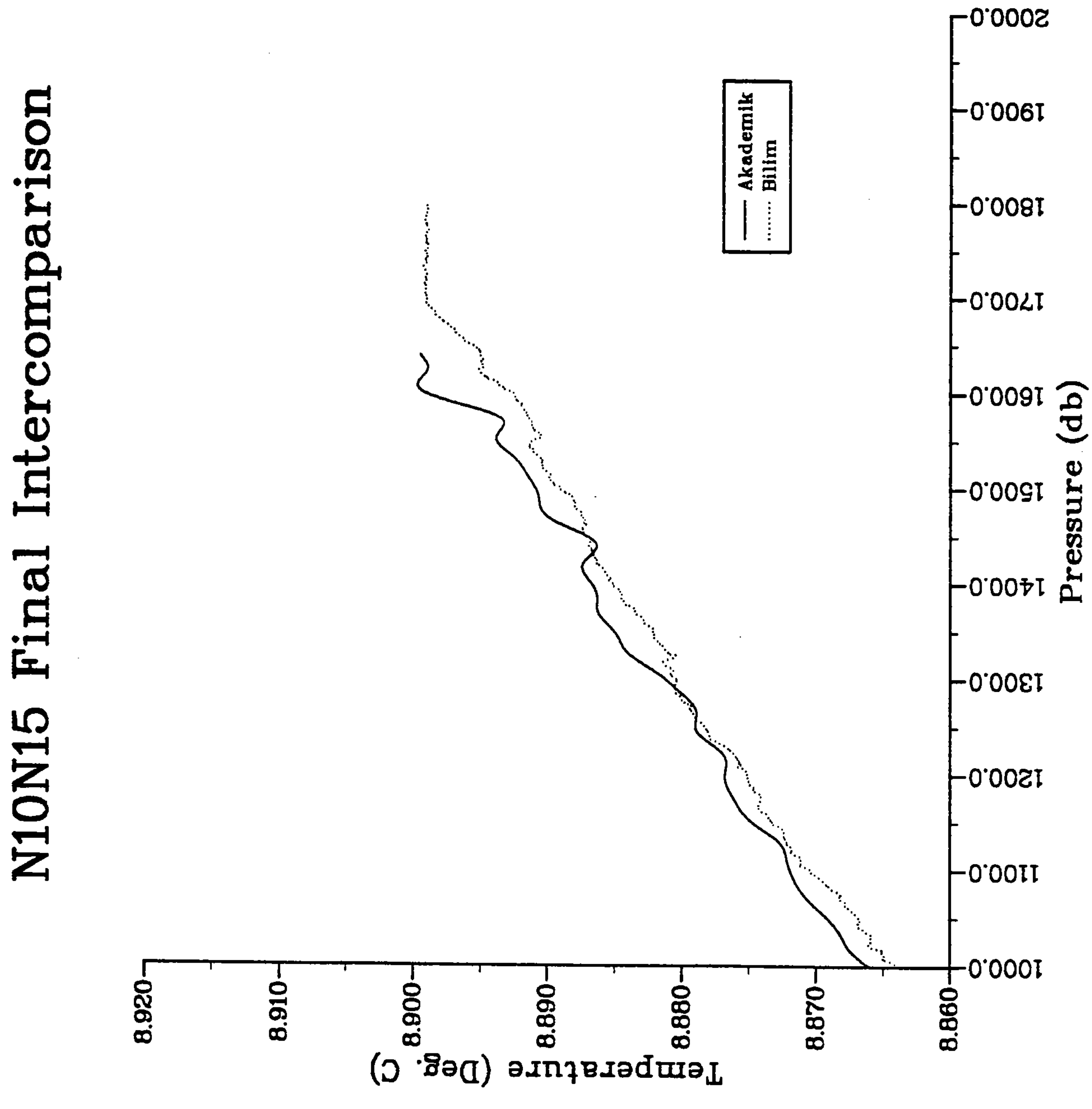



Figure 24: After intercalibration, the temperature data for the Akademik and the Bilim are approximately overlying at station N10N15. The low-frequency wiggles in the Akademik data are due to spiking and the effects of the low-pass filter. The temperatures are within 0.003°C or less throughout this depth range.

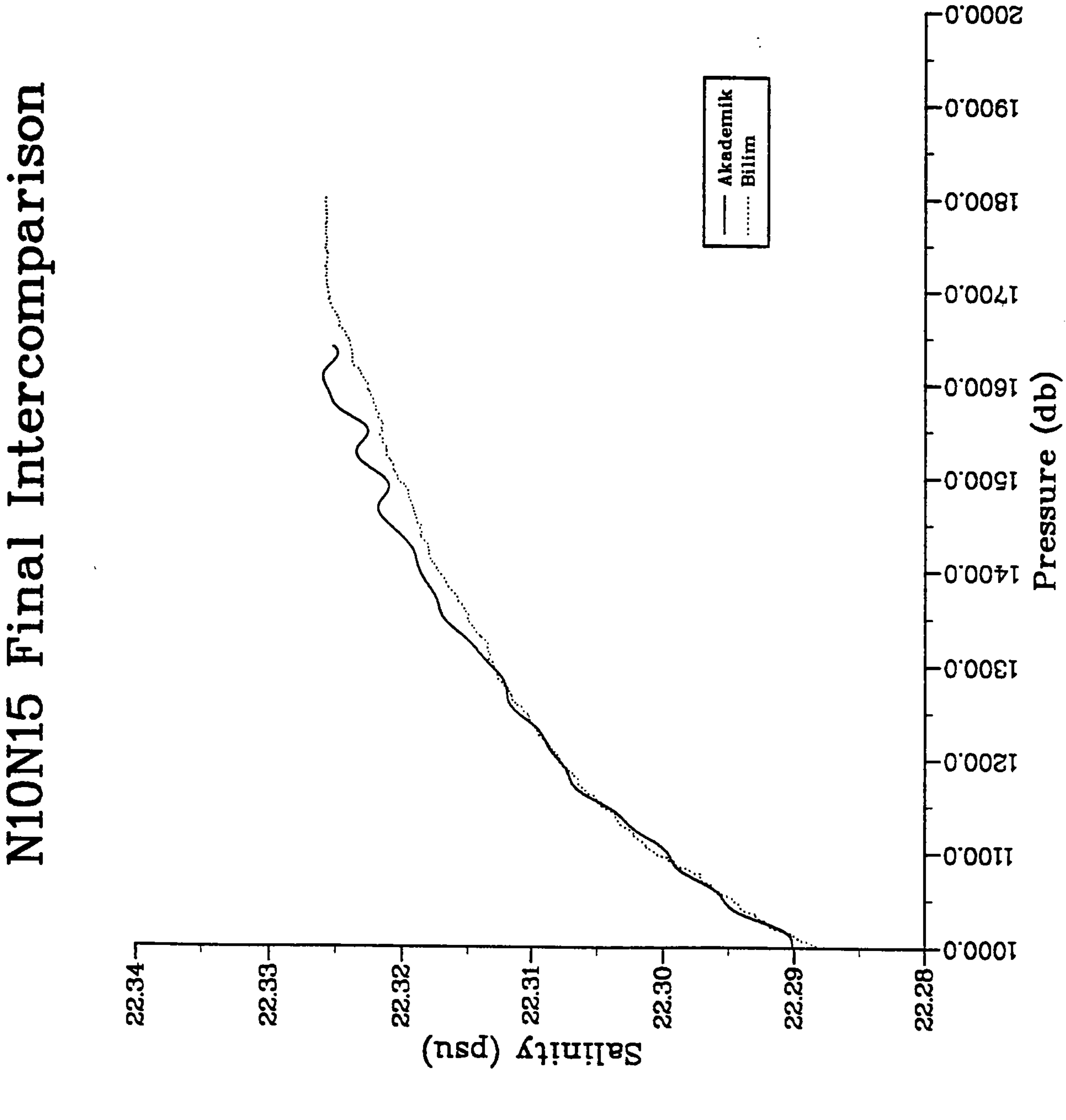



Figure 25: After intercalibration, the salinity data for the Akademik and the Bilim are approximately overlying at station N10N15. The low-frequency wiggles in the Akademik data are due to spiking in temperature and the effects of the low-pass filter. The salinities are within 0.003 psu or less throughout this depth range.

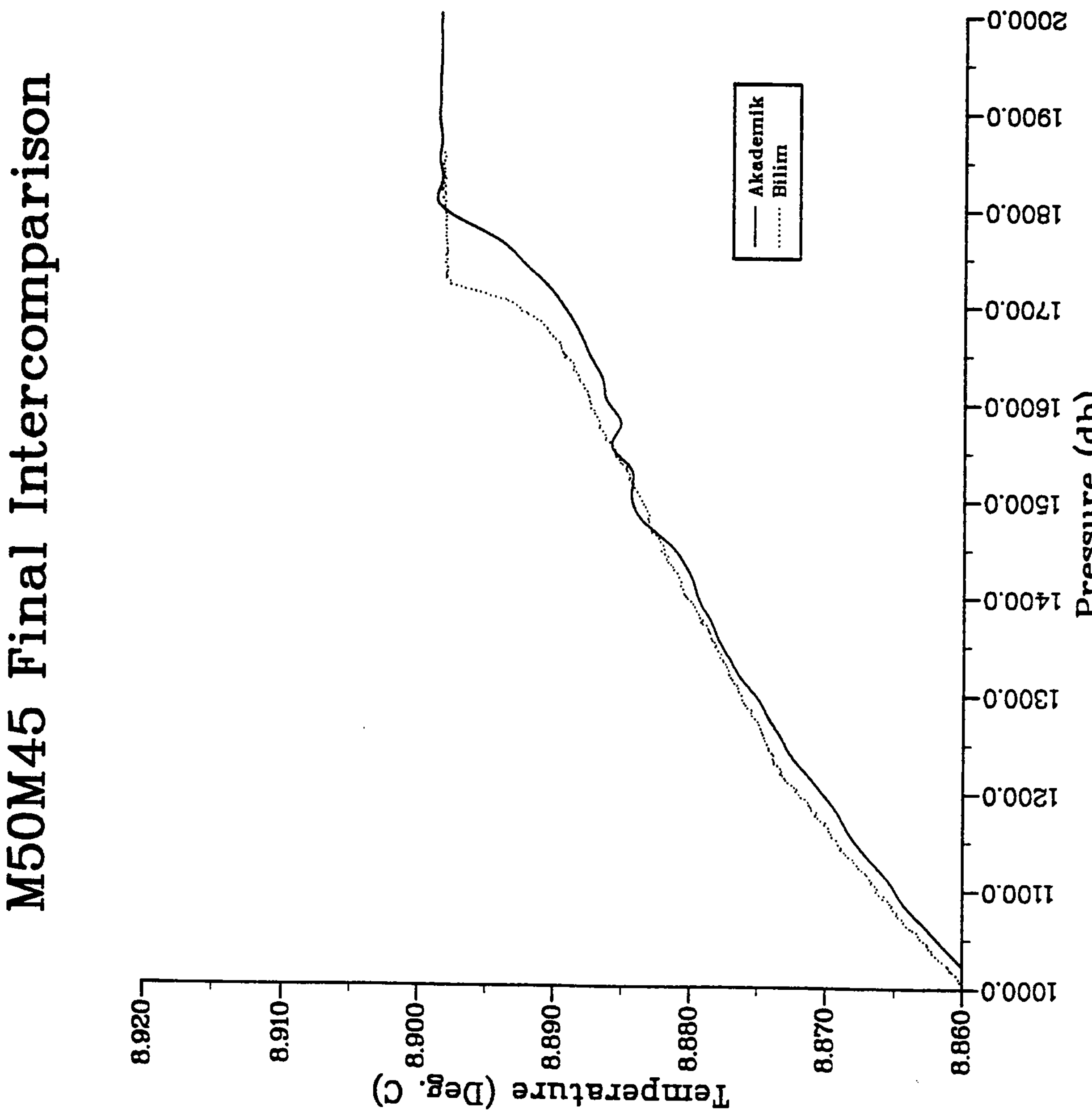



Figure 26: After intercalibration, the temperature data for the Akademik and the Bilim are approximately overlying at station M50M45. The low-frequency wiggles in the Akademik data are due to spiking and the effects of the low-pass filter. The temperatures are within 0.003°C or less over this depth range, and the temperatures in the bottom mixed layer differ by less than 0.001°C.

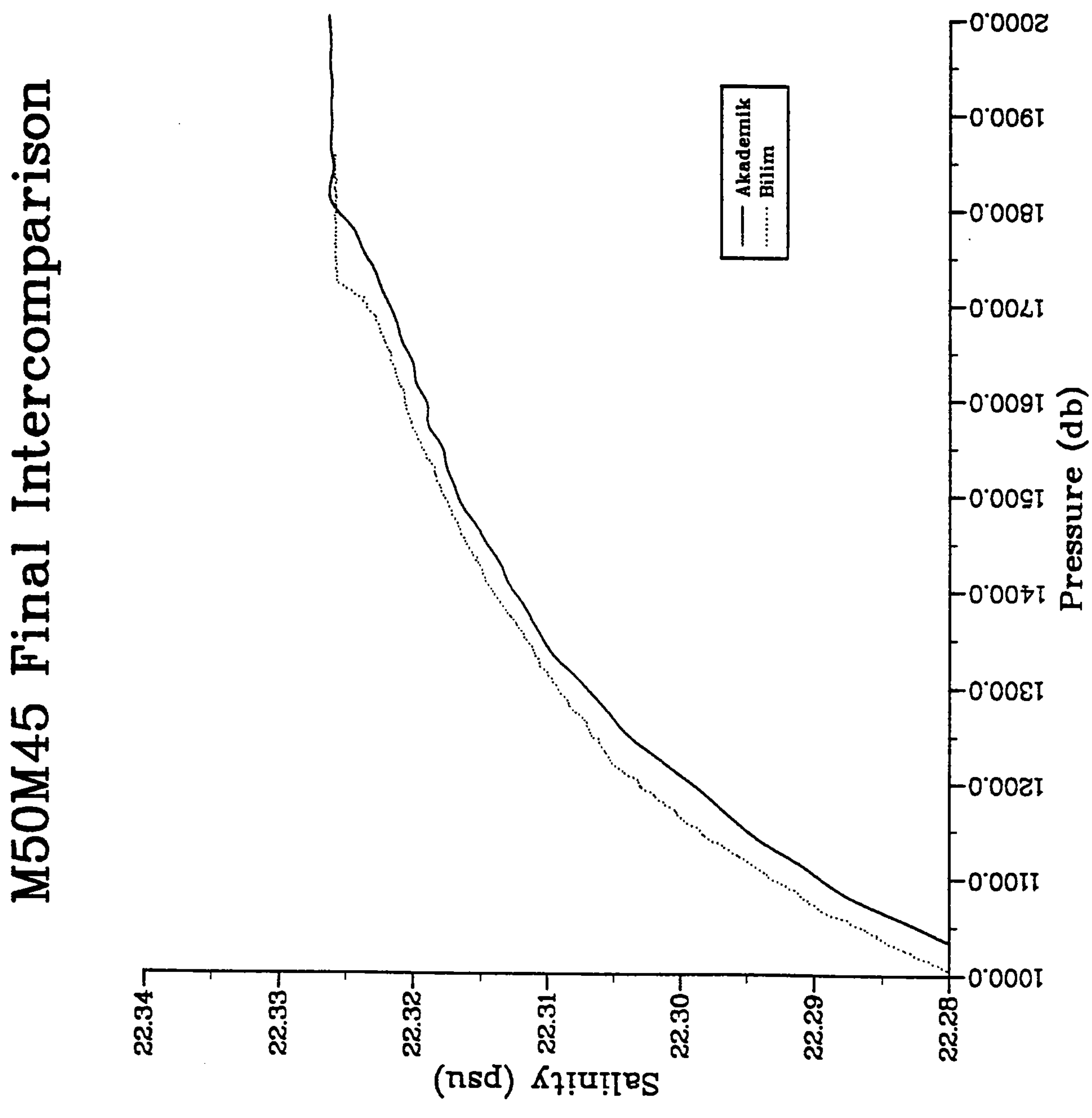



Figure 27: After intercalibration, the salinity data for the Akademik and the Bilim are approximately overlying at station M50M45. The low-frequency wiggles in the Akademik data are due to spiking in temperature and the effects of the low-pass filter. The salinities are within 0.003 psu or less throughout this depth range, and within 0.01 psu within the bottom mixed layer.

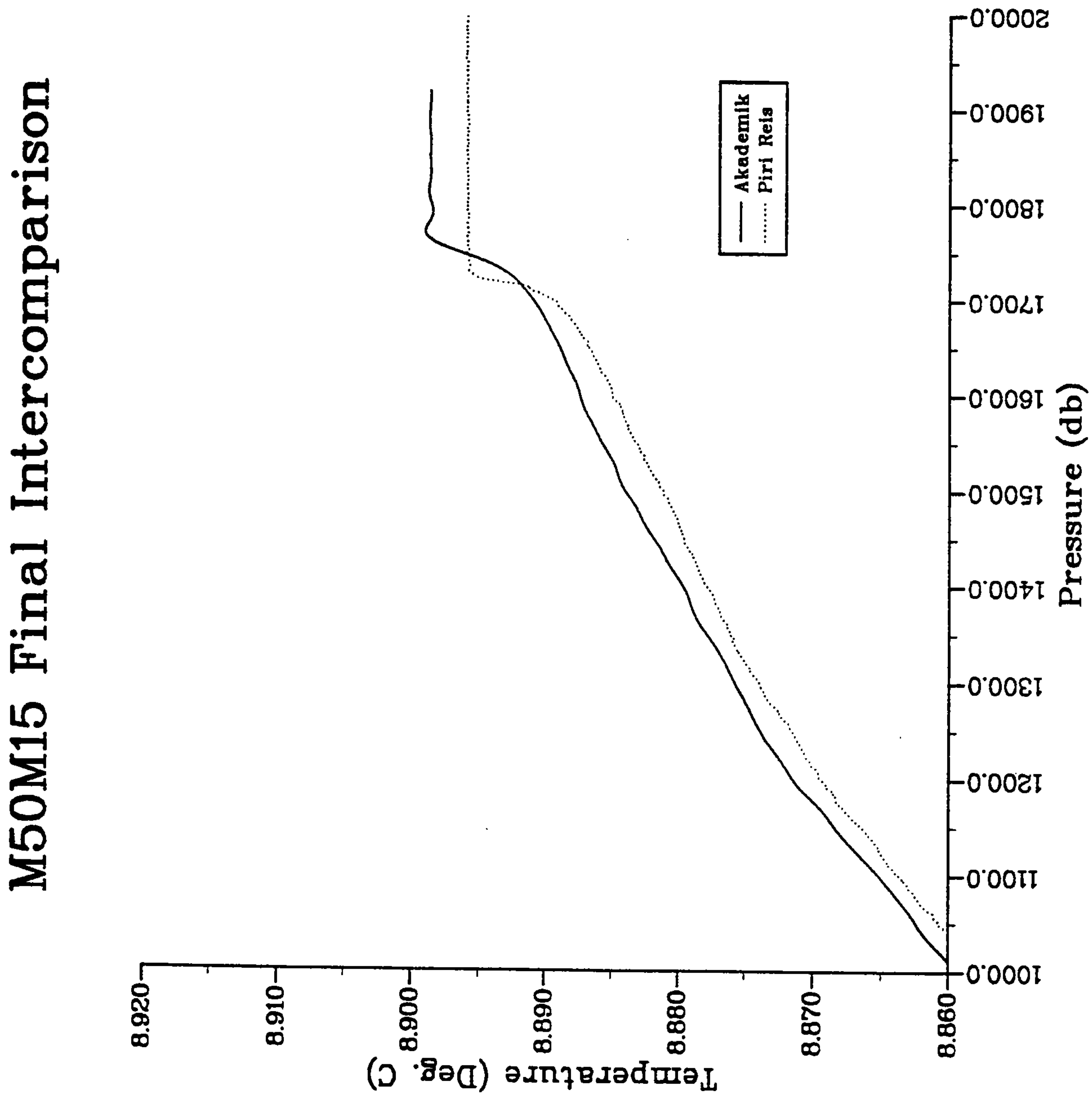



Figure 28: After intercalibration, the temperature data for the Akademik and the Piri Reis are approximately overlying at station M50M15. The temperatures are within 0.005°C or less throughout this depth range, and the temperatures in the bottom mixed layer are less than 0.003°C different.

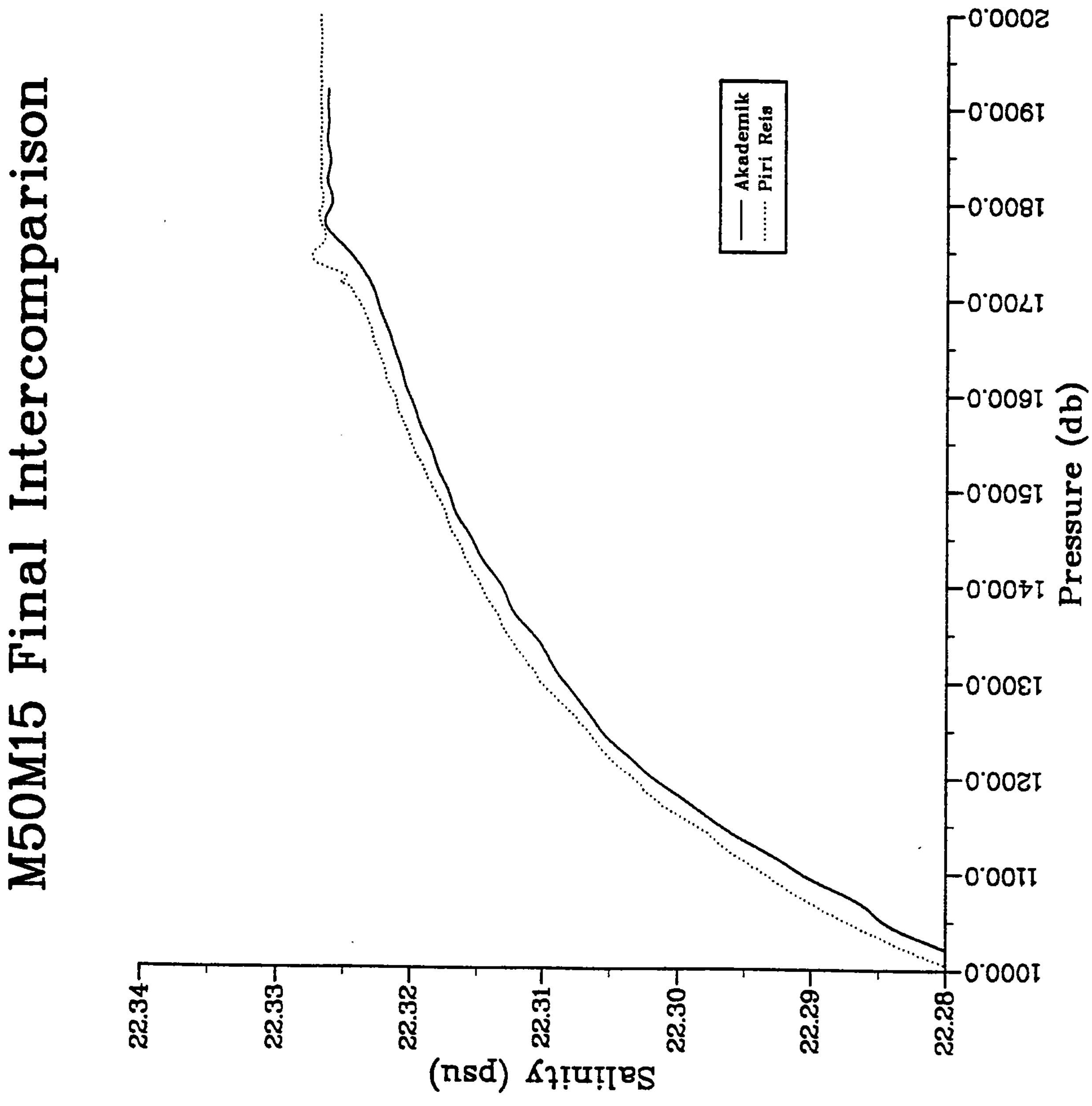



Figure 29: After intercalibration, the salinity data for the Akademik and the Piri Reis are approximately overlying at station M50M15. The salinities are within 0.003 psu or less throughout this depth range, and within 0.01 psu within the bottom mixed layer.

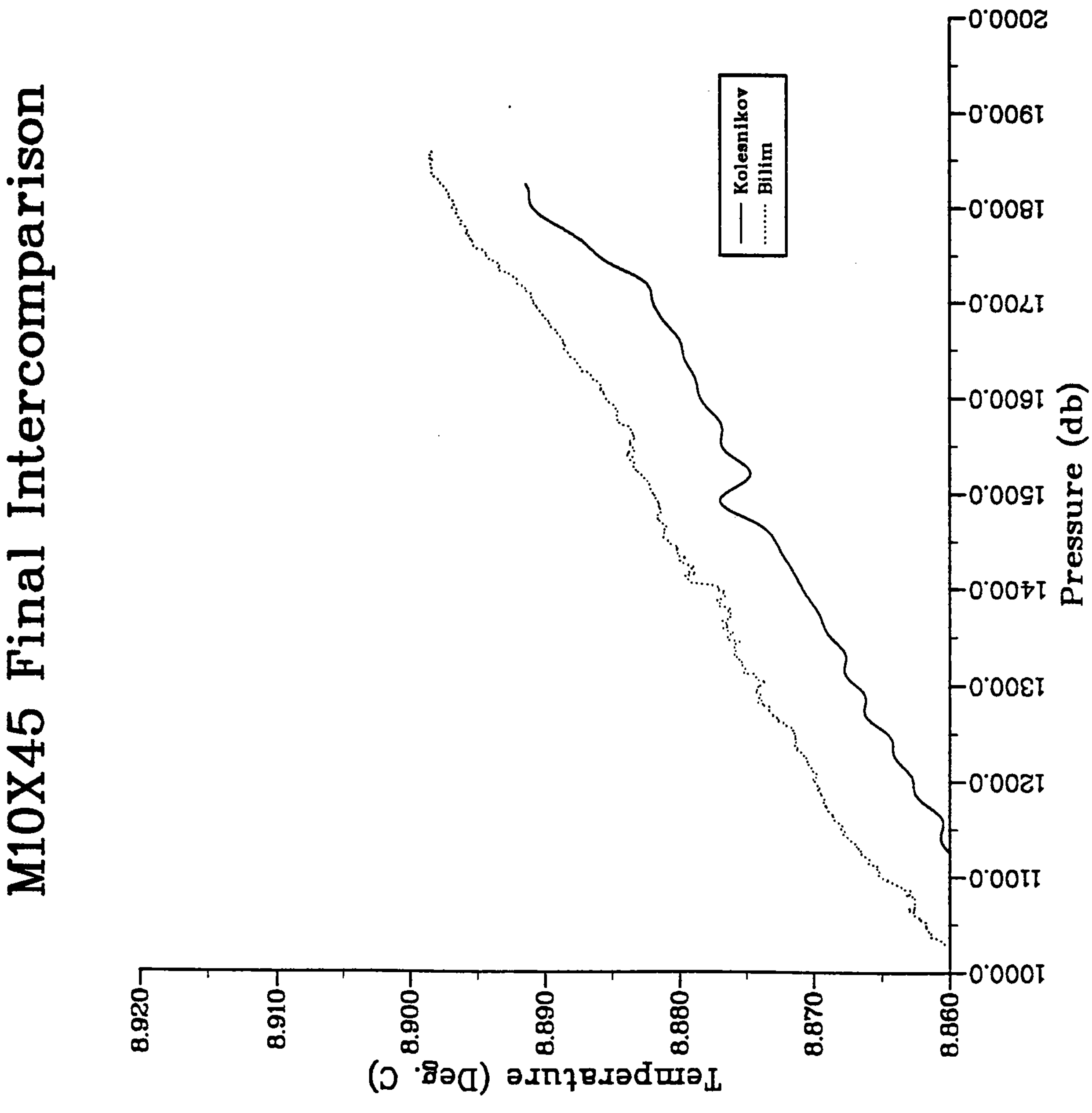



Figure 30: After intercalibration, the temperature data for the Kolesnikov and the Bilim are offset at station M10X45. The temperatures are within 0.01°C or less throughout this depth range. The temperature difference reflects the decision to apply one regional, average temperature correction to the Kolesnikov data, rather than a time-dependent value (see Fig. 7).

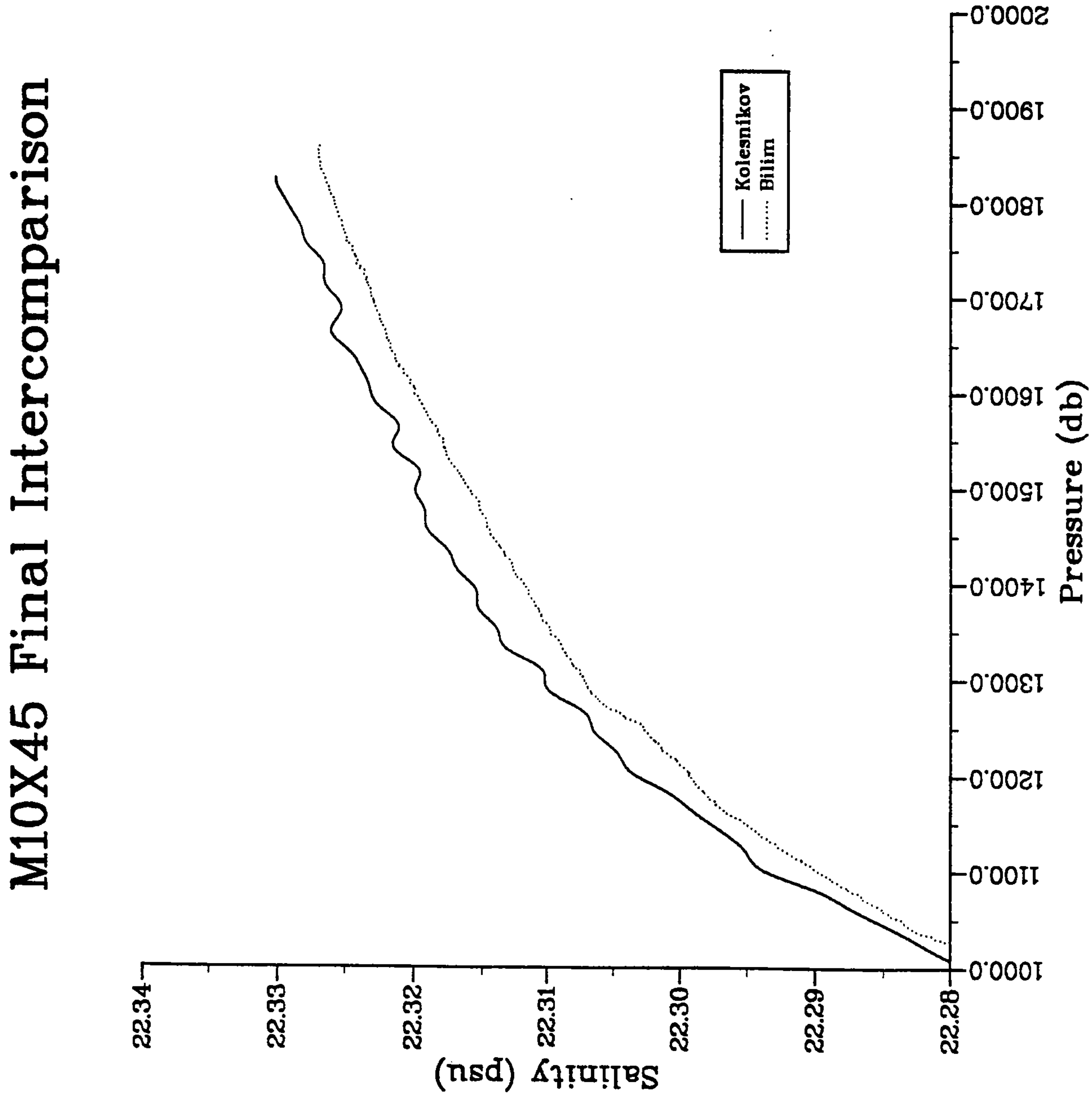



Figure 31: After intercalibration, the salinity data for the Kolesnikov and the Bilim are offset at station M10X45. The salinities are within 0.005 psu or less throughout this depth range. The differences reflect in part the temperature difference, and the depth-dependent conductivity correction.

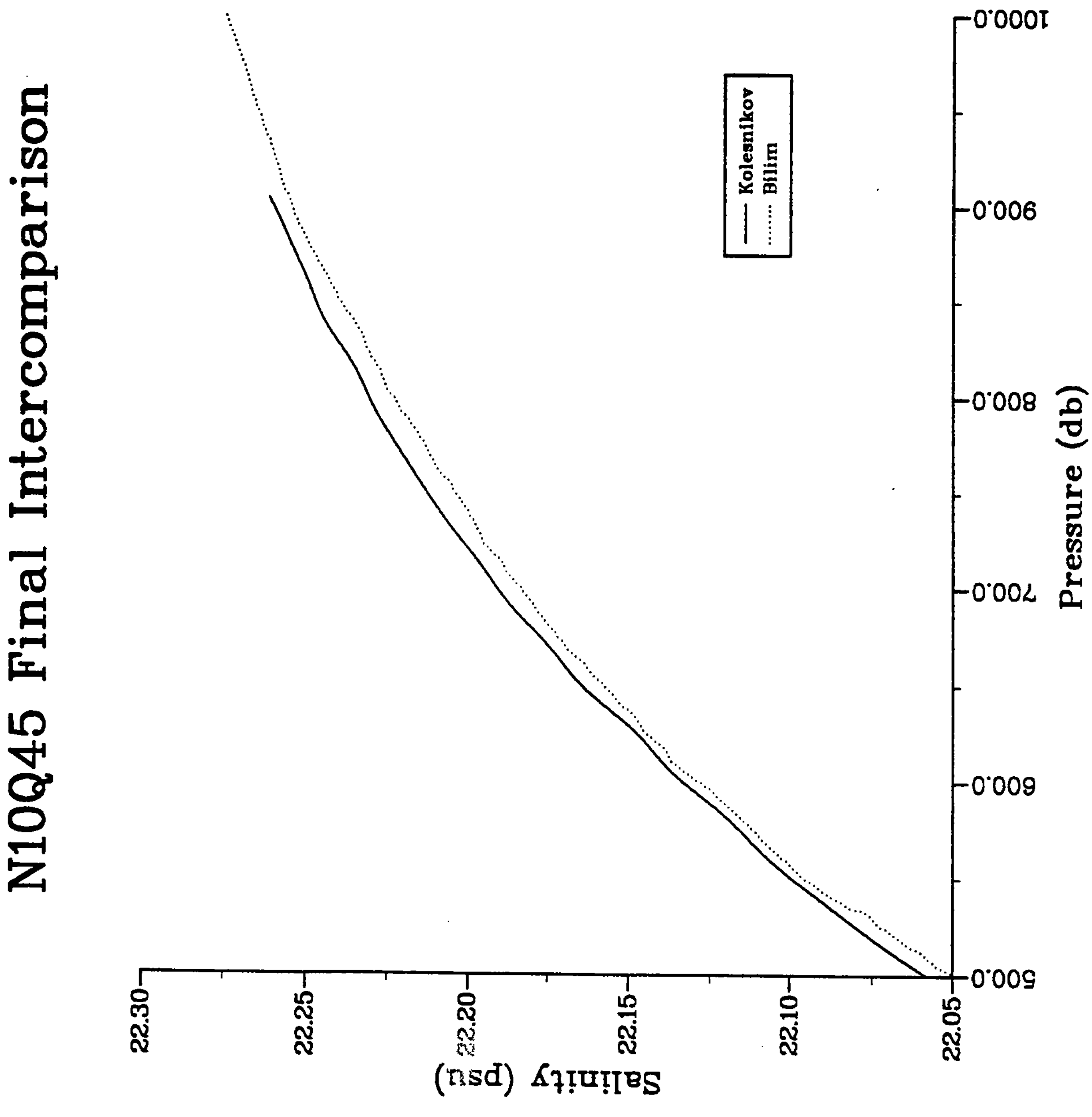



Figure 32: After intercalibration, the salinity data for the Kolesnikov and the Bilim are nearly overlapping at station N10Q45. The salinities are within 0.003 psu or less over this depth range. Contrast this excellent fit with Fig. 31 at another station.

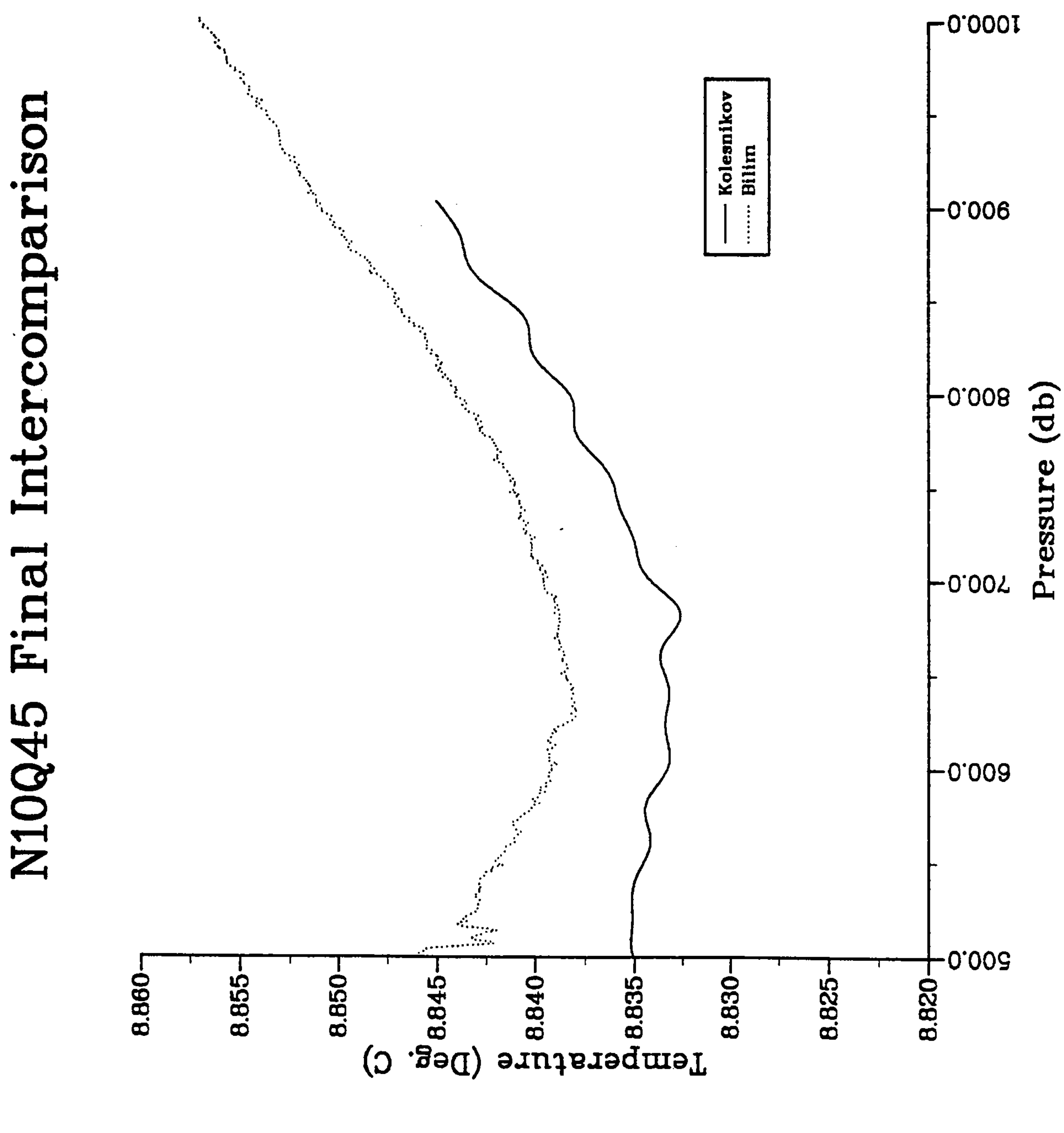



Figure 33: After intercalibration, the temperature data for the Kolesnikov and the Bilim are offset at station N10Q45. The temperatures are within 0.01°C or less over this depth range.

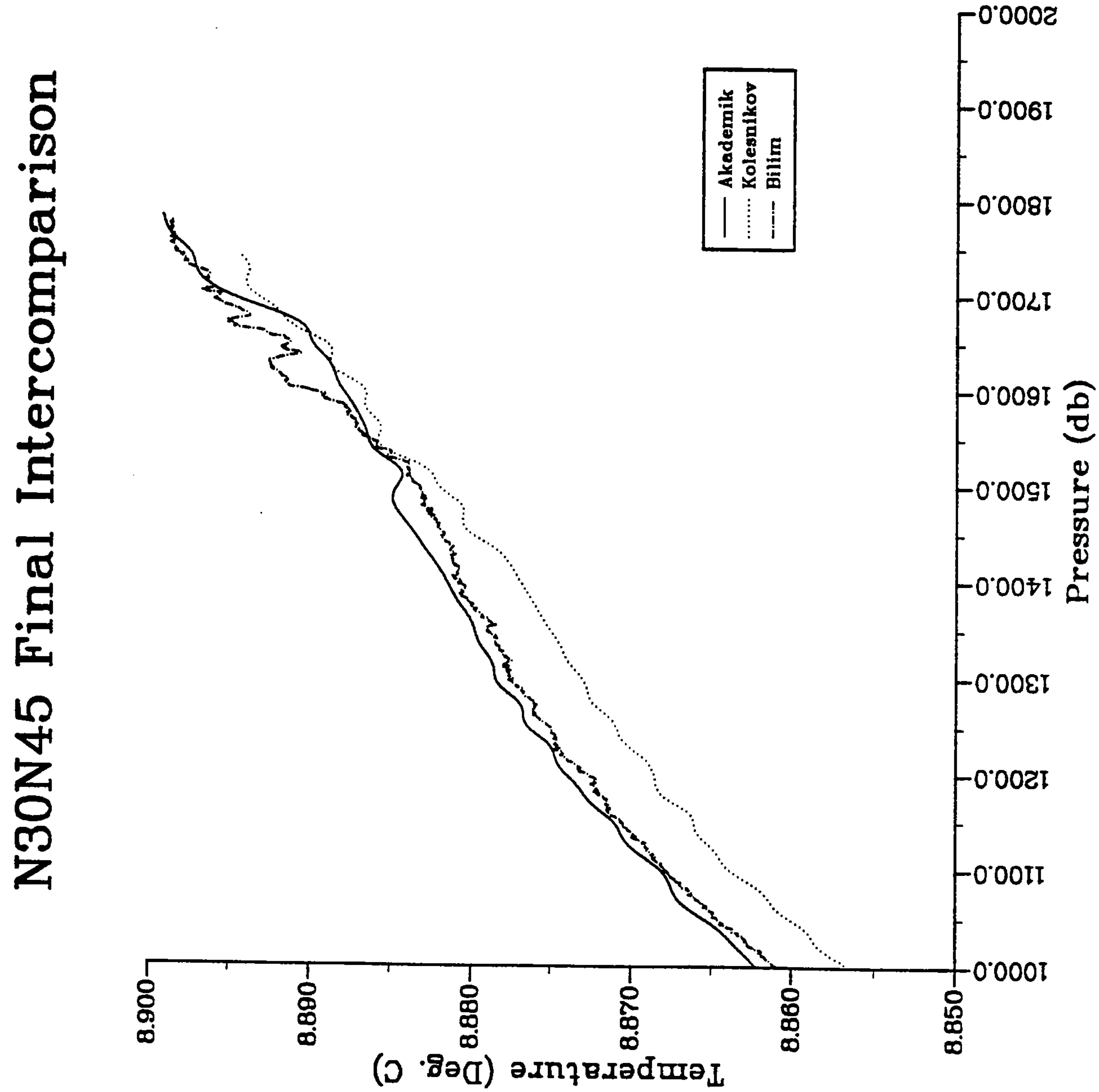



Figure 34: After intercalibration, a temperature comparison between the Akademik, Kolesnikov, and Bilim, at station N30N45. The temperatures are within 0.005 except for the Kolesnikov in the shallower portion of the section.

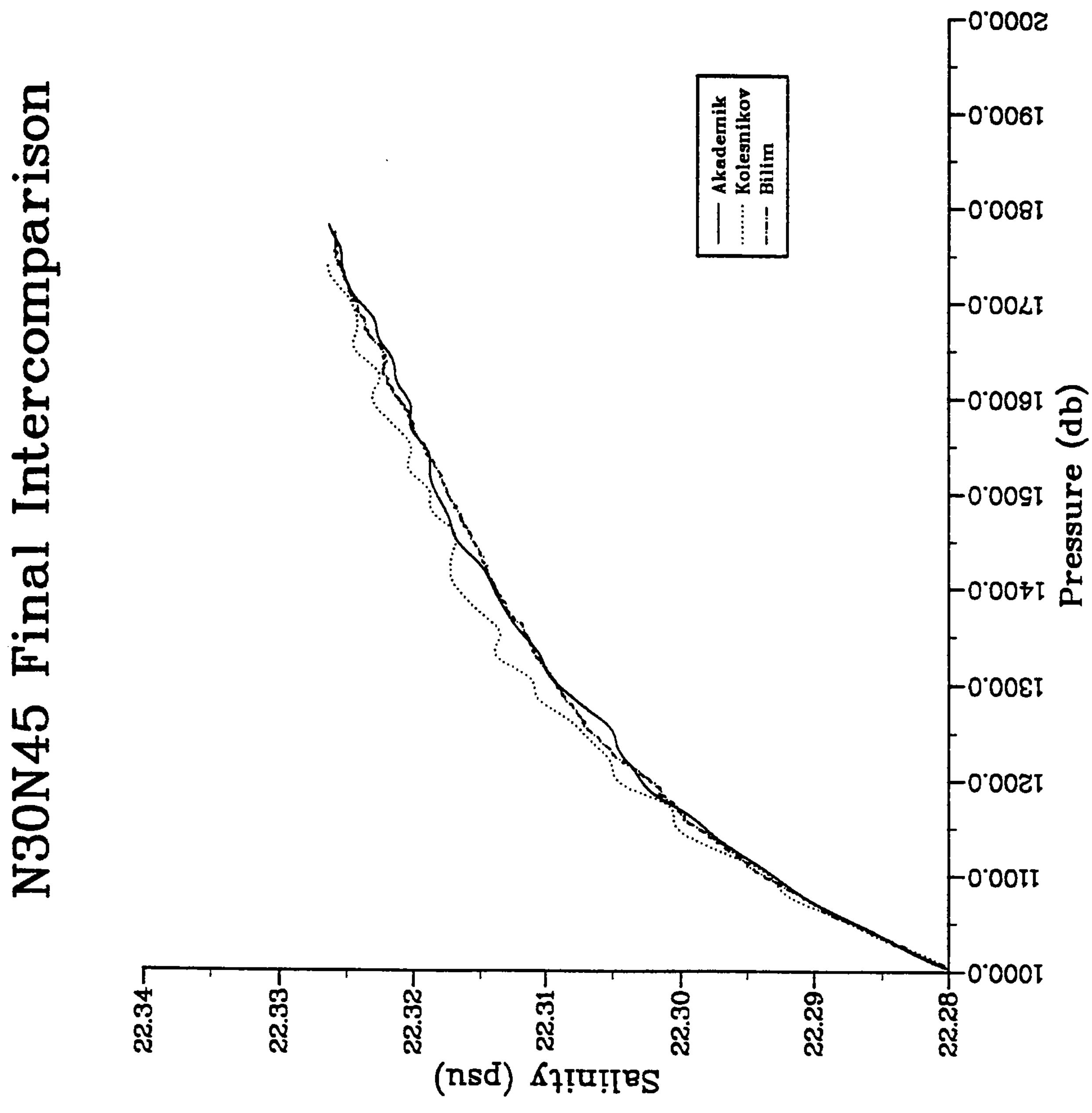



Figure 35: After intercalibration, a salinity comparison between the Akademik, Kolesnikov, and Bilim at station N30N45. The salinities are all within 0.005 psu. The wiggles in the Kolesnikov salinity reflect discontinuities in the temperature data for the CTD.

**TABLE 4**
**TEMPERATURE DIFFERENCES (1200-1400 db)**
**(°C)**

| Station Code (Table 3) | Akd.-P. Reis | Akd.-Bilim | Bilim-P.Reis | Bilim-Kolesnikov before Filtering | Bilim-Kolesnikov after Filtering | Akd.-Kolesnikov before Filtering | Akd.-Kolesnikov after Filtering |
|---|---|---|---|---|---|---|---|
| 226 | | | | -0.023±0.001 | -0.023±0.0008 | | |
| 266 | | | | -0.003±0.001 | -0.003±0.0007 | | |
| 50 | -0.002±0.004 | | | | | | |
| 70 | -0.002±0.006 | -0.001±0.0006 | +0.003±0.0003* | | | | |
| 82 | | 0.008±0.0006 | | | | | |
| 83 | | | | | | -0.005±0.0015 | -0.005±0.0003 |
| 101 | | 0.001±0.0004 | | -0.006±0.001 | -0.006±0.0003 | -0.005±0.0010 | -0.005±0.0003 |
| 165(B)/173(K) | | | | -0.021±0.001 | -0.021±0.0007 | | |
| 203(B)/215(K) | | | | -0.009±0.001 | -0.009±0.0006 | | |
| 24(R)/42(B) | | | -0.002±0.001 | | | | |
| 247(K)/248(B) | | | | | | | |
| 147(K)/148(B) | | | | | -0.020±0.0006 | | |
| | | | | | -0.012±0.0006 | | |

* Station 50 is used for P. Reis

## TABLE 5
## CONDUCTIVITY DIFFERENCES (1200-1400 db)
## (S/M)

| Station Code (Table 3) | Akd.-P. Reis | Akd.-Bilim | Bilim-P.Reis | Bilim-Kolesnikov before Filtering | Bilim-Kolesnikov after Filtering | Akd.-Kolesnikov before Filtering | Akd.-Kolesnikov after Filtering |
|---|---|---|---|---|---|---|---|
| 226 | | | | -0.014±0.002 | -0.025±0.0006 | | |
| 266 | | | | -0.011±0.001 | -0.022±0.0009 | | |
| 50 | -0.005±0.001 | | | | | | |
| 70 | -0.006±0.001 | 0.003±0.001 | -0.009±0.0004 | | | | |
| 82 | | 0.008±0.001 | | | | | |
| 83 | | | | | | -0.003±0.001 | -0.013±0.001 |
| 101 | | 0.007±0.0008 | | -0.011±0.001 | -0.021±0.0008 | -0.004±0.001 | -0.015±0.001 |
| 165(B)/173(K) | | | | -0.012±0.001 | -0.023±0.0010 | | |
| 203(B)/215(K) | | | | -0.012±0.001 | -0.025±0.0004 | | |
| 24(R)/42(B) | | | -0.013±0.0003 | | | | |
| 247(K)/248(B) | | | | | -0.021±0.0006 | | |
| 147(K)/148(B) | | | | | -0.025±0.0010 | | |
| | | 0.006±0.001 | -0.010±0.0003 | | -0.022±0.0007 | | |

TABLE 6

WATER BOTTLE SAMPLE RESULTS: IN SITU AND TITRATED

| | STATION | PRESSURE | CTD cond | titr. cond | titration(ckp) | ctd-titr. cond |
|---|---|---|---|---|---|---|
| 1 | M50V45 | 1046.000 | 25.01200 | 25.00300 | 24.9991 | -0.0129 |
| 2 | M50W45 | 1042.000 | 25.00900 | 25.00410 | 25.0002 | -0.0088 |
| 3 | M30X15 | 1006.000 | 24.98800 | 24.98050 | 24.9767 | -0.0113 |
| 4 | M30X45 | 756.000 | 24.80400 | 24.78980 | 24.7870 | -0.0170 |
| 5 | M10Y15 | 767.000 | 24.80400 | 24.79170 | 24.7888 | -0.0152 |
| 6 | M10Y45 | 509.000 | 24.53300 | 24.50960 | 24.5077 | -0.0253 |
| 7 | L50Z15 | 1110.000 | 25.04500 | 25.04200 | 25.0378 | -0.0072 |
| 8 | M30Z15 | 513.000 | 24.53300 | 24.52150 | 24.5196 | -0.0134 |
| 9 | M40Z00 | 759.000 | 24.80700 | 24.79750 | 24.7947 | -0.0123 |
| 10 | M30Y45 | 403.000 | 24.37400 | 24.36320 | 24.3617 | -0.0123 |
| 11 | M30Y15 | 1524.000 | 24.68900 | 25.22640 | 25.2206 | 0.0000 |
| 12 | M50Y45 | 760.000 | 24.81800 | 24.81220 | 24.8094 | -0.0086 |
| 13 | M50X45 | 1008.000 | 24.98500 | 25.00650 | 25.0027 | 0.0177 |
| 14 | M50X15 | 1018.000 | 24.99900 | 24.97880 | 24.9750 | -0.0240 |
| 15 | N10X15 | 808.000 | 24.85100 | 24.83720 | 24.8342 | -0.0168 |
| 16 | N24X35 | 1165.000 | 25.07300 | 25.06280 | 25.0584 | -0.0146 |
| 17 | N30W45 | 1019.000 | 24.99300 | 24.98400 | 24.9802 | -0.0128 |
| 18 | N50W45 | 762.000 | 24.80900 | 24.80530 | 24.8025 | -0.0065 |
| 19 | P10W15 | 762.000 | 24.80700 | 24.78020 | 24.7774 | -0.0296 |
| 20 | P10W15 | 1013.000 | 24.99600 | 24.98950 | 24.9857 | -0.0103 |
| 21 | P10W15 | 1731.000 | 25.31890 | 25.31250 | 25.3059 | -0.0130 |
| 22 | N50W15 | 810.000 | 24.85600 | 24.84280 | 24.8398 | -0.0162 |
| 23 | N30W15 | 508.000 | 24.56300 | 24.59230 | 24.5904 | 0.0274 |
| 24 | N10W45 | 762.000 | 24.81800 | 24.81470 | 24.8119 | -0.0061 |
| 25 | N10W15 | 906.000 | 24.93300 | 24.92620 | 24.9228 | -0.0102 |
| 26 | N30V45 | 1520.000 | 25.23200 | 25.22650 | 25.2207 | -0.0113 |
| 27 | N10V15 | 2027.000 | 25.43400 | 24.98880 | 24.9812 | 0.0000 |
| 28 | N10V45 | 1032.000 | 25.00100 | 25.42460 | 25.4207 | 0.0000 |
| 29 | N30V15 | 408.000 | 24.41200 | 24.39860 | 24.3971 | -0.0149 |
| 30 | N30V15 | 1015.000 | 24.98800 | 24.96850 | 24.9647 | -0.0233 |
| 31 | N50V45 | 605.000 | 24.67500 | 24.66860 | 24.6664 | -0.0086 |
| 32 | N50V15 | 504.000 | 24.56800 | 24.57620 | 24.5743 | 0.0063 |
| 33 | N50T45 | 759.000 | 24.82300 | 24.81850 | 24.8157 | -0.0073 |
| 34 | N30T45 | 490.000 | 24.40600 | 24.43360 | 24.4318 | 0.0258 |
| 35 | N30T15 | 1212.000 | 25.09200 | 25.08080 | 25.0762 | -0.0158 |
| 36 | N50T15 | 1015.000 | 24.99000 | 24.97710 | 24.9733 | -0.0167 |
| 37 | P10T45 | 1519.000 | 25.23200 | 25.20490 | 25.1992 | -0.0328 |
| 38 | P10V15 | 1019.000 | 24.99900 | 24.99460 | 24.9908 | -0.0082 |
| 39 | P10V45 | 1831.000 | 25.36000 | 25.35430 | 25.3473 | -0.0127 |
| 40 | P28V45 | 749.000 | 24.80700 | 24.79700 | 24.7942 | -0.0128 |
| 41 | P30V15 | 507.000 | 24.53800 | 24.52910 | 24.5272 | -0.0108 |
| 42 | P45V05 | 608.000 | 24.68100 | 24.67860 | 24.6763 | -0.0047 |
| 43 | P30T45 | 913.000 | 24.93500 | 24.92110 | 24.9177 | -0.0173 |
| 44 | P10T15 | 808.000 | 24.84800 | 24.83950 | 24.8365 | -0.0115 |
| 45 | P30T15 | 711.000 | 24.77100 | 24.55140 | 24.5488 | 0.0000 |
| 46 | P30S45 | 1022.000 | 24.98800 | 24.96240 | 24.9586 | -0.0294 |
| 47 | P10S45 | 1822.000 | 25.35500 | 25.34900 | 25.3421 | -0.0129 |
| 48 | N50S45 | 505.000 | 24.52200 | 24.51830 | 24.5164 | -0.0056 |
| 49 | N30S45 | 1052.000 | 25.00400 | 24.99450 | 24.9906 | -0.0134 |
| 50 | N30S15 | 1416.000 | 25.18200 | 25.14980 | 25.1445 | -0.0375 |
| 51 | N50S15 | 810.000 | 24.83700 | 24.82700 | 24.8240 | -0.0130 |
| 52 | P10S15 | 909.000 | 24.91100 | 24.90110 | 24.8977 | -0.0133 |
| 53 | P39S15 | 505.000 | 24.54900 | 24.54110 | 24.5392 | -0.0098 |
| 54 | P36R45 | 757.000 | 24.81500 | 24.80700 | 24.8042 | -0.0108 |
| 55 | P10R45 | 2029.000 | 25.43400 | 25.43060 | 25.4229 | -0.0111 |
| 56 | P10R15 | 1050.000 | 25.01200 | 25.00810 | 25.0042 | -0.0078 |

| | STATION | PRESSURE | CTD cond | titr. cond | titration(ckp) | ctd-titr. cond |
|---|---|---|---|---|---|---|
| 57 | N50R15 | 1515.000 | 25.23200 | 25.23120 | 25.2255 | -0.0065 |
| 58 | N50R45 | 813.000 | 24.85600 | 24.85310 | 24.8501 | -0.0059 |
| 59 | N30R45 | 1011.000 | 25.99000 | 24.98680 | 24.9830 | 0.0000 |
| 60 | N10R15 | 1015.000 | 24.99000 | 24.98570 | 24.9819 | -0.0081 |
| 61 | N10R15 | 1523.000 | 25.22900 | 25.22350 | 25.2177 | -0.0113 |
| 62 | N10R15 | 2044.000 | 25.43700 | 25.42180 | 25.4140 | -0.0230 |
| 63 | N10Q45 | 906.000 | 24.92500 | 24.91600 | 24.9126 | -0.0124 |
| 64 | N30R15 | 1029.000 | 25.00400 | 24.99230 | 24.9884 | -0.0156 |
| 65 | N30Q45 | 1315.000 | 25.14400 | 25.13070 | 25.1257 | -0.0183 |
| 66 | N30Q45 | 1723.000 | 25.31900 | 25.31600 | 25.3095 | -0.0095 |
| 67 | N50Q15 | 1416.000 | 25.18500 | 25.18270 | 25.1774 | -0.0076 |
| 68 | N50Q15 | 1877.000 | 25.37400 | 25.36560 | 25.3585 | -0.0155 |
| 69 | P10Q15 | 1039.000 | 24.99600 | 24.98520 | 24.9813 | -0.0147 |
| 70 | P25Q08 | 406.000 | 24.37900 | 24.38290 | 24.3814 | 0.0024 |
| 71 | P07Q45 | 883.000 | 24.91400 | 24.90080 | 24.8975 | -0.0165 |
| 72 | N30Q15 | 507.000 | 24.56300 | 24.56050 | 24.5586 | -0.0044 |
| 73 | N30P45 | 1516.000 | 25.23200 | 25.22640 | 25.2207 | -0.0113 |
| 74 | N30P45 | 1925.000 | 25.39300 | 25.39050 | 25.3832 | -0.0098 |
| 75 | N50P45 | 1040.000 | 25.00100 | 24.99090 | 24.9870 | -0.0140 |
| 76 | N50P15 | 1211.000 | 25.09400 | 25.09380 | 25.0892 | -0.0048 |
| 77 | N30P15 | 911.000 | 24.92700 | 24.92550 | 24.9221 | -0.0049 |
| 78 | N30N45 | 1619.000 | 25.27500 | 25.26640 | 25.2603 | -0.0147 |
| 79 | N50N45 | 1040.000 | 25.00400 | 24.99930 | 24.9954 | -0.0086 |
| 80 | N30N15 | 1425.000 | 25.19600 | 25.19310 | 25.1877 | -0.0083 |

## INTERCALIBRATED DATA ANALYSIS

Using available intercalibrated data, various calculations were made to illustrate different aspects of the physical oceanography of the Black Sea. These calculations were compared to subjective analyses of hydrophysical fields to assure the validity of the computer analysis. Computer analysis was completed on a SUN SparcStation II, using MATLAB and UNIMAP software licensed to the Woods Hole Oceanographic Institution.

**DYNAMIC HEIGHT:** Calculations of dynamic height were made using standard analysis techniques. All calculations were referenced to the 900 db level. Below this level, prior calculations have shown dynamic height contributions to be on the order of mm's. Neglect of lower levels does not affect the interpretation of these calculations. The dynamic topography at 5 db (Figure 36) depicts the major circulation within the Black Sea, including the rim current, the major sub-basin scale cyclones, plus a series of anticyclones, some permanent, rimming the basin. Additional dynamic topography plots are included in Appendix V.

**HORIZONTAL AND VERTICAL SECTIONS:** Horizontal and vertical sections of temperature, salinity, and density were made along several transects across the Black Sea to describe briefly the distribution of these properties. Results are provided in Appendix V.

## RECOMMENDATIONS FOR FUTURE

### SEVASTOPOL WORKSHOP: FEBRUARY 1992

An interdisciplinary workshop will be held in Crimea, Ukraine, in February 1992. The workshop will be held to perform the complete intercalibration of biological and chemical data, and to integrate those data with the physics. We recommend that the following take place:

- Adoption of the simpler numerical scheme identifying stations instead of the more cumbersome scheme adopted during the cruise.
- That technical reports be issued on the intercalibration of the biological and chemical data.
- That the full data sets be placed on a common computer, and analyzed jointly to examine for inter-relationships in an interdisciplinary sense.

### PUBLICATIONS

Joint publications for the HYDROBLACK '91 material will follow the general guidance of the Cruise Planning Document (see Appendix II). In general, we expect the publications to be in International as well as National journals, and will follow in several general areas:

- Basin-wide CTD results
- Coastal ocean physics and site-specific hydrography
- Interdisciplinary relationships between the different data sets: such as oxygen distribution, hydrogen sulfide distribution, suboxic zones, etc. and their relationship to the physics and biology.

The publications should be sent to the Steering Committee office, to be given a publication number for the Cooperative Marine Science Program on the Black Sea, and to be listed in summaries of Cooperative Program results. Authorship is expected to include participants from the member countries. We recommend that specific articles be outlined during the Crimea meeting in February, 1992.

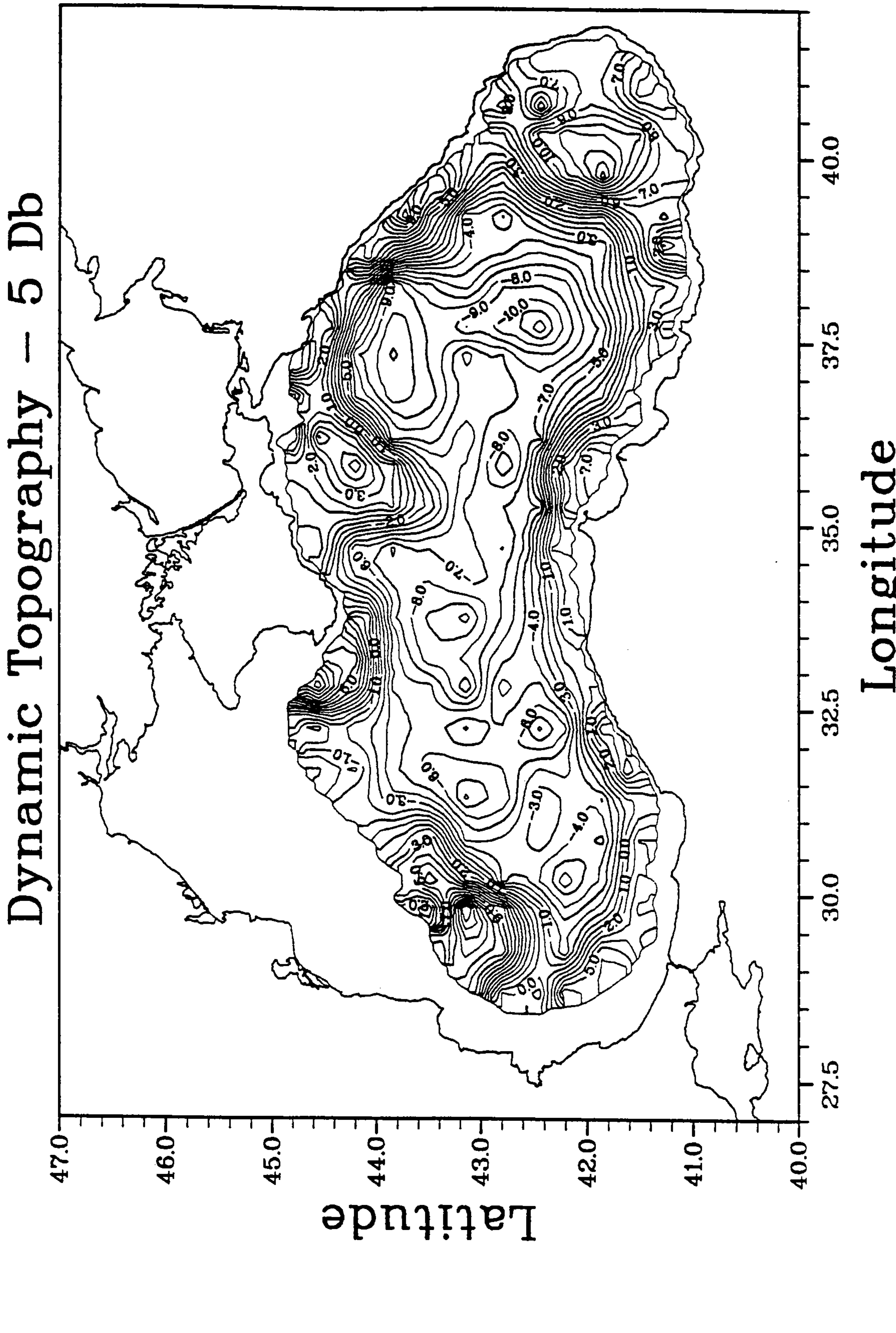



Figure 36: Dynamic topography for stations having depths exceeding 900 m. The dynamic topography is for 5 db level, referenced to 900 db.

## FUTURE HYDROBLACK EXPEDITIONS

The Hydroblack framework is an extremely useful one for basin-wide monitoring and observations. We recommend that these cruises continue on a twice-yearly basis, to provide complete seasonal data on the ocean physics, biology, geology, and chemistry. These quasi-synoptic measurements will be useful not only for basin-wide monitoring, but also for providing the framework for site-specific, process-oriented studies that will take place as part of the Cooperative Marine Science Program.

Future Hydroblack expeditions should be carried out with more complete intercalibration plans, particularly for the biological and chemical measurements. Future Hydroblack expeditions should learn from the deficiencies of HYDROBLACK '91. One goal of the February 1992 Crimea meeting should be to clarify improvements to the sampling and analysis protocol for the Hydroblack expeditions of the future.

For example, the present CTD intercalibration exercise demonstrated several deficiencies in the CTD analysis:

- The CTD's used should have accuracies on the order of that provided by the Sea Bird SBE 9. Since deep-water processes are of interest to the interdisciplinary study team, the CTD's must be accurate to full water depths of 2200 m.

- More effort should be placed on having ships take synoptic intercalibration samples in the Black Sea during the cruise. Variability in upper waters during intervals of weeks complicates the intercalibration exercise.

- Vertical bottle samples should be taken at several intercalibration stations, including bottles taken at approximately 5 depths throughout the water column. This exercise will help calibrate the individual CTD's throughout the cruise, to evaluate for drift and calibration offsets. The bottles used must be glass, and must follow a specific protocol to assure good salinities can be derived from high quality salinometers.

- Sampling density (rate, lowering speed, etc.) must be carefully adhered to, to prevent spiking near the intense chemocline. Similarly, water column sampling for chemistry and biology should be aware of the filtering effects of a heaving ship with a sampler hanging in a sharp chemocline.

Similar improvements should be derived for the other biological and chemical sampling and analysis protocols, and implemented during future Hydroblack expeditions.

Finally, additional measurements should be incorporated into future Hydroblack expeditions. For instance:

- Current meters would be useful for linkage with the dynamic height calculations, particularly for use with diagnostic numerical circulation models.

- Tracer studies, focusing on cesium and other Chernobyl products, should be incorporated to improve our understanding of mixing processes on longer time scales.

- Numerical model simulations should be incorporated to provide a feedback between model development and field data.

## REFERENCES

Fofonoff, N.P. and R.C. Millard, 1983. Algorithms for Computation of Fundamental Properties of Seawater. Unesco Technical Papers in Marine Science NO. 44, 53 pp.

Oppenheim, A.V. and R.W. Schafer, 1975. Digital Signal Processing. Prentice-Hall, Englewood Cliffs, New Jersey, 585 pp.

## ACKNOWLEDGMENTS

Hydroblack 1991 was made possible through the combined efforts of the Interim Steering Committee members of the nascent International Cooperative Marine Science Program for the Black Sea, which began planning the exercise in April, 1991. Particular thanks should be given to Dr. U. Unluata as overall cruise coordinator, and the in-country cruise coordinators Z. Belberov (Bulgaria), V. Diaconu (Romania), and V. Latun (Ukraine). R. Limeburner of WHOI helped to plan and carry out the exercise, participating on the Bulgarian/Romanian expedition aboard the R/V Akademik. In addition, the scientists and crewmembers of all the ships participating in the cruise are thanked for their hard and careful work.

P. Barrows and F. Gable helped make the arrangements for this intercalibration meeting at Woods Hole. Funding for this meeting was provided by the Vettleson Foundation and the Mobil Foundation Inc., through the Coastal Research Center of the WHOI. Funding for HYDROBLACK 1991 itself came from the individual countries, the Andrew W. Mellon Foundation (New York), the Regional Environmental Center for Central and Eastern Europe (Budapest), and the National Science Foundation of the U.S.A.

Wayne Spencer aided during the intercalibration exercise. Nordeen Larson of Sea Bird also provided valuable assistance in interpreting CTD problems with the Akademik CTD. Their help is gratefully acknowledged.

# APPENDIX I:

## WORKSHOP AGENDA

HYDROBLACK 1991

INTERCALIBRATION MEETING

1-10 DECEMBER 1991

SCHEDULE

30 Nov - 1 Dec.: Arrival of participants to Woods Hole

Monday, 2 Dec. 0800 Arrival in Clark 257

Agenda: Discuss goals of intercalibration exercise.
Agree on strategies for intercalibration exercise
Show preliminary results of some intercalibration procedures
Discuss programming languages, plotting packages, etc.
View intercalibration issues on computer screen: evaluate techniques for filtering, wild-point editors, etc.
Discuss bottle samples versus ship intercalibration procedures
Enter Parshin data to SUN workstation

Evening: Free. Shopping as required.

Tuesday, 3 Dec. 0800 Arrival in Clark 257

Agenda: Complete programming for filtering, spike-removal, and determine intercalibration constants.
Apply intercalibration to all stations

1800: Dinner at Aubrey's

Wednesday, 4 Dec. 0800: Arrival in Clark 257

Agenda: Complete intercalibration for all stations.
Prepare horizontal and vertical sections of hydrographic parameters, to evaluate the success of the intercalibration. Examine and correct for poor intercalibration
Add available chemical and biological data to data base. Examine the interrelationships between these data.

Evening: Free. Shopping in Town, touring, etc.

Thursday, 5 Dec. 0800: Arrival at Clark 257

Agenda: Calculate dynamic heights for all intercalibrated stations. Reference to 1000 m depth.

Plot hydrophysical fields, including T-S diagrams, sections, etc. Discuss deep sea and shelf circulation patterns, water masses.

Begin final plots and writing for technical report: Intercalibration study.

Evening: free.

Friday, 6 December 0800: Arrival at Clark 257

Agenda: Complete technical report draft.

Evening: Cocktail party at Aubrey's.

Saturday, 7 December 0800: Arrival at Clark 257 (Pick-up: no shuttle service)

Agenda: Outline paper(s) on HYDROBLACK 1991: discuss science issues. For example, discuss articles on water masses, general circulation, relationships to oxygen/chemoclines, shelf mixing processes, etc.

Evening: Free

Sunday, 8 December Possible tour of Cape Cod or trip to Boston.

Monday, 9 December 0800: Arrival at Clark 257

Agenda: Discuss science issues.

Evening: Free

Tuesday, 10 December 0800: Arrival at Clark 257

Agenda: Review Technical Report on Intercalibration exercise. Finalize report.

Wednesday, 11 December Depart Woods Hole

# APPENDIX II:

# HYDROBLACK 91 CRUISE PLAN

APPENDIX II

# HYDROBLACK-1991

# INTERNATIONAL RESEARCH CRUISE

# ON HYDROGRAPHY OF THE BLACK SEA

## CRUISE PLANNING

JULY 1991

# 1. SCIENTIFIC OBJECTIVIES OF HYDROBLACK-1991

The existing scientific studies on the Black Sea oceanography indicate that the major physical, chemical and biological processes are poorly understood and further studies are essential. There is growing recent evidence that the environmental conditions of the sea are changing. It is timely to carry out multi-institutional interdiciplinary studies on the oceanography of the Black Sea because the problems to be adressed have regional importance, their solutions are of practical consequence, and they require coordinated research efforts between neighboring countries.

Dynamical characteristics of the Black Sea are influenced by winds and density differences due to heating/cooling, evaporation, precipitation, inflow/outflow from straits and the river run-off. All these sources act on the Black Sea and contribute to its temporally and spatially complex pattern of circulation. The circulation consists of a permanent cyclonic rim current complicated by a field of eddies, intense jets, filaments and meandering currents along the coasts. The circulation seems to have both transient and stationary components: at times the mesoscale variability appears to mask the general circulation.

In the Black Sea, the so-called Cold Intermediate Water mass is formed in the northwestern shelf region as well as in the upwelled waters of the basin's interior. Neither the process of formation (e.g. intensity and patchiness of convection events) nor the subsequent spreading, mixing and transformation characteristics of this water mass are clearly understood and deserve further scientific studies.

The overall scientific objective for the Black Sea oceanographic studies is to establish a definitive phenomenology to understand and quantify the roles of the fundamental physical processes and their impact on the biology and chemistry of the Black Sea. The results will form a better understanding of the transport and dispersion of material, the biological productivity of the basin, the efficient utilization of marine resources and environmental management including the control of pollution. The following are some specific problems that need to be adressed to achieve this objective:

* intercomparison of the main forcing mechanisms; the wind versus thermohaline forcing, source/sink flow through

straits as reflected in the spatial as well as seasonal and interannual variability and budgets,

* the role played by the topography and the irregular coastline,

* characteristics of the convection processes associated with the Cold Intermediate Water formation and its subsequent sinking, spreading and mixing,

* identification of the major features of circulation, its variability, energetics and basic space and time scales,

* analysis of available historical data sets and satellite imagery (both AVHRR and CZCS),

* determination of the dissolved oxygen and hydrogen sulfide concentrations and the features of the oxic/anoxic interface,

* the influence and implications of the circulation on the distribution of biological and chemical properties,

* determination of important sources and sinks of nutrients and the role of eddies in the nutrient transport and primary productivity,

* determination of horizontal and vertical material fluxes within the sea and their variability

* investigation of the primary biogeochemical processes of the euphotic and aphotic zones of the water column,

* impact of eddies and other features of circulations on fisheries through recruitment and/or production,

The program will contain not only hydrographic and biochemical measurements, but also remotely sensed data to aid in the interpretation of the hydrophysical measurements as well as numerical modelling studies to motivate a better understanding of the dynamical background of the physical processes.

## 2. ELEMENTS OF THE HYDROBLACK-1991 RESEARCH PROGRAM

In order to achieve some of the scientific objectives specified in the previous section, a basin-wide multi-institutional survey is planned during September 1991. The survey is aimed to quantify the spatial distribution of important physical and biochemical parameters and their interrelations with the mesoscale features (eddies, jets and filaments, etc.). The objectives listed above can be accomplished by the determination and/or measurement of the following parameters:

### Meteorological Measurements

The following meteorological parameters will be measured aboard each ship:

1. Time (GMT; Greenwich Mean Time)
2. Location (latitude/longitude, using GPS if possible)
3. Air temperature (degrees Celsius)
4. Humidity (Relative humidity, dew point or wet bulb)
5. Wind speed and direction (m/sec, degrees from north)
6. Atmospheric pressure (millibars)
7. Sea surface temperature (degrees Celsius)

These measurements will be made every three hours starting from 00.00 GMT. Parameters 3 through 5 should be measured as closely as possible to the 10m height as required by bulk flux formulae. Additional measurements could be helpful but are not required.

### Physical Measurements

The station network for the HydroBlack-1991 September survey is shown in Figure 1a,b. The CTD stations (Figure 1a) are located on a grid with spacing of 1/3° latitude (20 miles) and 1/2° longitude (about 22 miles). CTD measurements (depth versus temperature and conductivity) will be obtained up to a nominal depth of 1000m excluding the predetermined intercalibration stations and one out of every third deep station, where the measurements will extend to the bottom (about 2000m). CTD system should be lowered at a rate of about 0.5 m/sec and data should be collected during downcast.

The raw CTD data obtained for all stations shall be processed by each party in the form of pressure, temperature, salinity, sigma-t. The processed data must be in bin-averaged form at 1 db pressure intervals.

**Biochemical measurements**

The biochemical parameters (Table 1) will be measured at the stations shown in Figure 1b. Dissolved oxygen, hydrogen sulfide, phosphate, nitrate and chlorophyl-a are the main parameters to be measured in the HydroBlack-1991 program. The other parameters listed in Table 1 are optional.

Biochemical measurements are carried out at smaller number of stations along selected transects. These transects will be chosen before the cruise in the regions where important physical variability is anticipated. The water samples should be taken with the Rosette samplers at prespecified depth levels depending on the biological and chemical quantities desired. The standard depth levels specified for this study are 5m, 20m, 50m, 75m, 100m, 125m, 150m, 200m, 250m, 300m, 400m, 500m, 750m, 1000m, 1250m, 1500m, 1800m and 2000m.

Secchi disk depths will be measured at all of the CTD stations.

**Intercalibration requirements**

Intercalibration constitutes an essential component of the HydroBlack-1991 program. All measurements should be carried out with calibrated instruments. Meteorological instruments should be calibrated with the local meteorological service before the cruise. CTD sensors should be calibrated before the cruise by the manufacturer.

Intercalibration stations are selected for the comparison and intercalibration of the different sets of instruments used in each joint researh area. These stations should ideally be occupied simultaneously by the individual ships but a resonable time lag between the measurements would have to be allowed. The uniform properties of the Benthic Boundary Layer (about 400m deep) near the bottom forms an ideal environment for the intercalibration of the physical measurements.

Integration of the CTD observations from different profilers requires an estimate of the error associated with each CTD profiler. Salinity values will be calibrated against salinometer in Woods Hole Oceanographic Institution (WHOI).

For this purpose, one 100 ml water sample will be taken during the upcast at a depth where temperature and salinity are vertically homogeneous . Salinity sample bottles will be provided by WHOI. The following information should be recorded at each station: Station name, Time & Date (GMT), CTD pressure, CTD temperature, CTD conductivity, CTD salinity (three decimal places), and the sample bottle number. After the cruise, the water samples and a copy of the station log will be sent to Dave Aubrey at WHOI where the bottle salinity will be measured with the high quality salinometer. The in situ true conductivity will then be calculated from the CTD pressure and temperature, and the bottle salinity. The difference between the in situ true conductivity and the CTD conductivity is the sensor error. Systematic errors can later be used to correct the raw conductivity.

For the intercalibration of nitrate, phosphate and chlorophyll-a, standard water samples will be provided by the Institute of Marine Sciences, Erdemli-Turkey. These samples will be distributed amongst parties prior to the cruise, if possible.

**Remote Sensing**

The HydroBlack-1991 program will also be supported by the remote sensing facilities of the participating institutions. Woods Hole Oceanographic Institution (USA), Marine Hydrophysical Institute - Ukranian Academy of Sciences (USSR) and Institute of Marine Sciences - Middle East Technical University (TURKEY) will provide the AVHRR (infrared) imagery for the Black Sea. The imagery will include a sequence of pictures that will describe the temporal evolution of the features in the sea. A period of about one month starting from one week before the survey and ending a week after the end of the survey is accepted as the optimum period for the coverage of the AVHRR data.

The Institute of Marine Sciences - Middle East Technical University will attempt to provide the real time AVHRR infrared and visible satellite data through the Automatic Picture Tranmission (APT) system in use at Erdemli campus (APT System gives three AVHRR pictures of the Black Sea per day with the 4km x 4km pixel resolution).

## Data Exchange

The processed CTD data sets (i.e. one meter bin-averaged and converted to the form of pressure, temperature, salinity and density) will be exchanged between all participating groups in the form of ASCII files on IBM compatible 5.25 or 3.50 inches flexible diskettes. The precise format of the CTD data is given in Table 2. The CTD data will be exchanged at Varna-BULGARIA during the Workshop on the Black Sea to be held at the end of September, 1991.

A workshop is planned in November 1991 to pool all the CTD data, make a collective data set and carry out the cooperative and synthetic scientific analysis. For this purpose, the quality control of the CTD data sets will be first checked for instrument error. They will then be intercalibrated with respect to bottle-calibrated CTD measurements and by other means which will be set during the workshop. The final form of the pooled data set will contain pressure, potential temperature, salinity and sigma-theta.

The place and time of the November 1991 workshop will be decided by the Steering Commitee of the Black Sea programme during the Varna meeting.

Because a major part of the biochemical samples requires laboratory analyses, exchange of the biochemical data will be done within three months following the completion of the cruise. It is also exchanged in the form of ASCII files on the IBM compatible 5.25 and 3.50 inches diskettes. Considering the difficulty in assigning a common format for the data exchange of biochemical parameters, the form of the data will be decided individually by each party. A brief description of the format should,however, be provided together with the diskettes.

For a period of three years after exchange, the data will be considered to be property of the party collecting the data, and can not be published by another party without permission of the responsible party . Joint publications are encouraged. After three years, the complete data set will be considered common property of the participating institutions.

## Publications

On the basis of the data gathered during HydroBlack-1991 survey, a series of joint publications will be produced within the first three years. These joint publications will bear the name of scientists actively participating in the HydroBlack-1991 program. They will be prepared in English and submitted to peer-reviewed oceanographic journals. Additional articles may also be prepared in the native languages of each party.

Exchange of scientists between the participating groups is desirable for previewing and evaluation of the data and the preparation of joint articles. The time and place of these meetings will be decided by the organizing committee of the HydroBlack-1991 program and is subject to the availability of funds.

## 3. DETAILED CRUISE PROGRAM

The station network presented in Figure 1a,b is covered by six ships. The name of the ships, cruise coordinators and the chief scientists assigned for each ship are given in Table 3. The equipment available on board for each ship are listed in Table 4. The cruise schedule for the ships is planned such that a quasi-synoptic results are achieved. The survey period will start within the first week of September, 1991 and is expected to continue not more than two weeks. Approximate dates of starting the survey for each ship are given in Table 5. The locations of stations which will be visited by each party are listed in Table 6.

Each ship will cover a certain region (Figures 2-4) but there are some overlapping stations which will be visited by more than one ship during the survey. These common stations are essential for intercalibration purposes.

Areas of responsibility assigned for each ship are shown in Figures 2-4. Figure 2a shows a total of 138 CTD stations to be visited by the Soviet ships. The R/V Vodyanitsky will cover 72 CTD stations situated within the northeastern part, the R/V Kolesnikov will cover 36 CTD stations in the central part of the Black Sea and the R/V Gakkel is planned to work at 40 stations situated in the northwestern shelf area.

The R/V Vodyanitsky and the R/V Kolesnikov will visit 5 common stations located along 34°45' longitude. Similarly, the R/V Kolesnikov and the R/V Gakkel will have 2 common stations located along the continental slope of the northwestern Black Sea. The R/V Vodyanitsky and the R/V Kolesnikov will also have three intercalibration stations with the Turkish ships the R/V Bilim and the R/V K. Piri Reis.

Figure 2b shows the selected transects for the biochemical measurements carried out by the Soviet ships. There are 36 biochemical stations for R/V Vodyanitsky, 20 for R/V Kolesnikov and 18 for R/V Gakkel. As shown in Figure 2b, some of these stations are the common stations for the intercalibration/intercomparisision purposes.

Figure 3a displays CTD stations (a total of 126) which will be visited by the Turkish ships. The R/V Bilim will cover 76 stations within the eastern and central parts of the study area. The R/V K. Piri Reis will work on the western part (60 stations). The R/V Bilim has two intercalibration stations with the R/V Vodyanitsky, and two with the R/V

Kolesnikov. The R/V Bilim and the R/V K. Piri Reis will have 10 common stations.

Figure 3b shows the selected transects for the biochemical stations. There are 33 stations for the R/V Bilim and 27 stations for the R/V K. Piri Reis. The common stations are also indicated in Figure 3b.

Figure 4a shows the CTD stations (a total of 57) which will be covered by the R/V Akademik. As indicated above, there are some stations which will also be visited by other ships (e.g. RV K. Piri Reis, RV Kolesnikov, RV Gakkel).

Figure 4b displays the biochemical stations (a total of 32) studied by the R/V Akademik.

RV Bilim and RV Akademik have been assigned as the mother ships responsible for ship to ship communications during the survey. RV Bilim will be responsible for the communication on the daily operations of the RV Vodyanitsky and RV Kolesnikov. RV Akademic will carry out the same task with the RV Gakkel and RV K. Piri Reis. A Single side band will be assigned for this purpose. Ship to ship communications will be done twice a day at 0600 and 1400 GMT hours.

Starting date of the ships to the survey must be informed to other institutions. Institutions will be responsible to inform the others of the stations occupied by their ships every three days.

**TABLE 1**

**LIST OF BIOCHEMICAL PARAMETERS**

| parameters | stations | Amount sample required | depth levels | method & instrument | notes |
|---|---|---|---|---|---|
| Dissolved Oxygen ($O_2$) | every 3rd st. | 300 mL | 12 (0-200m) | winkler | (1) |
| Hyd. sulphide ($H_2S$) | every 3rd st. | 300 mL | 11 (75-1000m) | titration | (2) |
| Nutrients ($NO_3$, o-$PO_4$) | selected transects | 1 L | 14 (0-1000m) | autoanalyzer | (3) |
| Chlorophyll-a | every 3rd st. | | (0-100m) | | (5) |
| (a)in situ | | | continuous | fluorometer | |
| (b)water sampling | | 3 L | 5 levels | spectrophotometer | |

**Optional Parameters**

| parameters | stations | Amount sample required | depth levels | method & instrument | notes |
|---|---|---|---|---|---|
| Diss. Org. Car. (DOC) | selected stations | 100 mL | 14 (0-1000m) | autoanalyzer | (3) |
| Part. Org. Car. (POC) | selected stations | 10 L | 4 (0-500m) | CHN analyzer | (4) |
| Part. Org. Car. (PON) | selected stations | 10 L | 4 (0-500m) | CHN analyzer | (4) |
| Total Suspend. Sediment (TSS) | selected stations | 1 L | surface | gravimertry | |
| Eh & pH | selected stations | 300 mL | 9 (0-1000m) | pH-meter | (6) |
| phyto-plankton | selected stations | 1 L | surface | microscobe | |
| zoo-plankton | selected stations | 1 L | surface | microscobe | |

| Heavy metals | selected stations | 1 L | surface | atomic absorption |
|---|---|---|---|---|

(1) 12 depth levels; 7 of these corresponds to the standard depth levels (0m, 20m, 50m, 75m, 100m, 150m, 200m). The rest will be finer resolution near the oxic/anoxic interface which is predetermined and/or guessed by other means (e.g. by direct oxygen measurements with CTD probe). The depth of 8° C isotherm below the Cold Intermediate Layer might be a resonable depth level for starting the fine sampling.

(2) At the same stations with the dissolved oxygen and at 11 standard depth levels between 75m and 1000m (75m, 100m, 125m, 150m, 200m, 250m, 300m, 400m, 500m, 750m, 1000m). Additional water samples are taken near the oxic/anoxic interface with finer resolution.

(3) At 14 standard depth levels between 0m and 1000m (0m, 20m, 50m, 75m, 100m, 125m, 200m, 250m, 300m, 400m, 500m, 750m, 1000m).

(4) At 4 depth levels (20m, 100m, 200m, 500m).

(5) At 5 standard depth levels between 0m and 100m (0m, 20m, 50m, 75m, 100m). In the discrete water sampling, standard spectrophotometric method will be employed by using GFC or GFF Whatman glass fiber filters.

(6) At 10 depth levels between 0m and 1000m (0m, 20m, 50m, 100m, 150m, 200m, 300m, 500m, 750m, 1000m).

**TABLE 2**

**The Format of a CTD data file**

First line: Latitude in Degrees Minutes and Seconds
Second line: Longitude in Degrees Minutes and Seconds
Third line: Date and starting time for measurements;
(In the form of MONTH DAY YEAR HOURS MINUTES)
FOR EXAMPLE: 09 11 91 14 15
Fourth line: The total depth at the station (in meters)
Fifth line: The Secchi disk depth (in meters)
(In the case of no Secchi disk depth data for the station, this line should be a blank line)
Sixth line: blank
Seventh line: First line of the data set. Its form is:
(PRES. (Db), TEMP. (Deg C), SAL. (ppt), SIGMA-T)
Eighth line: Second line of the data set
: :
: :
: :

The following format will be used for the data

```
First line:    FORMAT(3I2)
Second line:   FORMAT(3I2)
Third line:    FORMAT(5(I2,2X))
Fourth line:   FORMAT(F5.0)
Fifth line:    FORMAT(F4.1)
Sixth line:    FORMAT(1X)
Seventh line:  FORMAT(I4, 3(1X,F7.4))
Eighth line:      "
      :           "
      :           "
```

In addition to the CTD data files for each station, there must be an ASCII file giving short descriptions for instruments, measurement techniques, the data processing procedure, etc.

TABLE 3

Ships, Cruise Coordinators and Chief scientists

| Nationality | Ship | Chief Scientist | Cruise Coordinator |
|---|---|---|---|
| Bulgaria | R/V Akademik | A. Konsulov & D. Aubrey | Z. Belberov |
| Romania | None | | V. Diaconu |
| Turkey | R/V Bilim | T. Oguz | U. Unluata |
| | R/V K. Piri Reis | T. Konuk | U. Unluata |
| U.S.A. | None | | D. Aubrey |
| U.S.S.R. | R/V Kolesnikov | V. Latun | V. Latun |
| | R/V Gakkel | unknown | V. Latun |
| | R/V Vodyanitsky | unknown | V. Latun |

**TABLE 4**

**Equipment available in the ships for HydroBlack-1991**

| Ship | CTD probe | Rosette sampler | Winkler Tit. syst. | Auto-analyzer | Fluoro-meter |
|---|---|---|---|---|---|
| RV BILIM | SeaBird SBE-9 | General Oceanics | semi-automatic (Hydro-Bios) | Technicon multichan. | Navitronic Q-200 |
| RV K. PIRI REIS | Seabird SBE-9 | General Oceanic | semi-automatic (Brand) | Skalar multichan. | not available |
| RV AKADEMIK | Neil Brown | not available | conventional lab. technique | not available | not available |
| RV VODYA-NITSKY | Seabird SBE-9 | ? | ? | ? | ? |
| RV KOLESNIKOV | SBE-19 or SBE Sealogger | ? | ? | ? | ? |
| RV GAKKEL | SBE-19 or SBE Sealogger | ? | ? | ? | ? |

## TABLE 5

**Starting dates to HydroBlack-1991 survey for the ships**

| | |
|---|---|
| R/V BILIM | September 1, 1991 |
| R/V K. PIRI REIS | September 5, 1991 |
| R/V AKADEMIK | September 3, 1991 |
| R/V KOLESHNIKOV | ? |
| R/V GAKKEL | ? |
| R/V VODYANITSKY | ? |

# APPENDIX III:

# CTD DESCRIPTIONS

## HYDROPHYSICAL SOUNDING COMPLEX MHI 4102 (ISTOK)

TECHNICAL CHARACTERISTICS
The device has the following data channels:
- temperature data channel
- el.conductivity data channel
- hydrostatic pressure data channel
- channel of control code formation (pilot channel)

| Channel | Range | Sensitivity | Accuracy | Output Code |
|---|---|---|---|---|
| Temperature | -2-(+35)°C | 0.0025°C | P=0.95, ±0.025°C | binary, 14 - digit |
| Conductivity (1st subrange) | 1.5-5.5S/m | 0.00025 S/m | P=0.95, | 14 binary, |
| (2d subrange) | 2.5-6.5 S/m | | ±(0.0002+3*10 ) S/m | 14 - digit |
| Hidrostatic | 0-60 MPa (Pmax) | 0.025%* | P=0.95, ±0.5%*(Pmax) | binary, consecutive 13 - digit |

Time of each parameter measurements is not more than 0.0625s. Discontinuity of each parameter measurements is not more then 0.25s. Heat inertia of the initial temperature-transformer-meter is not more then - 0.05s. Maximum lowering depth - 6000m

Dimensions of the device:
diameter - 600mm
height - 820mm
weight - 100kg

Input voltage 220 ± 20V , 50 ± 25Hz
Required power 70Wattt
Communication is provided by the carrying single cable (length 6,500m)
Environmental temperature - (-2)-(+40)°C
Relative humidity - up to 80% by 27°C
16 sample bottles are attached to the device. Single bottle volume is 1 l.

Data Recording

- binary and decimal code reflection on the informational panel;
- the information is carried to a personal computer.

Researcher : MHI, UkSSR Academy of Sciences, L.A.Koveshnikov.

The observations of the Secchi disk depth were performed with help of the standard white disk ( 0.3m diameter). Researcher : MHI, UkSSR Academy of Sciences, B.N.Krasheninnikov.

## CTD UNDERWATER UNIT SeaBird SBE 9

TECHNICAL CHARACTERISTICS

The SBE 9 underwater units include temperature, conductivity and pressure sensors. Resultant data in Manchester Code is transmitted to the Deck unit. Twelve ASCII HEX characters representing six bites are transmitted per CTD scan.

The format for CTD scan is :

ttttccccpppp

tttt four HEX characters representing 2 bytes of temperature data
cccc four HEX characters representing 2 bites of conductivity data
pppp four HEX characters representing 2 bites of pressure data.

| Sensor | Range | Resolution | Accuracy | Response Time |
|---|---|---|---|---|
| Temperature | -5 +35 deg C | 0.0003 deg C | +/- 0.003 deg C | 0.082 sec (0.5 m/sec drop) |
| | | | | 0.070 sec (1.0 m/sec drop) |
| Conductivity | 0-7 S/m | 0.00004 S/m | +/- 0.0004 S/m | 0.084 sec (0.5 m/sec drop) |
| | | | | 0.070 sec (1.0 m/sec drop) |
| Depth | 0-6000 m | 0.004 % | +/- 0.02 % | 0.001 sec |

Weight: 24 kg in air , 15 kg in water

Size: 1.1 m x 0.2 m x 0.3 m

Communication is provided by single cable with length 7000m - Akademik, 1860 m - Bilim and 2200 m -Piri Reis.

## CTD UNDERWATER UNIT SeaBird SBE 19

### TECHNICAL CHARACTERISTICS

The SBE 19 underwater units include temperature, conductivity and pressure sensors. Data were stored in Random Access Memory, and uploaded to a microcomputer on board the ship.

| Sensor | Range | Resolution | Accuracy | Response Time |
|---|---|---|---|---|
| Temperature | -5 +35 deg C | 0.001 deg C | 0.01 deg C/mo. | |
| Conductivity | 0-7 S/m | 0.0001 S/m | +/- 0.001 S/m/mo. | |
| Depth | 0-2000 m | 0.05 % | +/- 0.5 % | |

## HYDROPHYSICAL SOUNDING COMPLEX "HYDROZOND".

TECHNICAL CHARACTERISTICS
The device has the following data channels:
- temperature data channel
- el.conductivity data channel
- hydrostatic pressure data channel

| Channel | Range | Sensitivity | Accuracy | Output Code |
|---|---|---|---|---|
| Temperature | -2-(+32)°C | 0.01°C | P=0.95, ±0.03°C | binary, 12 digits |
| Conductivity | | | | |
| (1st subrange) | 0.5-3.5 S/m | 0.001 S/m | P=0.95, | binary, 12 digits |
| (2nd subrange) | 3.5-6.5 S/m | ±(0.0035) S/m | | |
| Hidrostatic | 0-3.8 MPa | 0.01MPa | ±0.04MPa | binary, |
| | 3.8-19.2MPa | 0.01MPa | ±0.2MPa | consecutive |
| | 19.2-60.0MPa | 0.02MPa | ±0.6MPa | 12 digits |

Time of each parameter measurements is not more than 0.064s. Discontinuity of each parameter measurements is not more then 0.32s. Heat inertia of the initial temperature-transformer- meter is not more then - 0.5s. Maximum lowering depth - 6000m

Dimensions of the device:
diameter - 601mm
height - 736mm
weight - 63kg

Input voltage - 220 Ò 20V , 50 Ò 25Hz
Required power - 300Wt
Communication is provided by the carrying single cable (length 4.000m)
Environmental temperature - (-2)-(+40)˜C
Relative humidity - up to 80% by 27˜C
24 sample bottles are attached to the device. Single bottle volume is 1 l.

Data Recording

--------------

- binary and decimal code reflection on the informational panel;
- the information is carried to a personal computer.

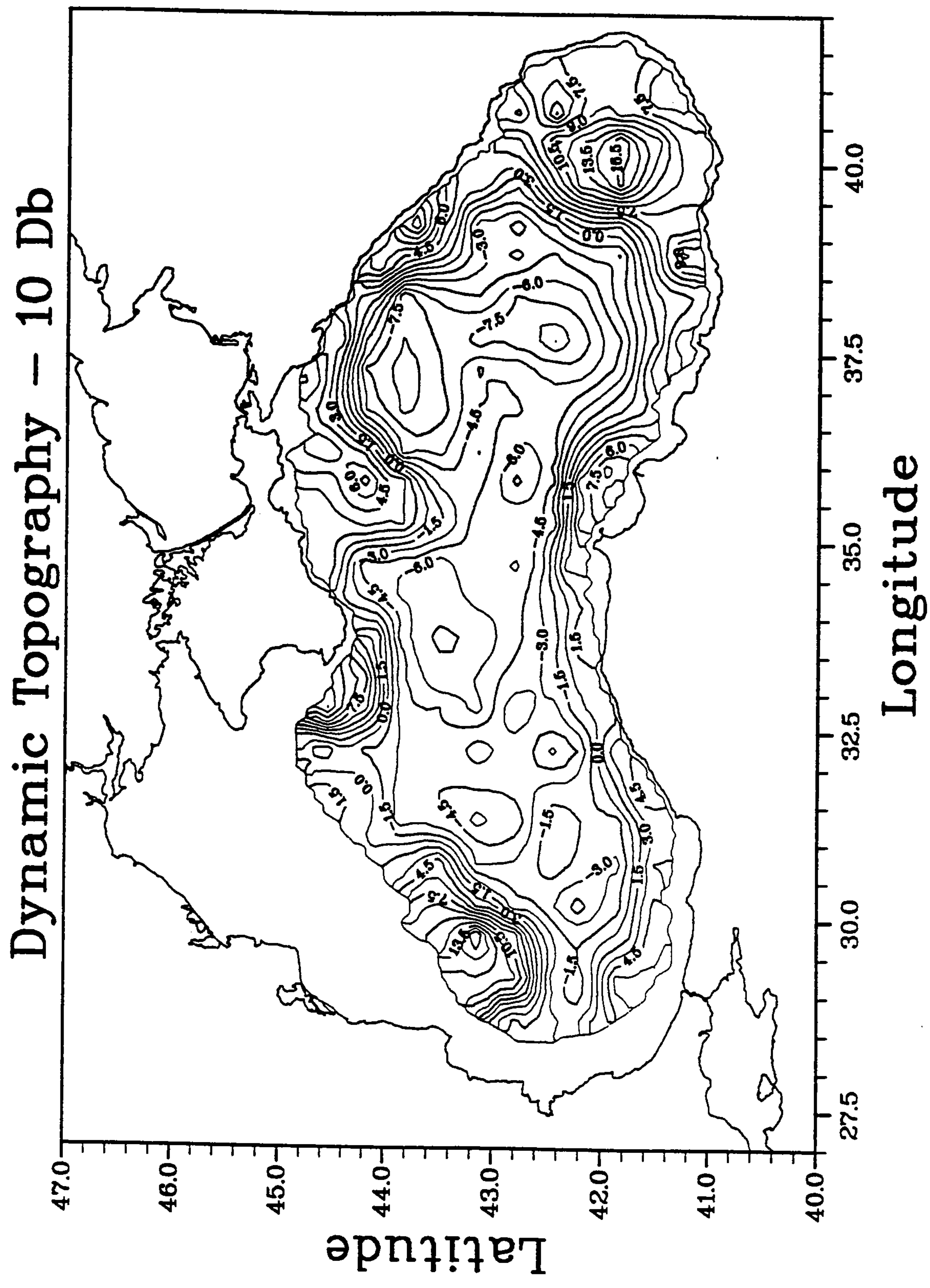
Researcher : SOIN, UkSSR Academy of Sciences, L.V.Matsokin.

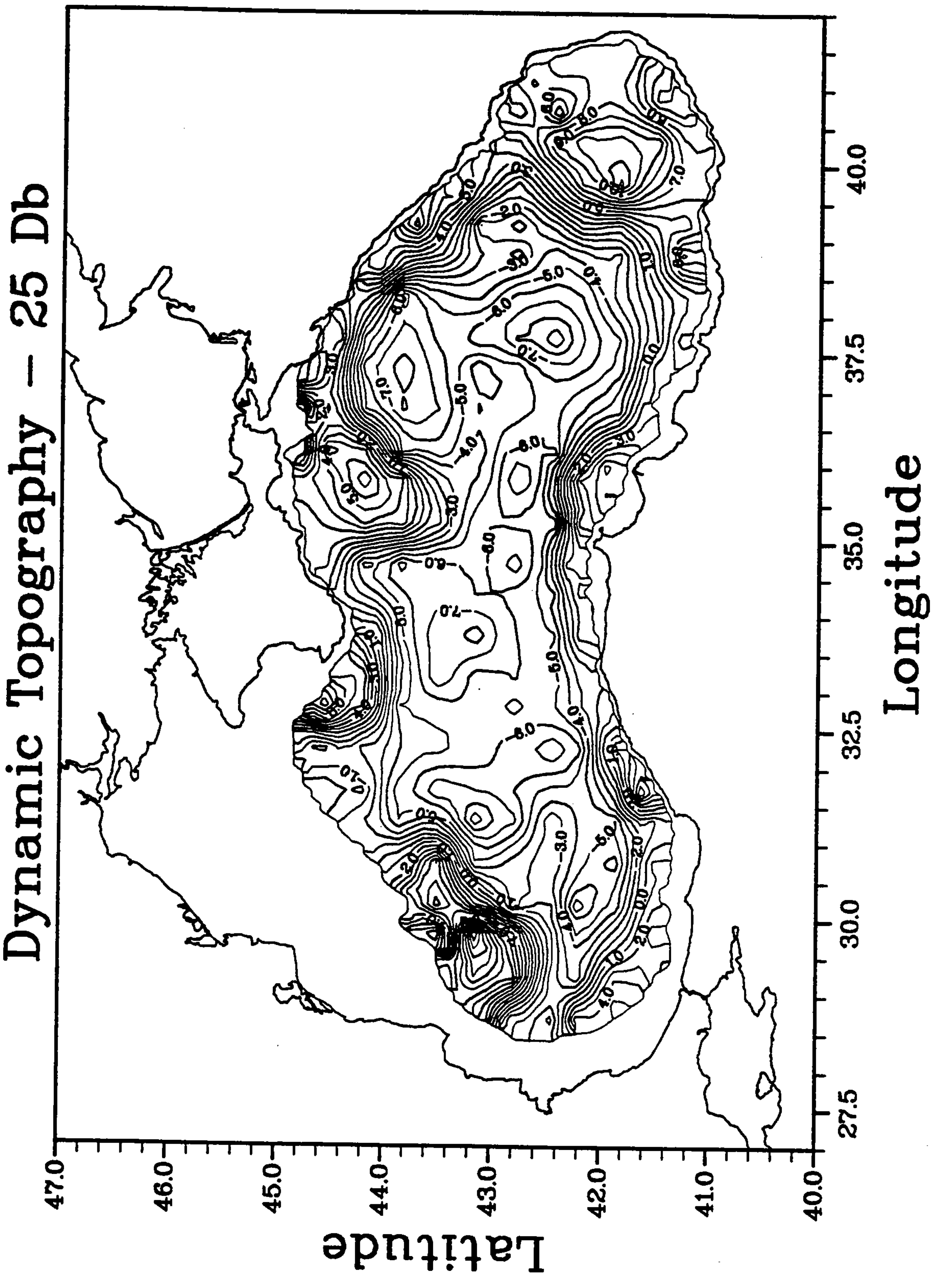
The observations of the Secchi disk depth were performed with help of the standard white disk ( 0.3m diameter).
Researcher : SOIN, UkSSR Academy of Sciences, V.V.Sidelnikov.

# APPENDIX IV:

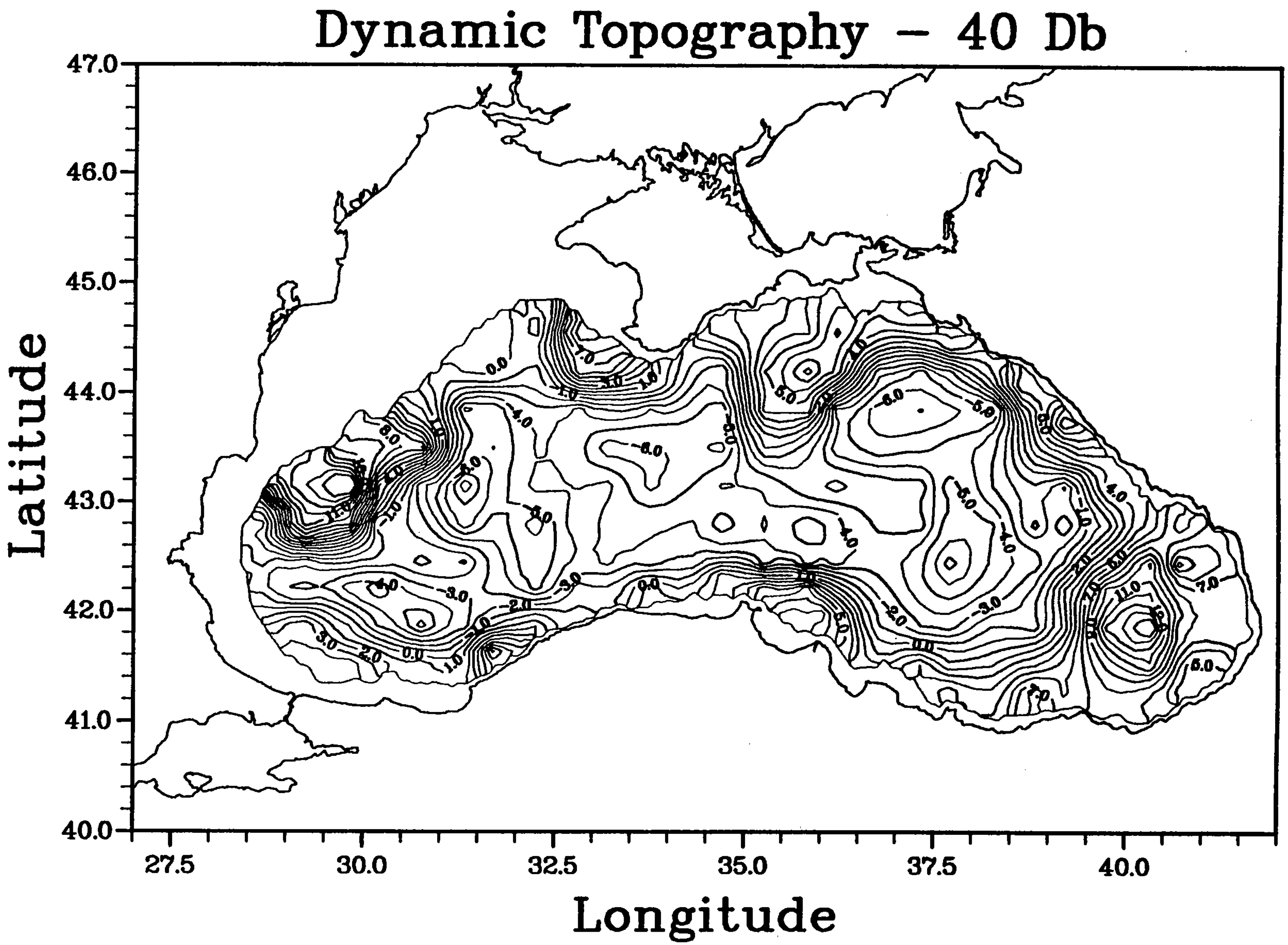
## DYNAMIC HEIGHTS REFERENCED TO 900 db

### Intercalibrated Results


Dynamic Topography - 10 Db
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
40.0
41.0
42.0
43.0
44.0
45.0
46.0
47.0

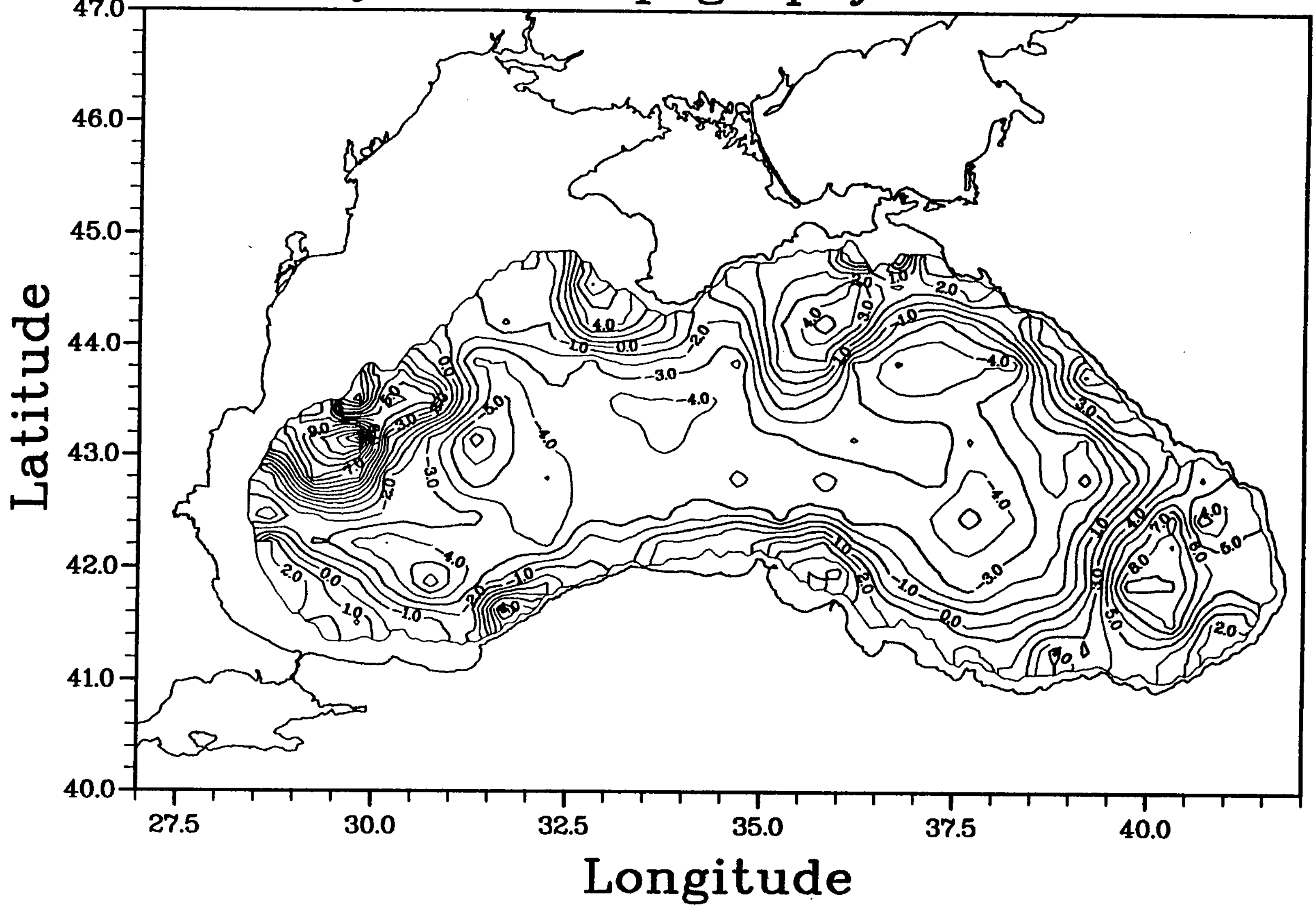


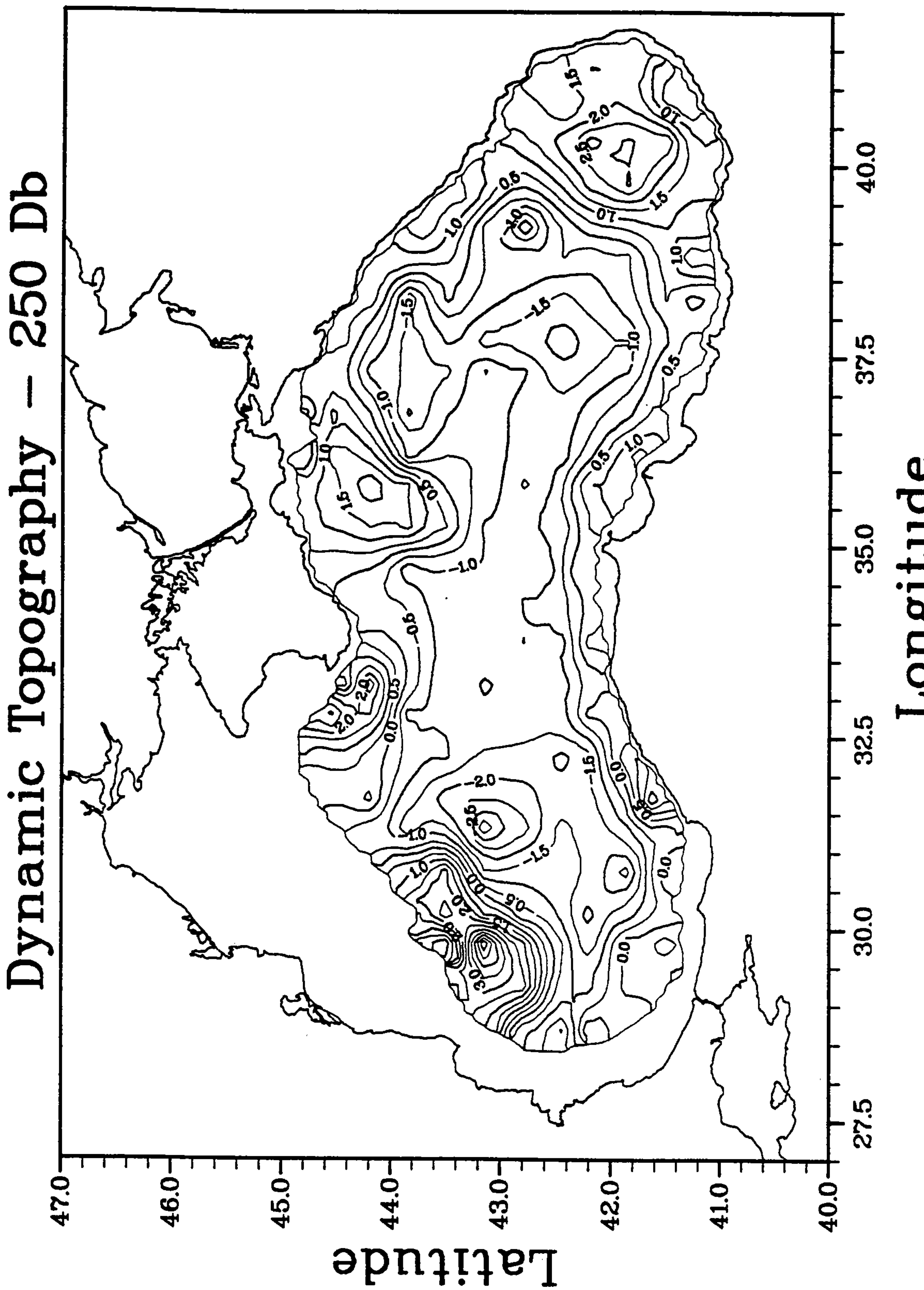
Dynamic Topography - 25 Db
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
40.0
41.0
42.0
43.0
44.0
45.0
46.0
47.0

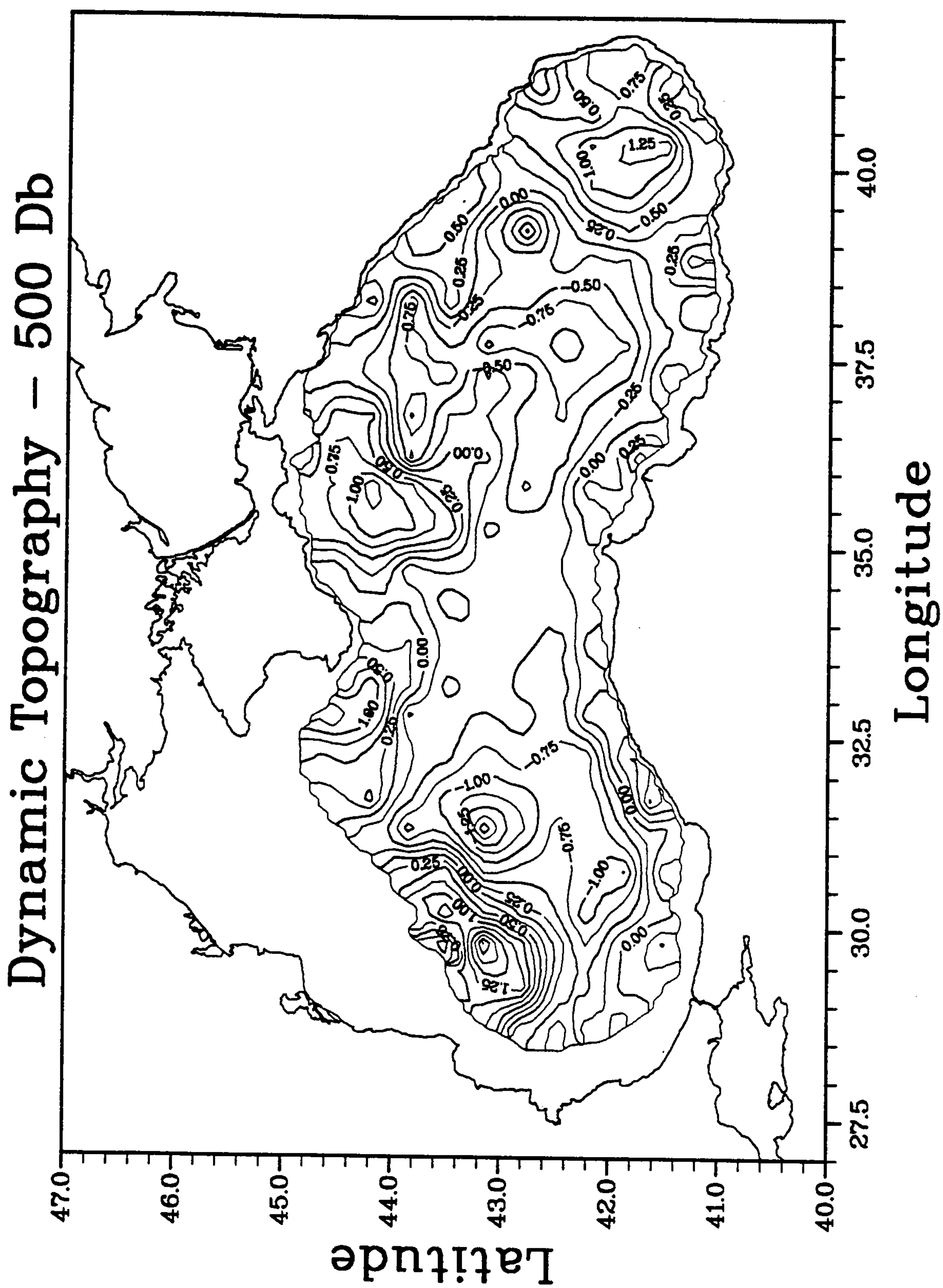


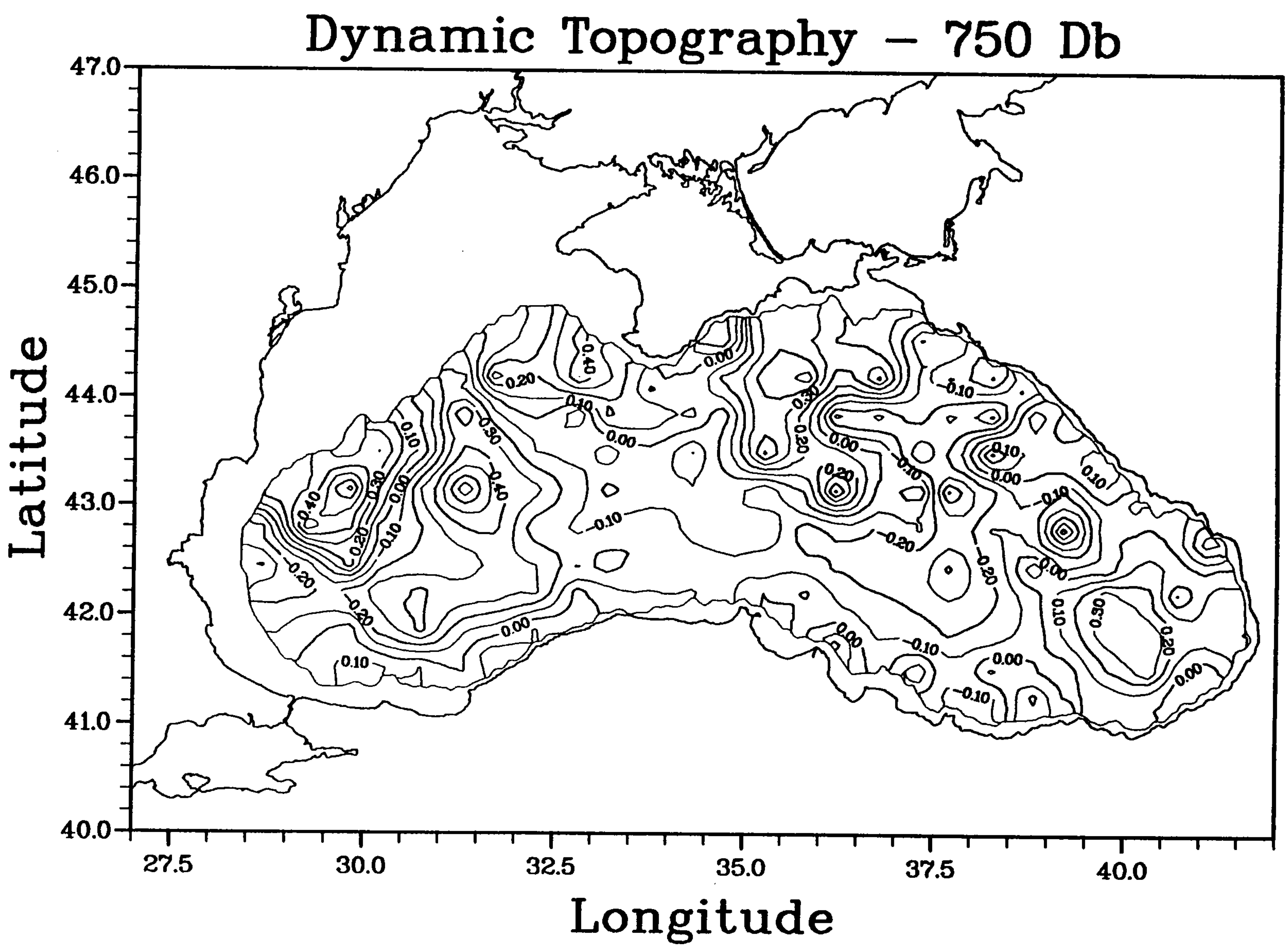
Dynamic Topography - 40 Db
Latitude
Longitude
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
27.5
30.0
32.5
35.0
37.5
40.0

# Dynamic Topography – 100 Db

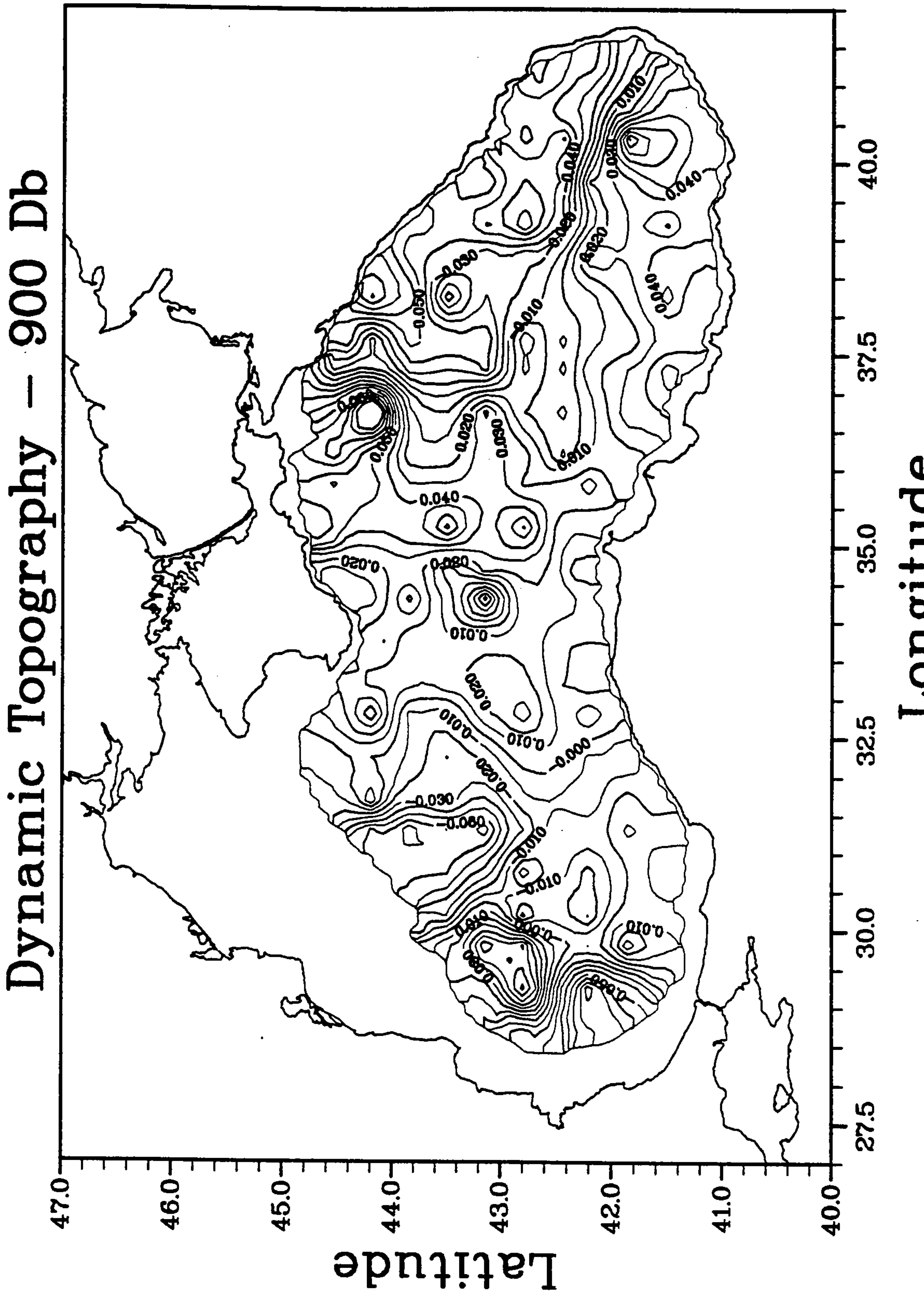



Dynamic Topography – 250 Db
Longitude
27.5
30.0
32.5
35.0
37.5
40.0
Latitude
40.0
41.0
42.0
43.0
44.0
45.0
46.0
47.0


Dynamic Topography - 500 Db
Longitude
27.5
30.0
32.5
35.0
37.5
40.0
Latitude
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0



Dynamic Topography - 750 Db
Latitude
Longitude
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
27.5
30.0
32.5
35.0
37.5
40.0



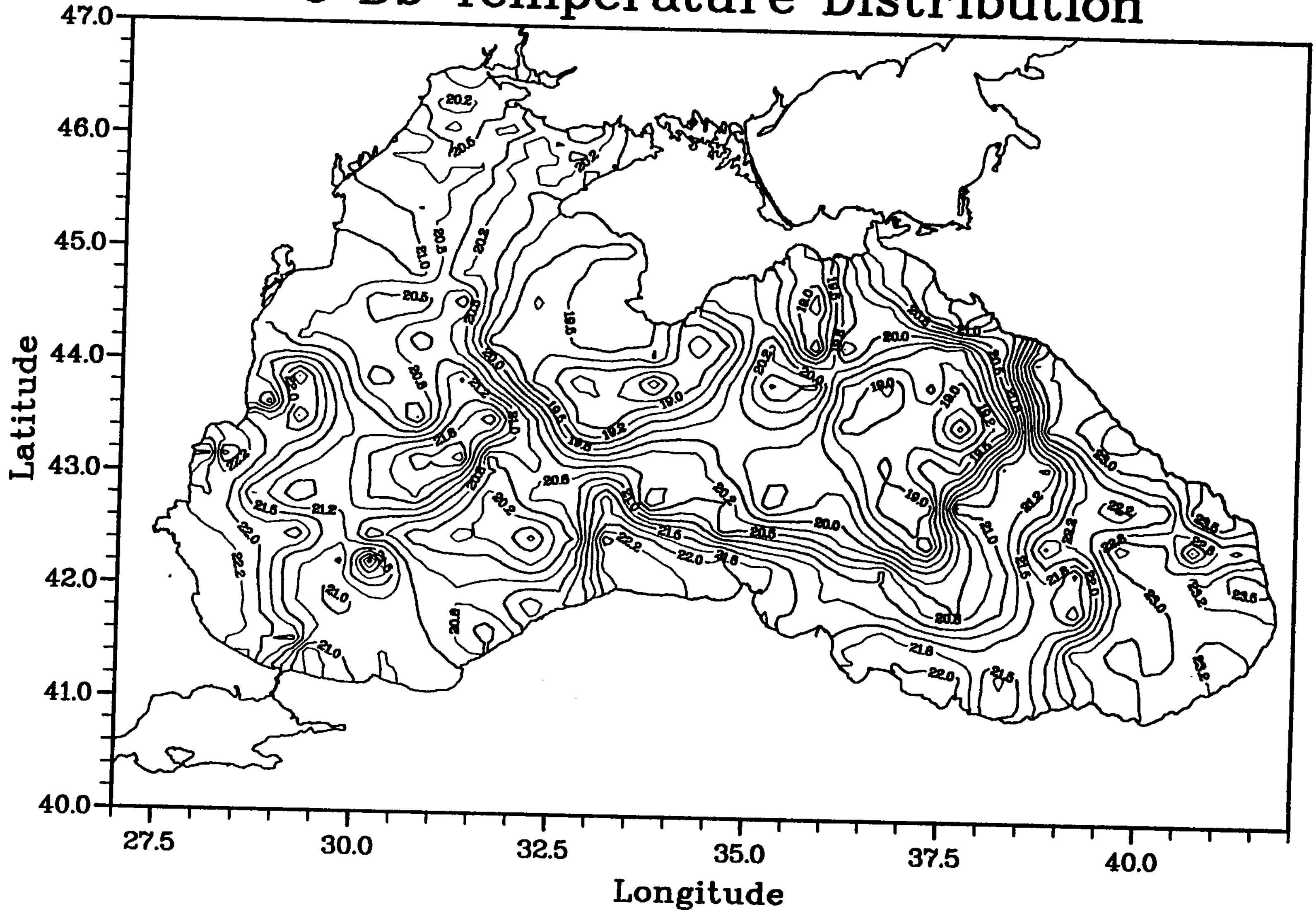
Dynamic Topography - 900 Db
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0

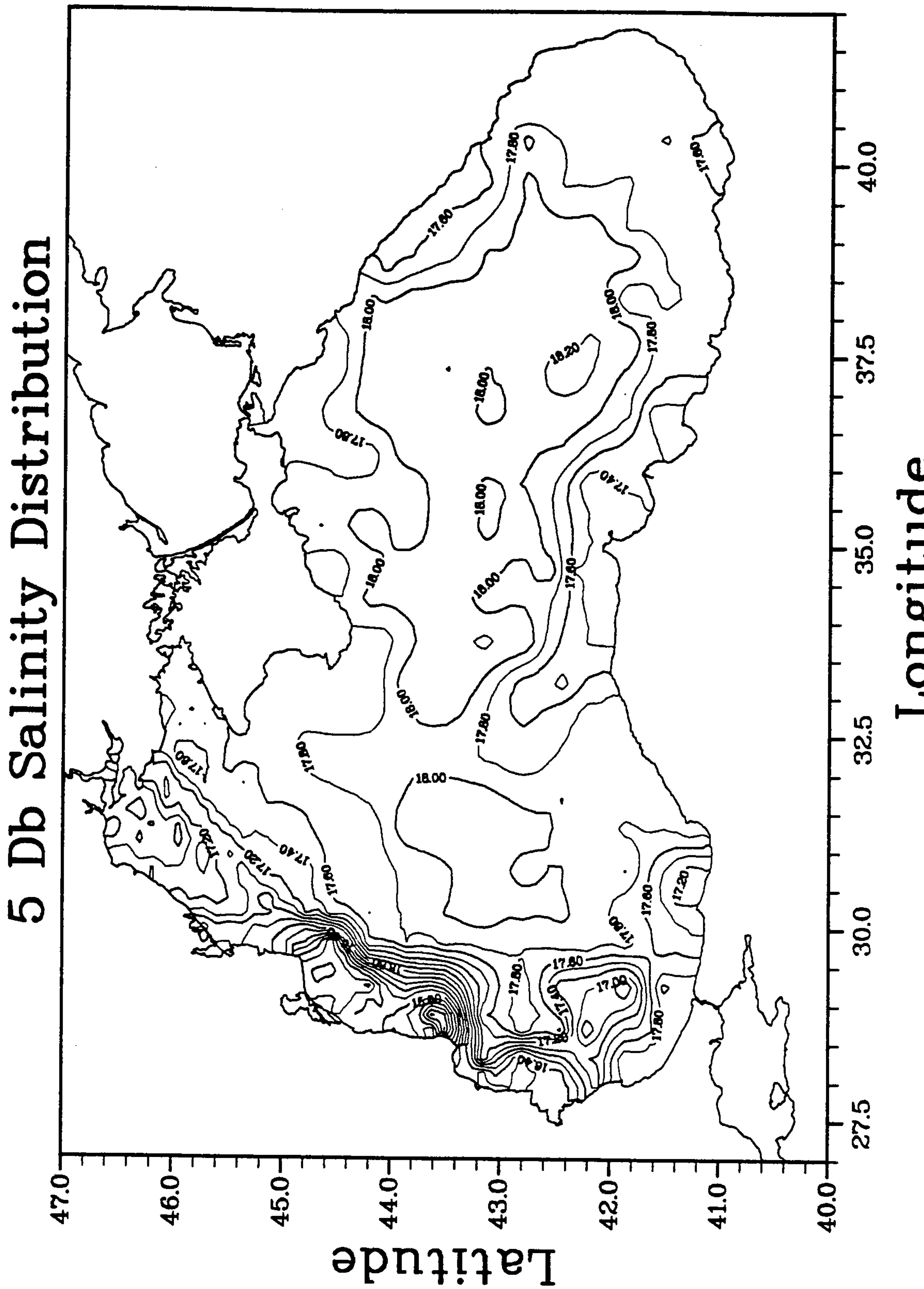
# APPENDIX V:

# SAMPLE SECTIONS OF SALINITY, TEMPERATURE, AND DENSITY

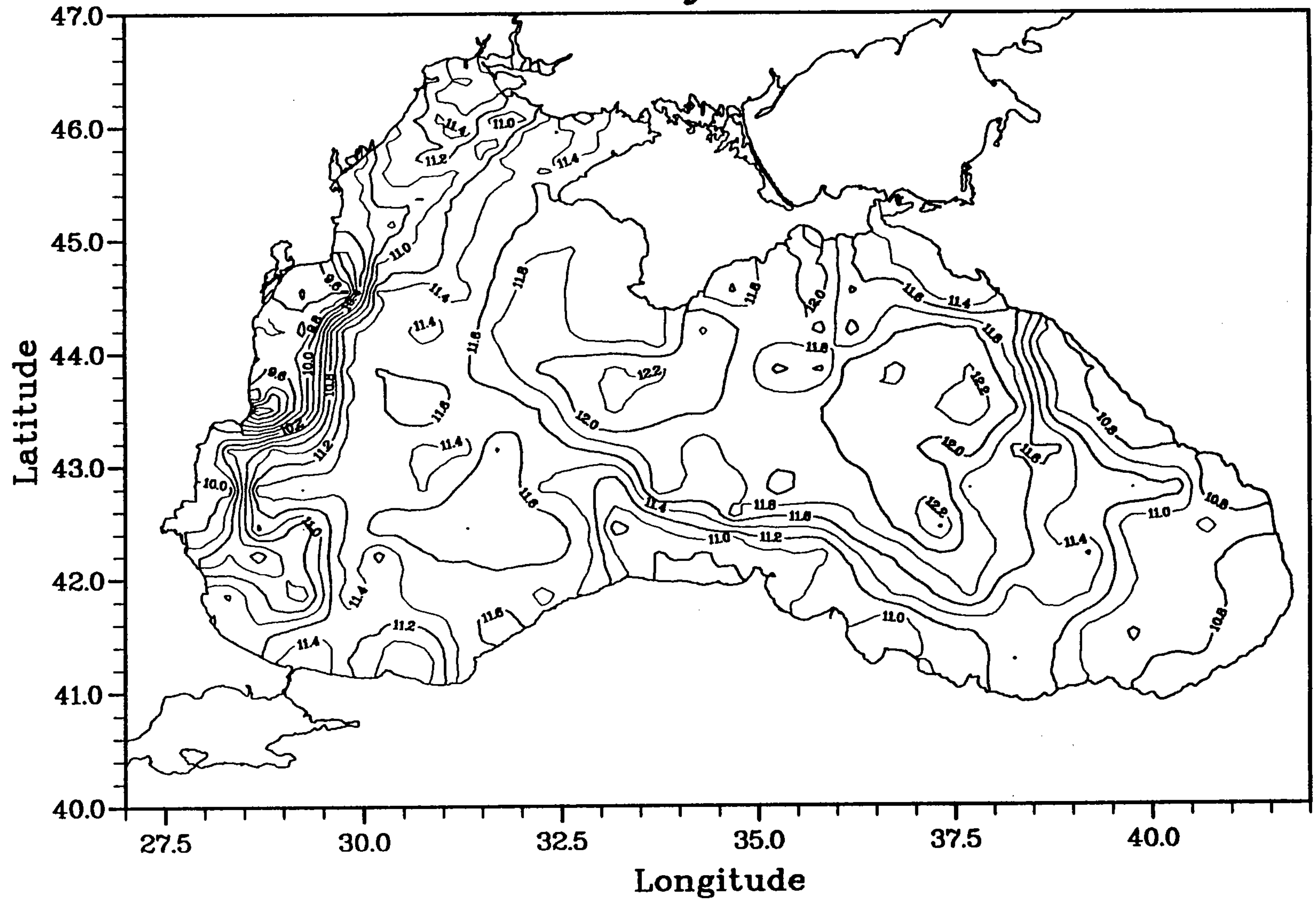
## Intercalibrated Results

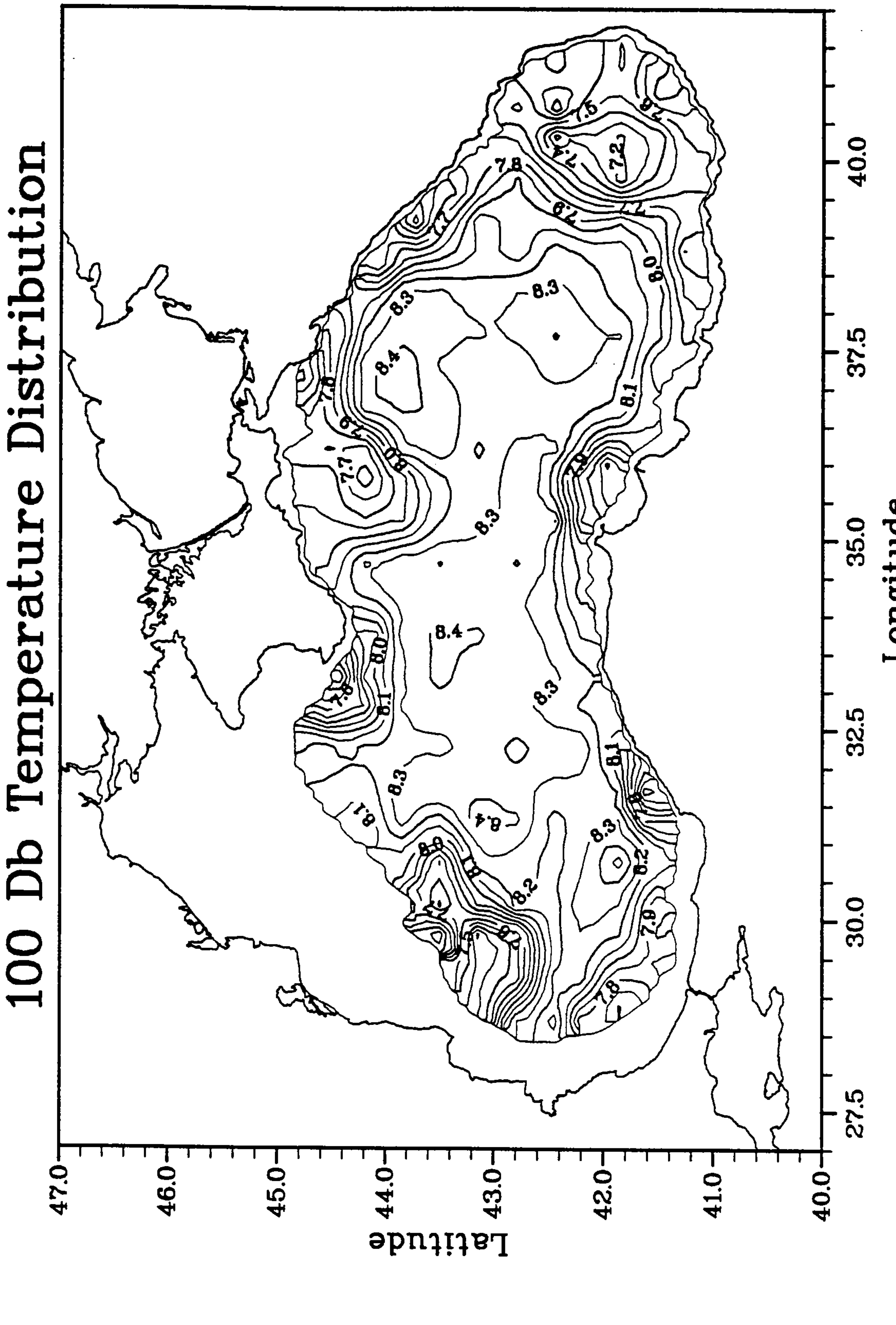
# 5 Db Temperature Distribution



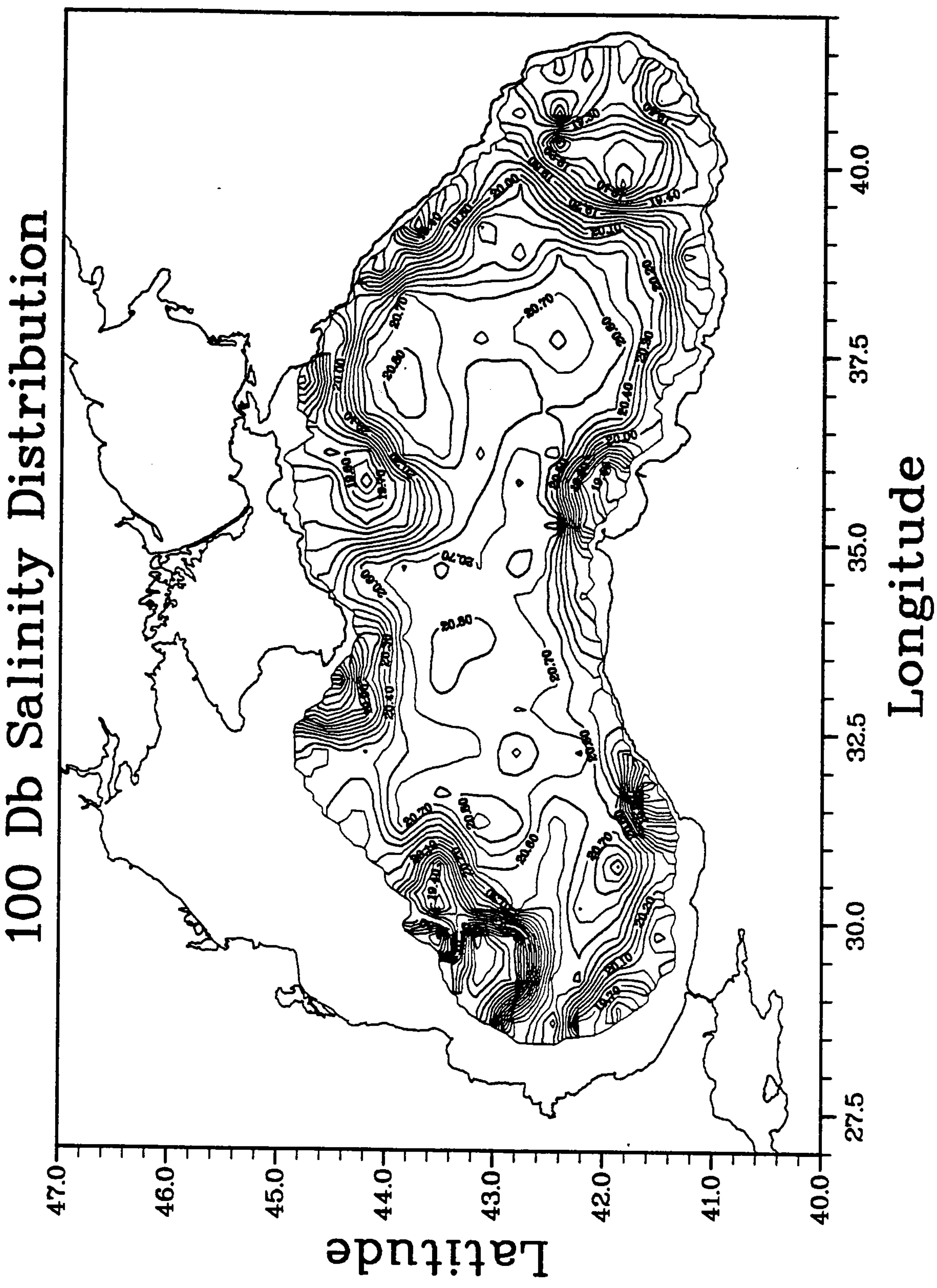

5 Db Salinity Distribution
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
18.20
18.00
17.80
17.60
17.40
17.20
17.00

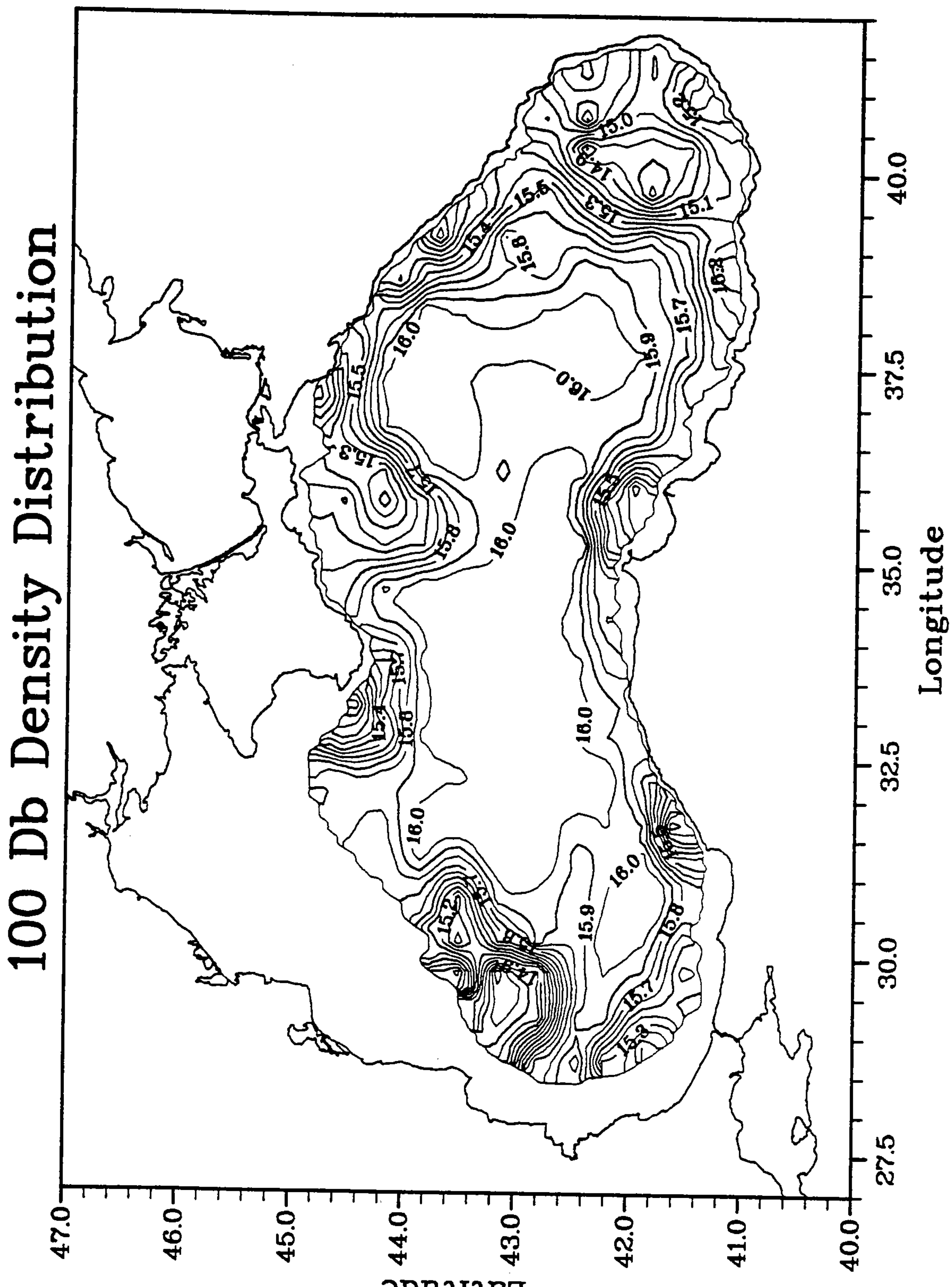
# 5 Db Density Distribution



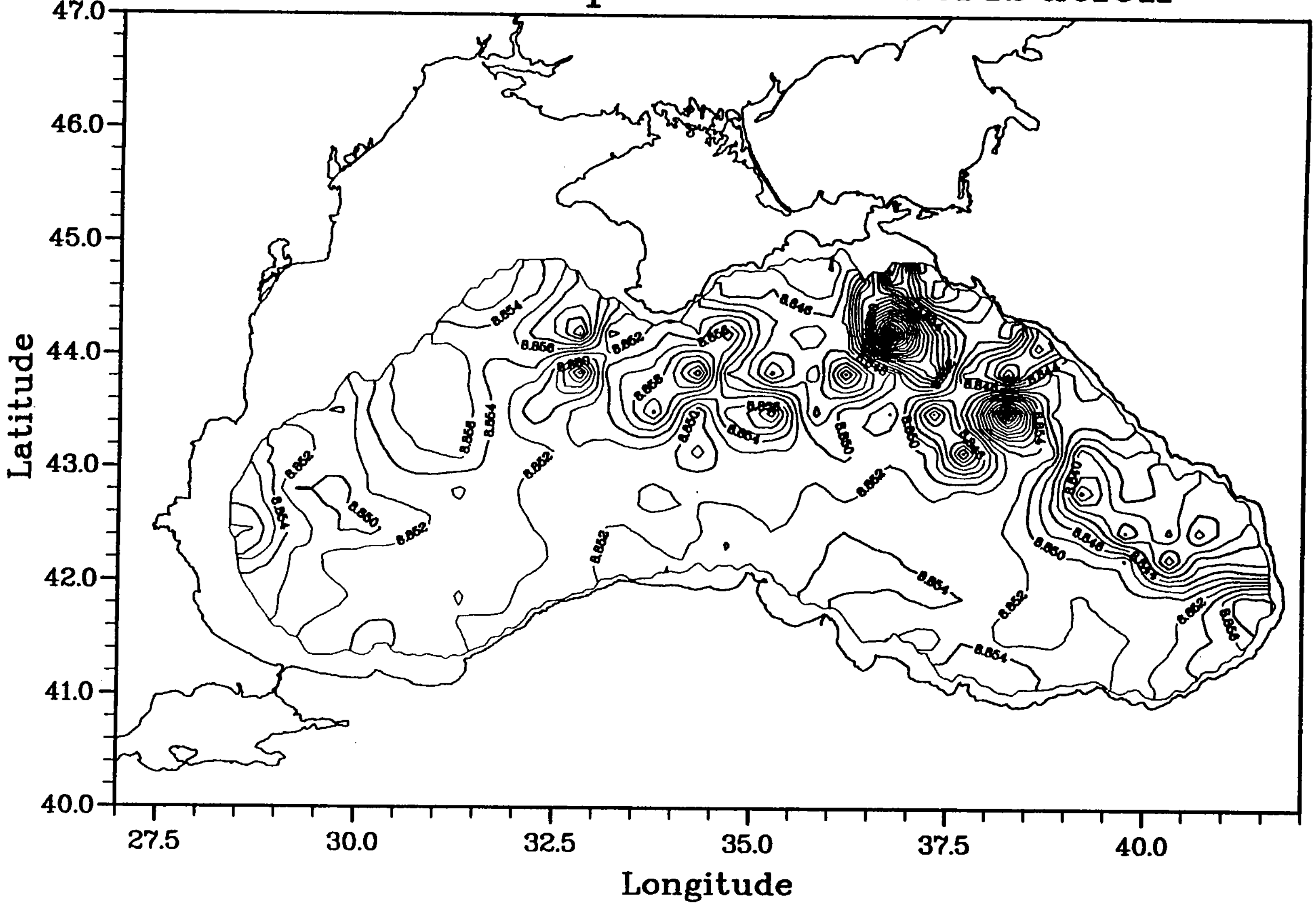


100 Db Temperature Distribution
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
8.3
8.4
8.1
8.0
8.2
7.9
7.8
7.7
7.5
7.4
7.2

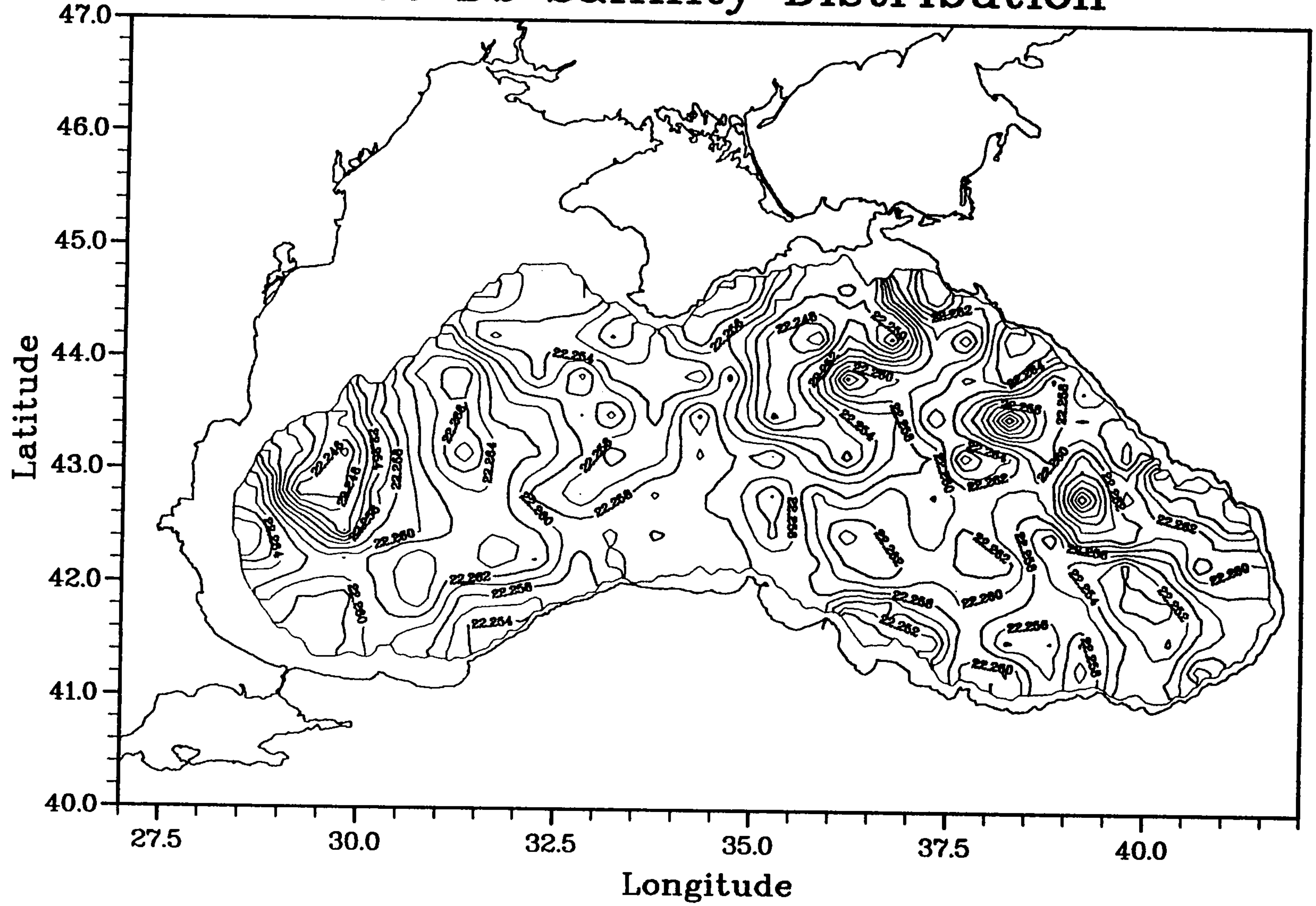

100 Db Salinity Distribution
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
40.0
41.0
42.0
43.0
44.0
45.0
46.0
47.0


100 Db Density Distribution
Latitude
Longitude
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
27.5
30.0
32.5
35.0
37.5
40.0
16.0
15.9
15.8
15.7
15.6
15.5
15.4
15.3
15.2
15.1
15.0
14.8

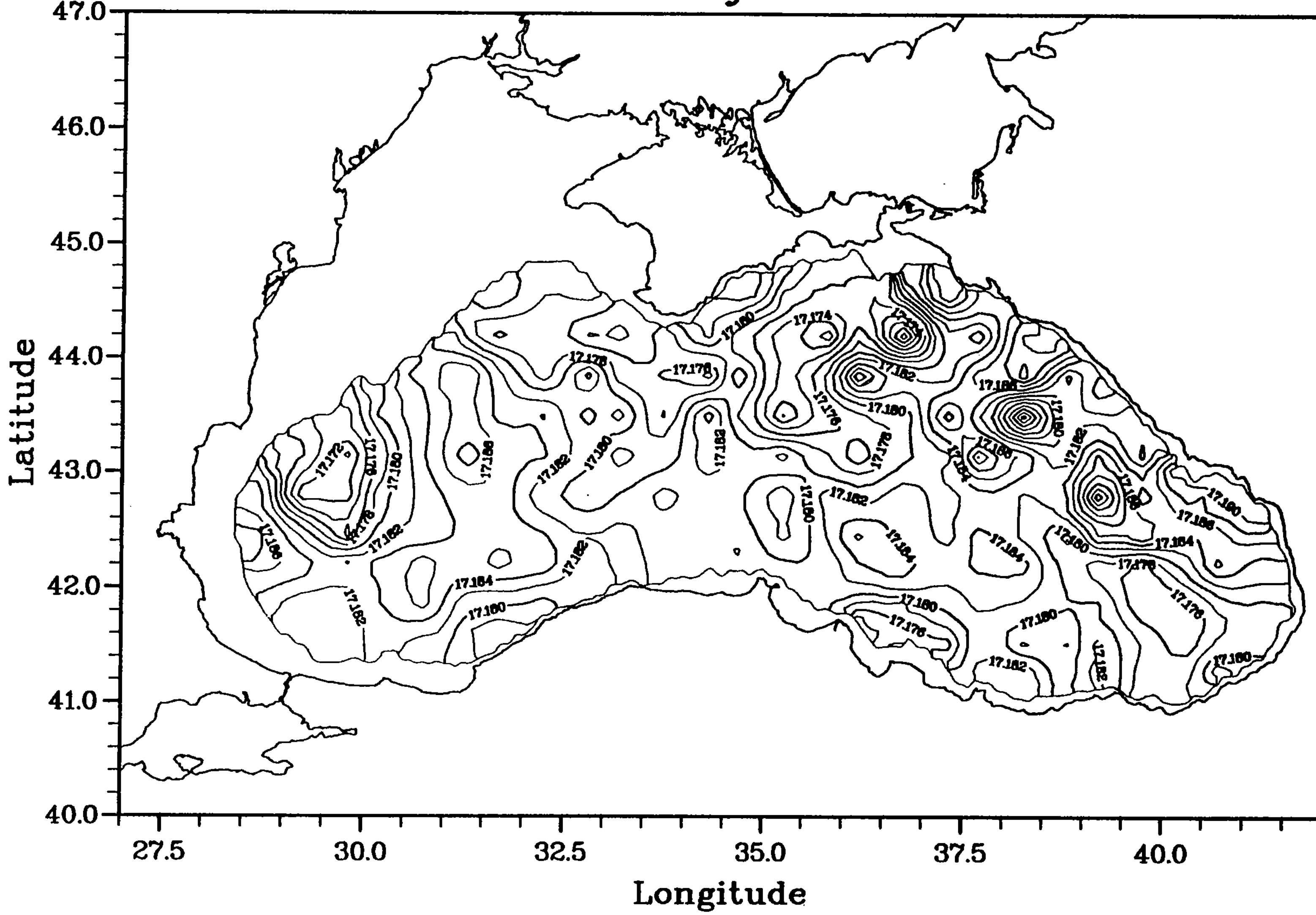
# 900 Db Temperature Distribution

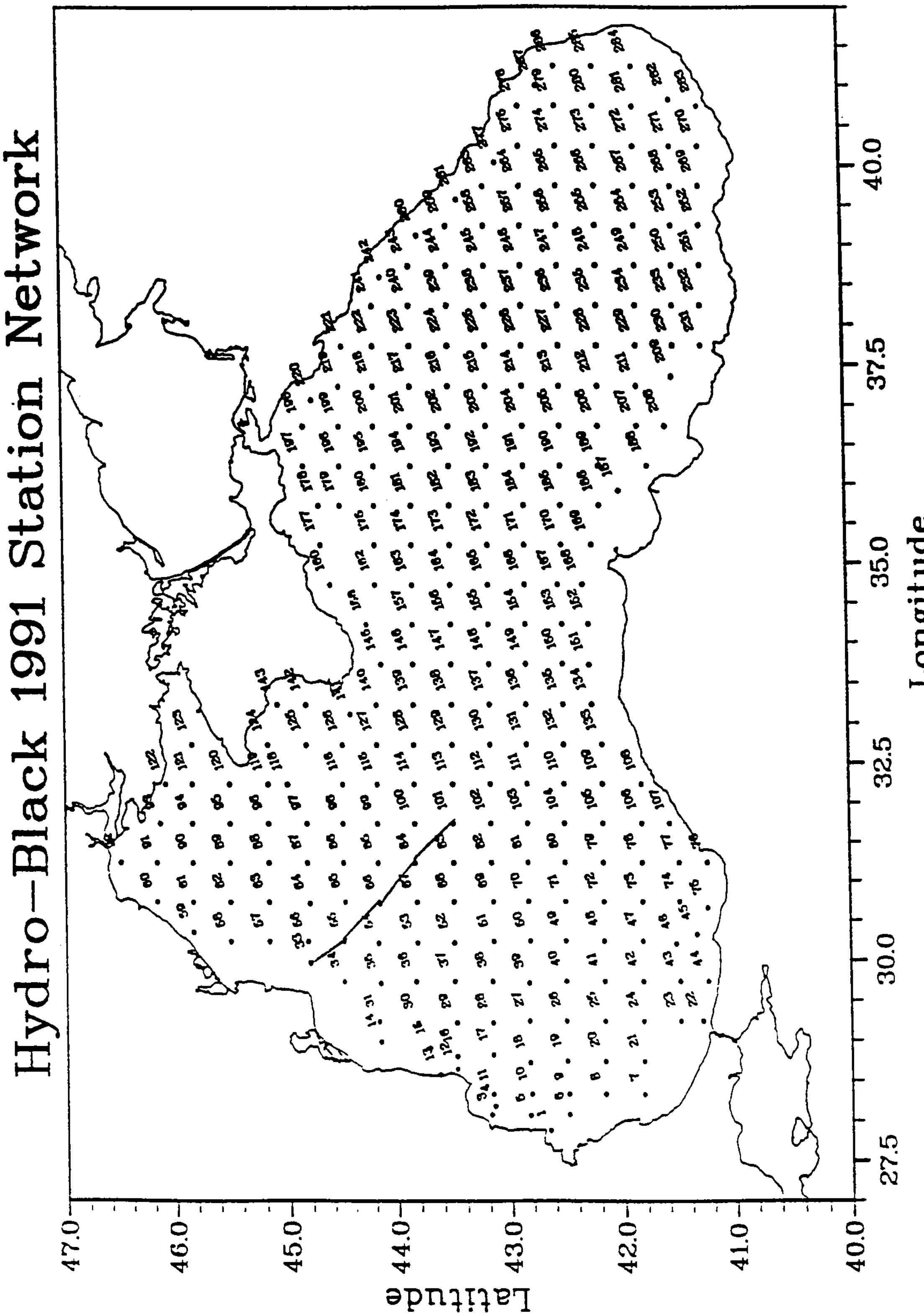


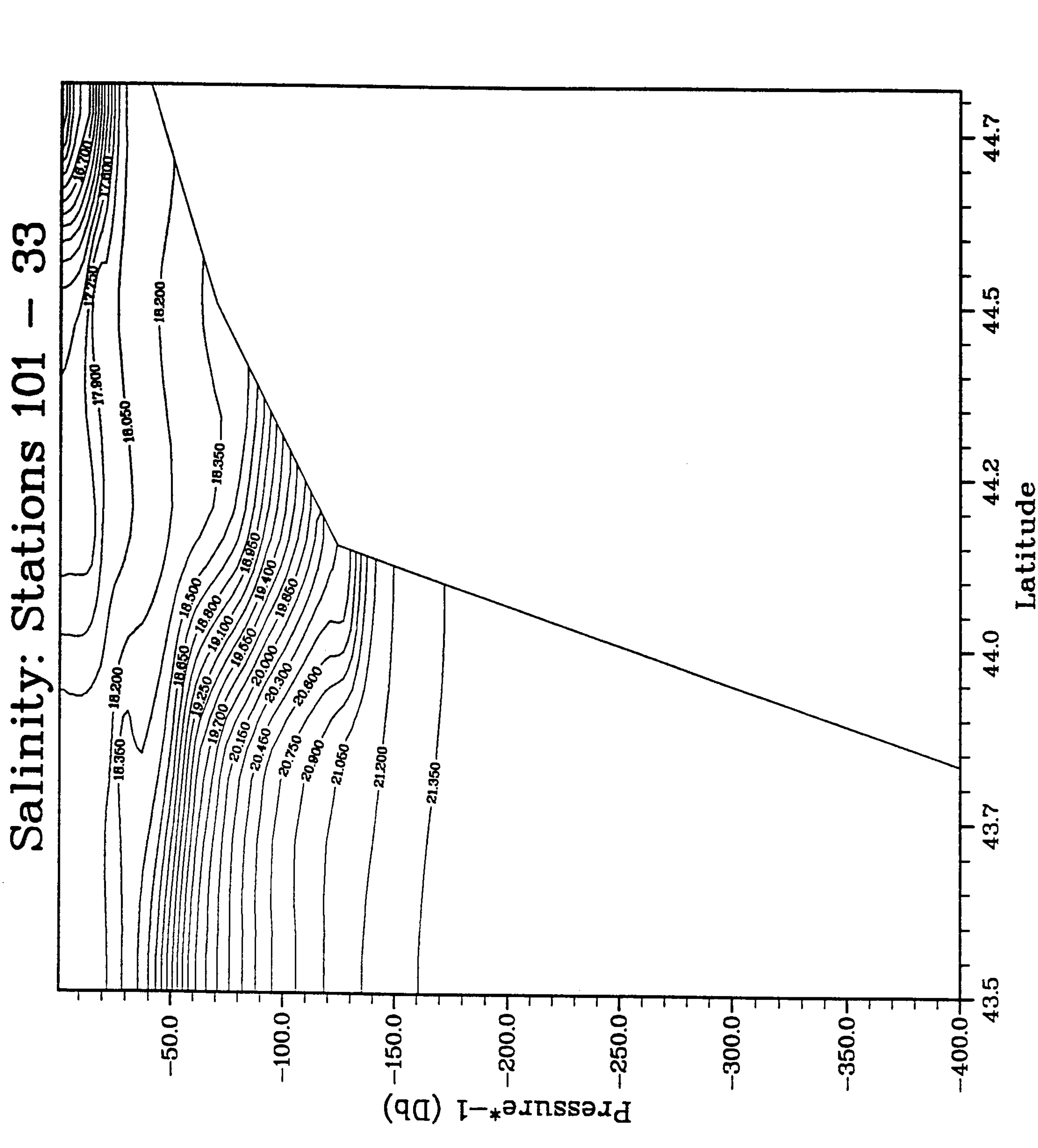
# 900 Db Salinity Distribution



# 900 Db Density Distribution

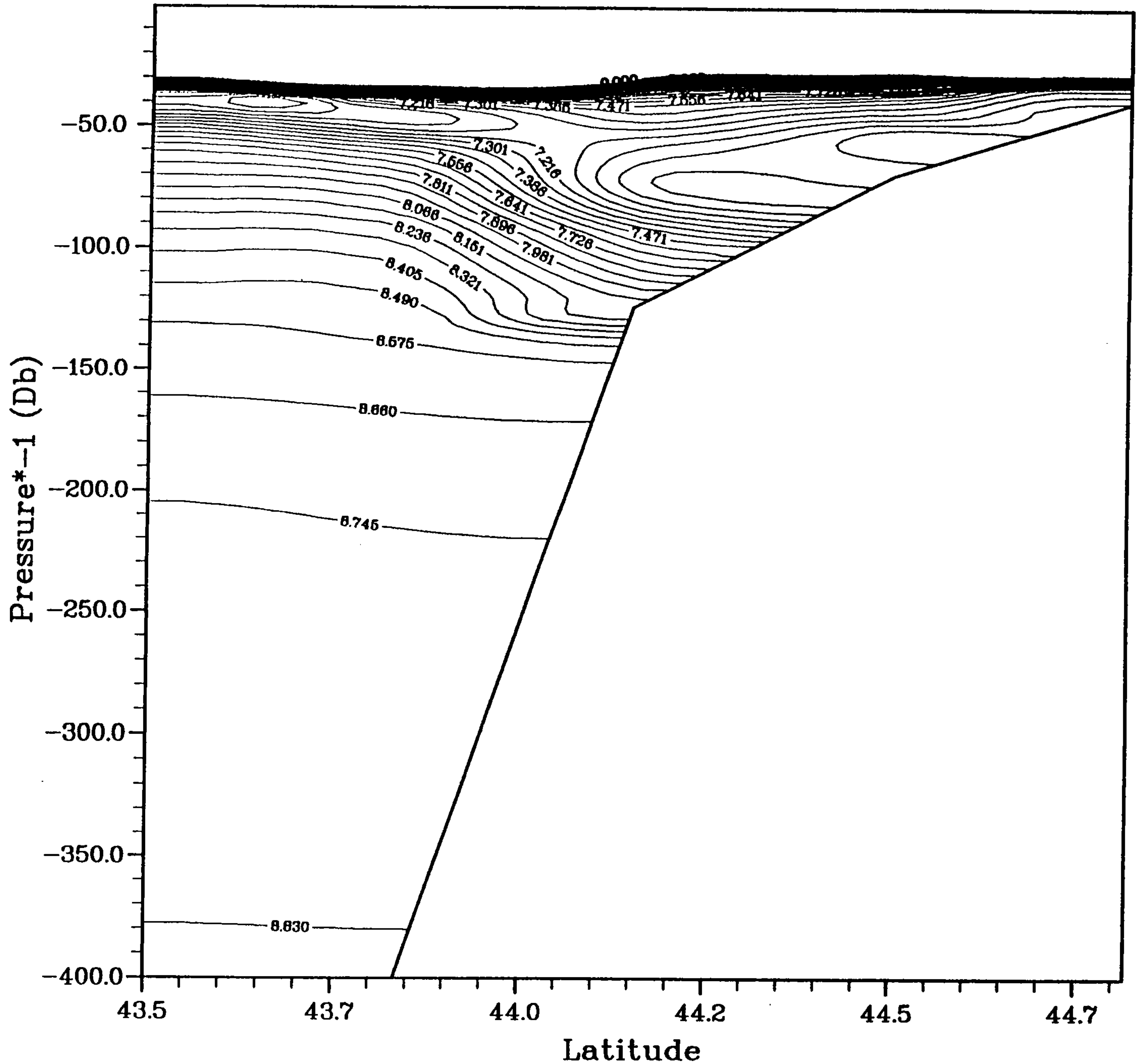


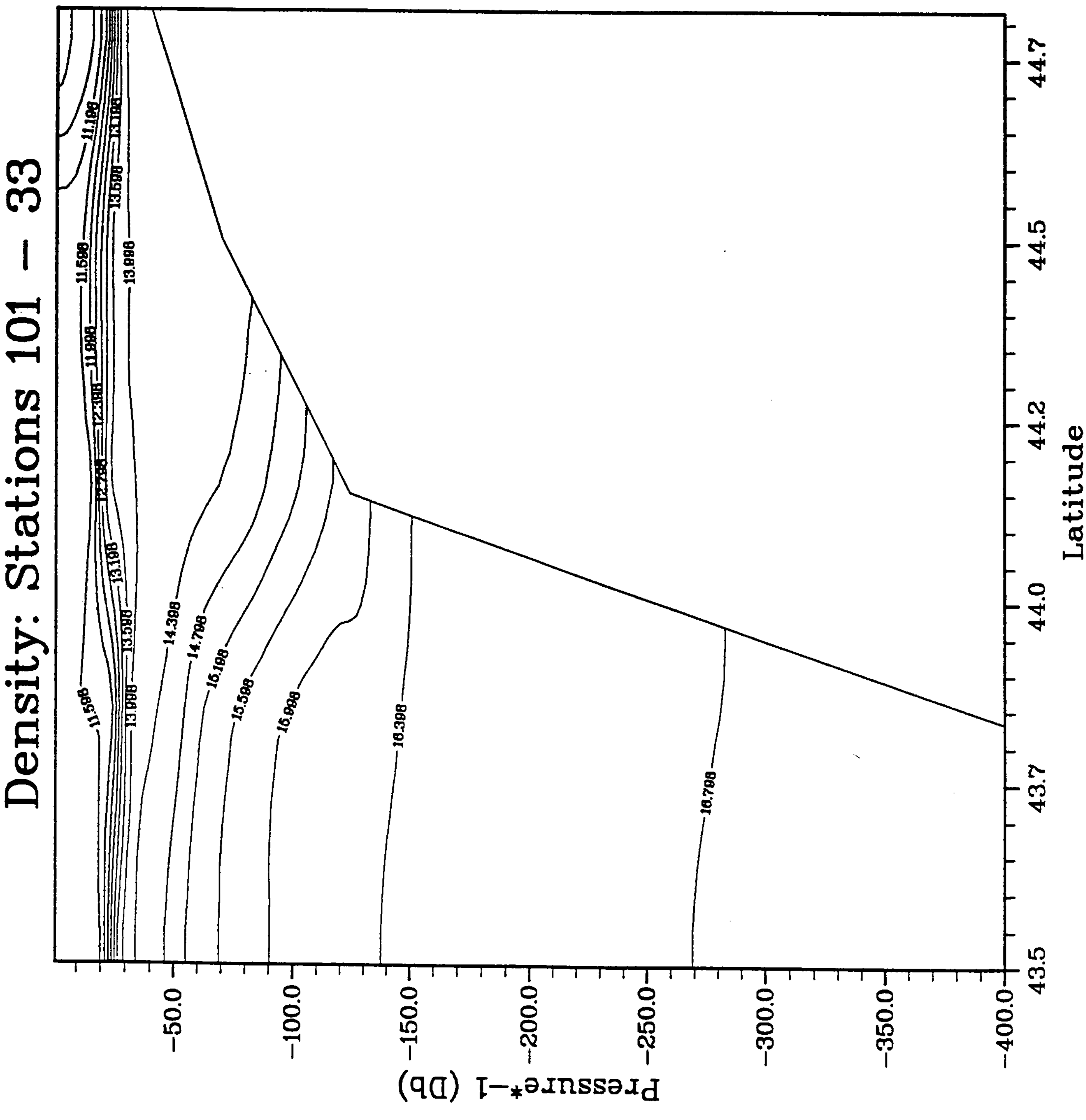

Hydro-Black 1991 Station Network
Longitude
Latitude
27.5
30.0
32.5
35.0
37.5
40.0
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0

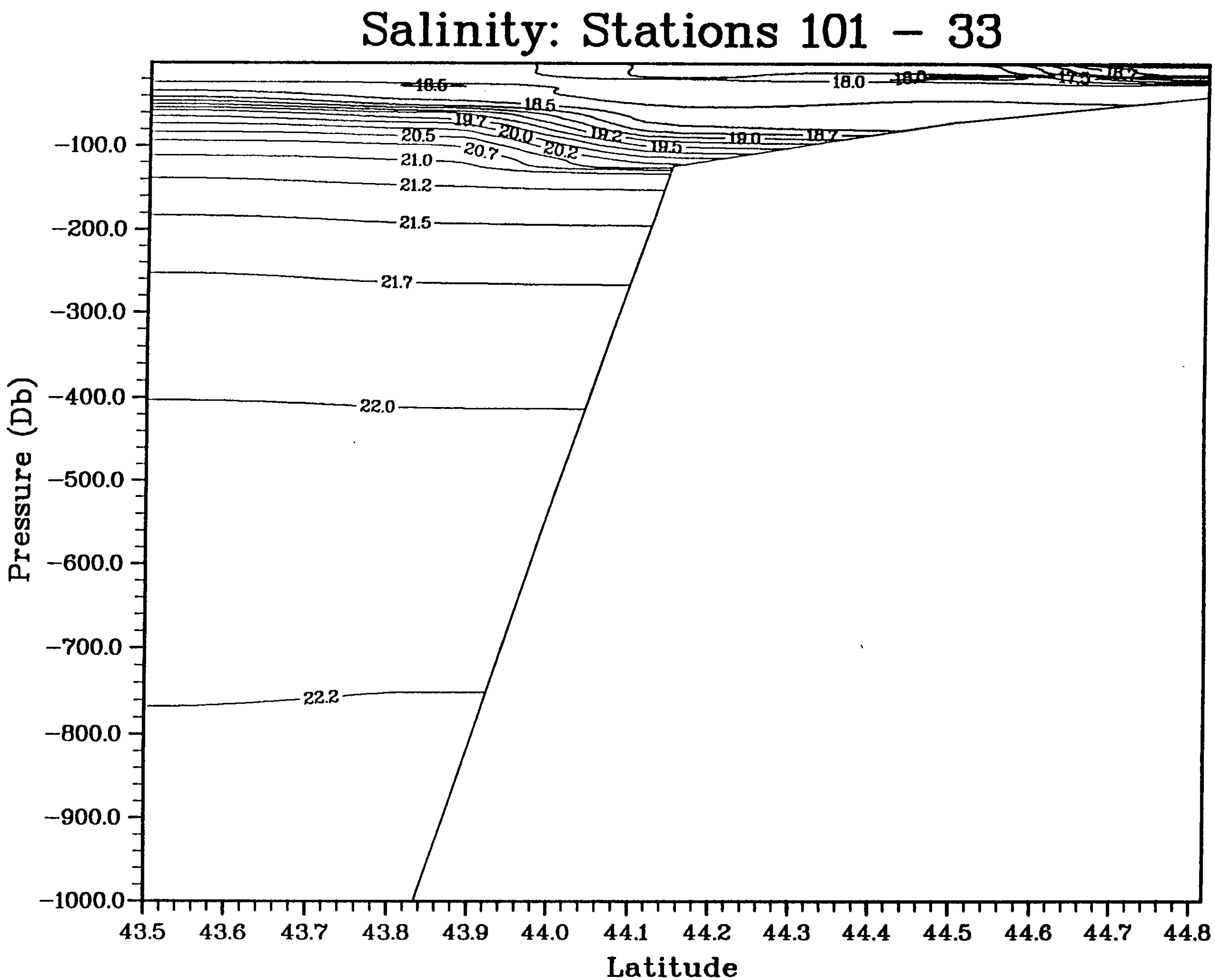


Salinity: Stations 101 - 33
Latitude
Pressure*-1 (Db)
43.5
43.7
44.0
44.2
44.5
44.7
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
-350.0
-400.0
17.750
17.900
18.050
18.200
18.350
18.500
18.650
18.800
18.950
19.100
19.250
19.400
19.550
19.700
19.850
20.000
20.150
20.300
20.450
20.600
20.750
20.900
21.050
21.200
21.350

Temperature: Stations 101 – 33

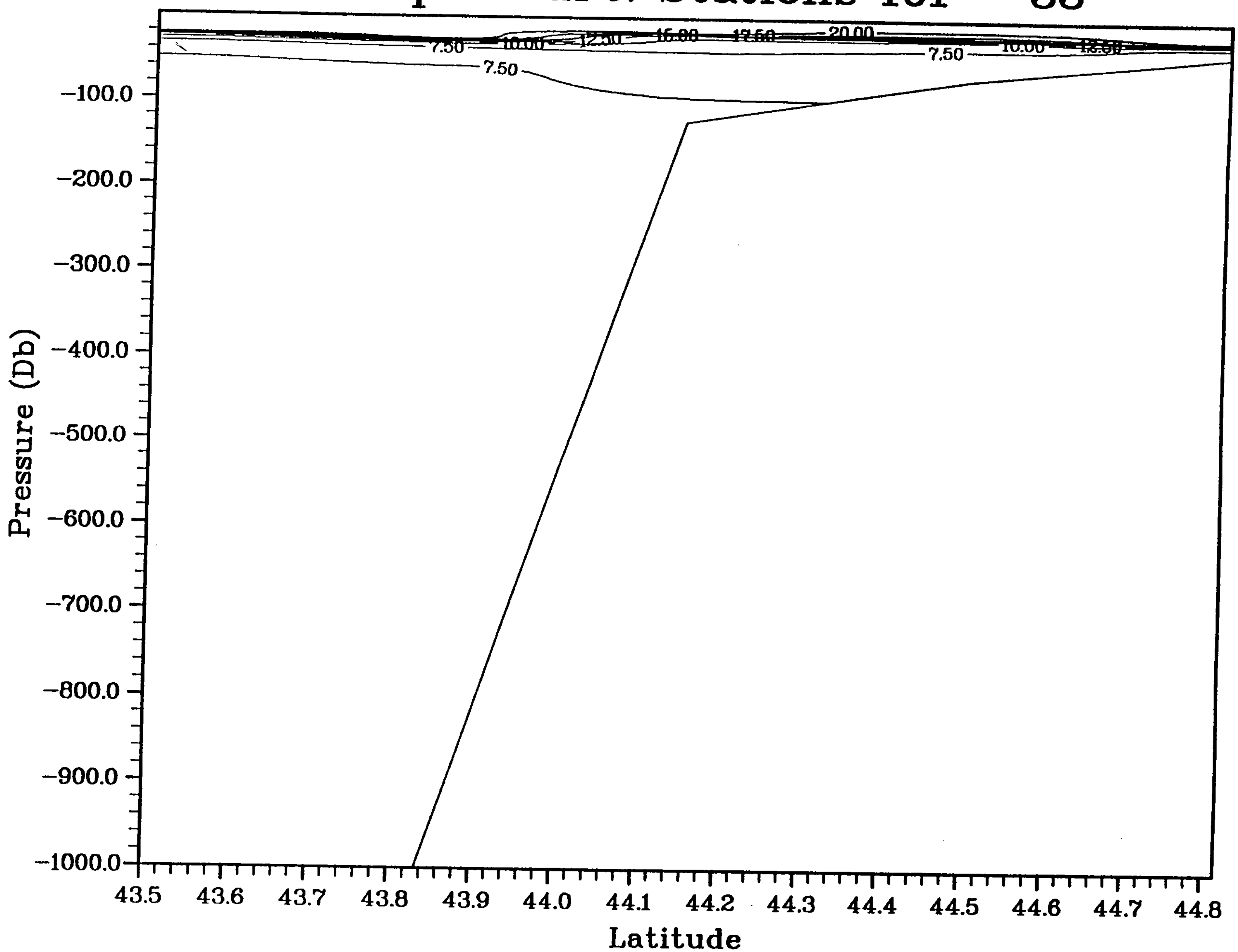


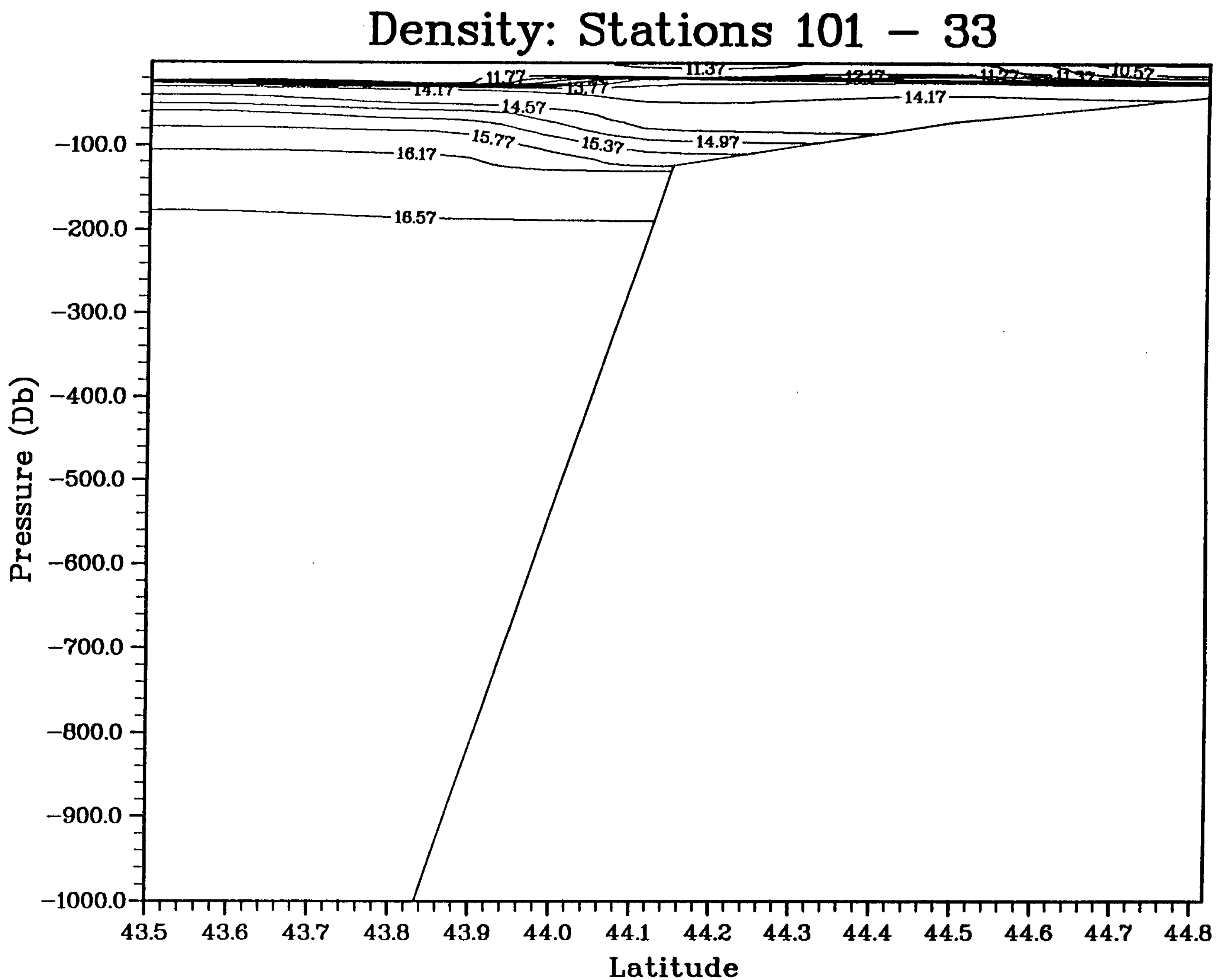

Density: Stations 101 - 33
Pressure*-1 (Db)
Latitude
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
-350.0
-400.0
43.5
43.7
44.0
44.2
44.5
44.7
11.198
11.598
11.998
12.398
12.798
13.198
13.598
13.998
14.398
14.798
15.198
15.598
15.998
16.398
16.798



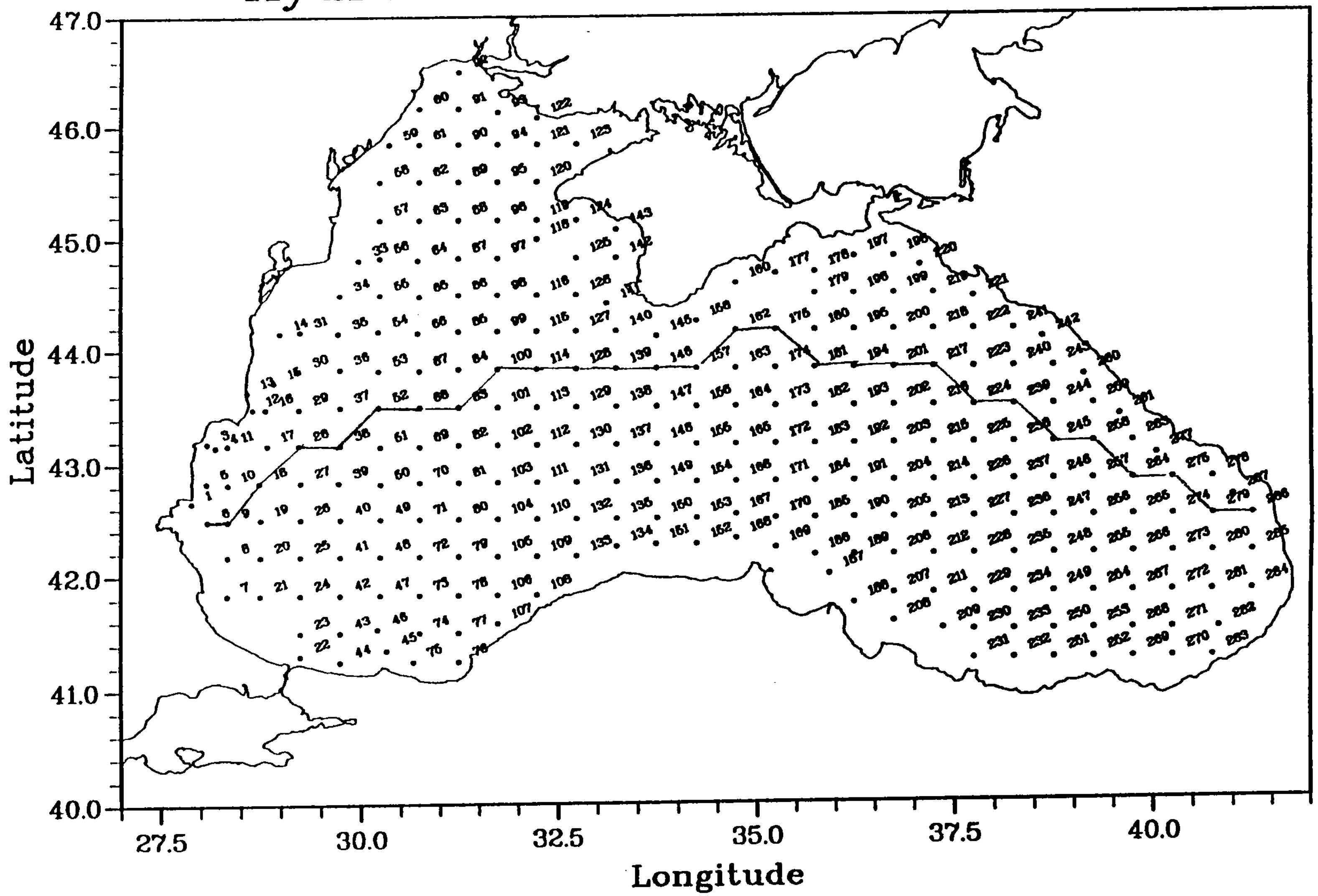
Salinity: Stations 101 – 33
Pressure (Db)
−100.0
−200.0
−300.0
−400.0
−500.0
−600.0
−700.0
−800.0
−900.0
−1000.0
43.5
43.6
43.7
43.8
43.9
44.0
44.1
44.2
44.3
44.4
44.5
44.6
44.7
44.8
Latitude
18.5
18.0
19.7
20.0
20.5
20.2
20.7
19.2
21.0
21.2
21.5
21.7
22.0
22.2

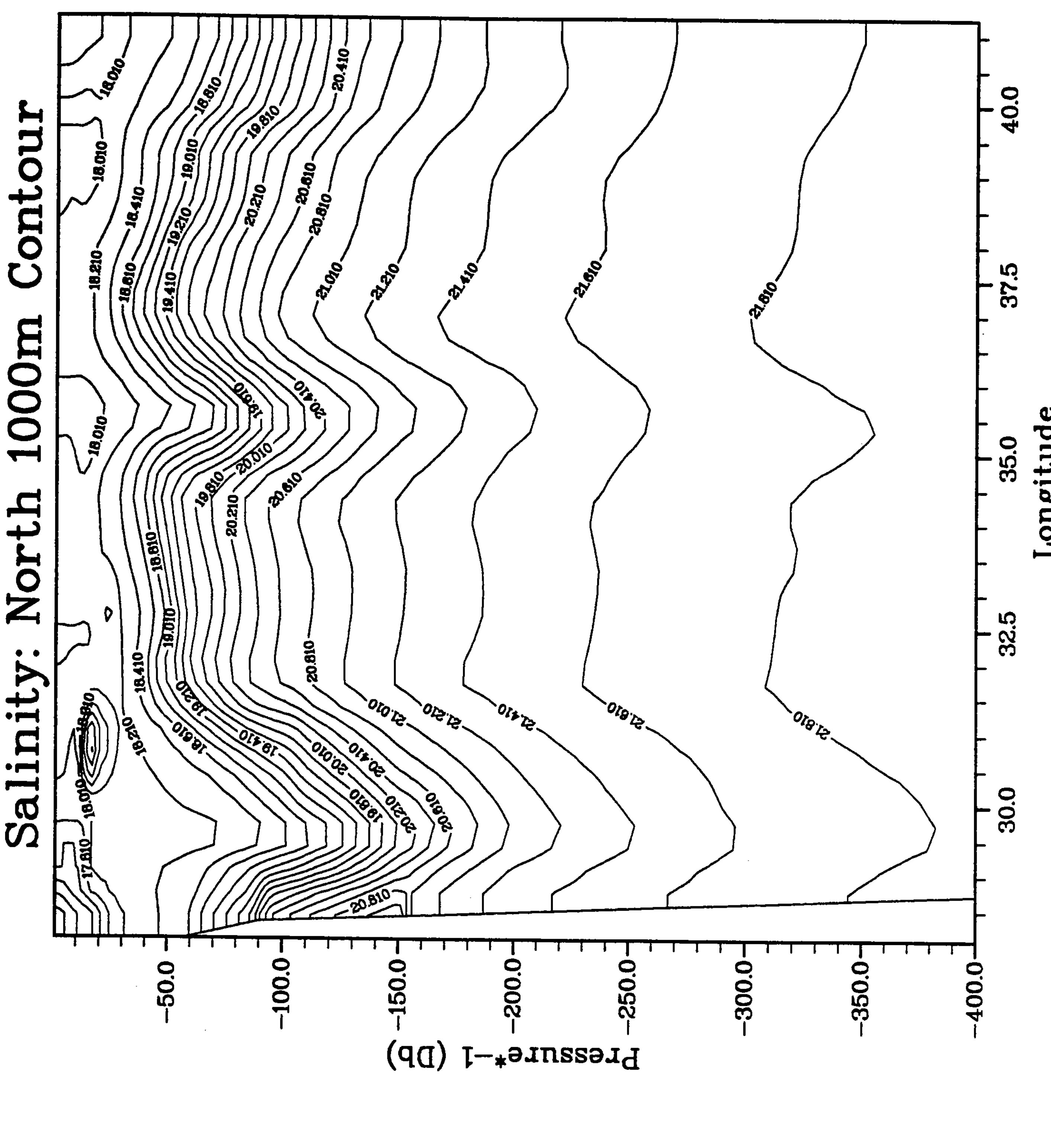
# Temperature: Stations 101 – 33



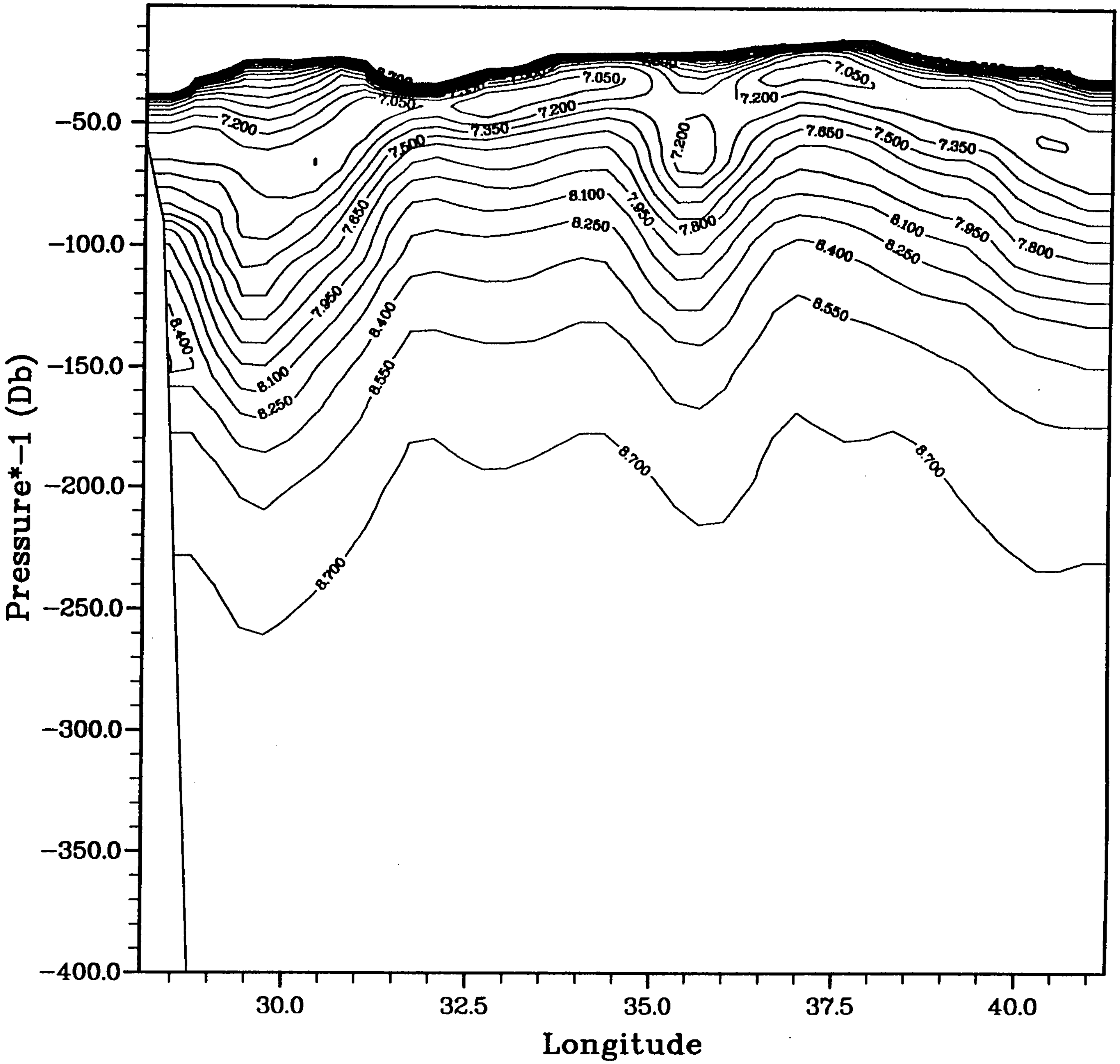

Density: Stations 101 – 33
Pressure (Db)
-100.0
-200.0
-300.0
-400.0
-500.0
-600.0
-700.0
-800.0
-900.0
-1000.0
43.5
43.6
43.7
43.8
43.9
44.0
44.1
44.2
44.3
44.4
44.5
44.6
44.7
44.8
Latitude
11.37
11.77
14.17
13.77
14.57
15.77
15.37
14.97
16.17
16.57
10.57

## Hydro-Black 1991 Station Network

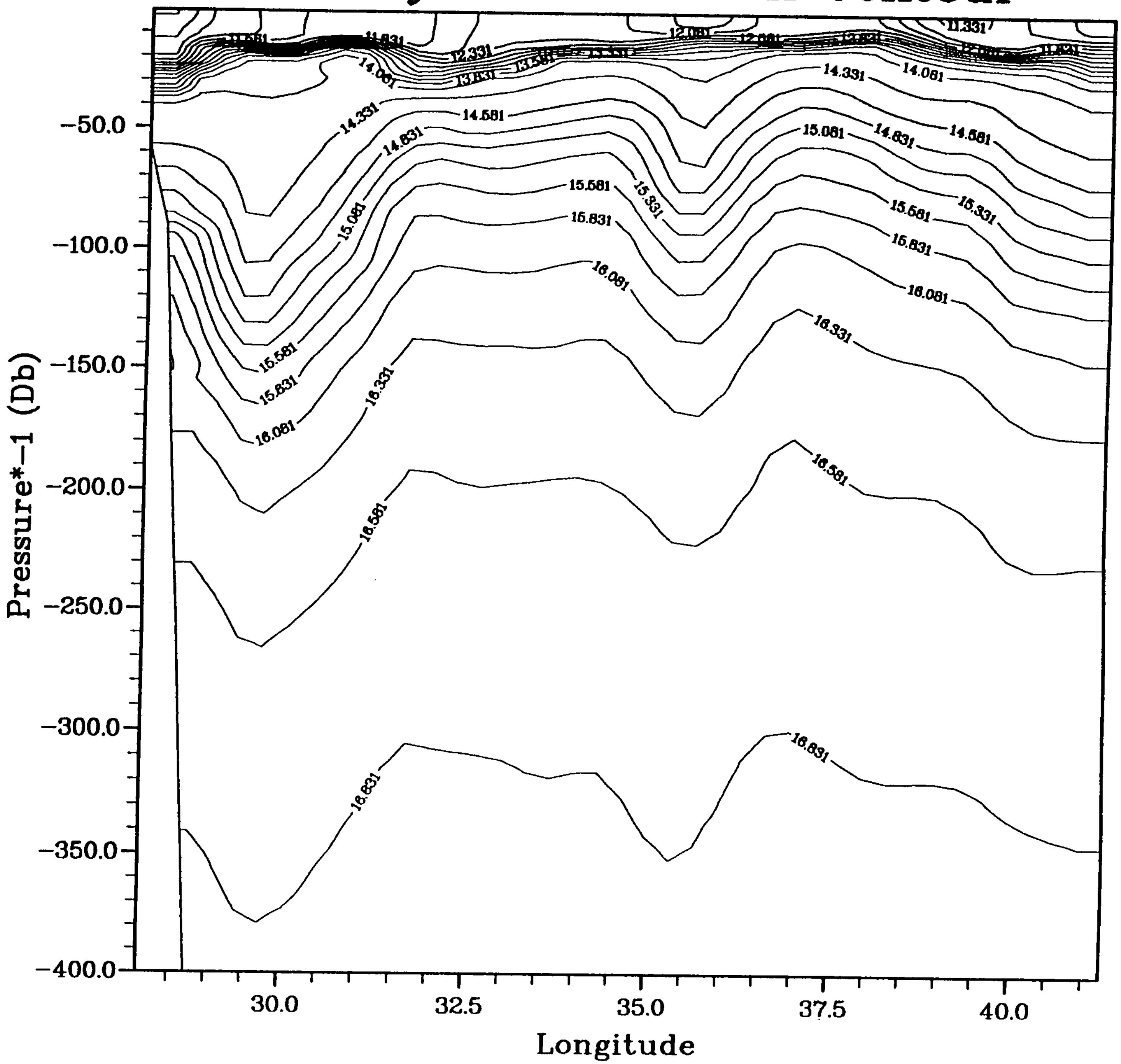



Salinity: North 1000m Contour
Longitude
30.0
32.5
35.0
37.5
40.0
Pressure*-1 (Db)
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
-350.0
-400.0

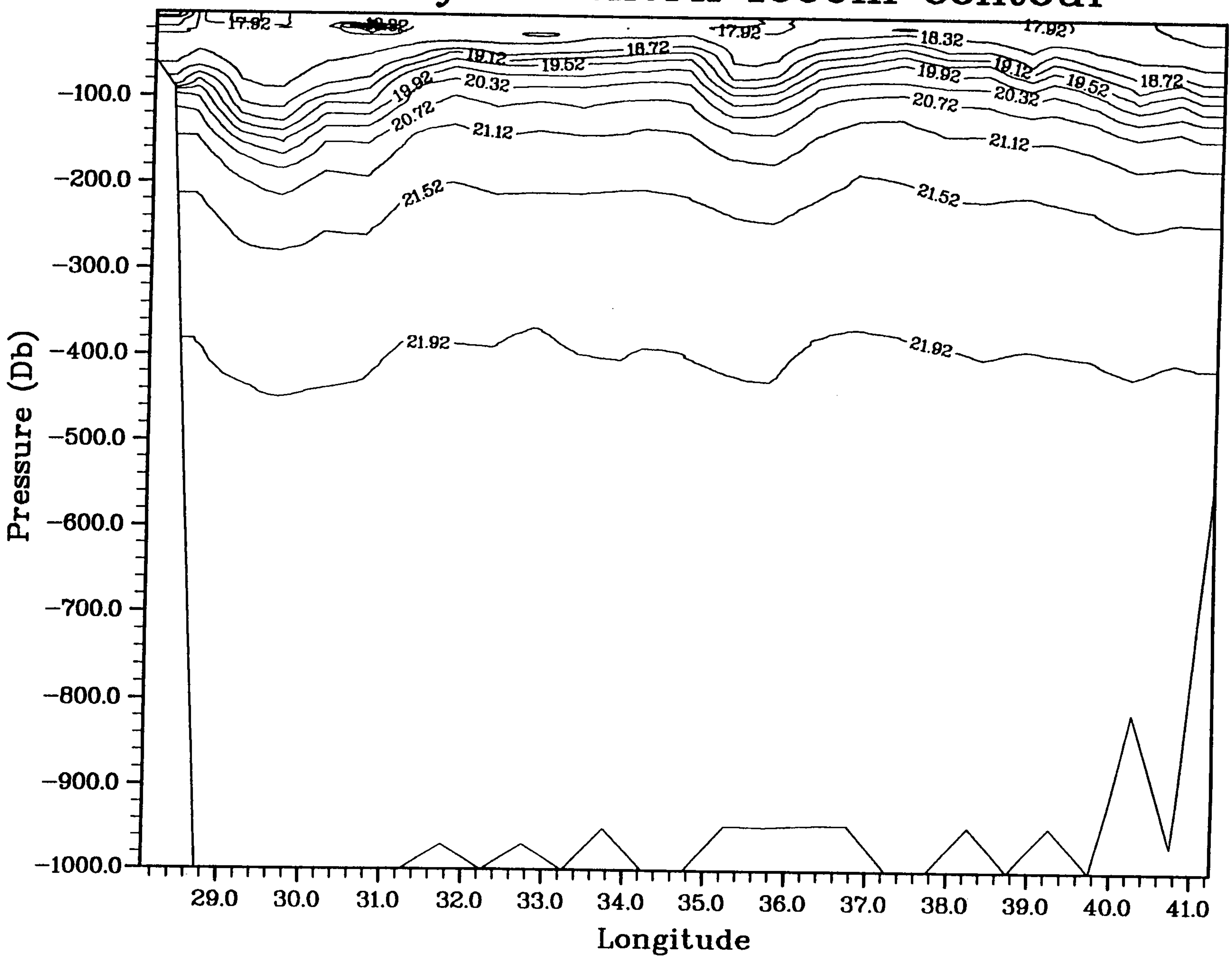
# Temperature: North 1000m Contour



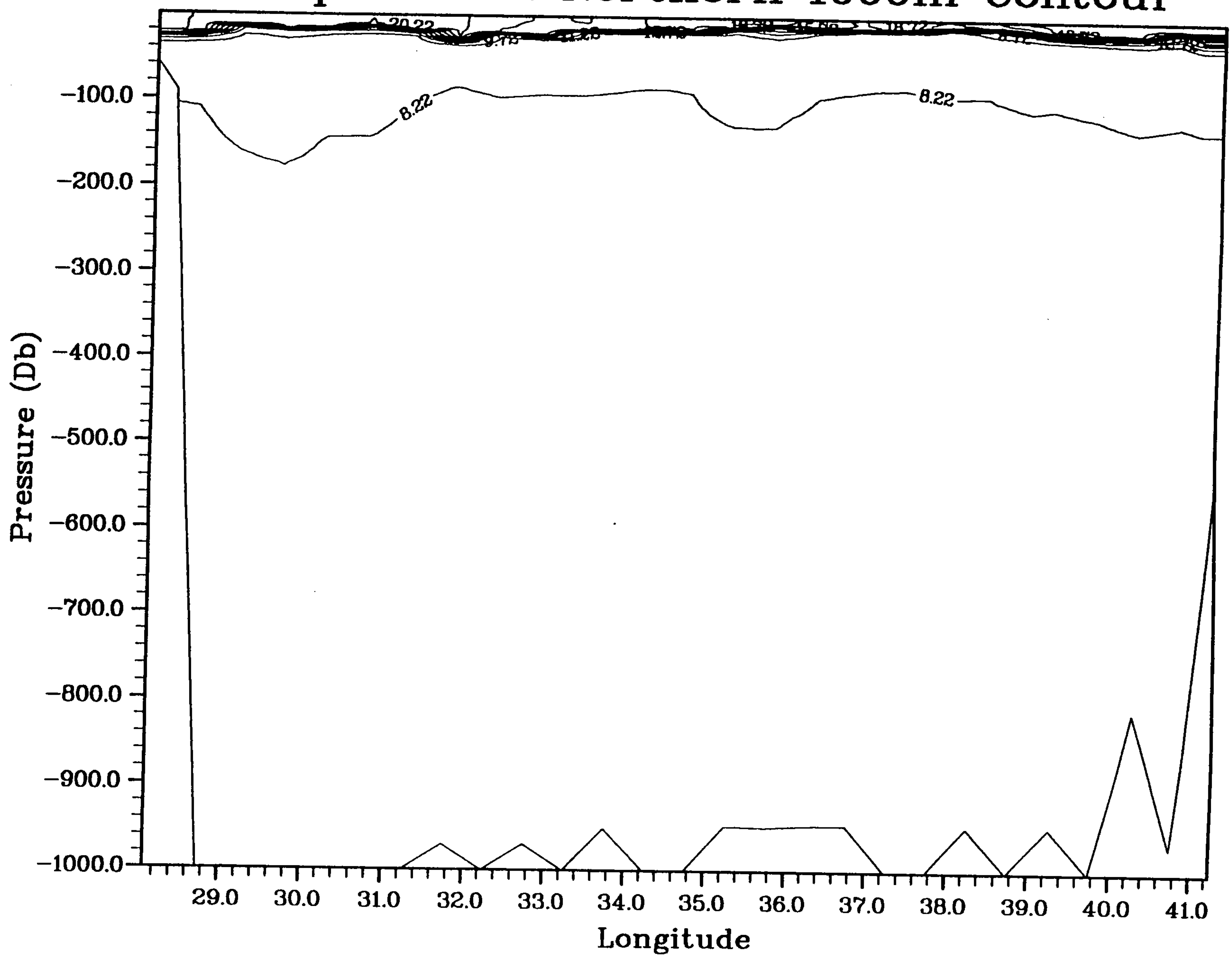
# Density: North 1000m Contour

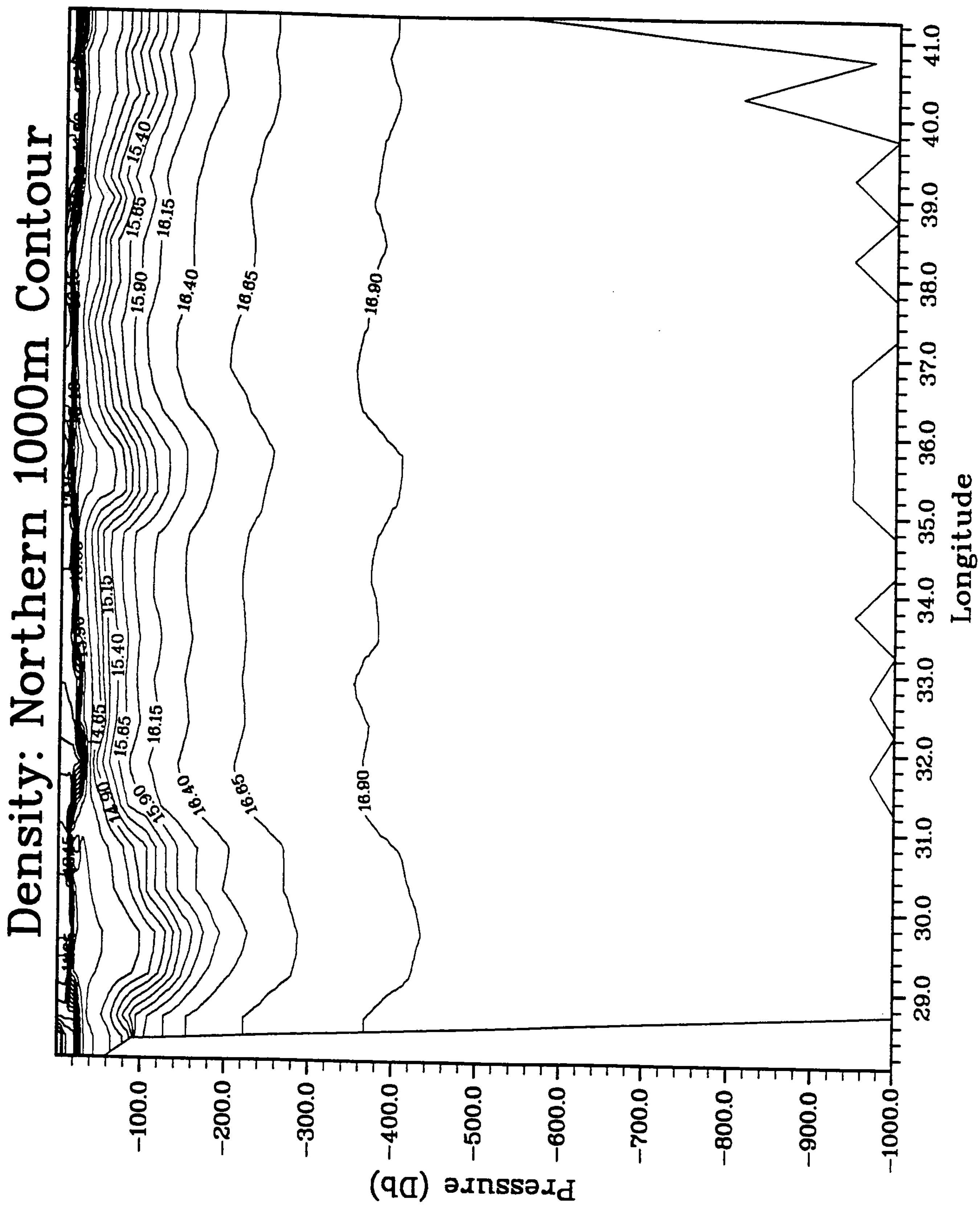


# Salinity: Northern 1000m contour

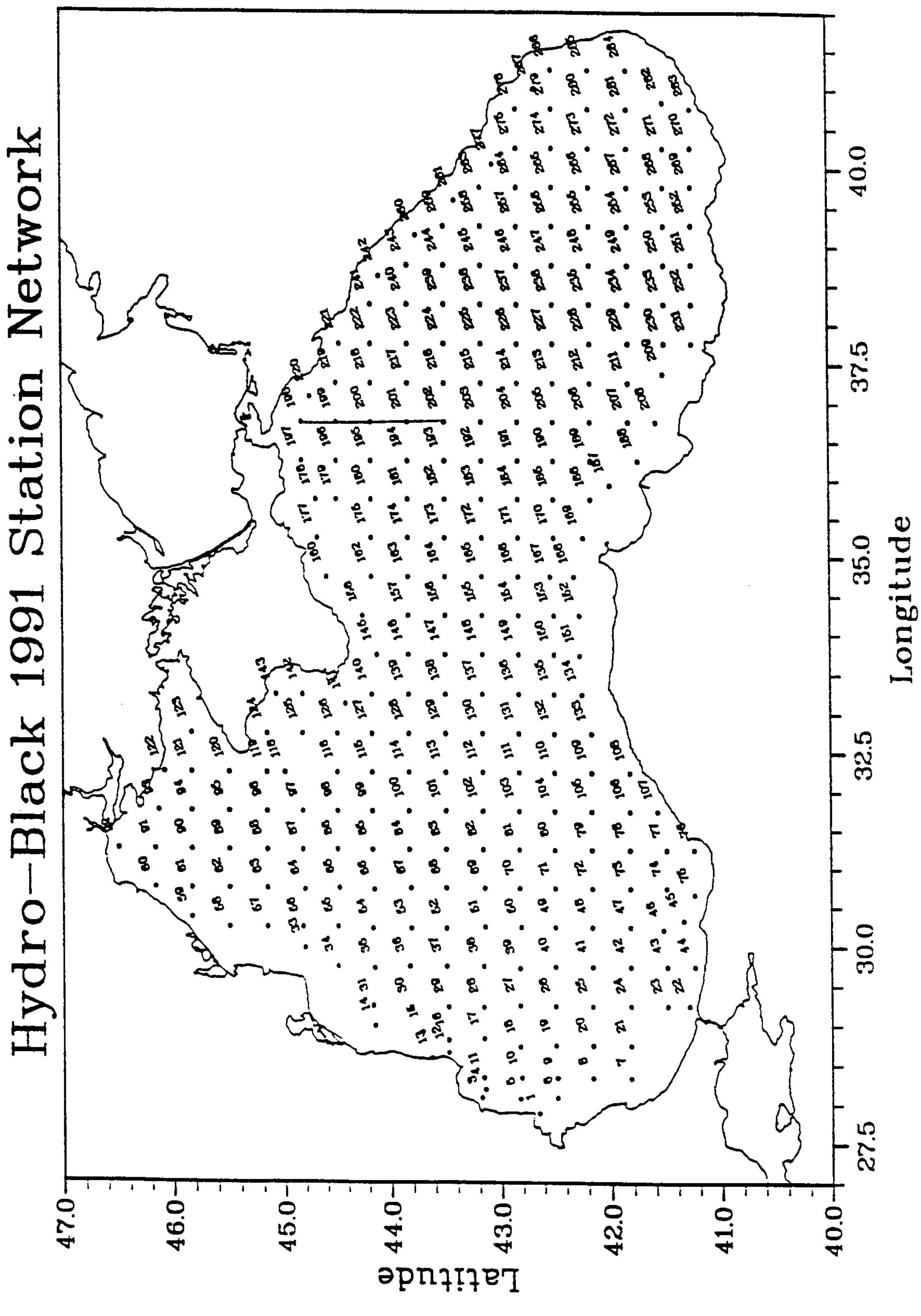


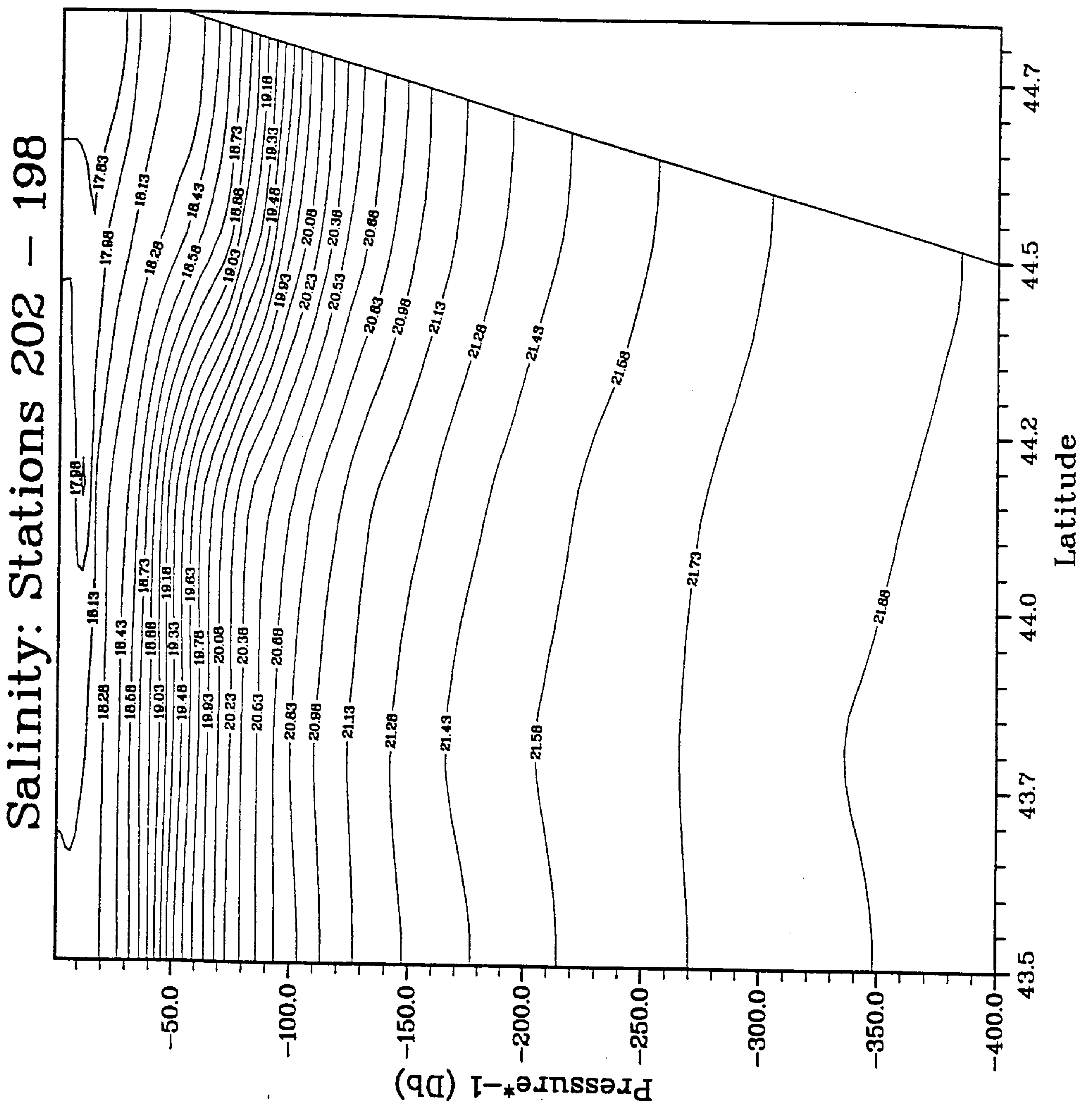
# Temperature: Northern 1000m Contour

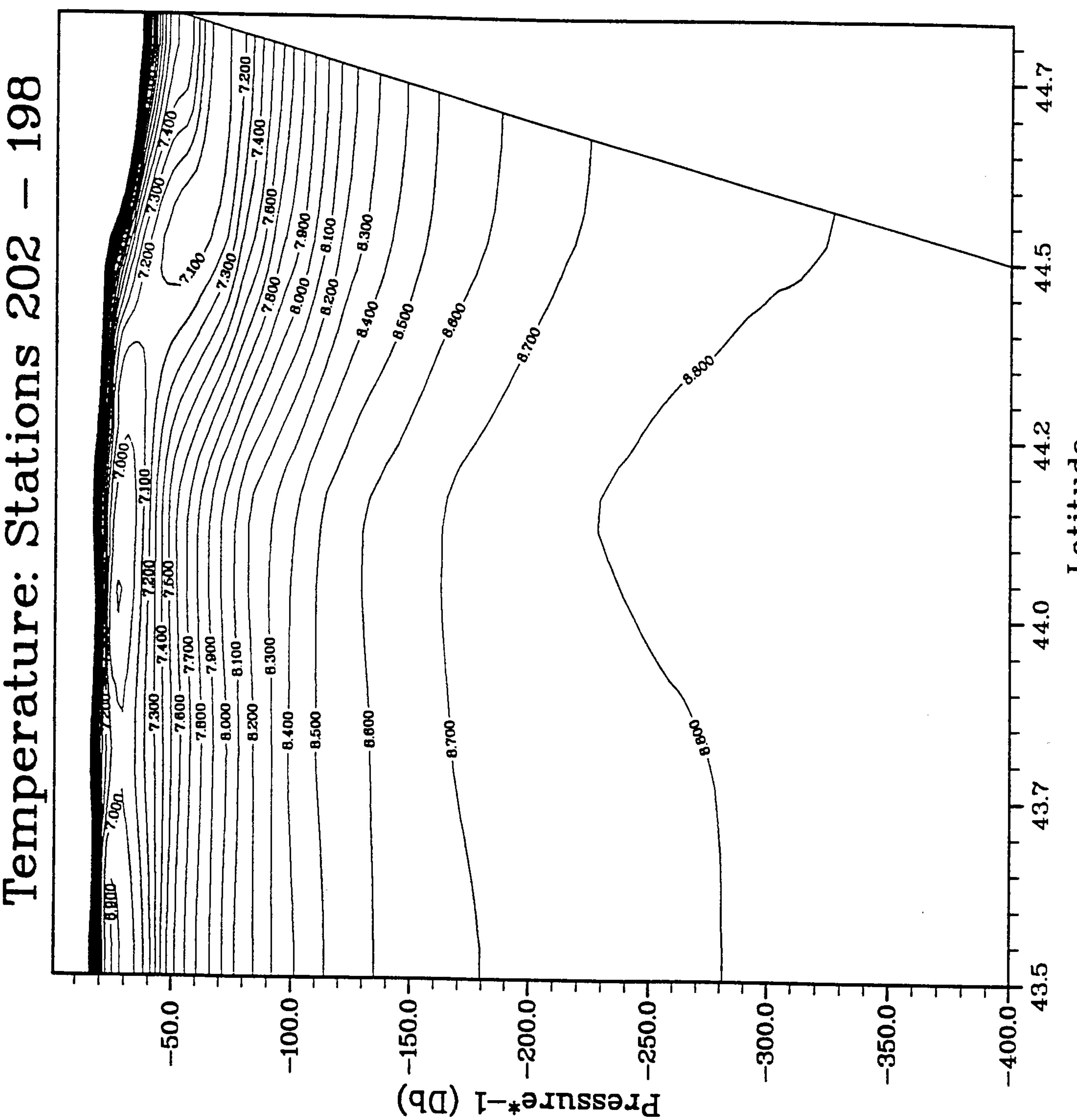


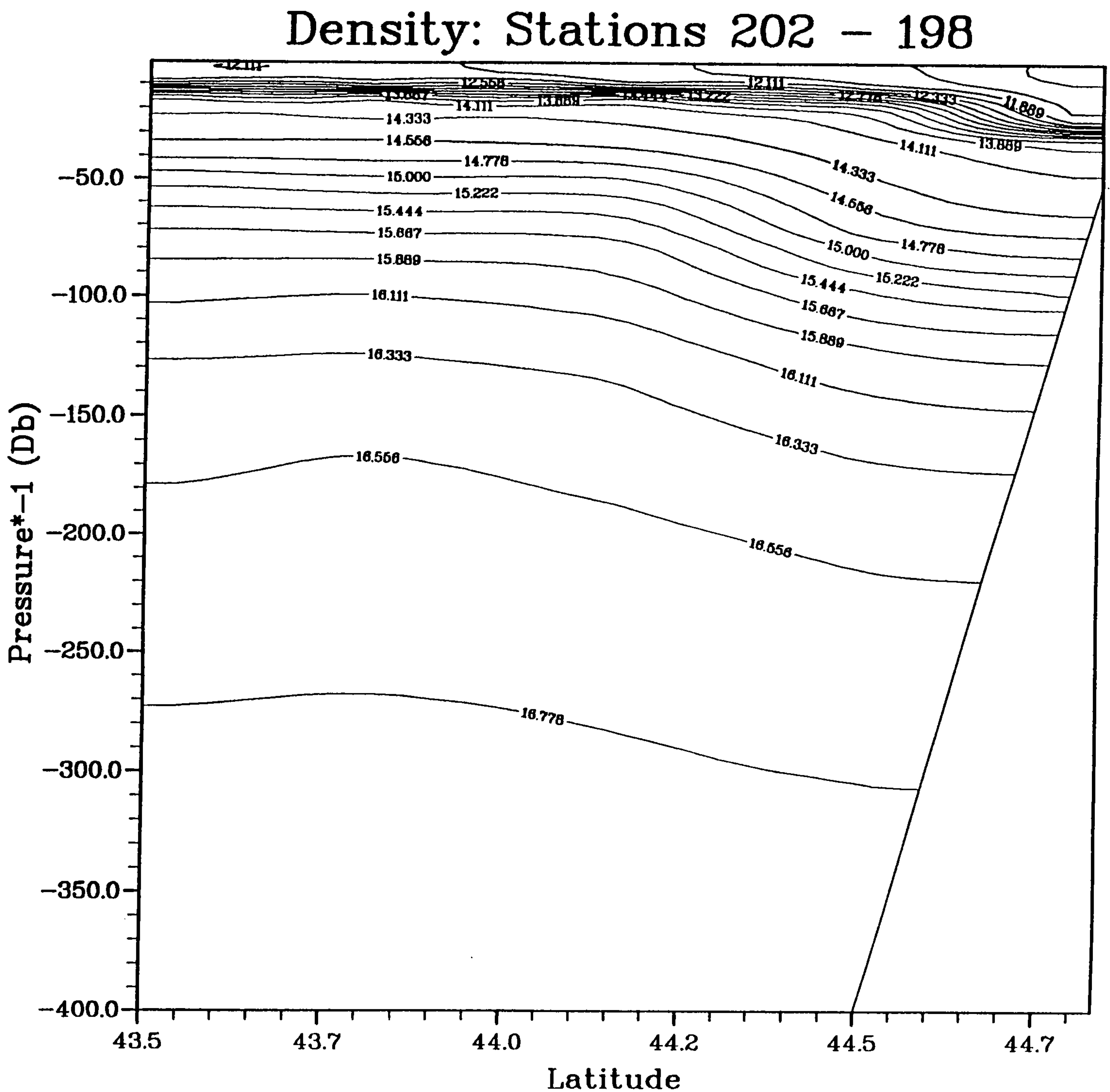


Density: Northern 1000m Contour
Pressure (Db)
Longitude
-100.0
-200.0
-300.0
-400.0
-500.0
-600.0
-700.0
-800.0
-900.0
-1000.0
29.0
30.0
31.0
32.0
33.0
34.0
35.0
36.0
37.0
38.0
39.0
40.0
41.0
14.65
14.90
15.15
15.40
15.65
15.90
16.15
16.40
16.65
16.90

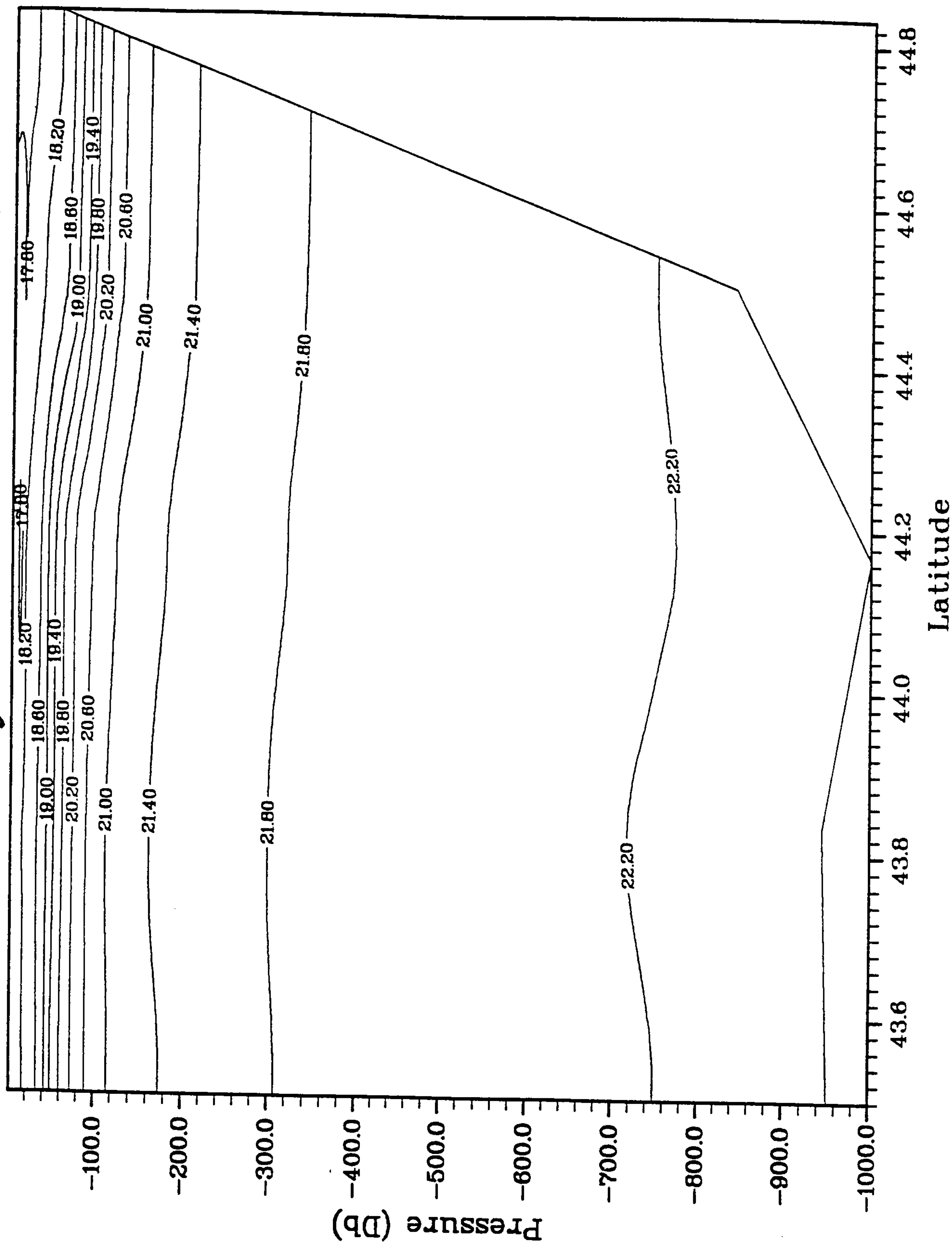

Hydro-Black 1991 Station Network
Latitude
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
Longitude
27.5
30.0
32.5
35.0
37.5
40.0

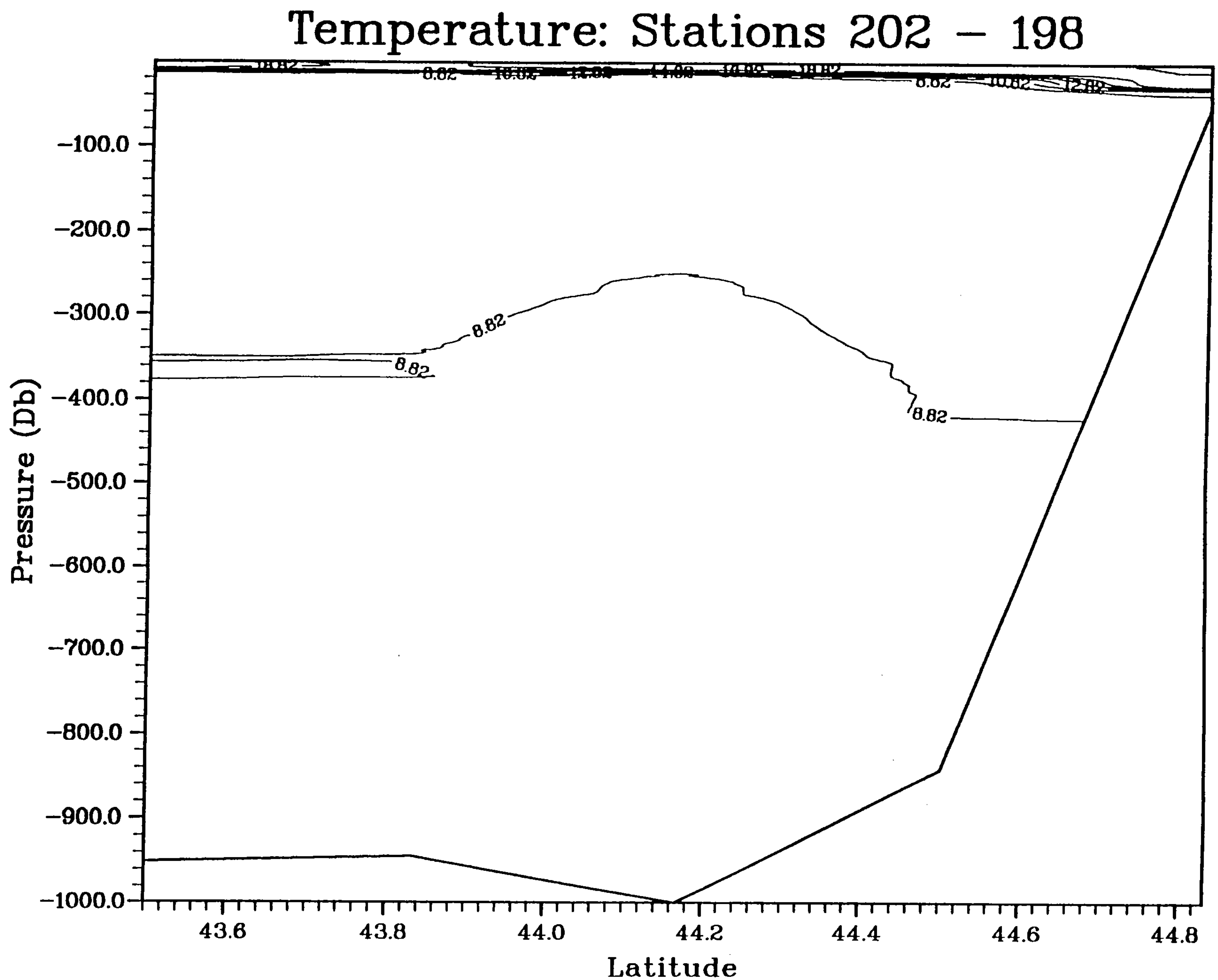

Salinity: Stations 202 — 198
Latitude
Pressure*-1 (Db)
43.5
43.7
44.0
44.2
44.5
44.7
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
-350.0
-400.0

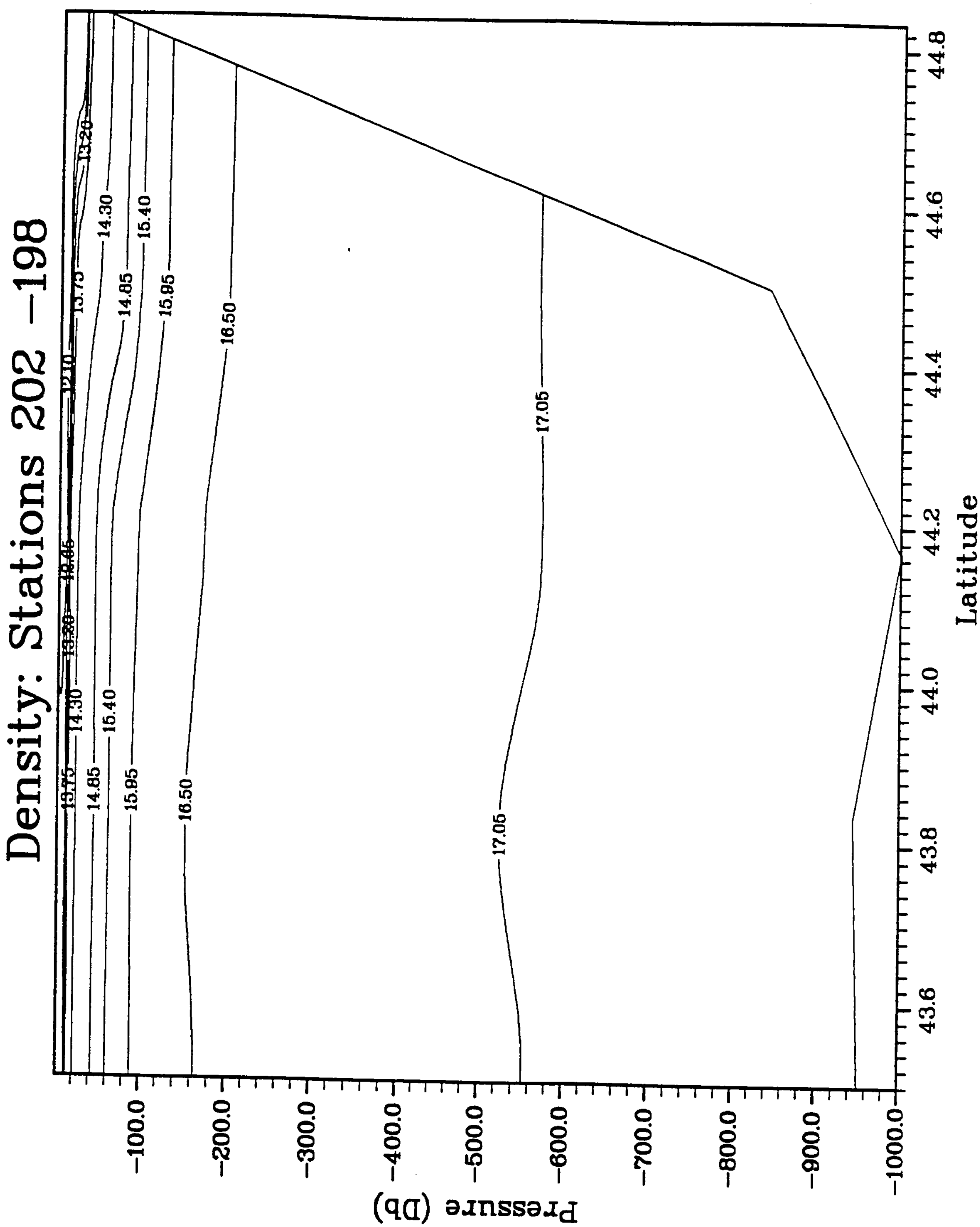

Temperature: Stations 202 - 198
Pressure*-1 (Db)
Latitude
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
-350.0
-400.0
43.5
43.7
44.0
44.2
44.5
44.7
8.800
8.700
8.600
8.500
8.400
8.300
8.200
8.100
8.000
7.900
7.800
7.700
7.600
7.500
7.400
7.300
7.200
7.100
7.000


Density: Stations 202 - 198
Pressure*-1 (Db)
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
-350.0
-400.0
43.5
43.7
44.0
44.2
44.5
44.7
Latitude
14.333
14.556
14.778
15.000
15.222
15.444
15.667
15.889
16.111
16.333
16.556
16.778
14.111
13.889
11.889
12.333
12.111
12.558

Salinity: Stations 202 - 198




Temperature: Stations 202 - 198
Pressure (Db)
-100.0
-200.0
-300.0
-400.0
-500.0
-600.0
-700.0
-800.0
-900.0
-1000.0
Latitude
43.6
43.8
44.0
44.2
44.4
44.6
44.8
8.82



Density: Stations 202 −198
Pressure (Db)
−100.0
−200.0
−300.0
−400.0
−500.0
−600.0
−700.0
−800.0
−900.0
−1000.0
Latitude
43.6
43.8
44.0
44.2
44.4
44.6
44.8
13.20
14.30
14.85
15.40
15.75
15.95
16.50
17.05

# APPENDIX VI:

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16. Abstract (Limit: 200 words)


An Intercalibration Workshop was held at the Woods Hole Oceanographic Institution (W.H.O.I.) from 1-10 December, 1991, for the CTD data acquired during HYDROBLACK '91. This intercalibration exercise was a prelude to an interdisciplinary HYDROBLACK '91 intercalibration to be held in Crimea, Ukraine, in February, 1992, incorporating the full suite of physical, biological, and chemical measurements acquired during the cruise.

HYDROBLACK '91 acquired for the first time a complete hydrographic, biological, and chemical data set for the entire Black Sea, to 2000 m water depth, with the participation of all Black Sea riparian countries as well as the U.S. Nearly 300 hydrographic stations were occupied to full water depth; biological and chemical measurements were made at 100 of these stations. This quasi-synoptic survey was accomplished using five ships during an interval of approximately three weeks.

Results show some disparities between CTD's from the different regions, but the intercalibrated results show a consistent and high resolution detail of the dynamic topography and other physical characteristics of the entire Black Sea basin. The intercalibrated data set is now available within each country and from W.H.O.I., and will form the basis for studies on ocean physics as well as interdisciplinary issues such as oxygen depletion within the basin and hydrogen sulfide distribution. This effort provides an intercalibrated, spatially-dense baseline against which all future and past measurements can be compared.

In spite of significant economic pressures arising from the changes in the eastern European countries, and the inadequate scientific exchange with the west during the past two decades, HYDROBLACK '91 is considered a success and a model for future international scientific and monitoring efforts throughout the Black Sea. Similar efforts are anticipated twice-yearly in the framework of the new Cooperative Marine Science Program for the Black Sea.


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dynamic height
hydrogen sulfide
water mass formation

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