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HYDROGRAPHIC DATA FROM THE SLOPE WATERS
OFF CENTRAL CALIFORNIA

26 November 1978 - 26 June 1980

Arlene A. Bird
Raymond J. Koob, AG2, USN
Jacob B. Wickham
Christopher N.K. Mooers

July 1984

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INTRODUCTION

The hydrographic data presented were collected as part of a study to describe the flow and watermass structure in the upper 500m of the slope waters off the central California coast. Two intersecting lines of STD stations were occupied: the San Martin line, Stations 1-12, and the Slate Rock line, Stations 12-23, Figure 1. The continental slope in this region is steep, exceeding .05 at the nearshore stations, and there is virtually no continental shelf. The 12 stations in each of the two lines are located at 3.9 km intervals and extend from 4 to 47 km offshore. Station number, location, water depth and distance along each line are tabulated in Table 1.

DATA ACQUISITION

Fourteen cruises, each completed in 24 hours or less, were made over the period 26 November 1978 through 26 June 1980. The sequence of cruises, the stations occupied and their positions along the San Martin line are diagrammed, Figure 2. The Slate Rock line was only sampled on the first four cruises, all in the winter of 1978-79. A list of cruise numbers with start and stop dates is provided, Table 2. For various reasons, such as instrumental difficulties and time limitations, there are spatial gaps in the sampling, (Fig. 2) for the San Martin line. Profiles were typically made to a depth of 450m or greater at Stations 2-23; at Station 1, casts were made to less than 100m depth because of the shallow water depth.

Temperature and salinity profiles were acquired aboard



Figure 1. Central California coast bathymetry.

TABLE 1. Station number, nominal position, water depth and distance offshore.

<u>STATION</u>	<u>LATITUDE</u>	<u>LONGITUDE</u>	<u>DEPTH (m)</u>	<u>DISTANCE OFFSHORE (km)</u>
1	35-53.0	121-29.8	100	4.0
2	35-52.5	121-32.3	357	7.9
3	35-52.1	121-34.7	520	11.6
4	35-51.6	121-37.4	668	15.8
5	35-51.1	121-39.9	759	19.7
6	35-50.7	121-42.4	833	23.5
7	35-50.2	121-45.0	915	27.5
8	35-49.7	121-47.6	988	31.6
9	35-49.2	121-50.1	1061	35.4
10	35-48.7	121-52.7	1150	39.5
11	35-48.3	121-55.4	1182	43.6
12	35-47.8	121-57.7	1044	47.2/47.9
13	35-49.5	121-56.1	1274	43.9
14	35-51.1	121-54.6	1183	40.2
15	35-52.7	121-53.0	1146	36.3
16	35-54.3	121-51.3	1089	32.4
17	35-55.9	121-49.9	1080	28.8
18	35-57.6	121-48.3	1098	24.8
19	35-59.3	121-46.8	997	20.9
20	36-00.9	121-45.2	842	17.1
21	36-02.5	121-43.5	732	13.2
22	36-04.3	121-42.0	560	9.1
23	36-05.9	121-40.2	350	5.1

LEGEND

- = Nominal positions
- = Actual positions

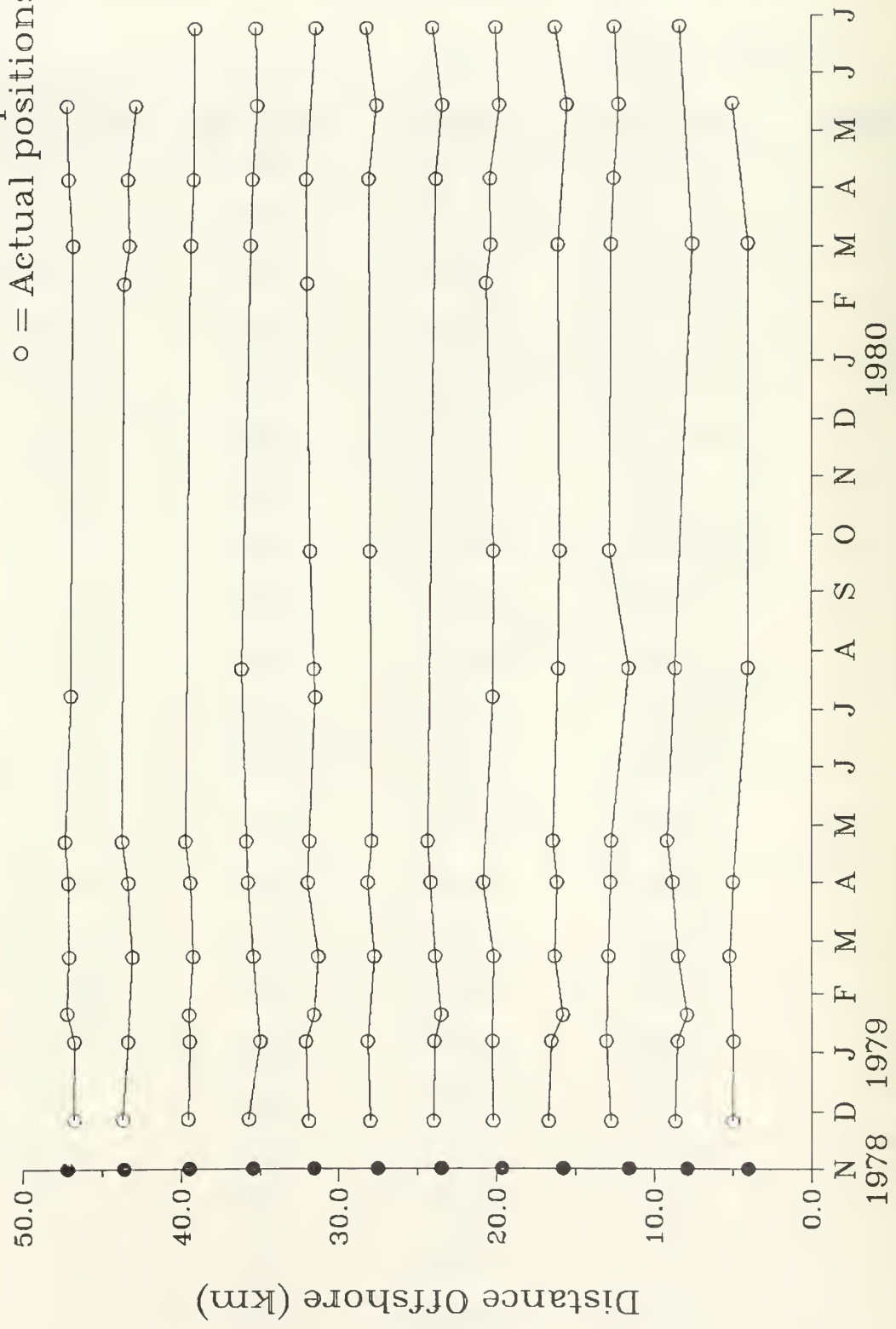


Figure 2. Nominal and actual STD stations occupied along the San Martin line.

TABLE 2. Cruise number, start date and time, and stop date and time.

<u>Cruise No.</u>	START		STOP	
	<u>Date</u>	<u>Time</u>	<u>Date</u>	<u>Time</u>
70	11/26/78	1855	11/27/78	0855
1	01/07/79	1030	01/08/79	0201
4	01/21/79	1408	01/22/79	1310
7	02/21/79	0830	02/22/79	0830
21	04/01/79	0830	04/01/79	1922
28	04/23/79	1647	04/23/79	2210
61	07/08/79	2200	07/09/79	0206
65	07/23/79	1212	07/23/79	2008
92	09/23/79	1840	09/23/79	2226
14	02/12/80	1401	02/12/80	1625
19	03/03/80	1445	03/03/80	2206
27	04/07/80	0738	04/07/80	1443
41	05/16/80	1120	05/16/80	1626
56	06/26/80	0855	06/26/80	1645

the R/V Acania of the Naval Postgraduate School (NPS) using a Bisset-Berman Model 9006 STD. Both down- and upcasts were recorded on magnetic tape cassettes via an HP 9800 series mini-computer. The raw data were then transferred to 9-track magnetic tapes for processing on the IBM 3033 mainframe computer at NPS.

DATA PROCESSING

The primary objective in the processing of the data was to obtain density profiles from which the alongshore component of geostrophic velocity could be computed. The first step in reducing the raw data to a usable form was to thin the vertical density of measurements in each profile from approximately three samples per meter to one sample every two meters by linear interpolation. The original hydrographic data contain considerable noise from two important sources. The first is the difference in time constants for the temperature and conductivity sensors used for calculating salinity; this difference often results in salinity spikes in the thermocline where temperature gradients are large. The second is multi-channel spiking arising intermittently in the electrical cable connecting the sensors with the recording system. This problem causes spiking in the profiles of both temperature and salinity. To suppress the noise, single point temperature spikes were first removed and density (σ_t) profiles were calculated using the International Equation of State for Seawater (1980). Next, to filter out the salinity spikes, the density profiles were constrained to be neutral or stably stratified, and the salinity values were adjusted

accordingly.

After suppressing the noise in the data, three processes were applied to fill in the spatial gaps in the profiles: addition of a mixed layer from the surface to the first observed level, extension of data to the reference level and interpolation of data for missing stations. Most of the raw observations extended from near the surface (<10m) to 450m or below. A mixed layer was added from the shallowest observation to the surface. Twelve profiles in a total of 187 were extended by 100m or less to 450m by interpolation from the adjacent station(s). In six cases of shallow Station 1 profiles and three Station 23 profiles, the profiles were extended to facilitate their use in the geostrophic calculations by appending the slope of the adjacent Station 2 profile onto the profile of Station 1. Profiles for 32 stations which were not occupied or which had unrecoverable data were constructed by linearly interpolating temperature and salinity data from the two stations on either side of the missing station. No attempt was made to create profiles for missing stations unless data existed on both sides of that station. In Table 3, the letters 'D' and 'I' indicate where stations have been deepened or added by interpolation; 'U' indicates a short profile which has not been deepened.

Finally, dynamic heights were calculated from each density profile using a 450 db reference level. From these, the relative alongshore geostrophic velocity was then computed.

TABLE 3. STD Observations.

SAN MARTIN LINE

<u>Cruise</u>	<u>Date</u>	<u>Station Number</u>												
		<u>12</u>	<u>11</u>	<u>10</u>	<u>9</u>	<u>8</u>	<u>7</u>	<u>6</u>	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>	
78-70	11/26/78	X	X	X	X	X	X	X	X	X	X	X	D	D
79-01	01/07/79	X	X	X	X	X	X	X	X	X	X	X	D	D
79-04	01/21/79	X	I	X	I	X	I	X	I	X	I	D		
79-07	02/21/79	X	X	X	X	X	X	X	X	X	X	X	D	D
79-21	04/01/79	X	X	X	X	X	X	X	X	X	D	D	D	
79-28	04/23/79	X	X	X	X	X	X	X		U	U	U		
79-61	07/08/79	X	I	I	I	X	I	X						
79-65	07/23/79				X	X	I	I	I	X	X	D	D	
79-92	09/23/79					X	D	I	X	X	X			
80-14	02/12/80		X	I	I	X	I	I	X					
80-19	03/03/80	X	X	X	X	I	I	I	X	D	X	D	D	
80-27	04/07/80	X	X	X	X	X	X	X	X	I	X			
80-41	05/16/80	X	X	I	X	I	X	X	X	X	D		U	
80-56	06/26/80	X	X	X	X	X	X	X	X	X	X	D		

SLATE ROCK LINE

<u>Cruise</u>	<u>Date</u>	<u>Station Number</u>											
		<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>20</u>	<u>21</u>	<u>22</u>	<u>23</u>
78-70	11/27/78	X	X	X	I	X	X	X	X	X	I	X	D
79-01	01/08/78	X	X	X	X	X	X	I	X	X	I	X	D
79-04	01/22/79	X	I	X	I	I	X	X	I	X	X	X	D
79-07	02/22/79	X	X	I	X	X	X	X	X	X			

DATA PRESENTATION

The hydrographic data are presented in three graphical formats: staggered profiles (Figures 3-20), temperature-salinity diagrams (Figures 21-38), and vertical sections (Figures 39-56) for each line of each cruise. Alongshore geostrophic velocities computed from the hydrographic data from each cruise are contoured (Figures 57-74).

Data Presentation - Profiles

Vertical profiles of temperature, salinity, sigma-t and Brunt-Vaisala frequency squared are displayed in staggered format for each line of each cruise (Figures 3-20). Temperature profiles are staggered by 2°C, salinity profiles by 1 ‰, sigma-t profiles by 1 kg/m³ and Brunt-Vaisala frequency squared by .0005 s⁻². The station number is located at the bottom of each profile.

11/26/78

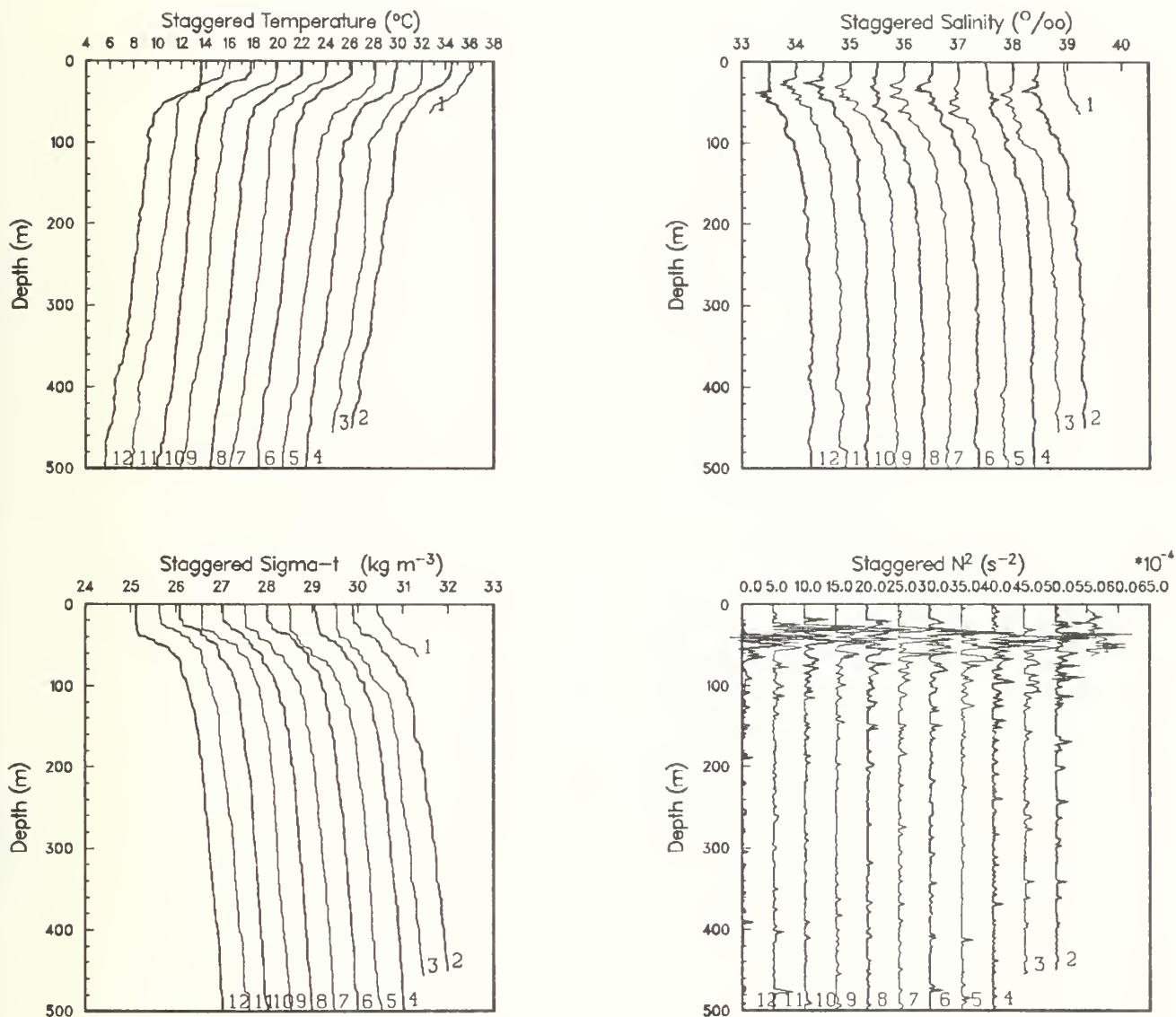


Figure 3.

11/27/78

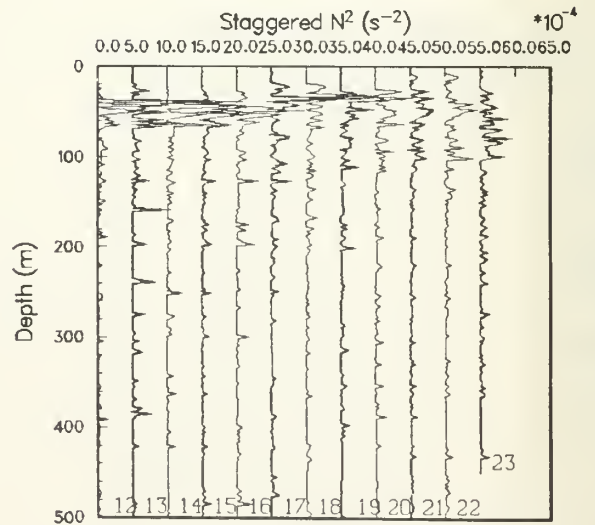
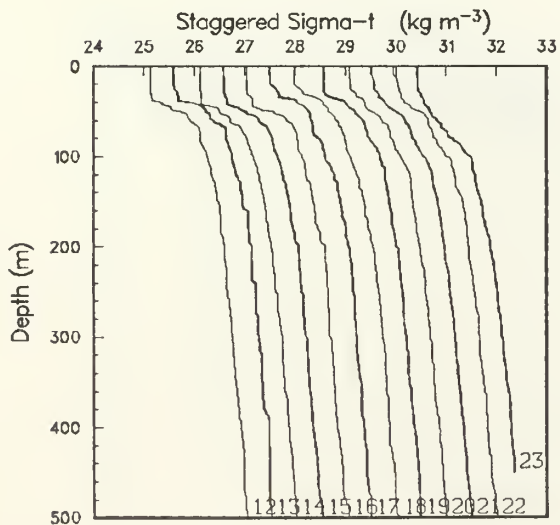
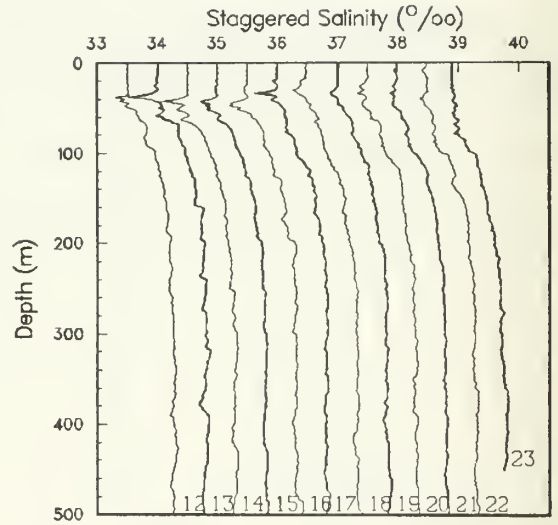
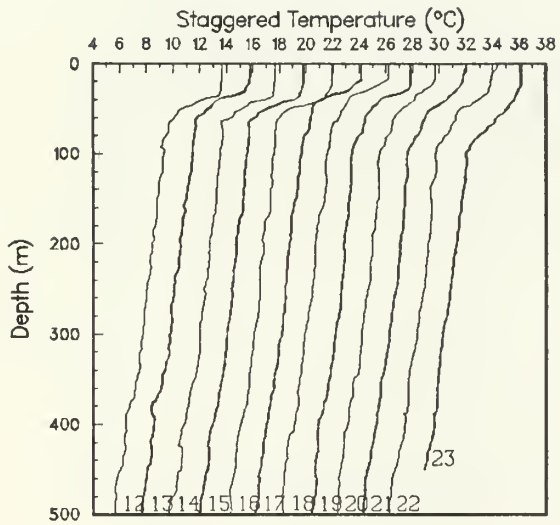


Figure 4.

1/7/79

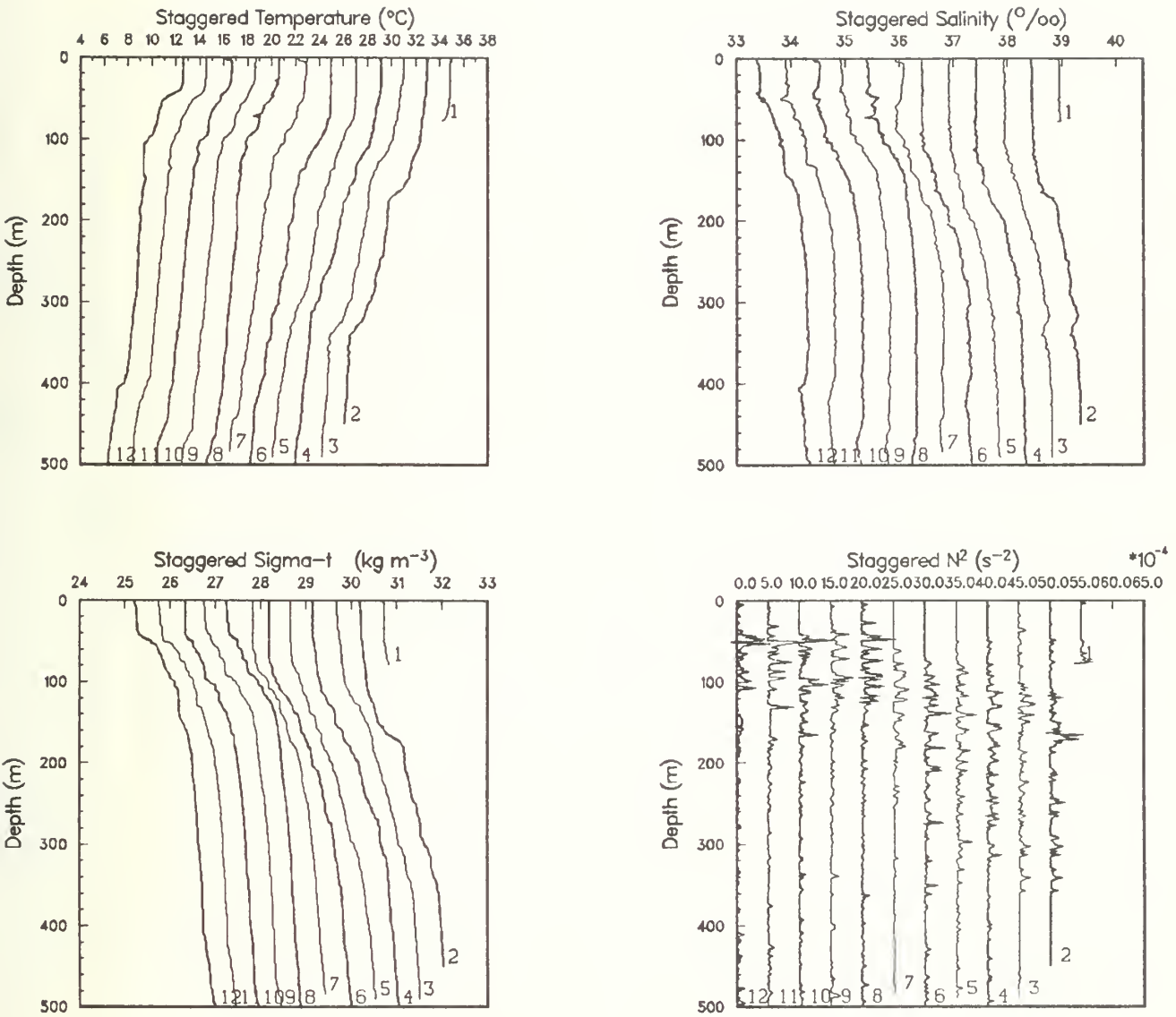


Figure 5.

1/8/79

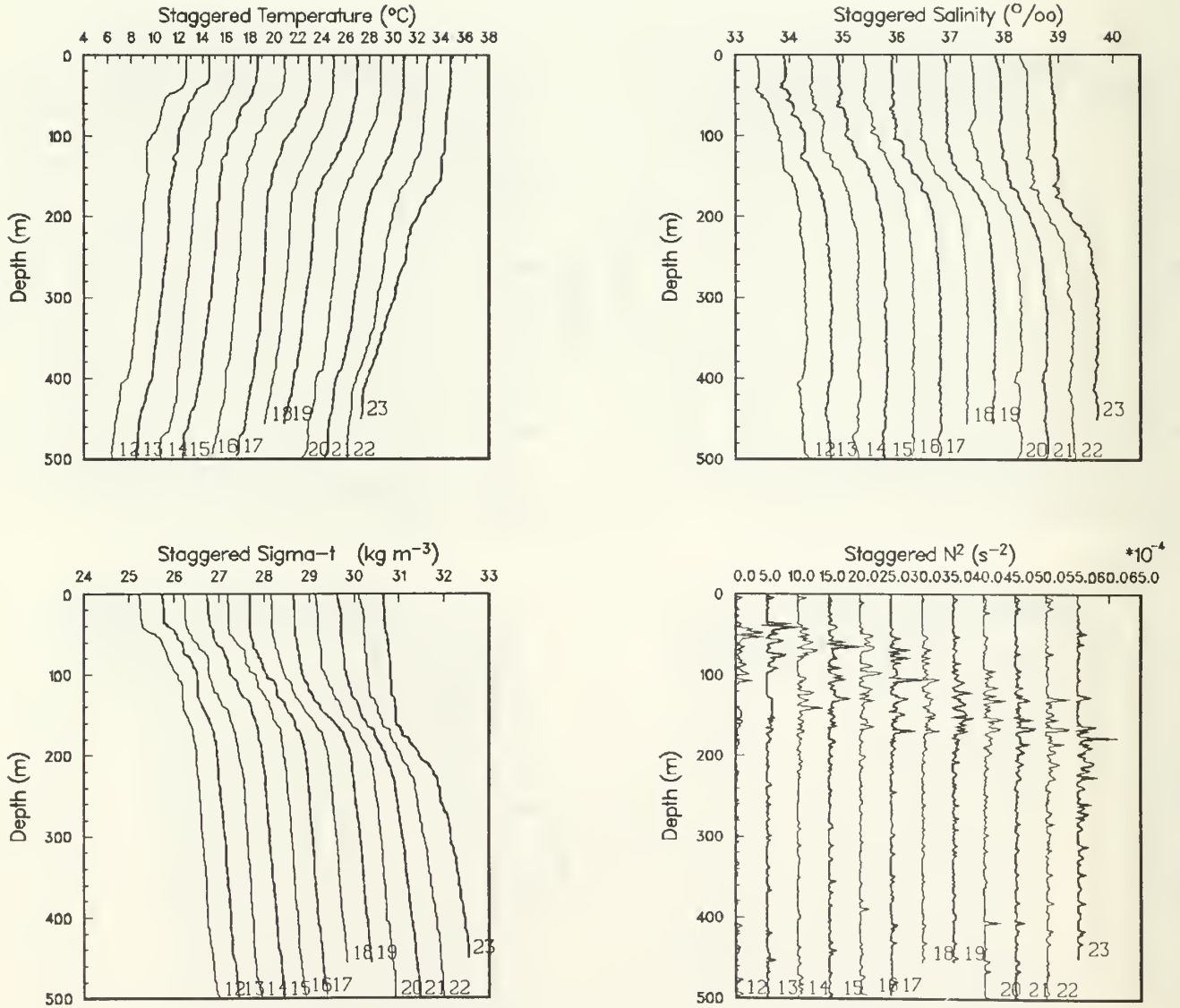


Figure 6.

1/21/79

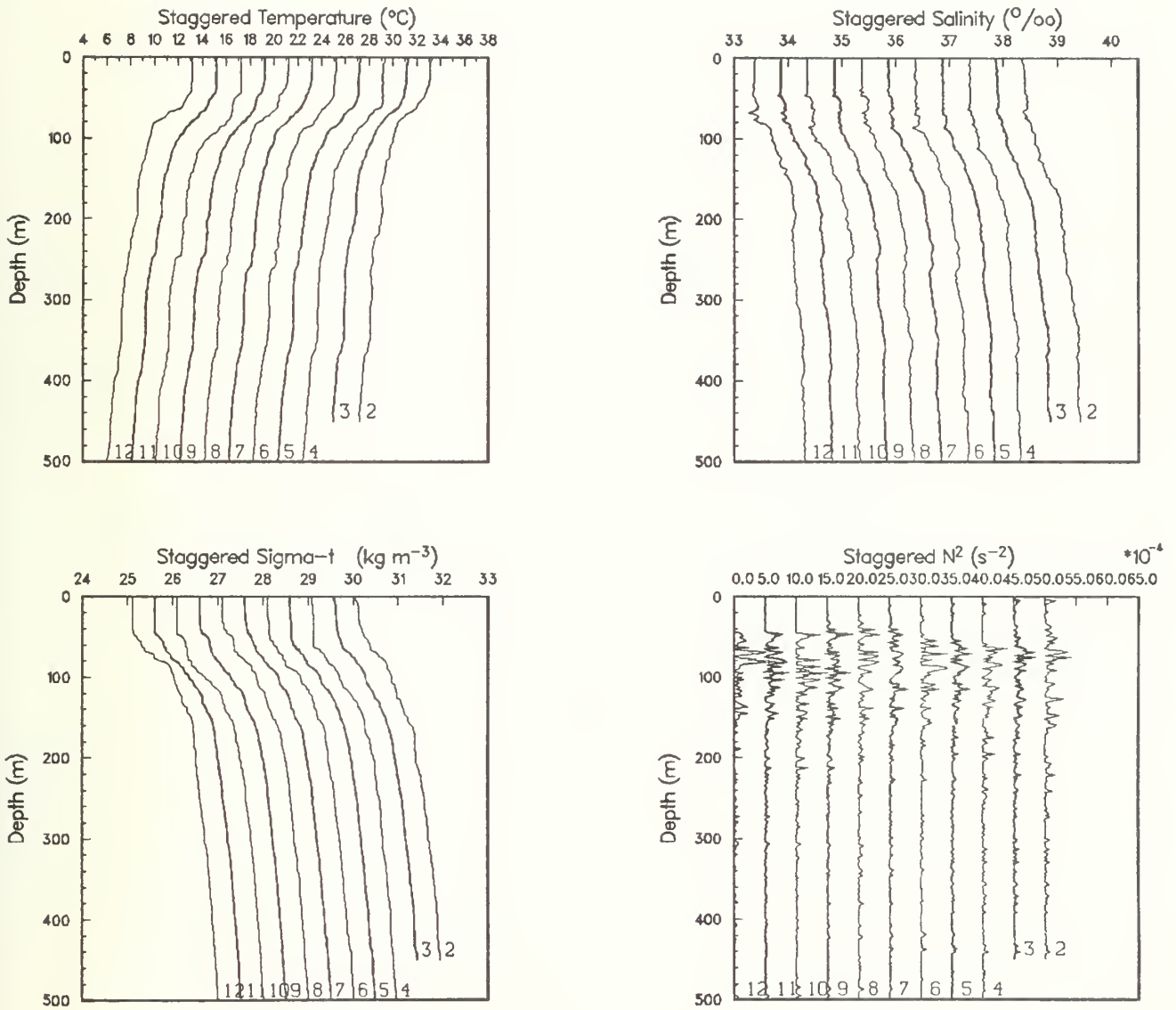


Figure 7.

1/22/79

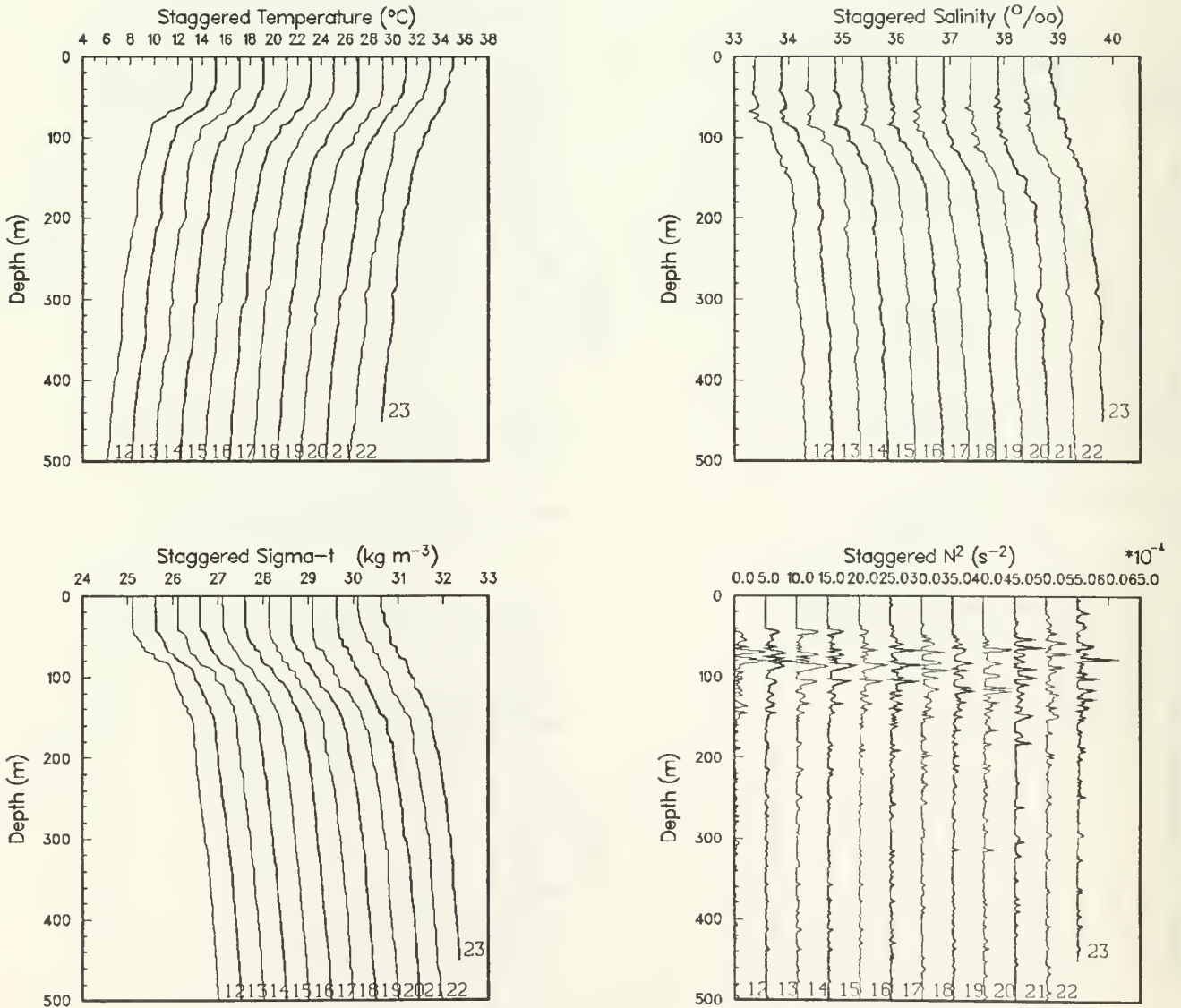


Figure 8.

2/21/79

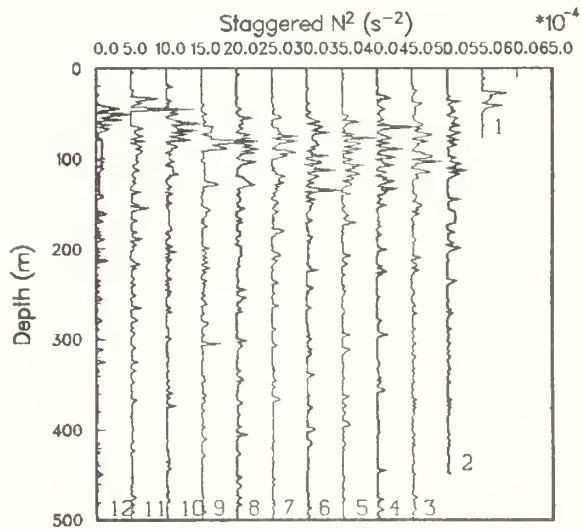
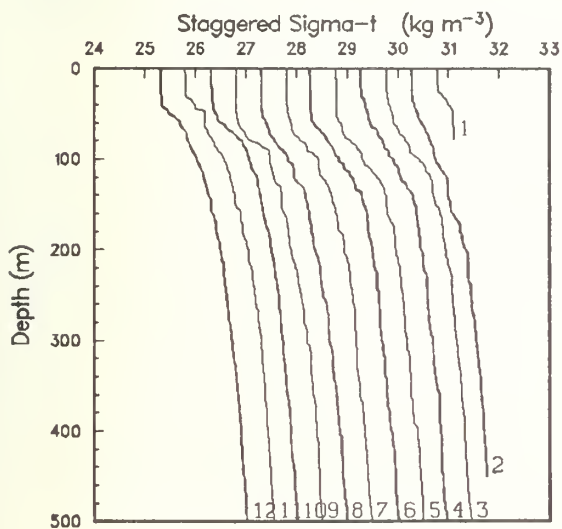
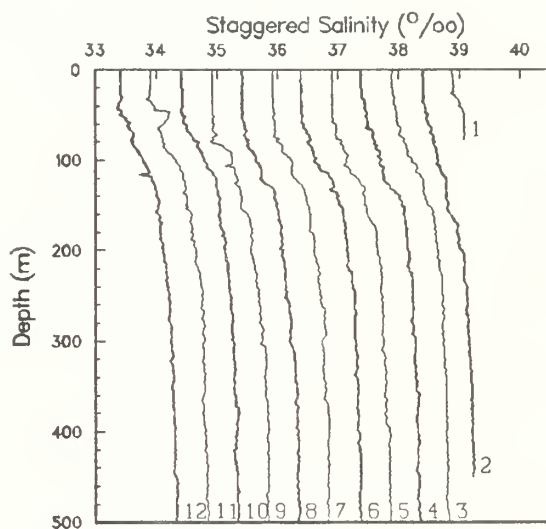
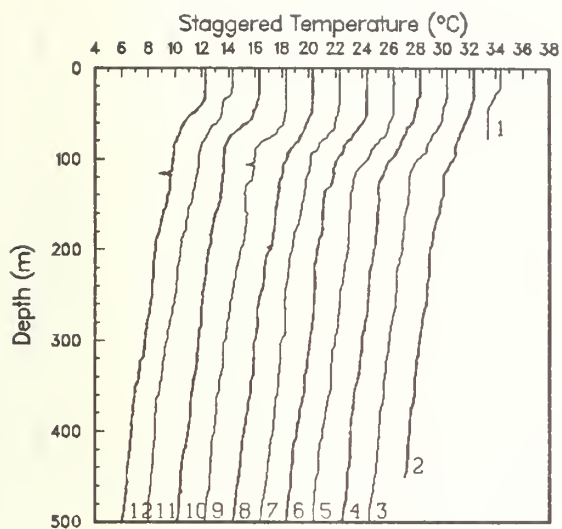


Figure 9.

2/22/79

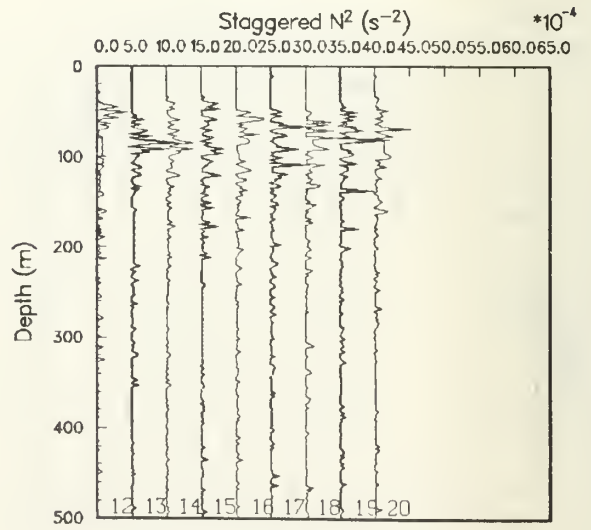
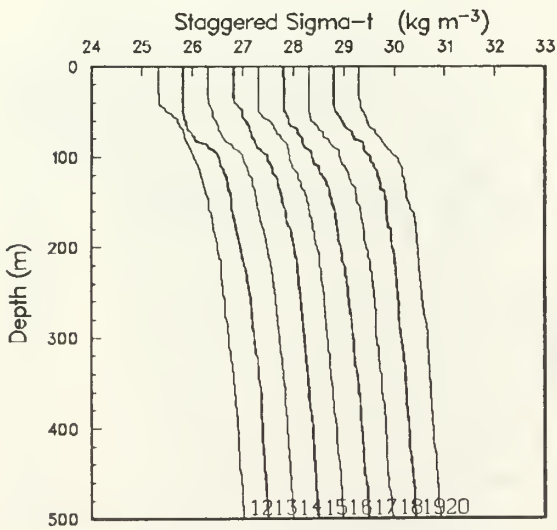
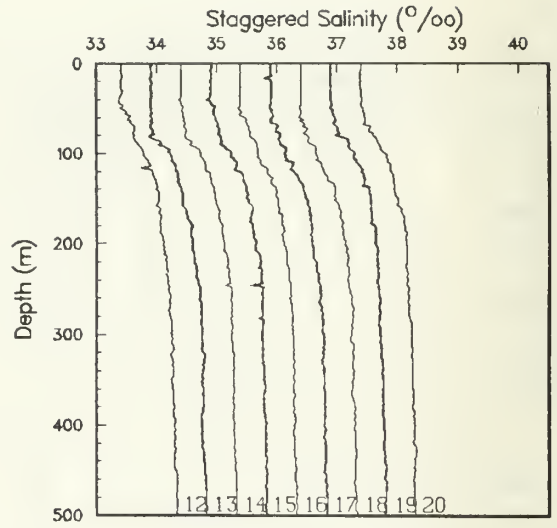
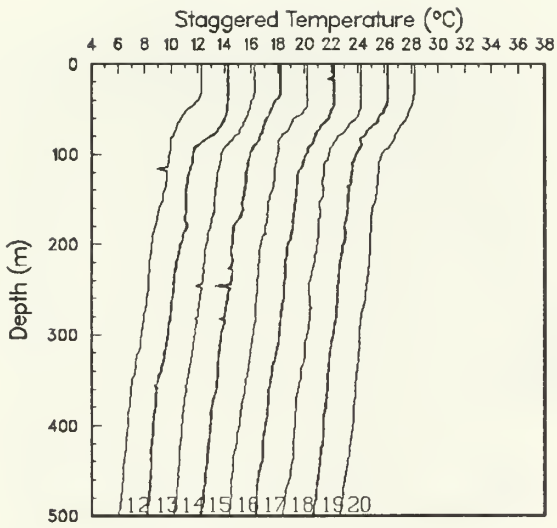


Figure 10.

4/1/79

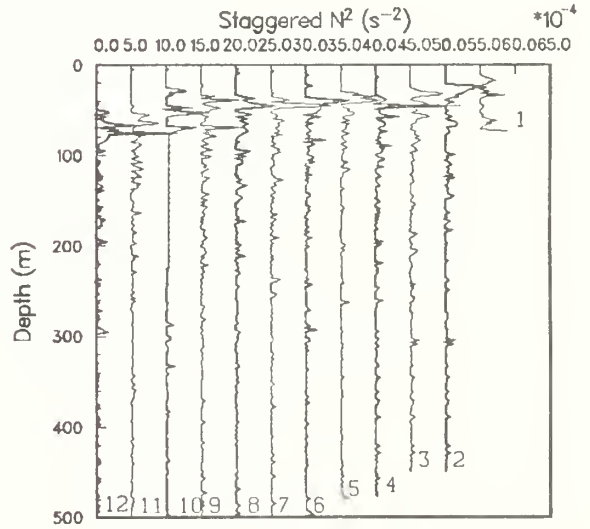
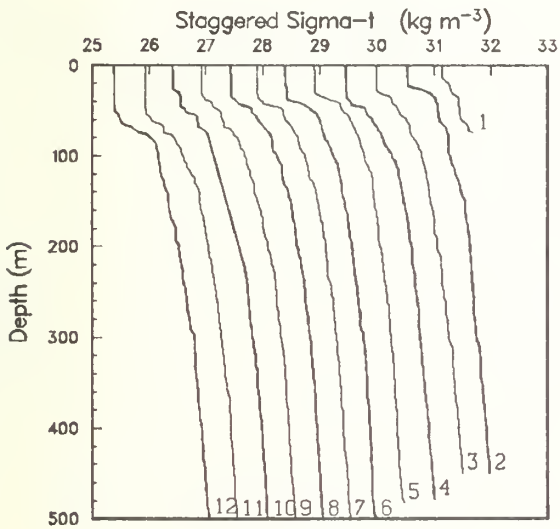
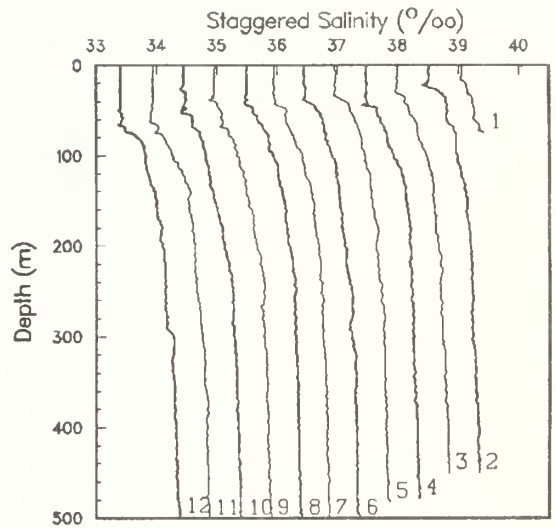
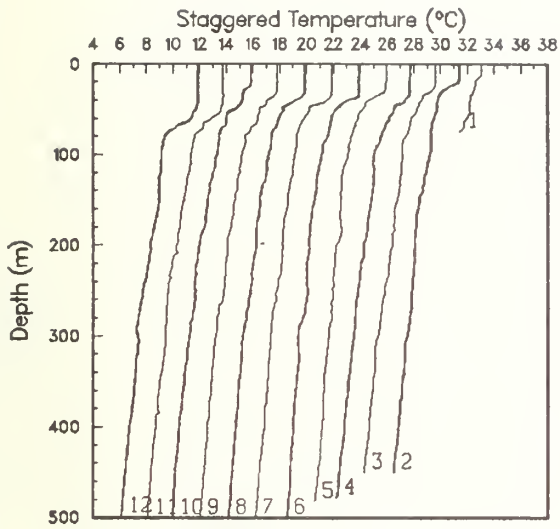


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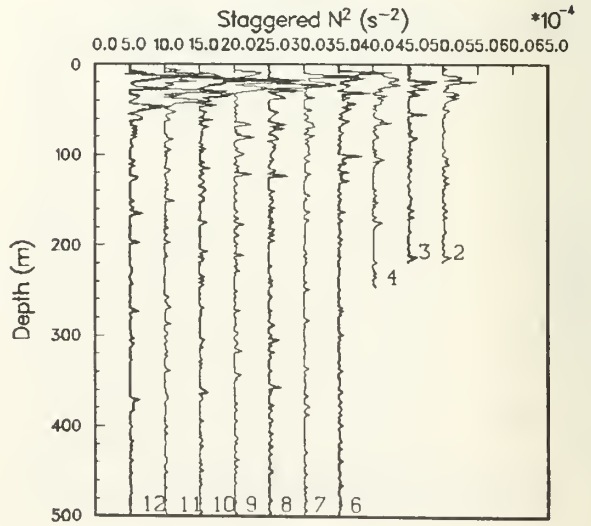
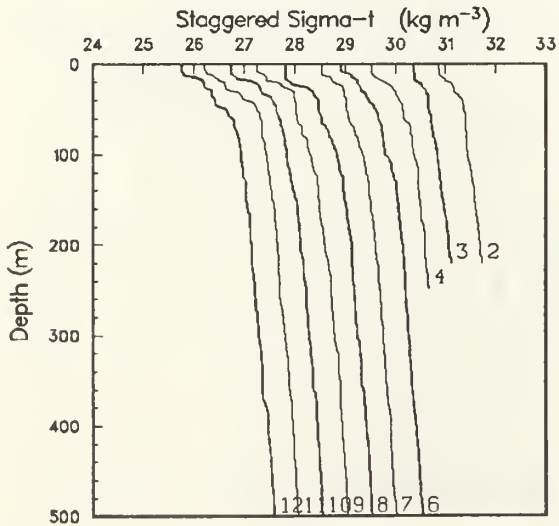
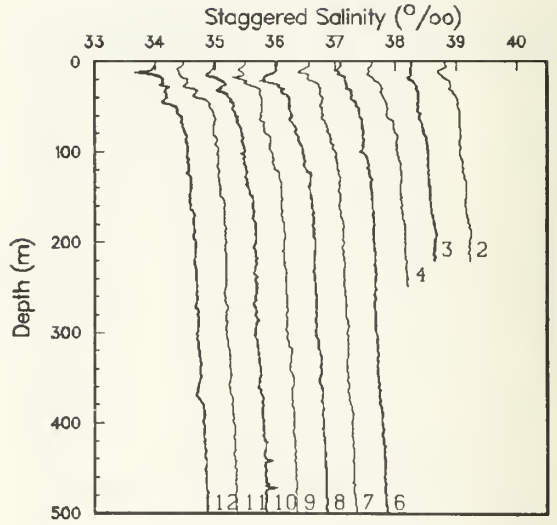
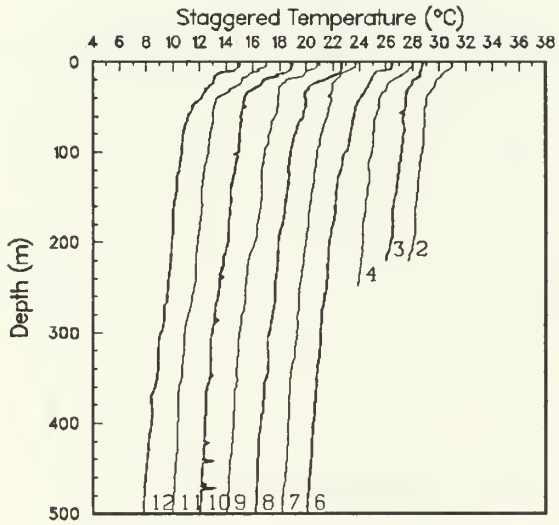


Figure 12.

7/8/79

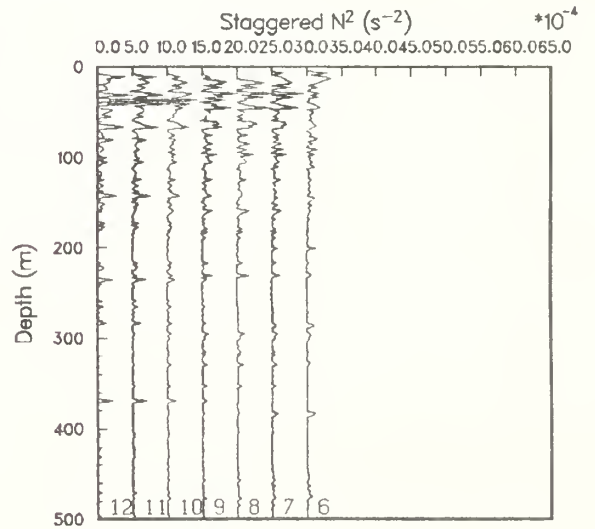
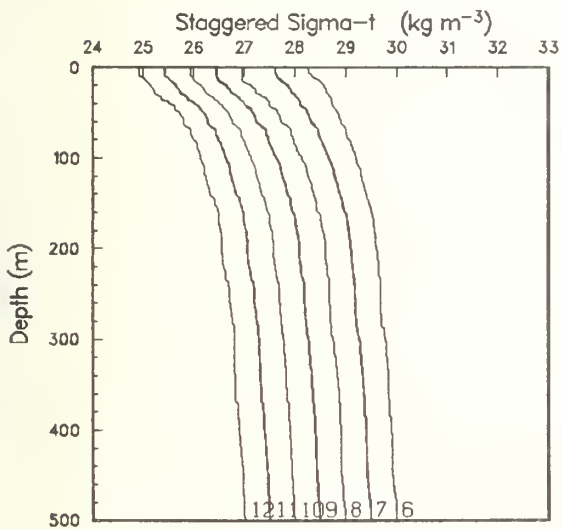
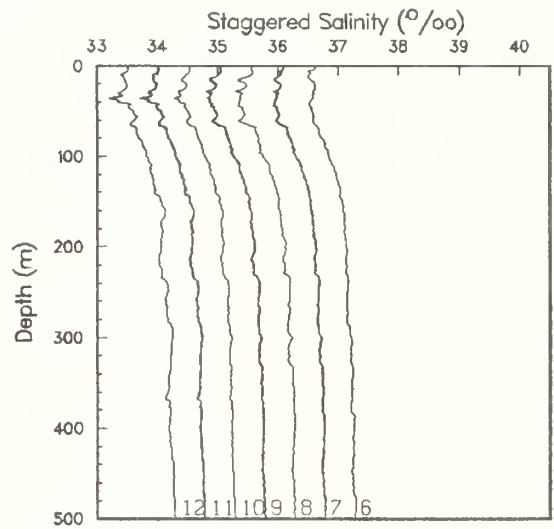
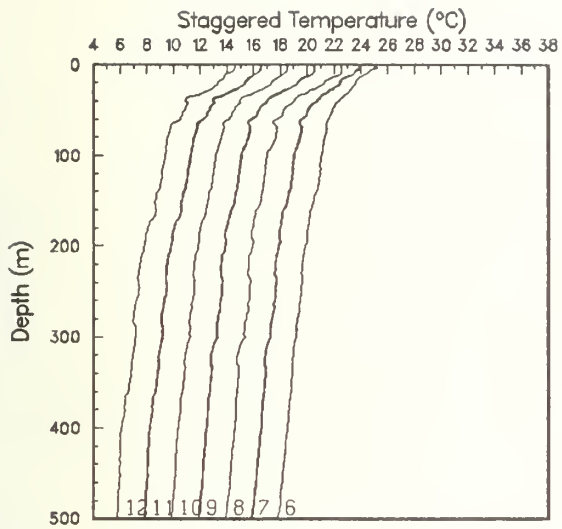


Figure 13.

7/23/79

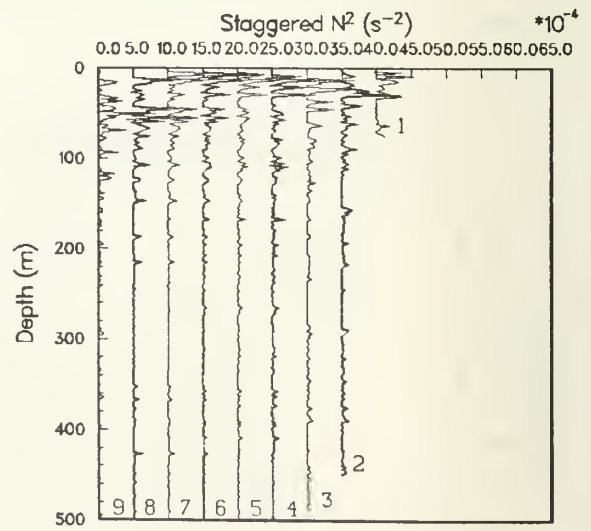
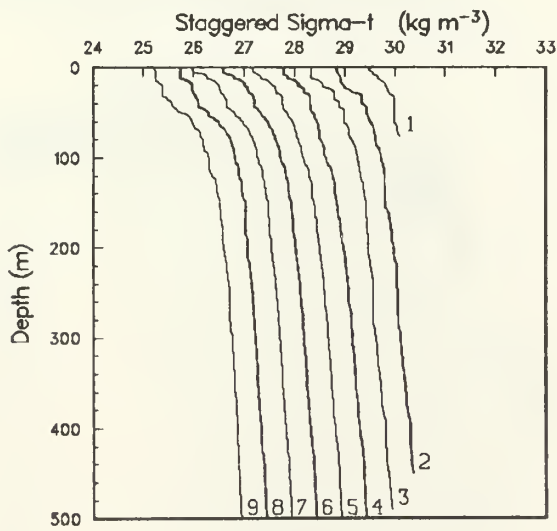
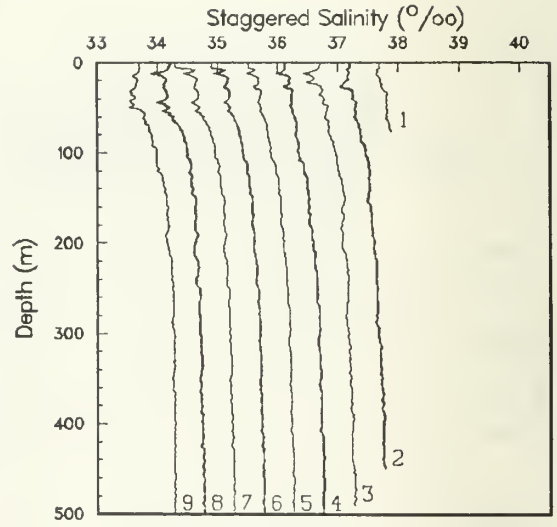
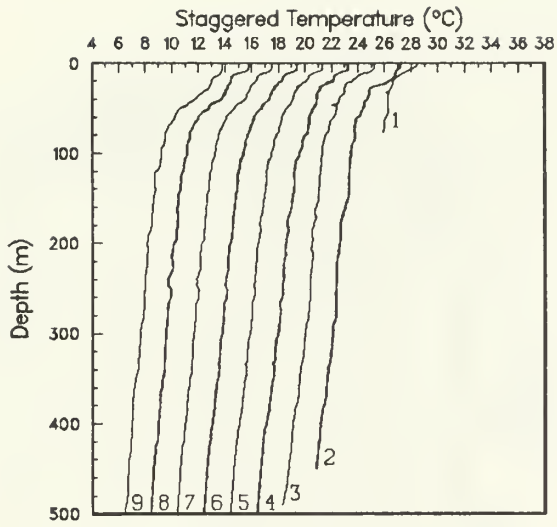


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9/23/79

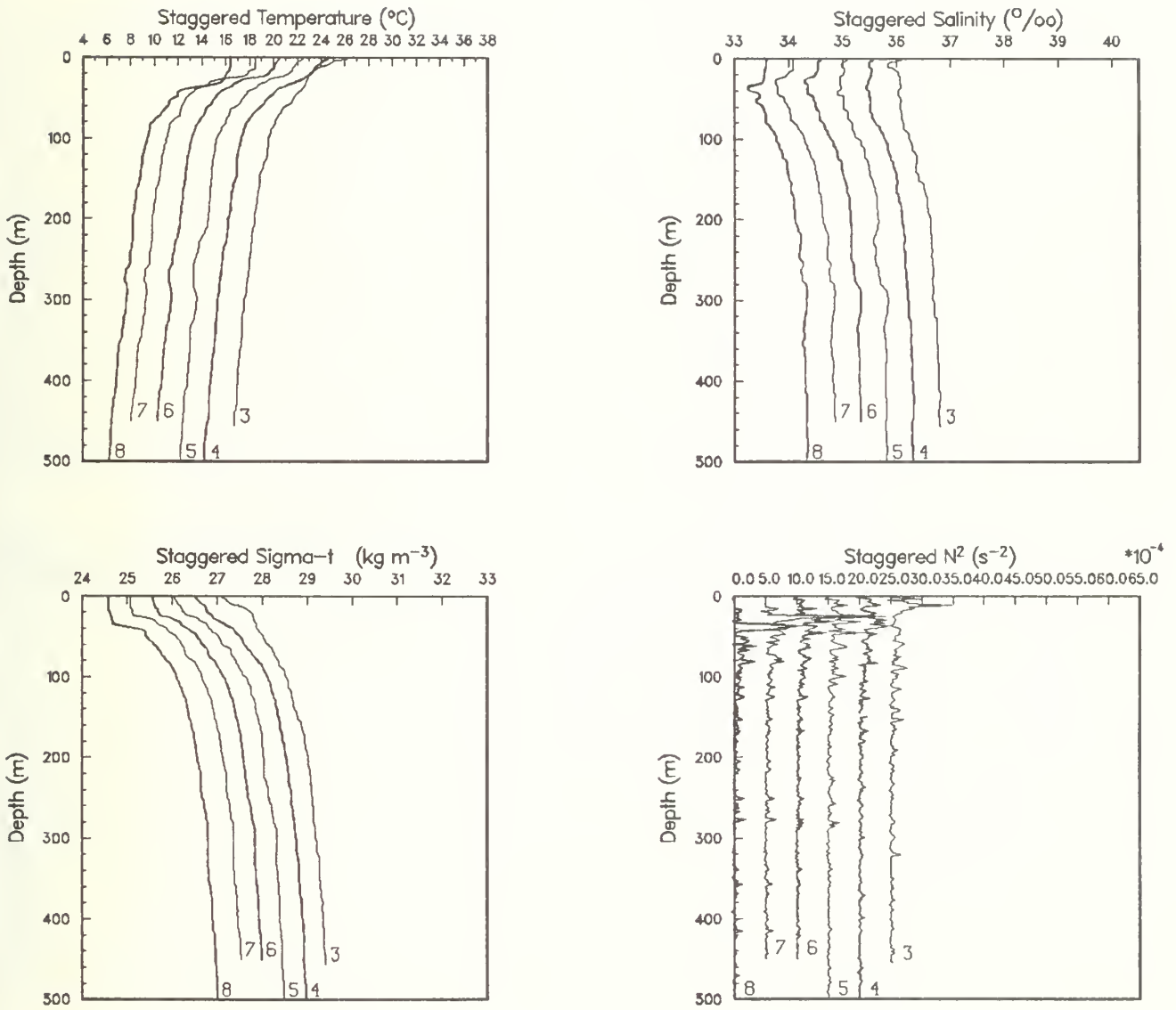


Figure 15.

2/12/80

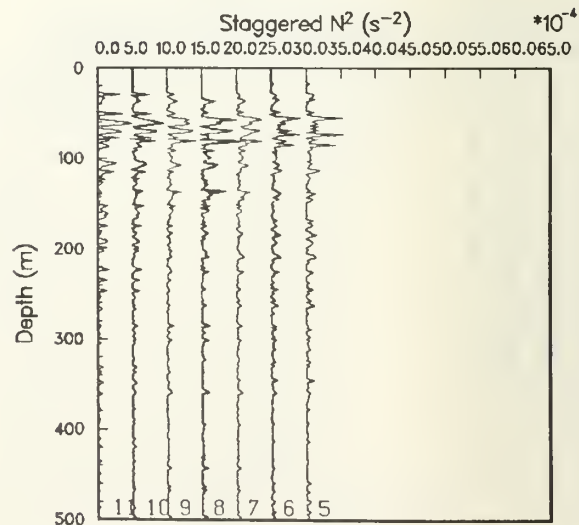
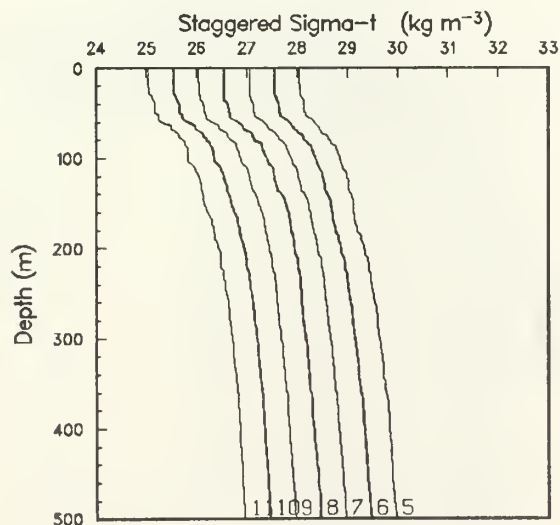
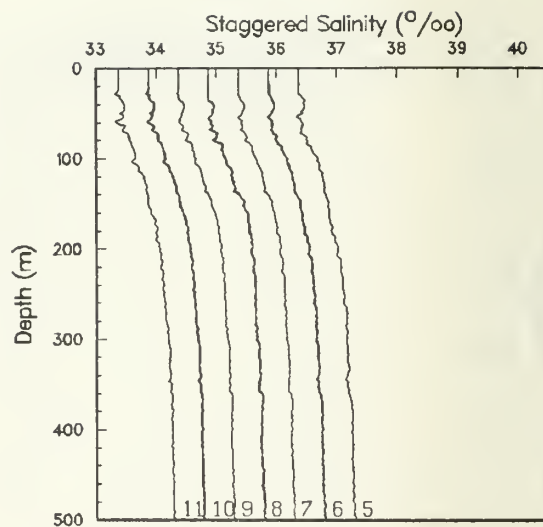
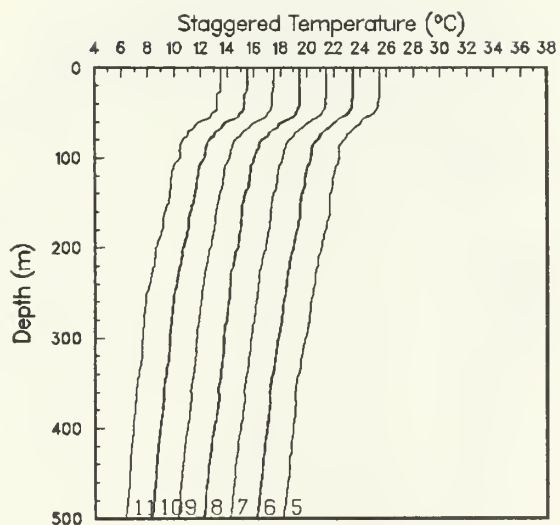


Figure 16.

3/3/80

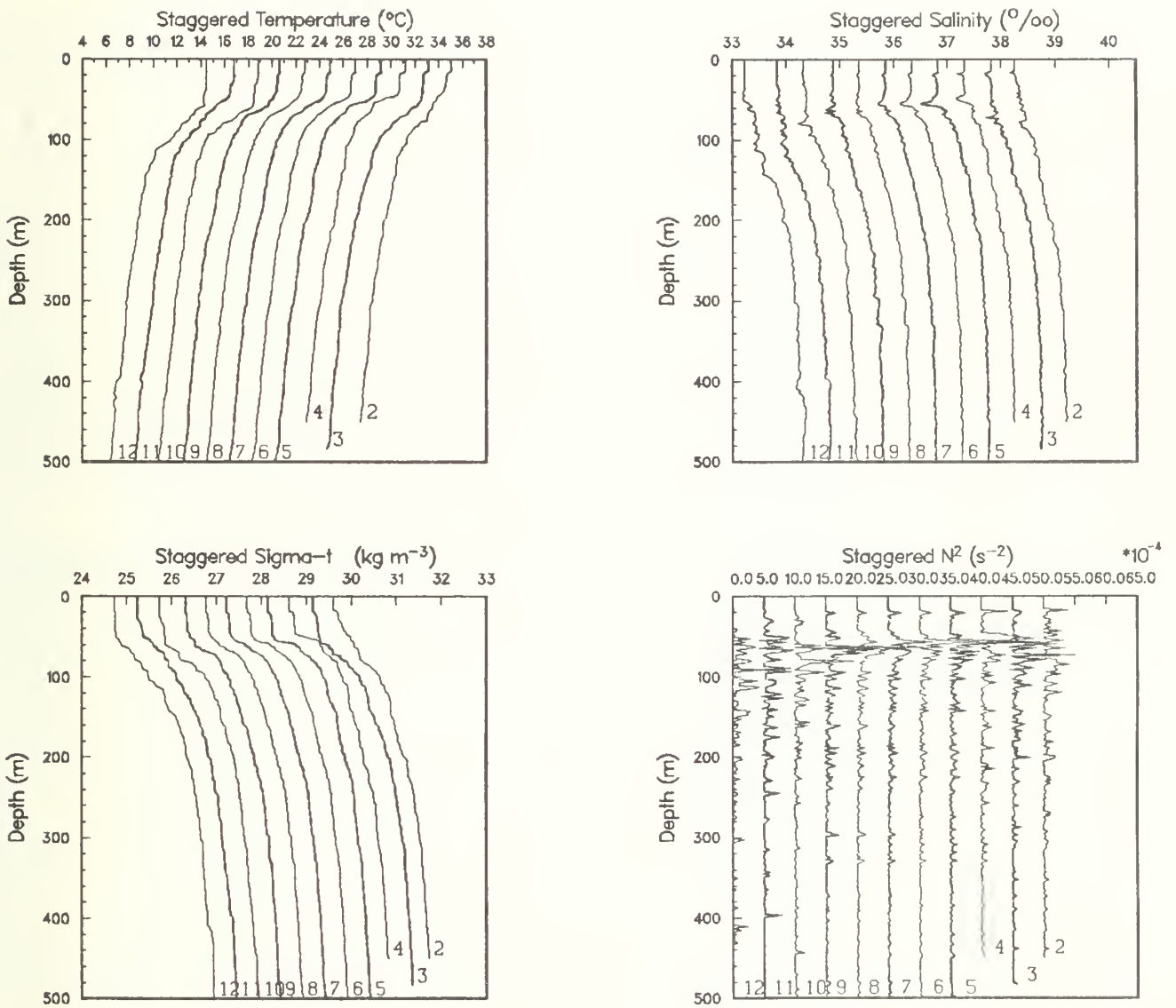


Figure 17.

4/7/80

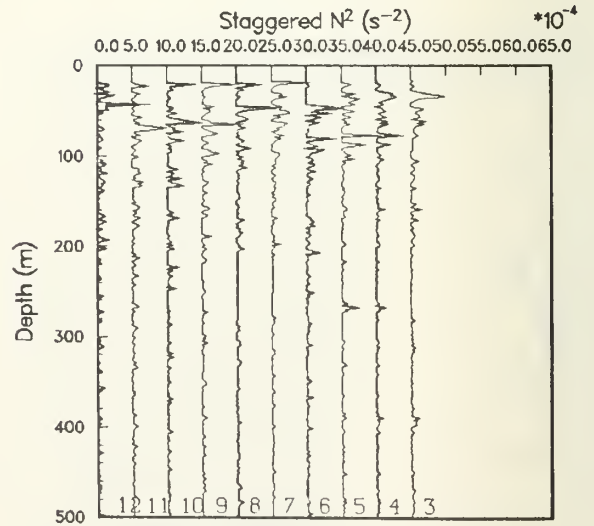
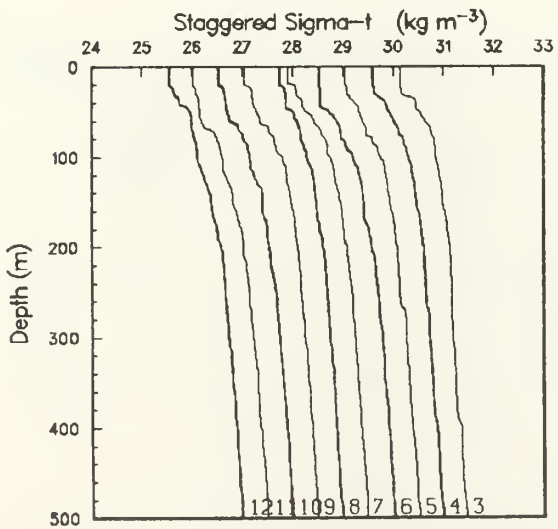
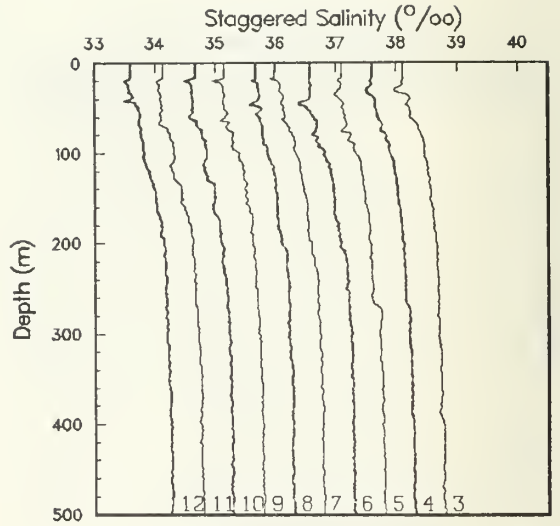
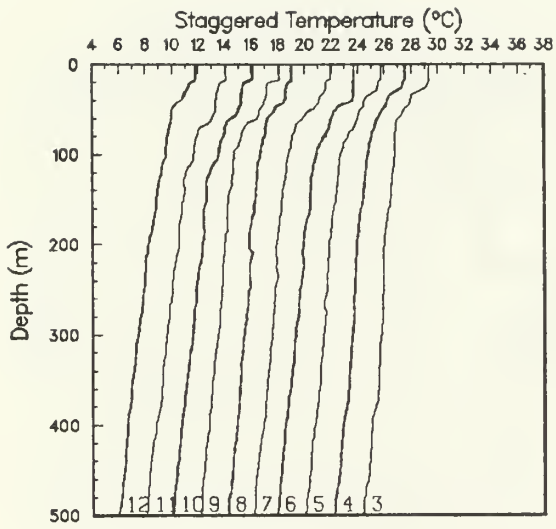


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5/16/80

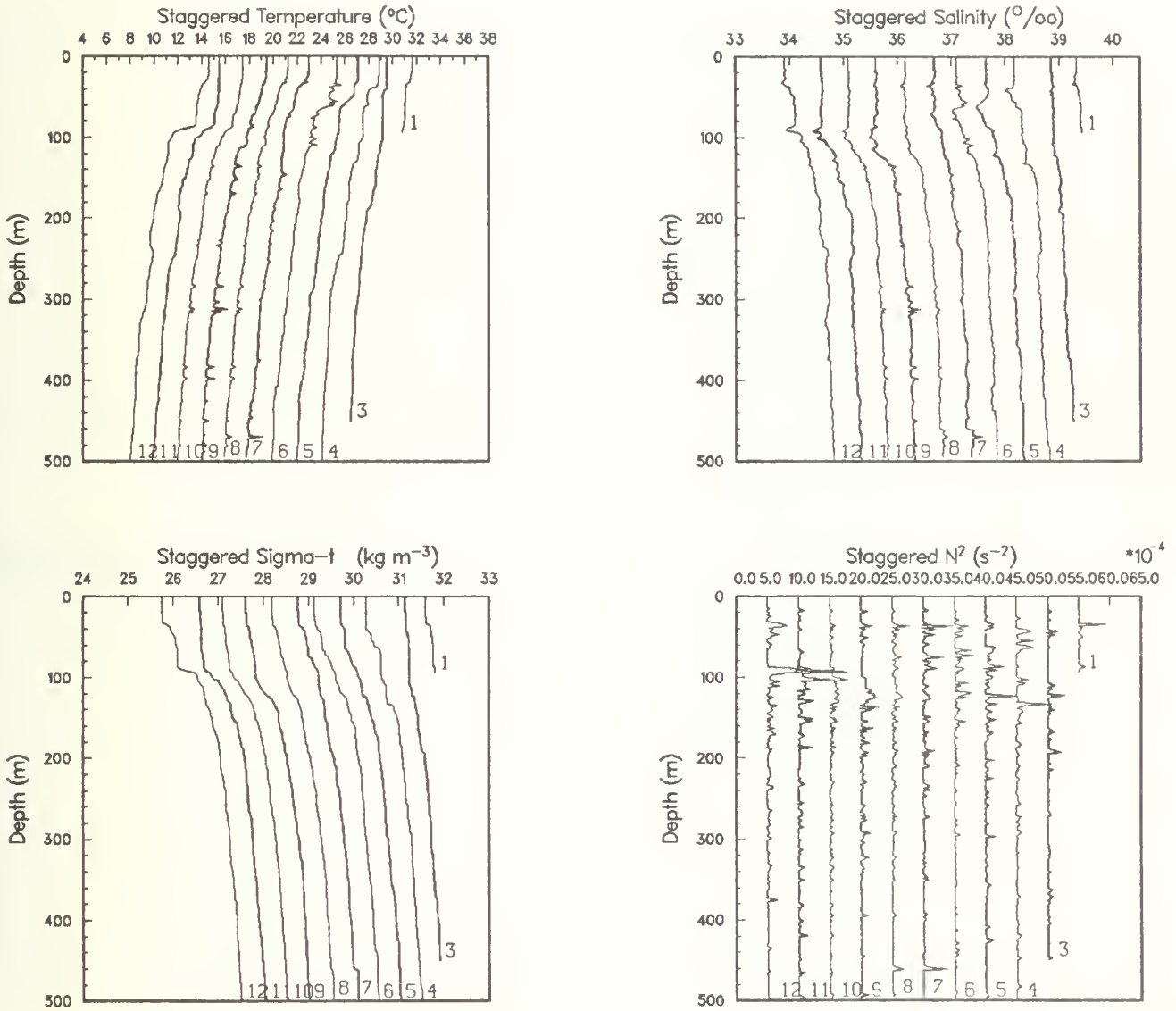


Figure 19.

6/26/80

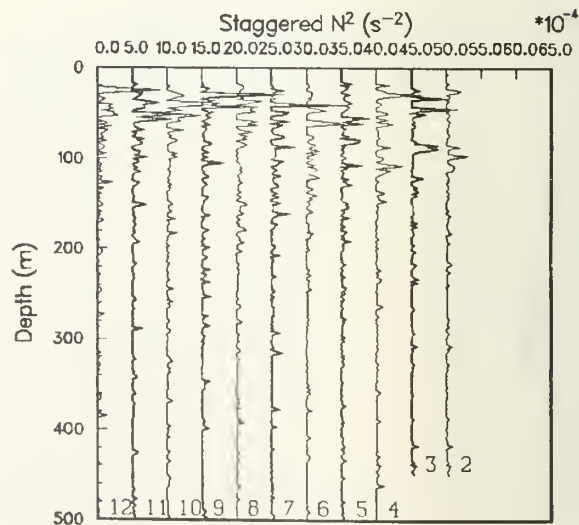
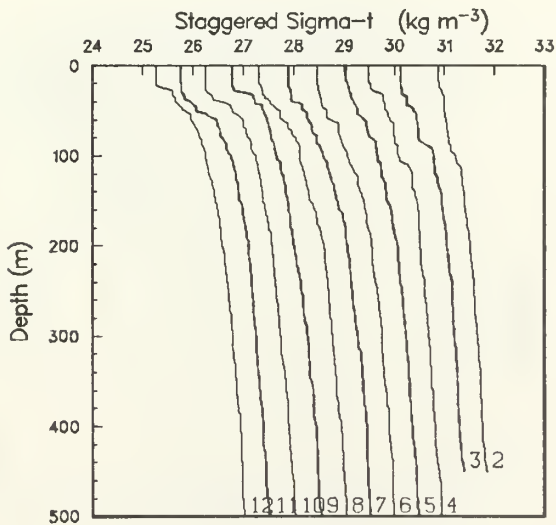
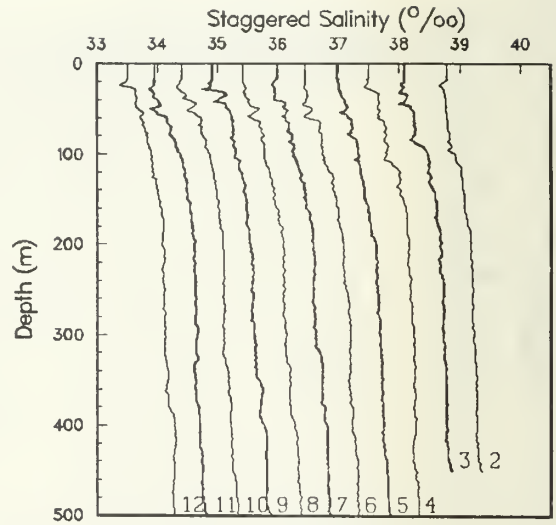
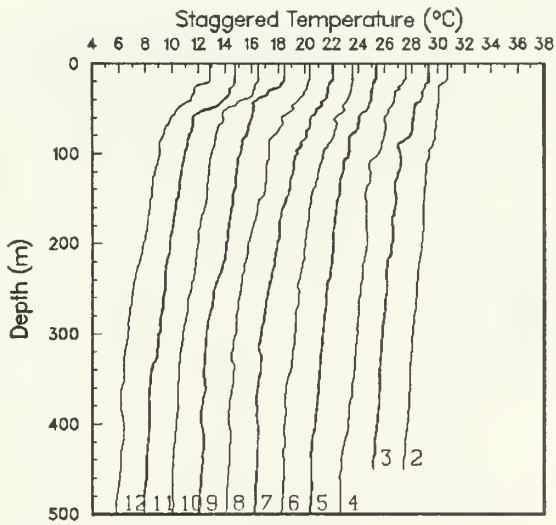


Figure 20.

Data Presentation - Temperature-Salinity Diagrams

Temperature-salinity diagrams for each cruise are displayed (Figures 21-38). The station number is plotted at the appropriate value of temperature and salinity for every 10m of each profile.

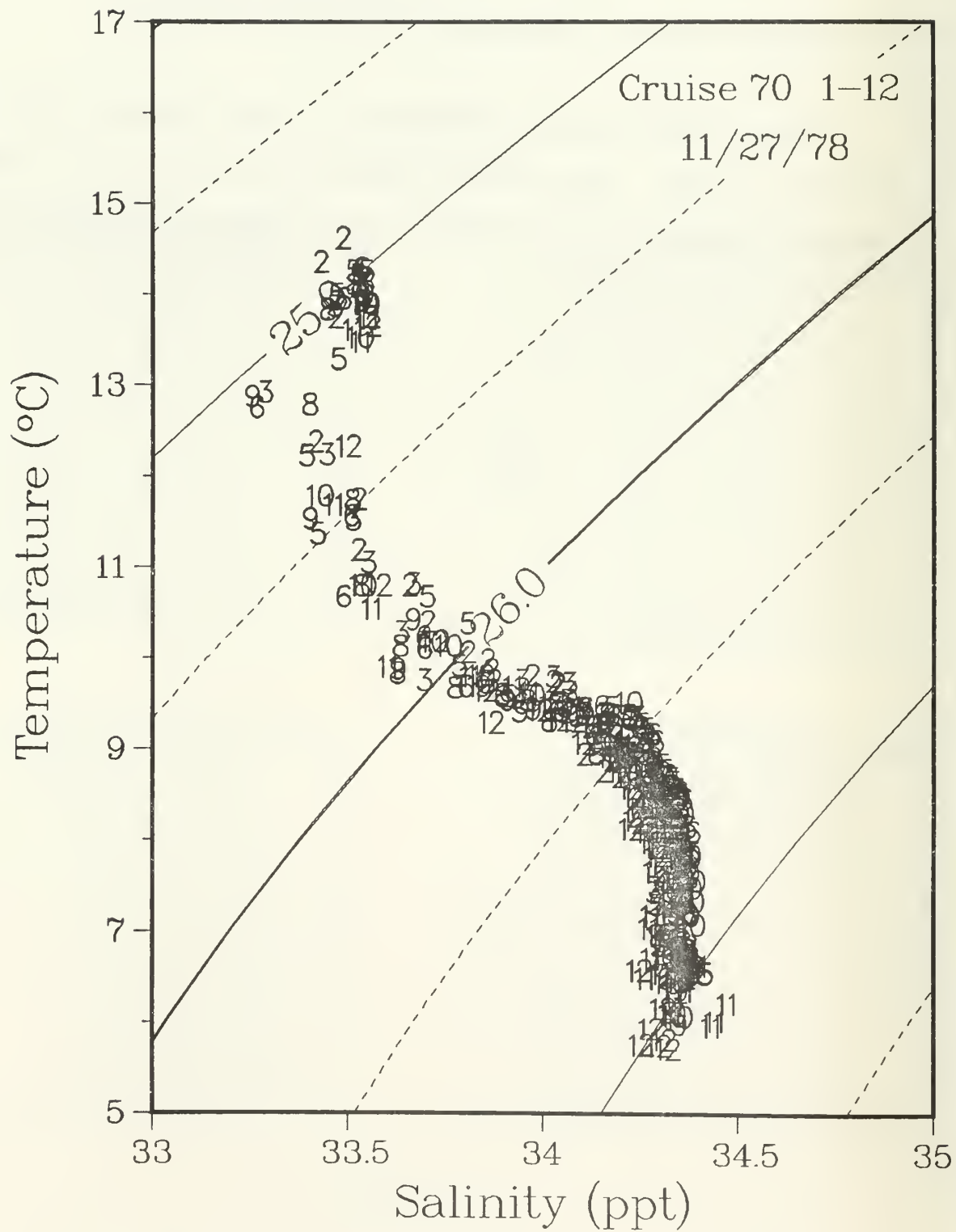


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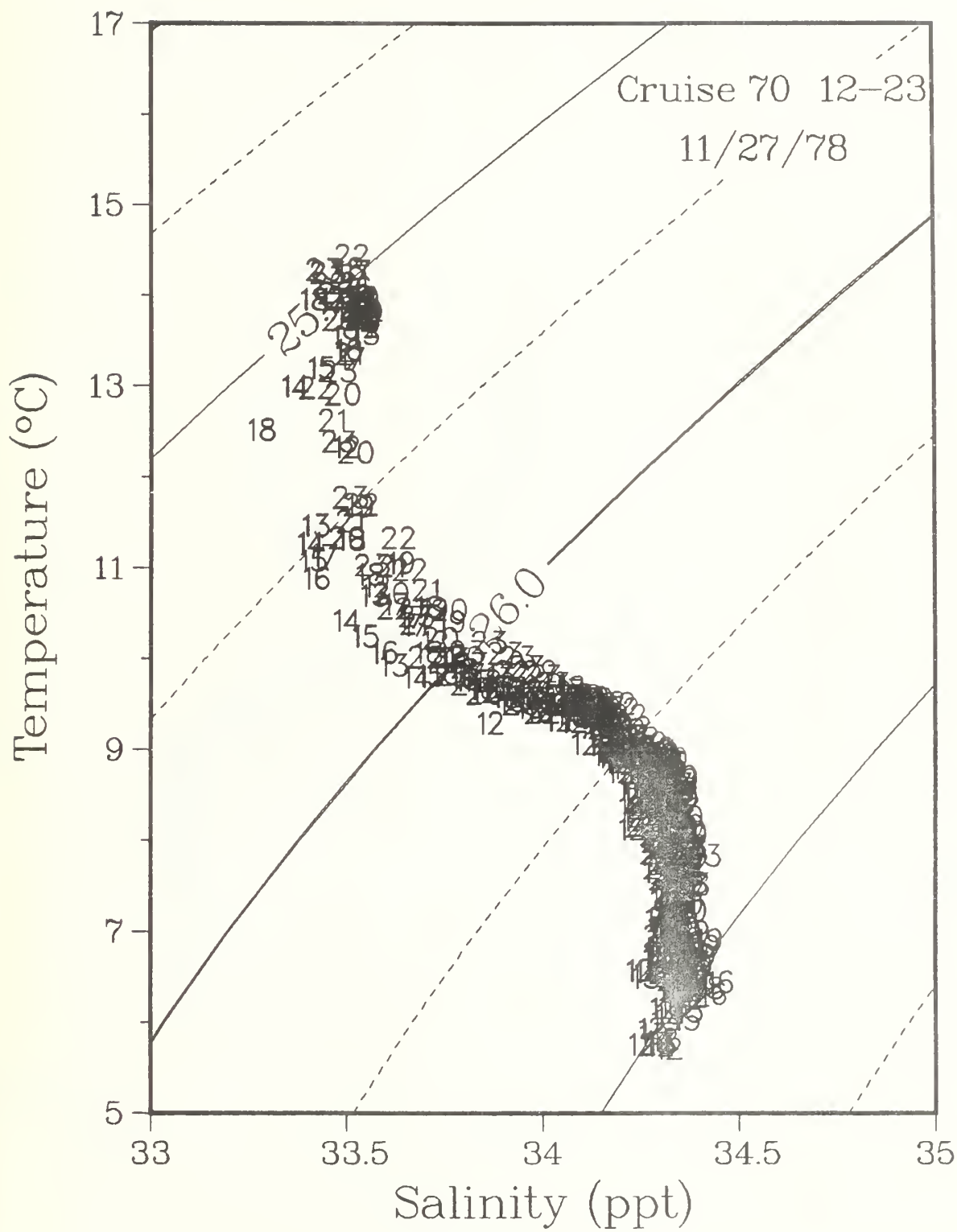


Figure 22.

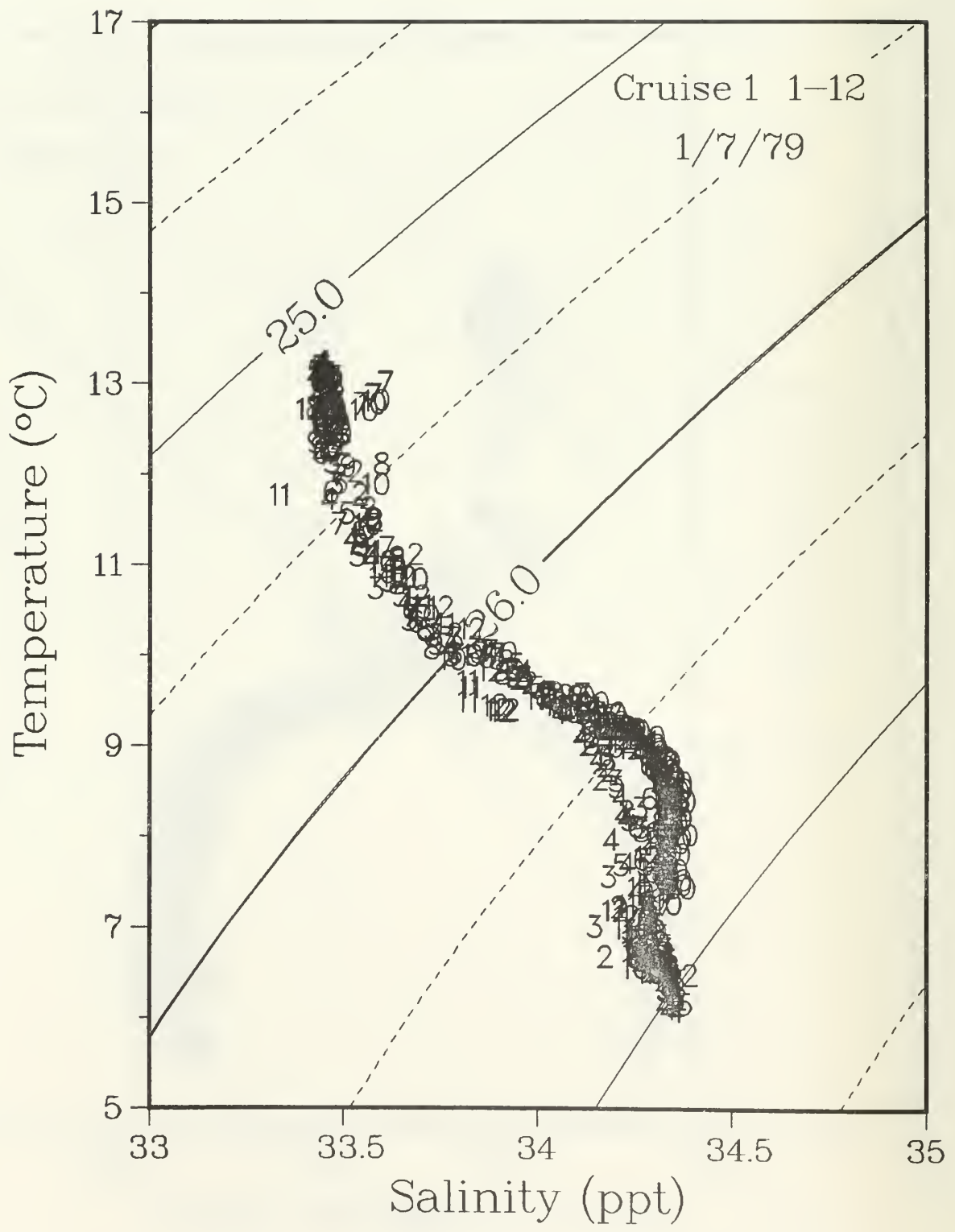


Figure 23.

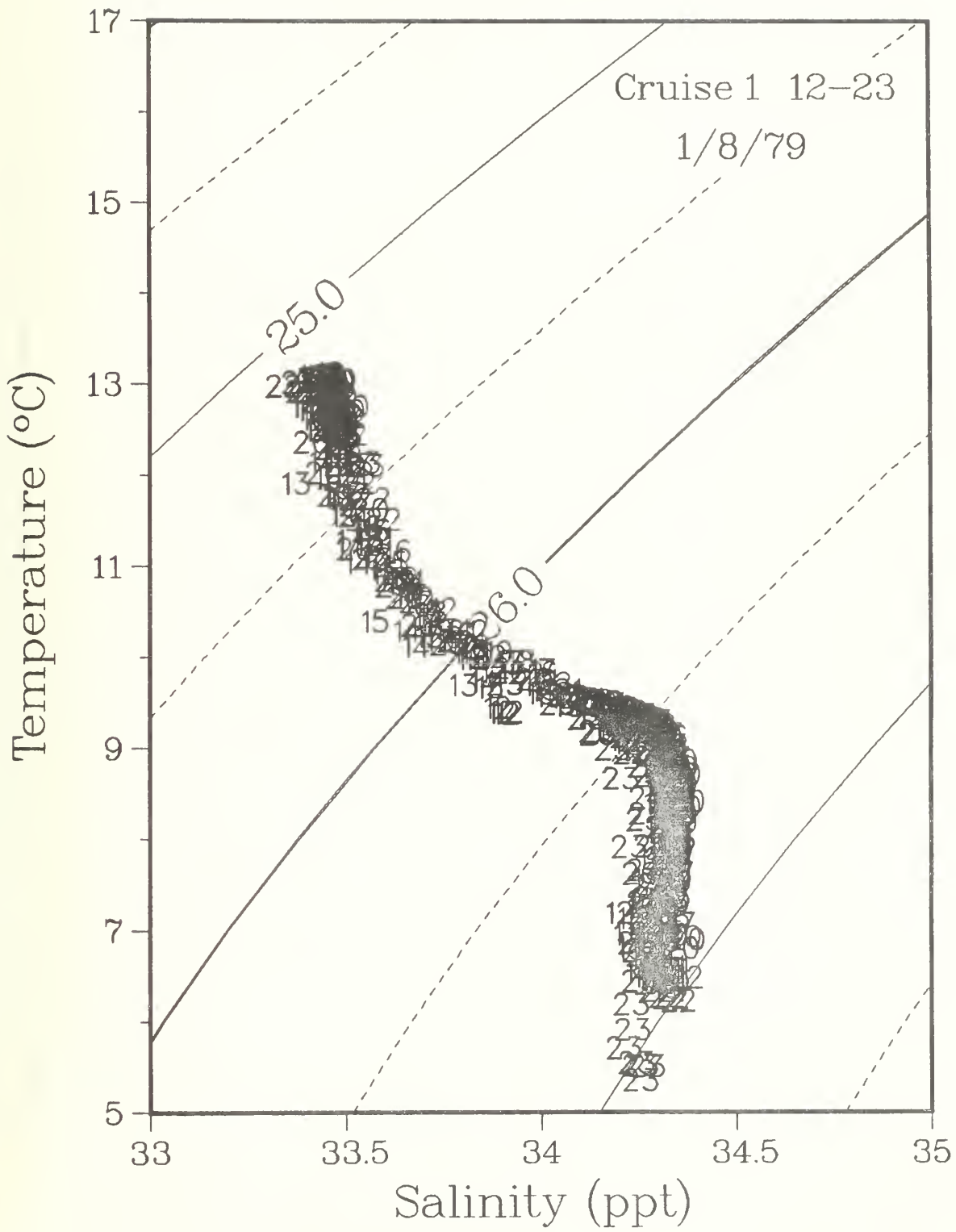


Figure 24.

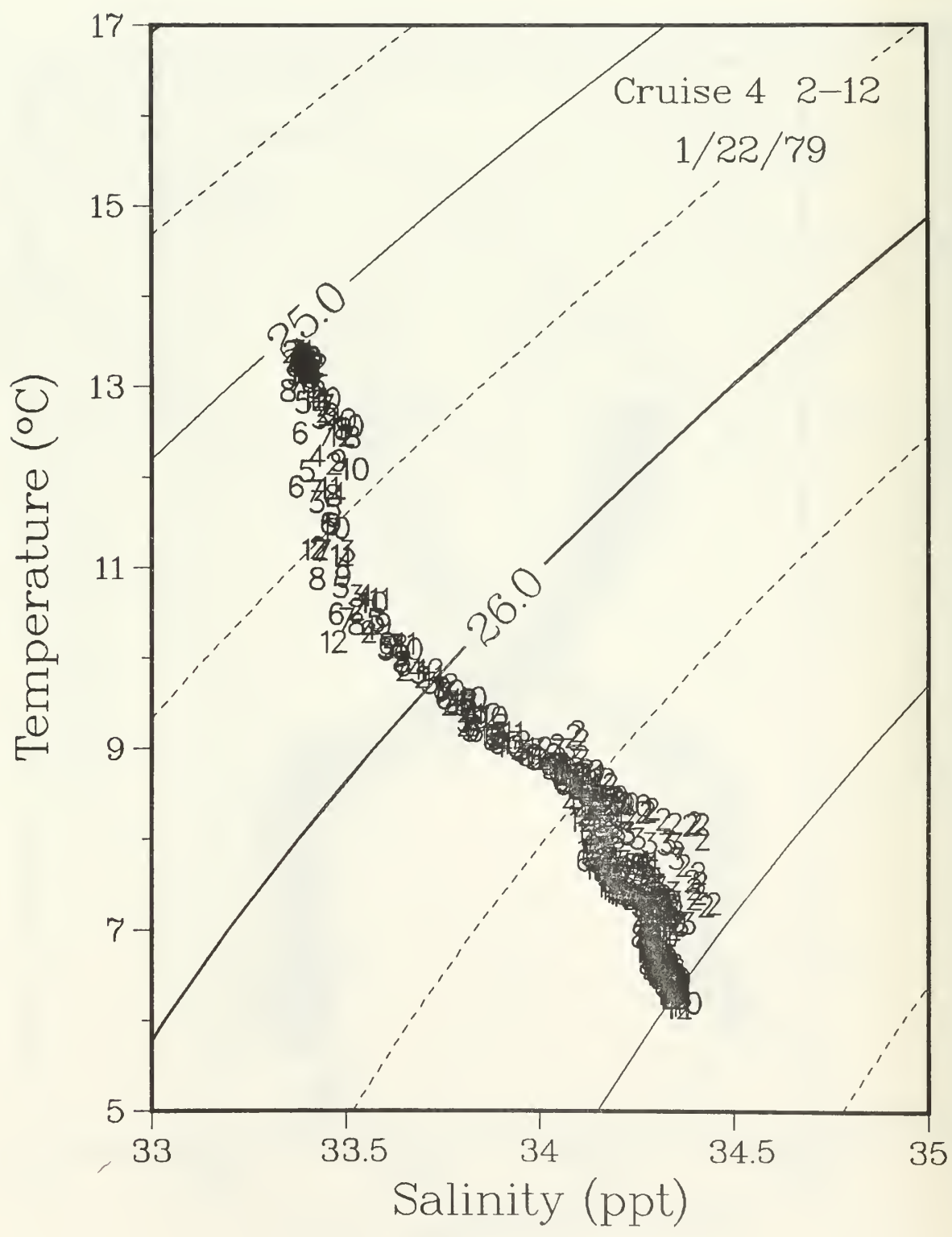


Figure 25.

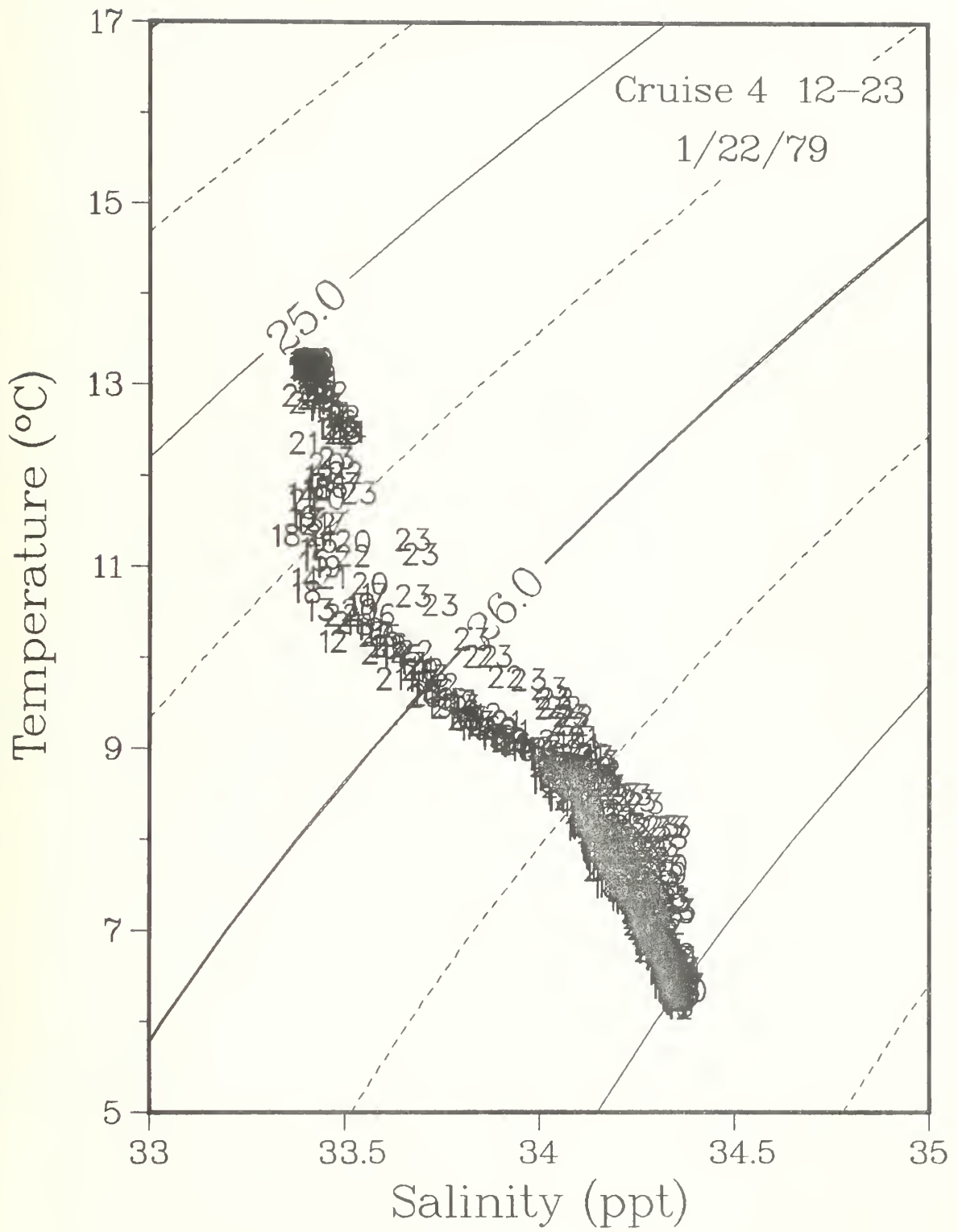


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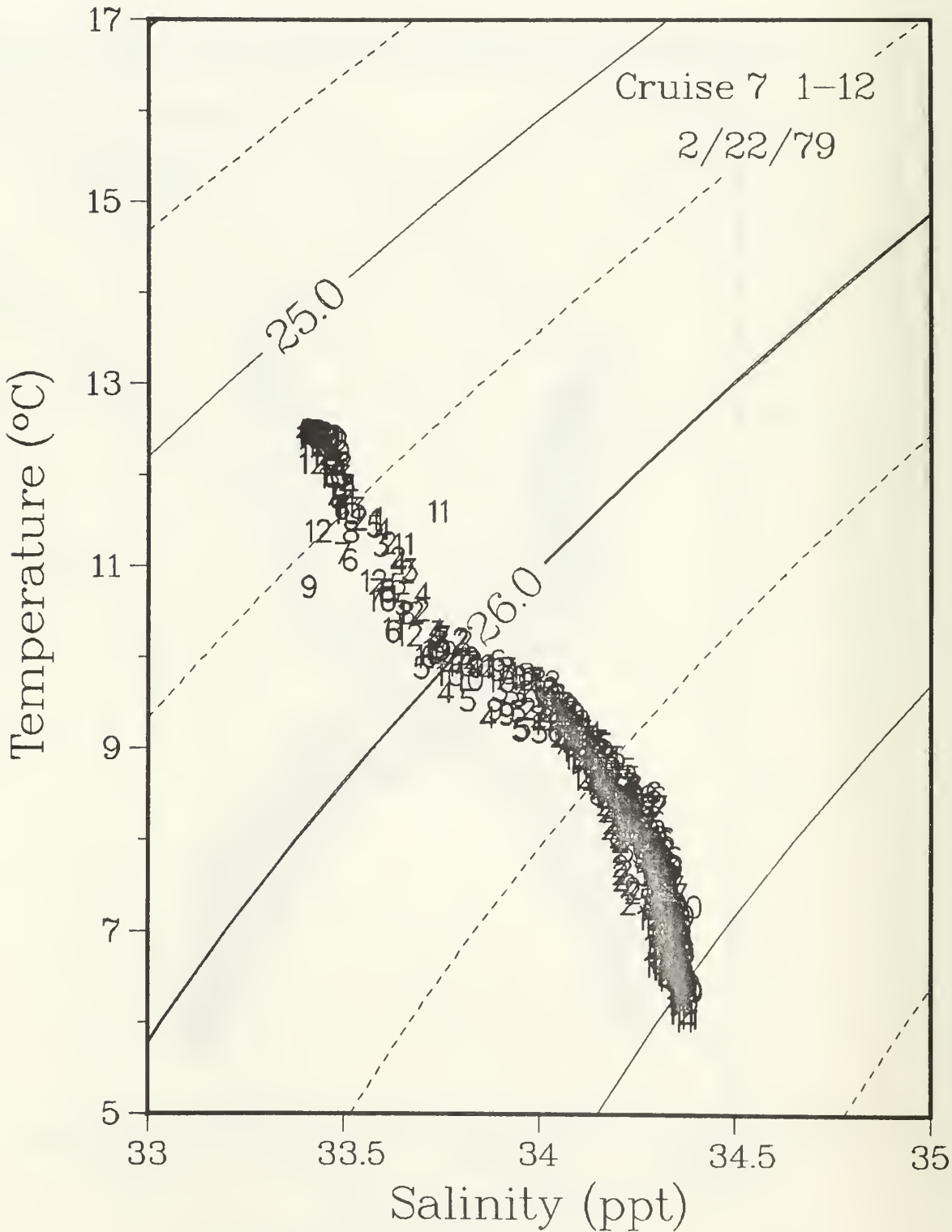


Figure 27.

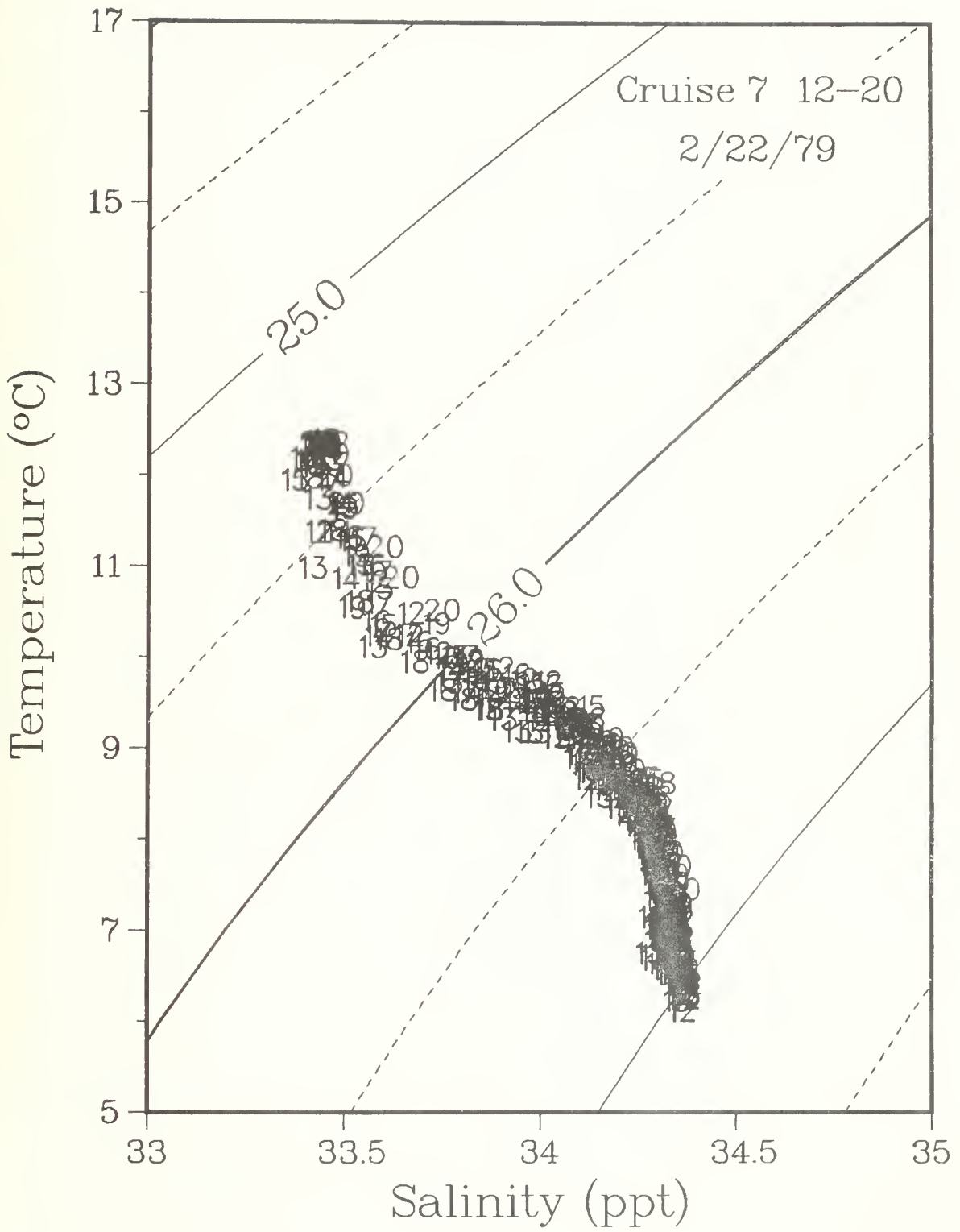


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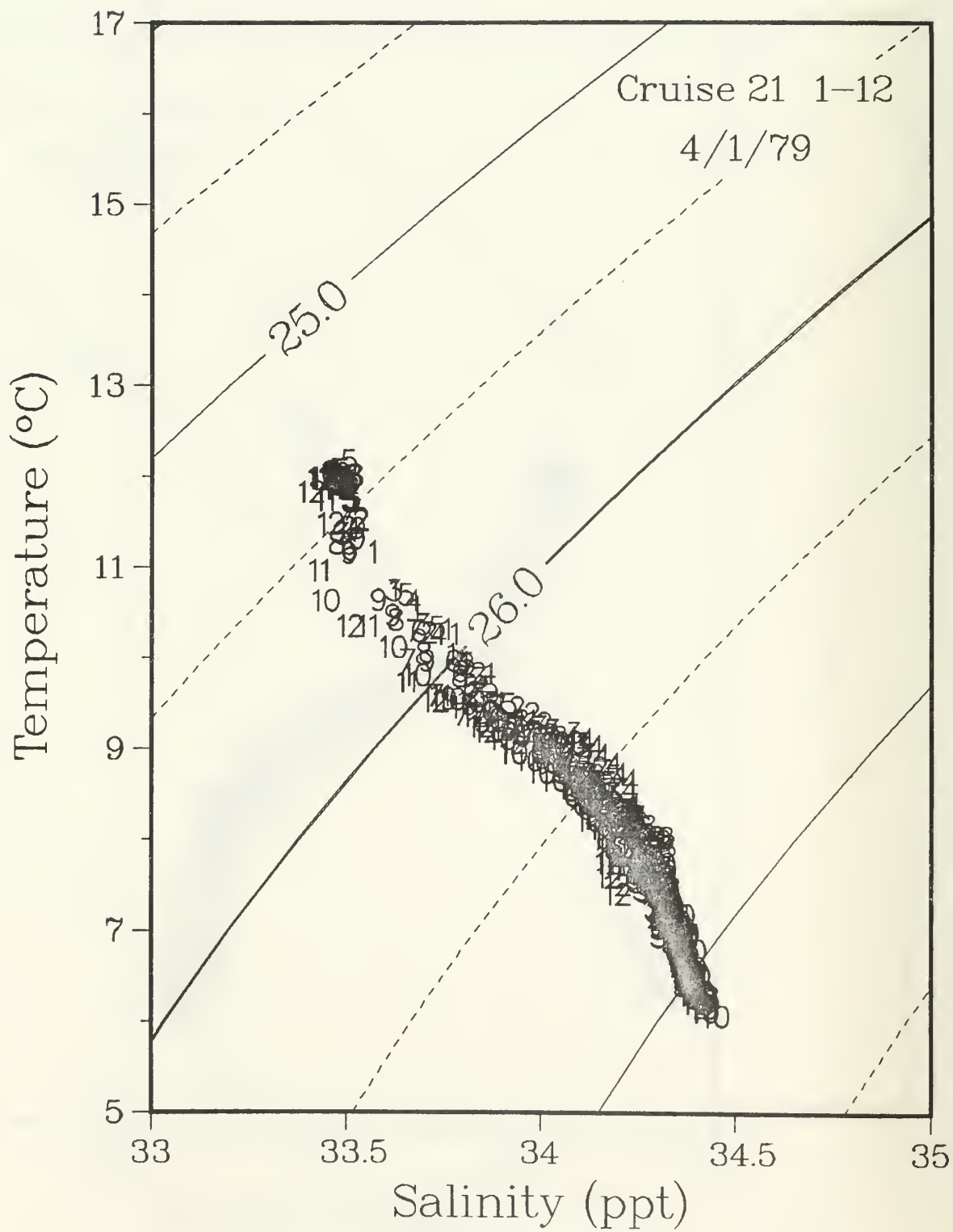


Figure 29.

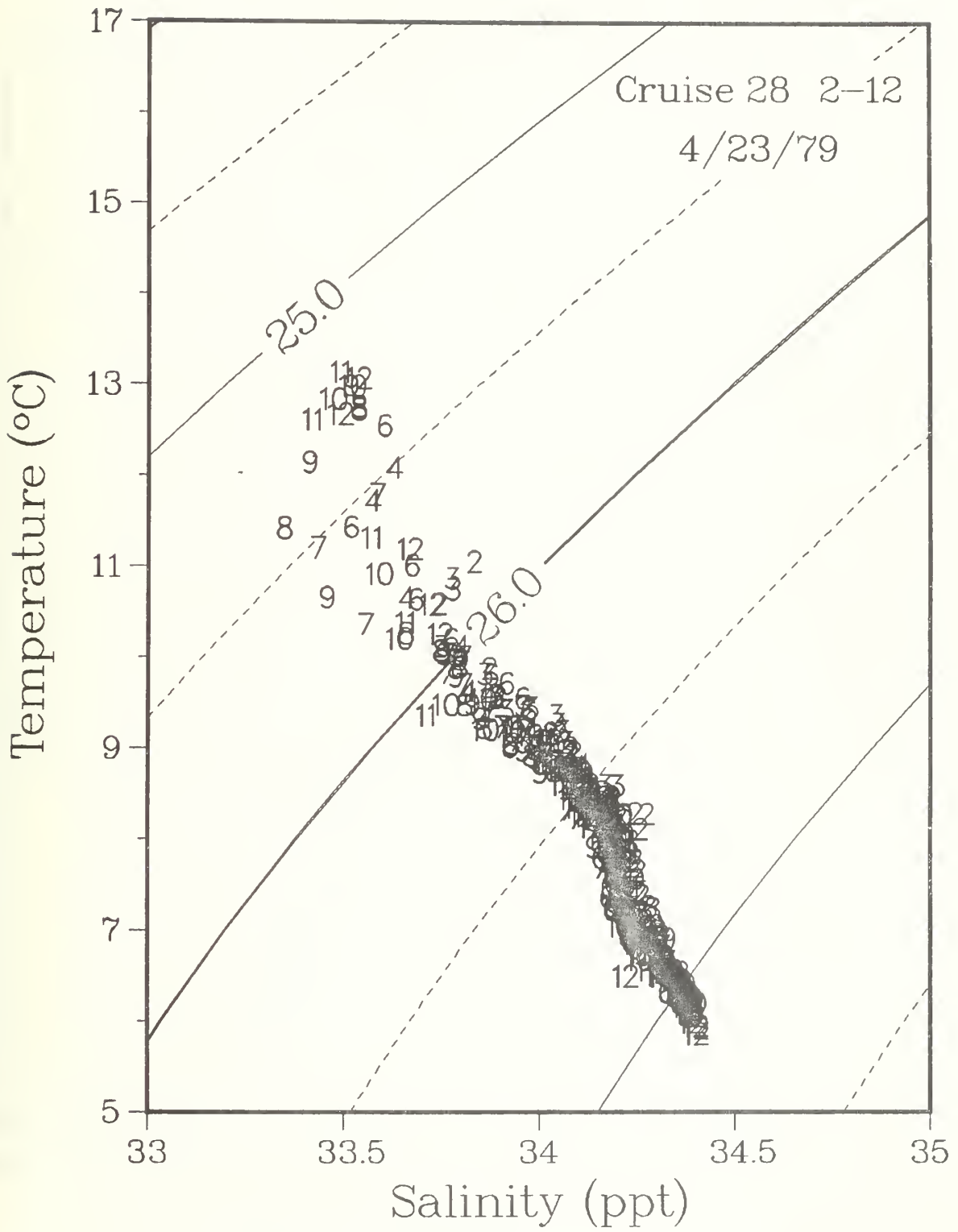


Figure 30.

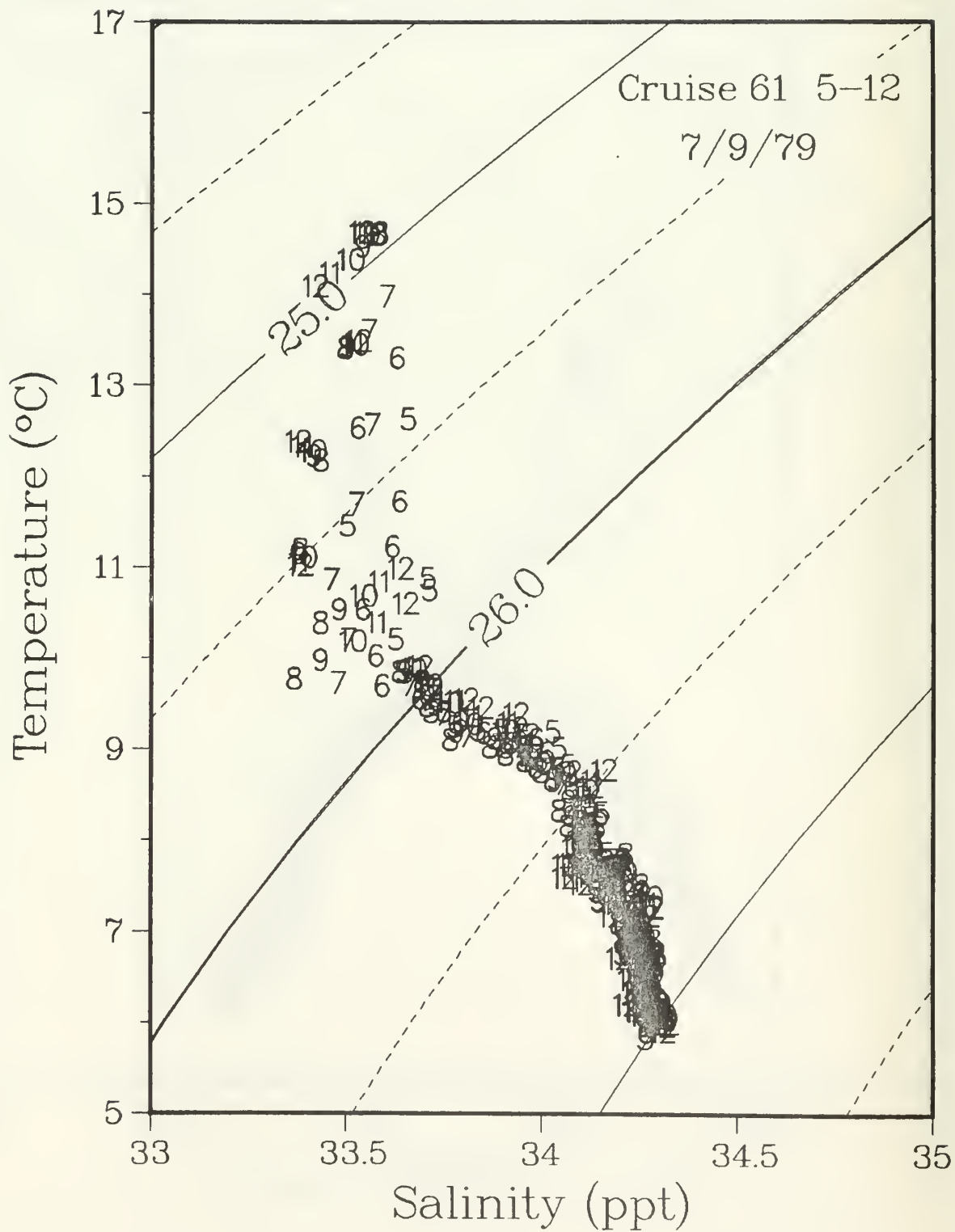


Figure 31.

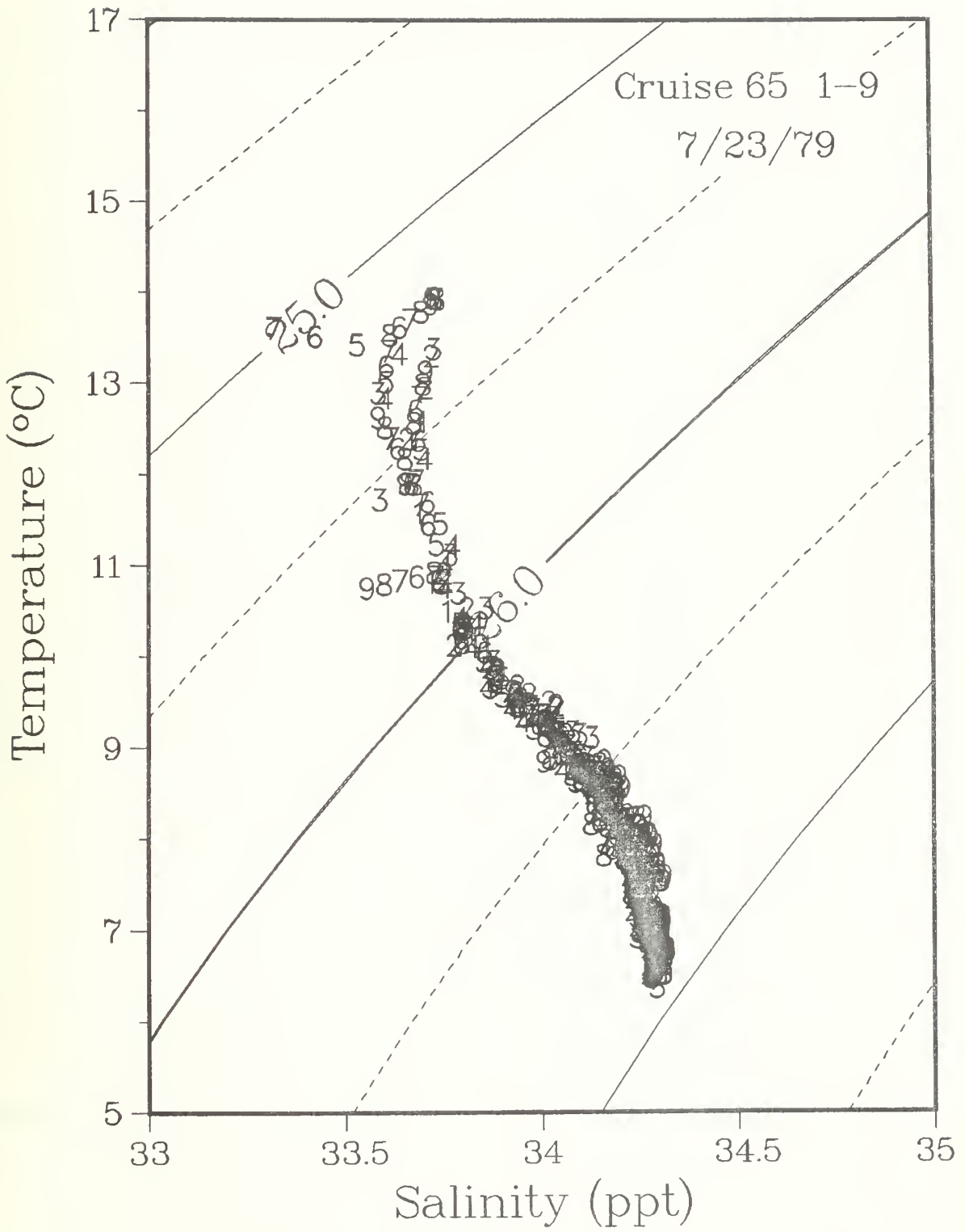


Figure 32.

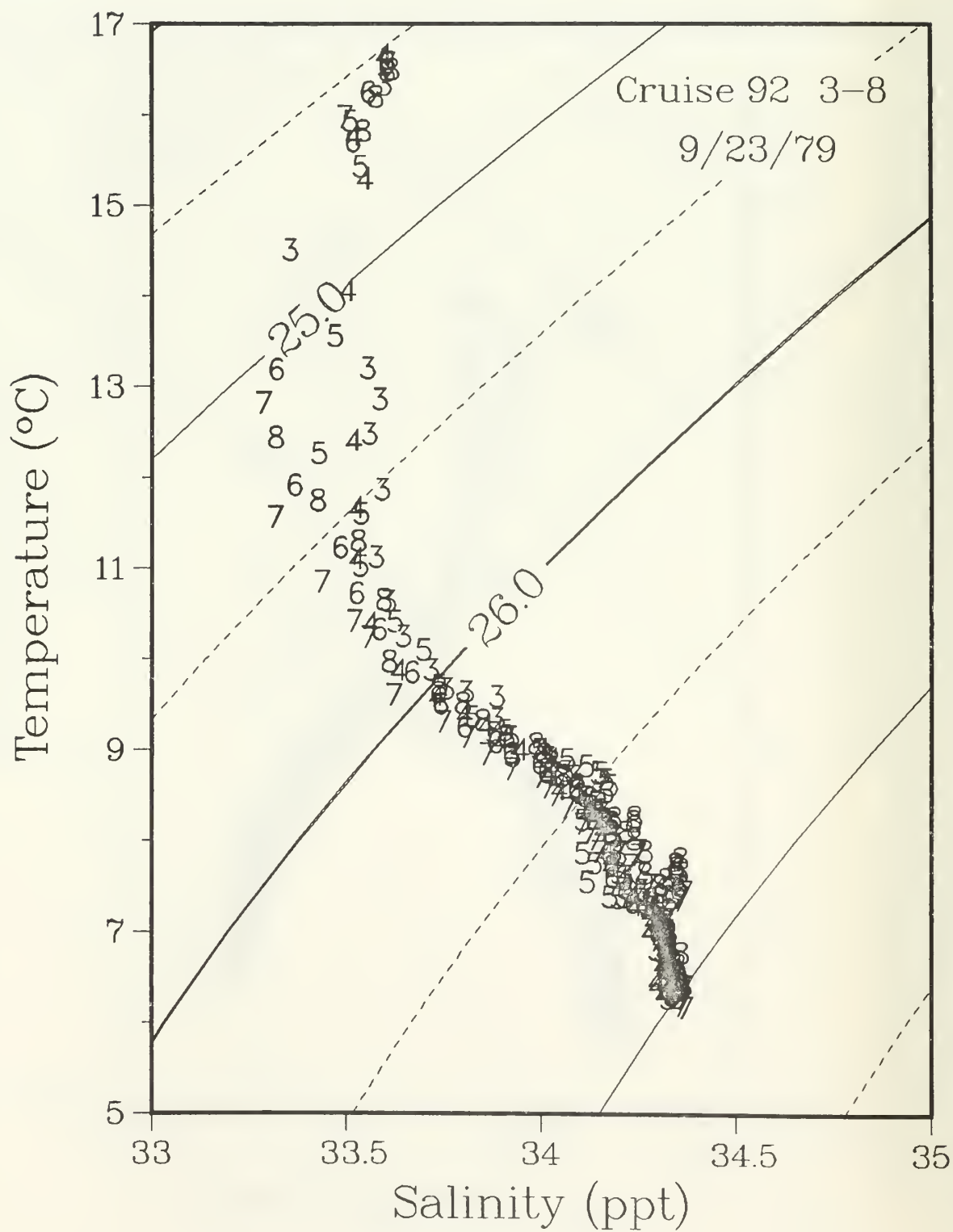


Figure 33.

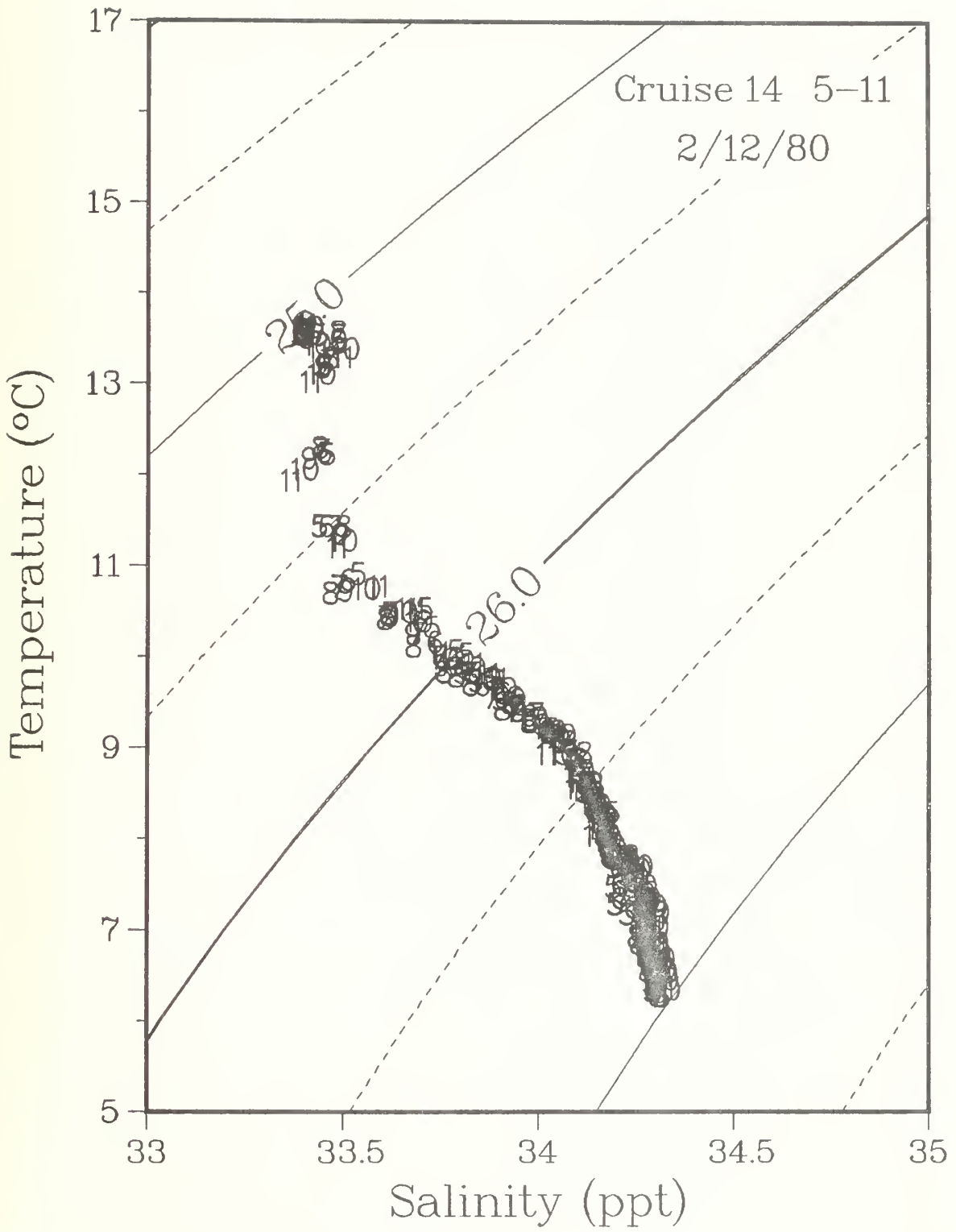


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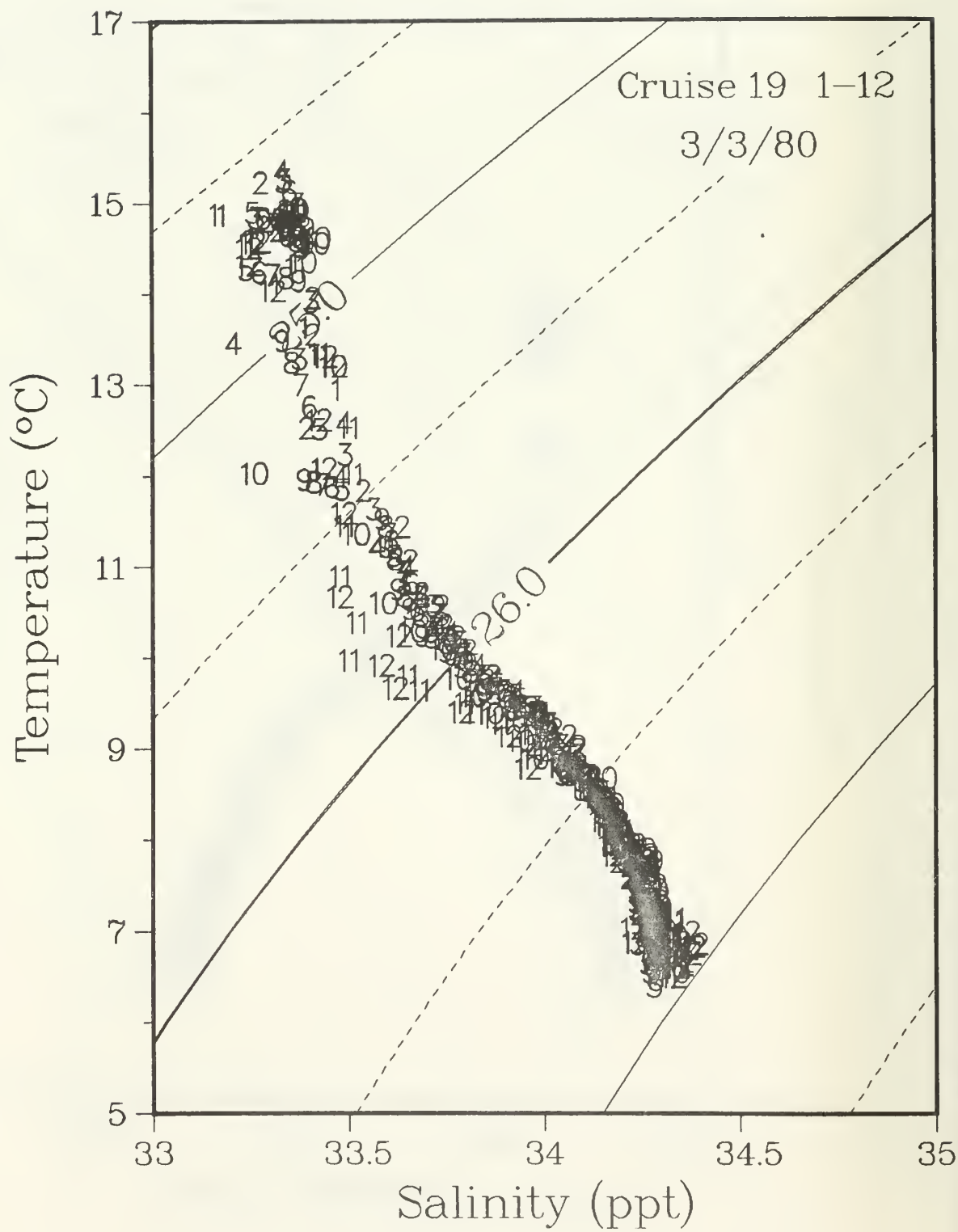


Figure 35.

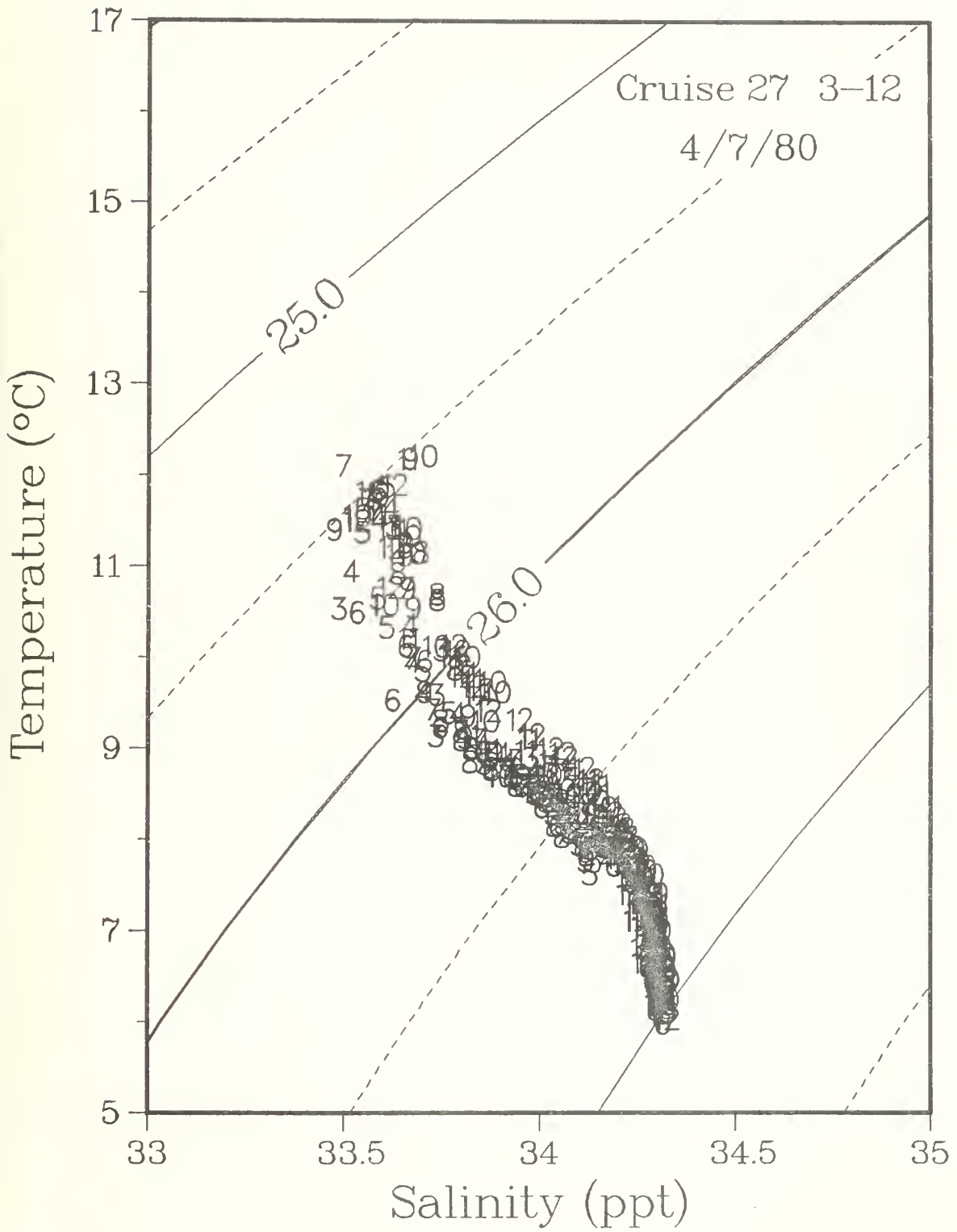


Figure 36.

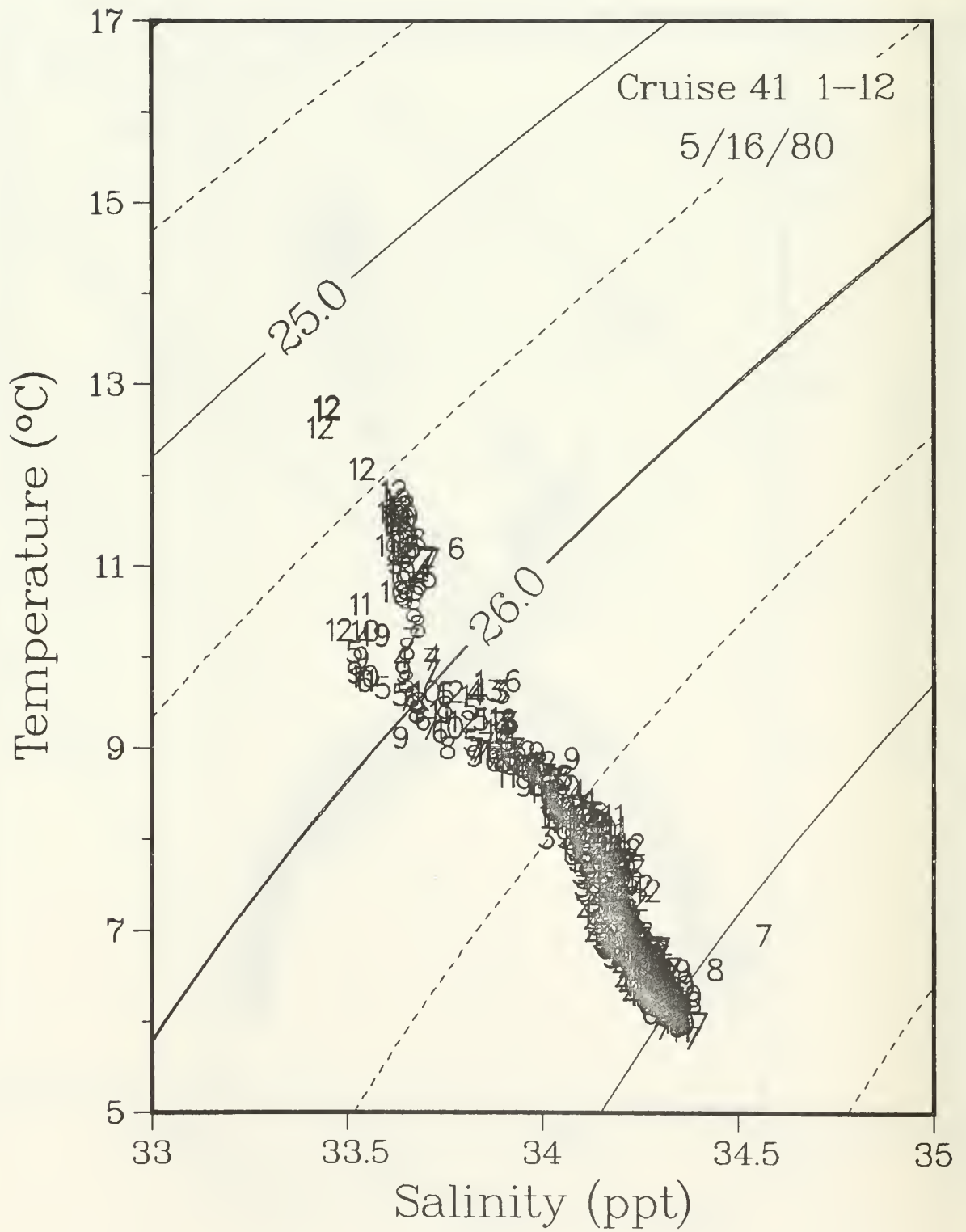


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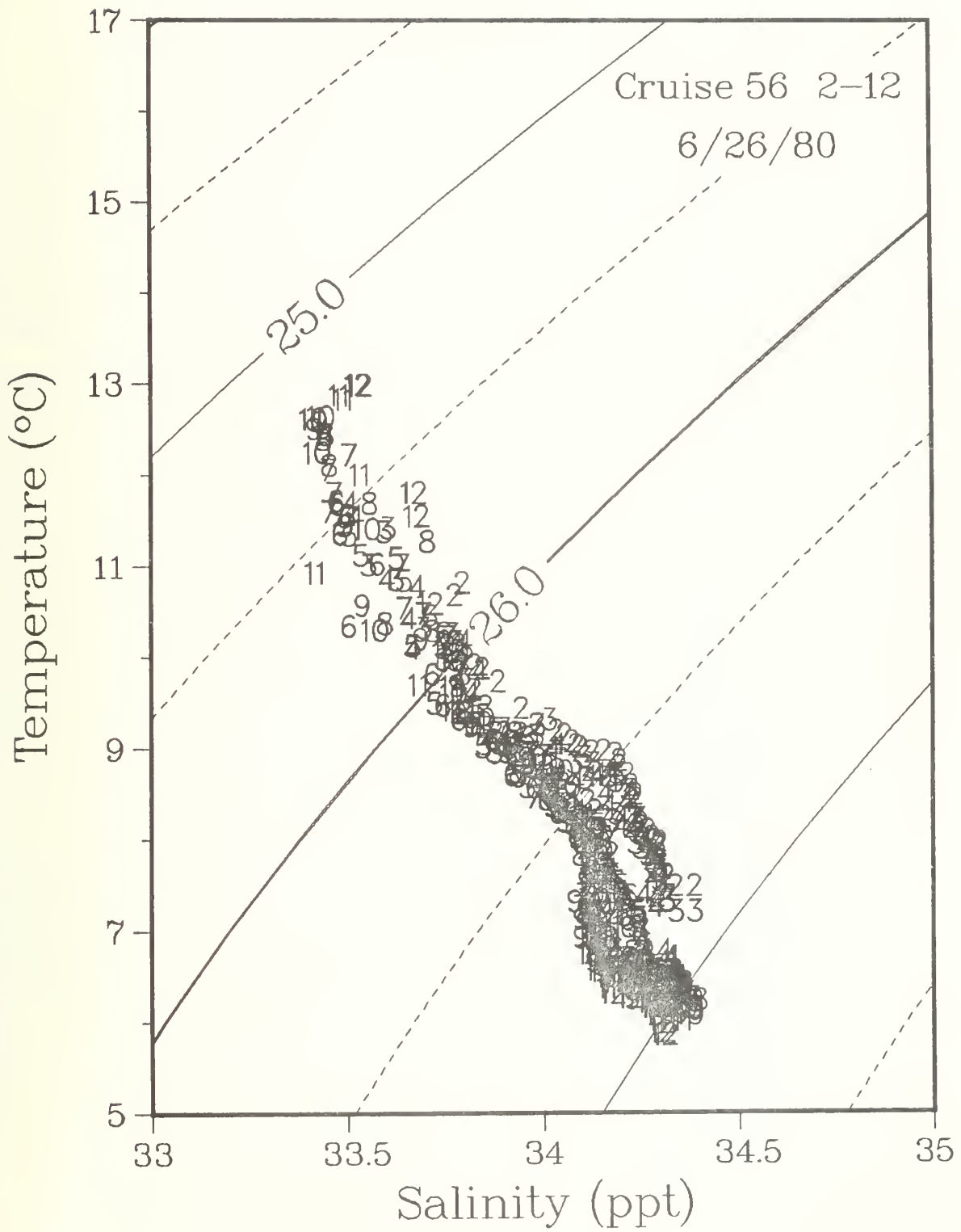


Figure 38.

Data Presentation - Hydrographic Sections

Isopleths of temperature, salinity and sigma-t for each line are displayed (Figures 39-56). The upper plot on each page shows temperature (solid) and salinity (dashed) at intervals of 2.0°C and 0.4‰, respectively. The lower plot contains sigma-t contours at 0.4 kg/m³ intervals. Actual station positions as well as distance from the nominal position of Station 1 are shown. The shaded area indicates the bottom topography.

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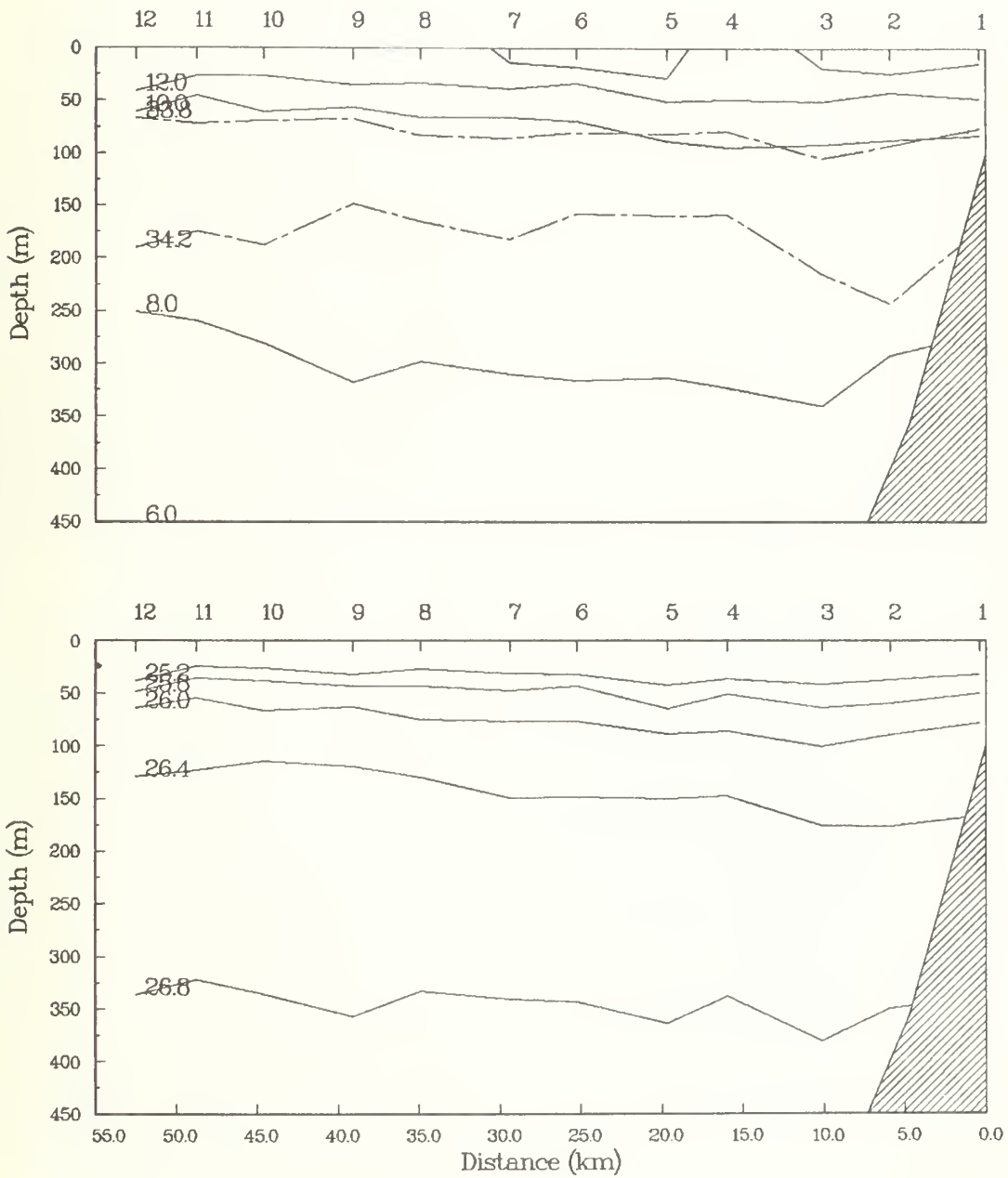


Figure 39.

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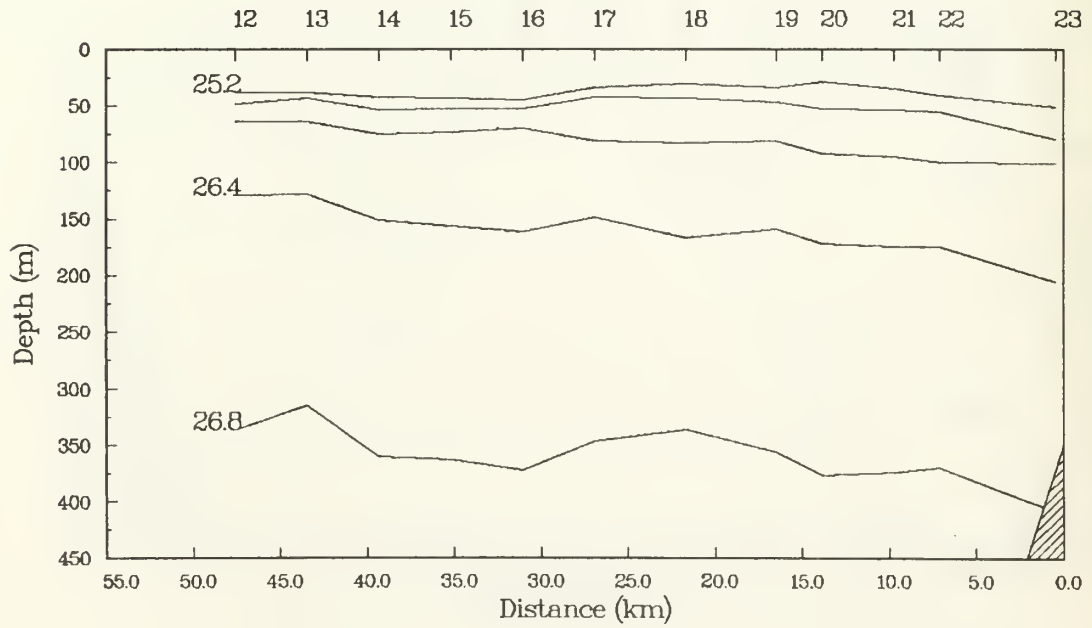
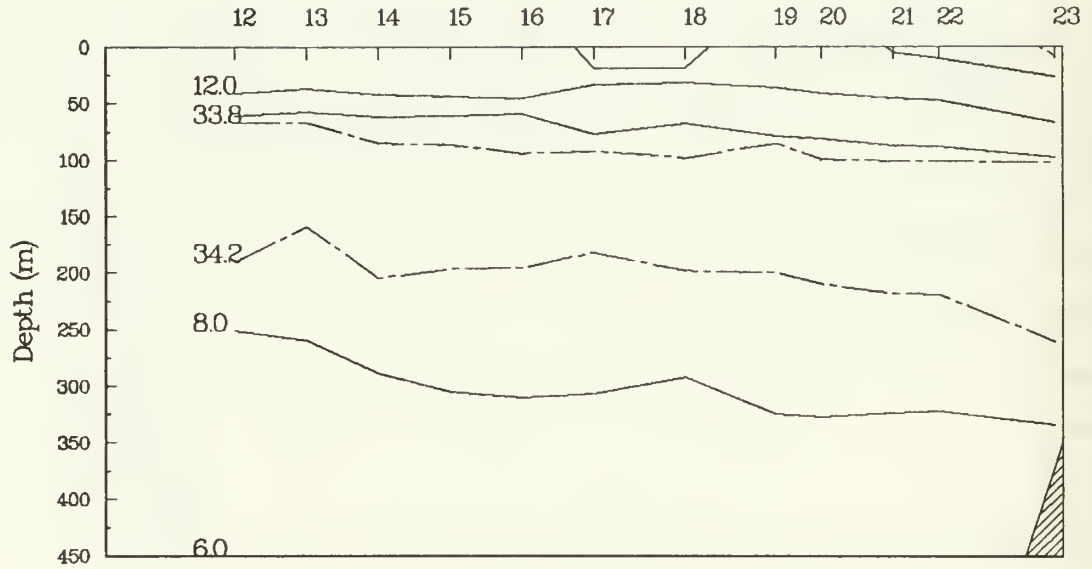


Figure 40.

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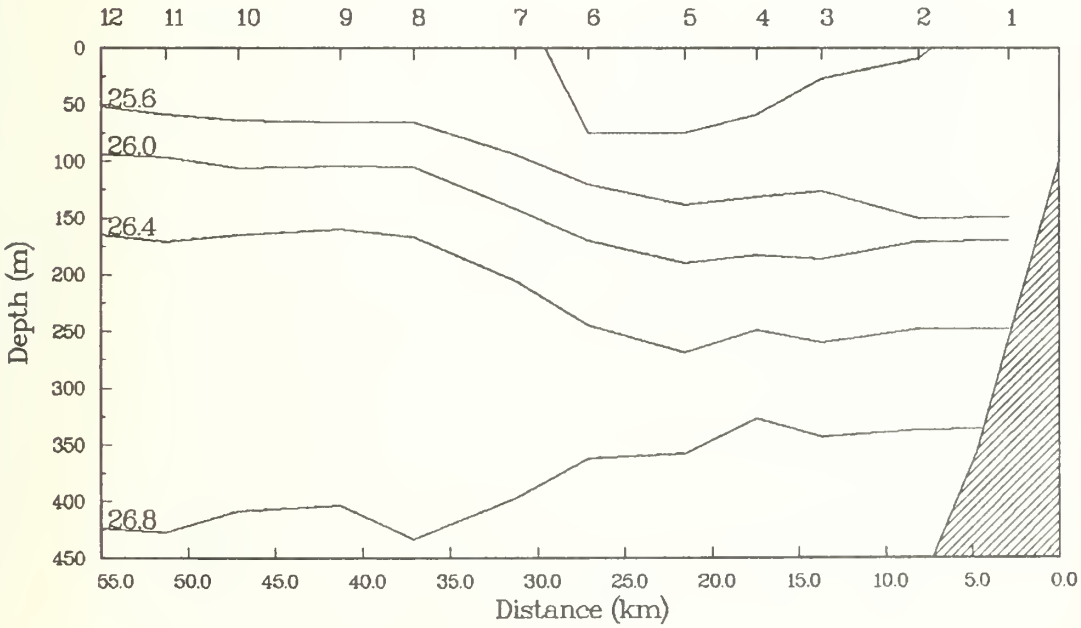
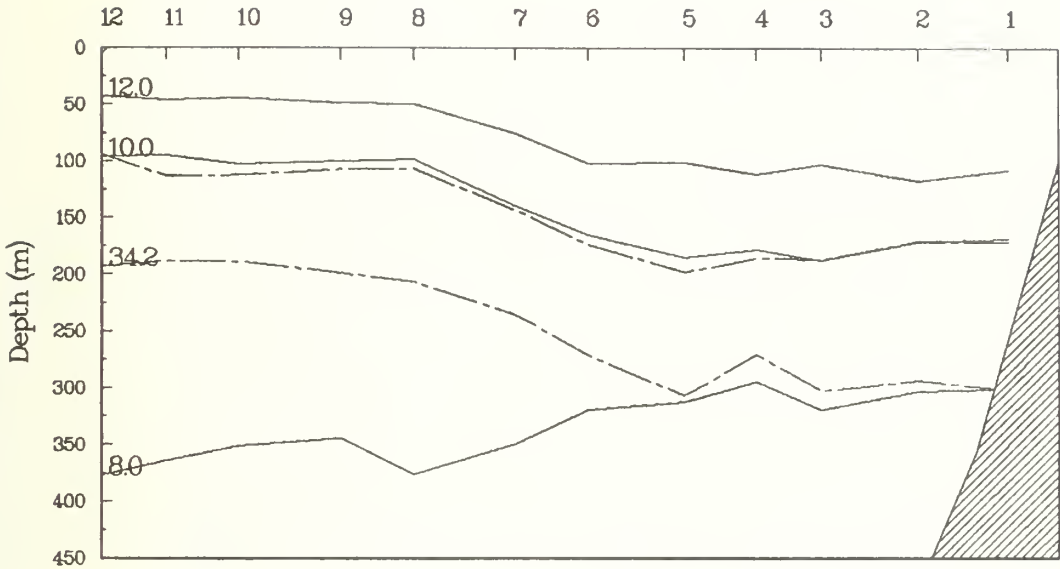


Figure 41.

1/7/79

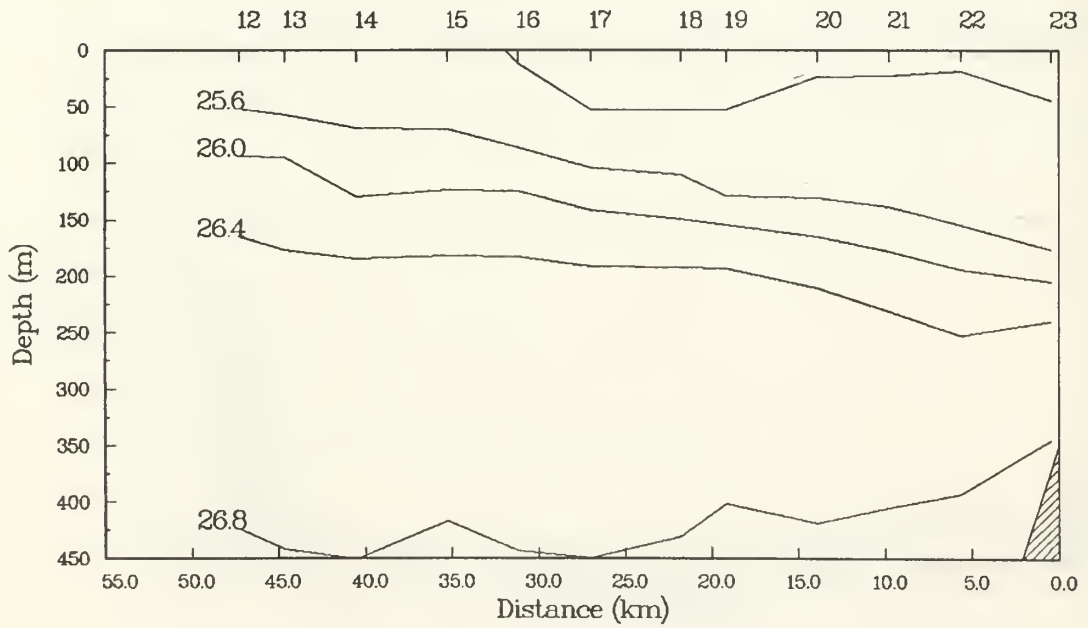
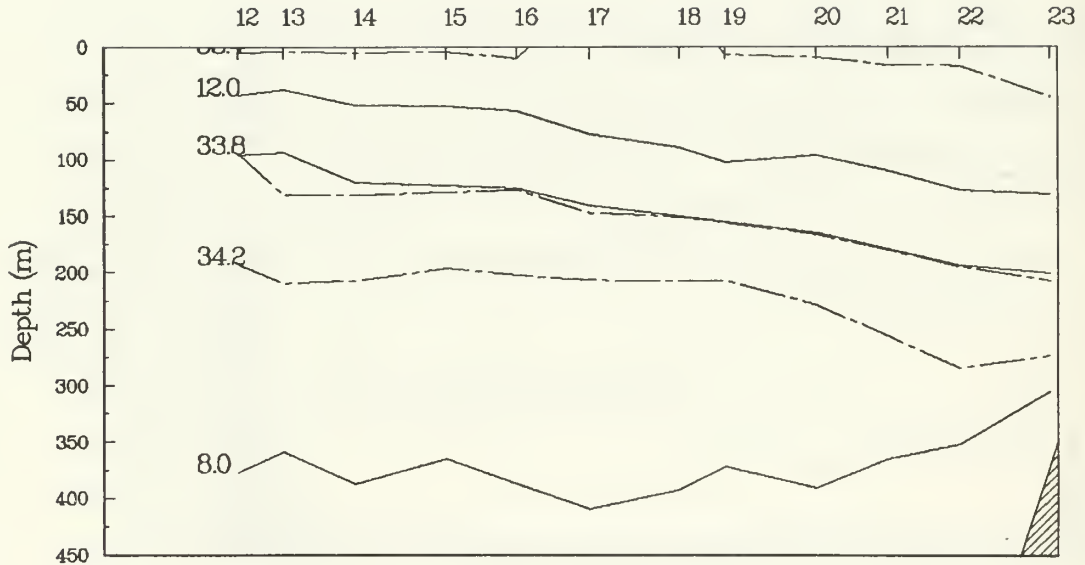


Figure 42.

1/21/79

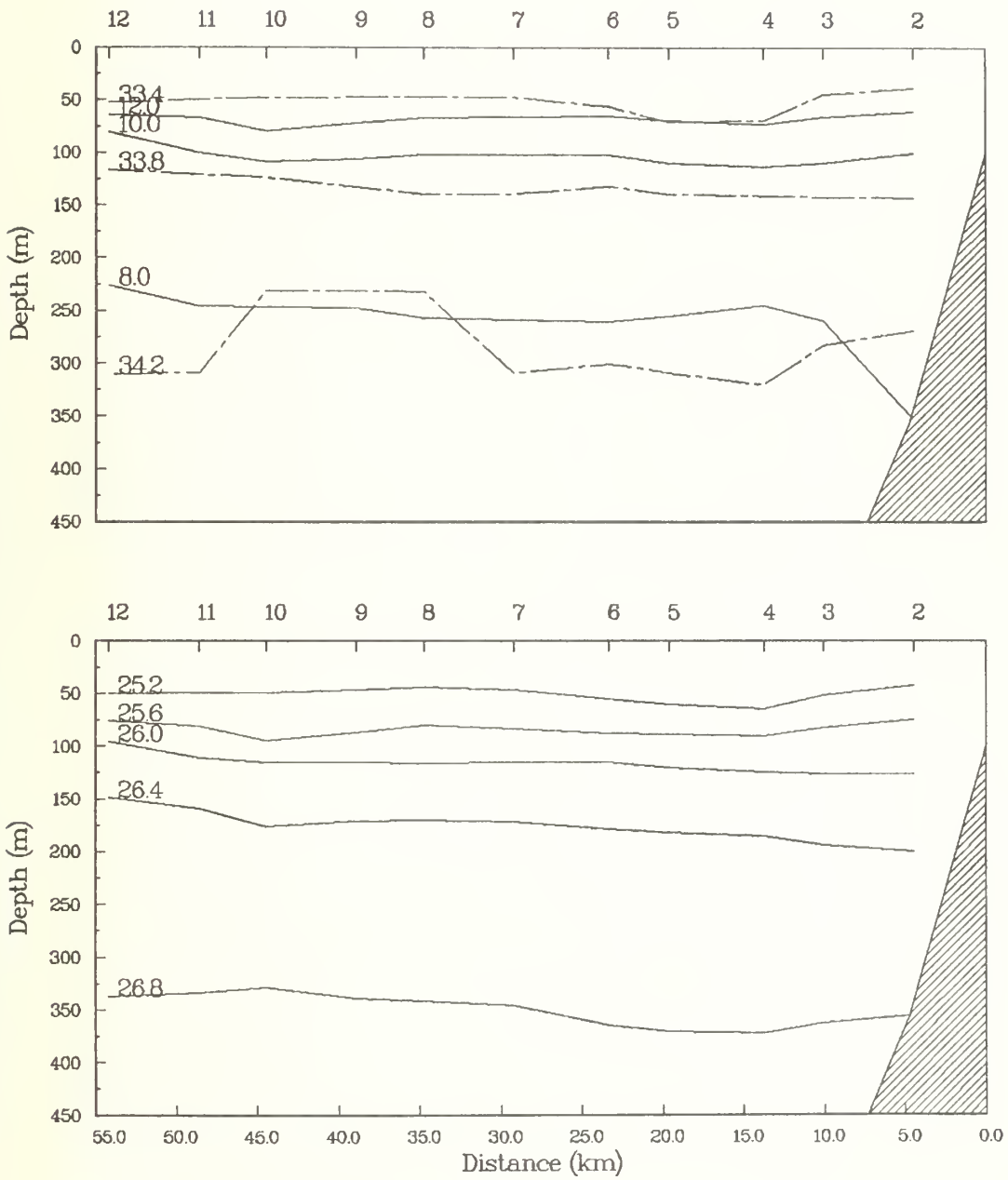


Figure 43.

1/22/79

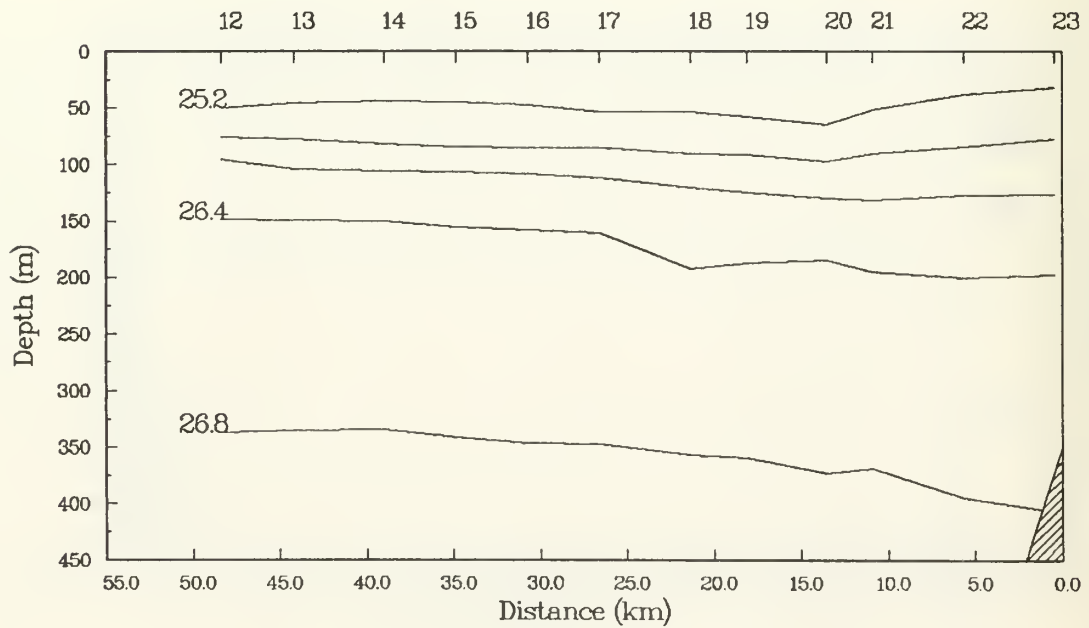
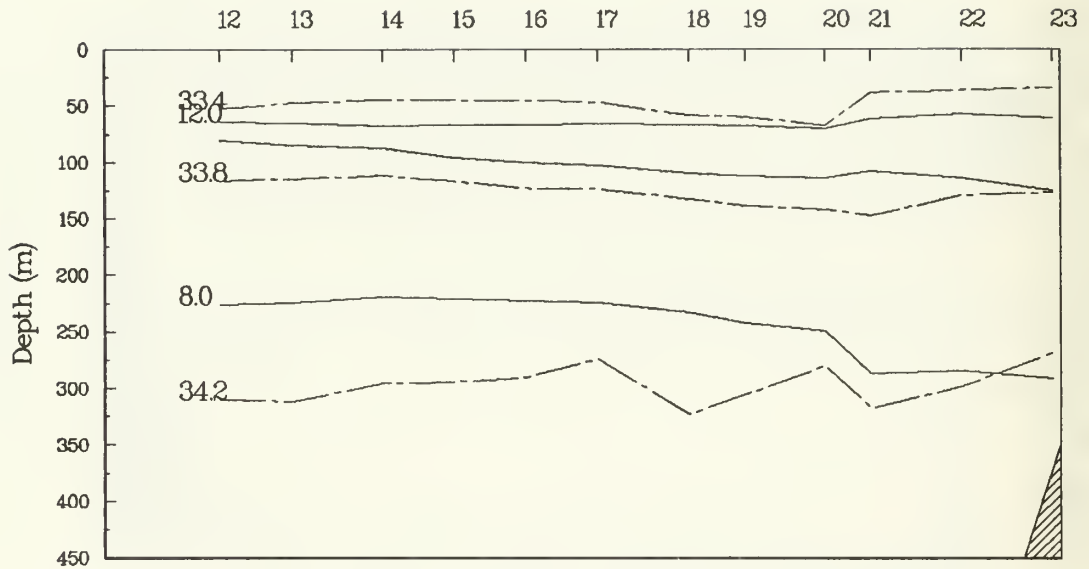


Figure 44.

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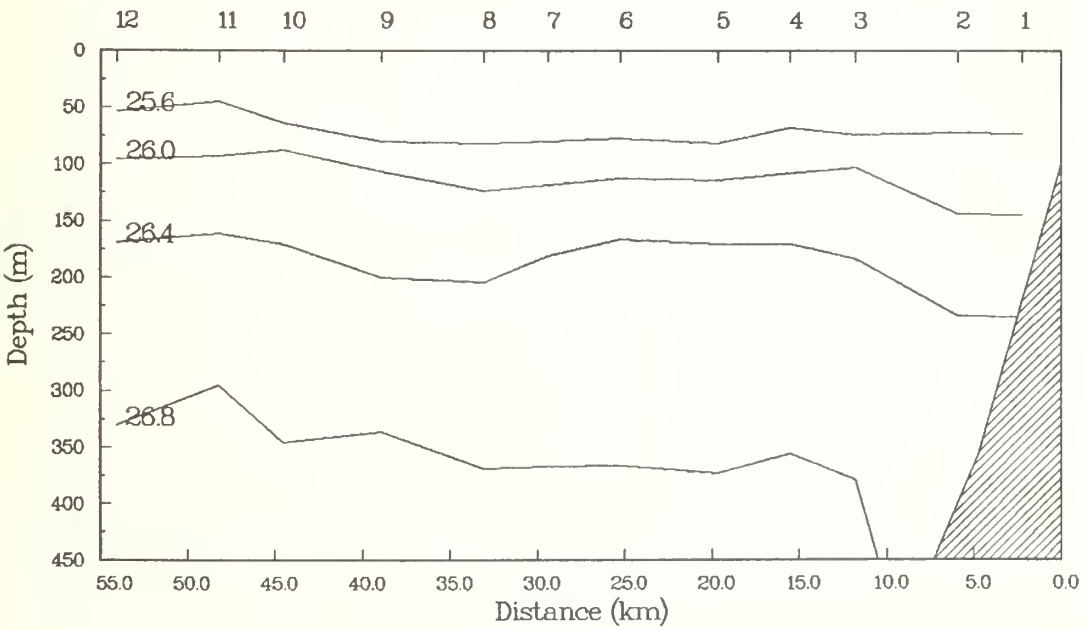
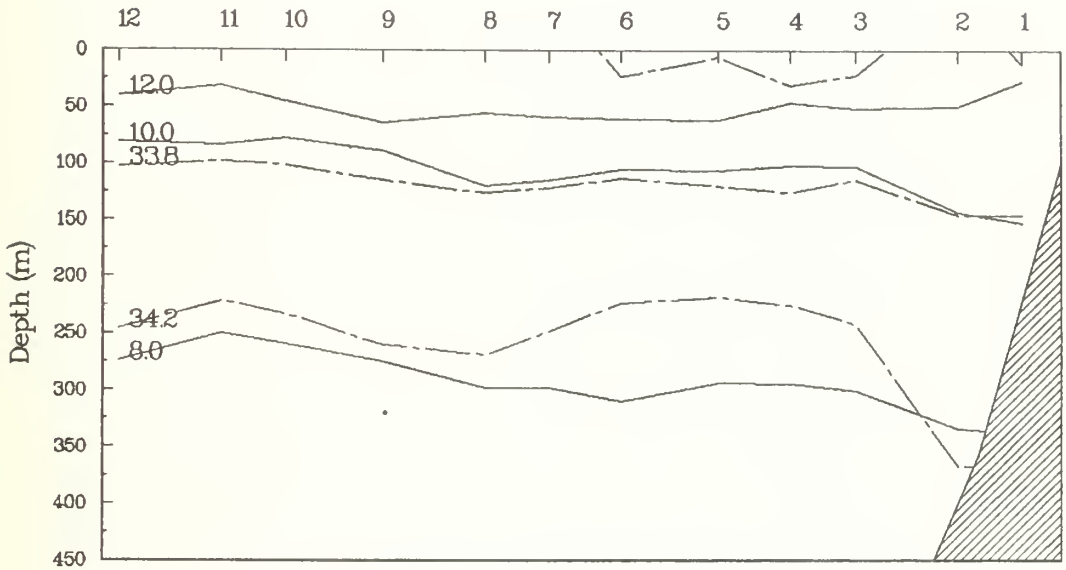


Figure 45.

2/21/79

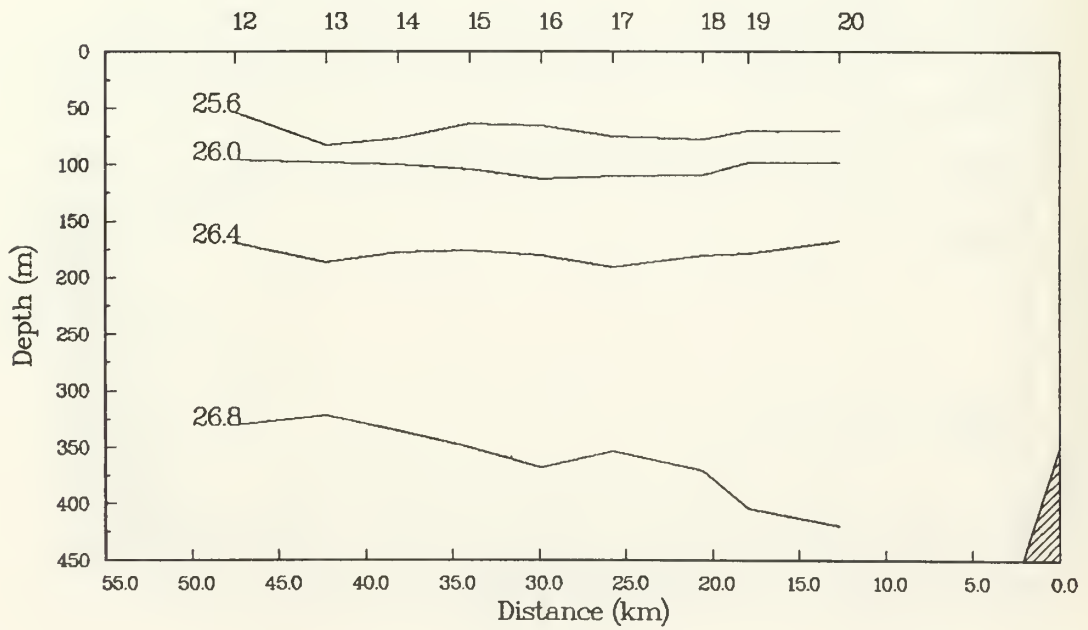
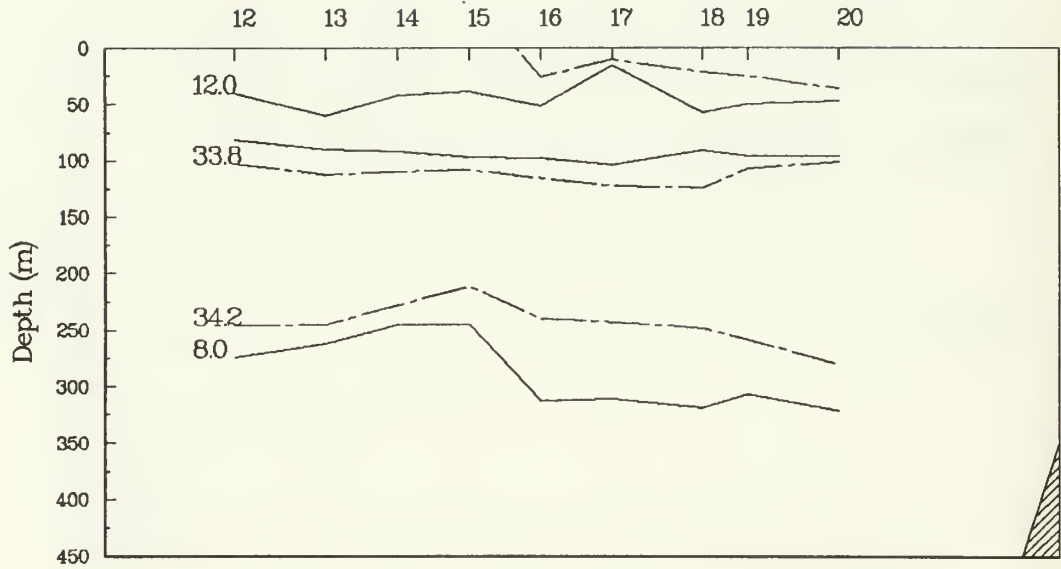


Figure 46.

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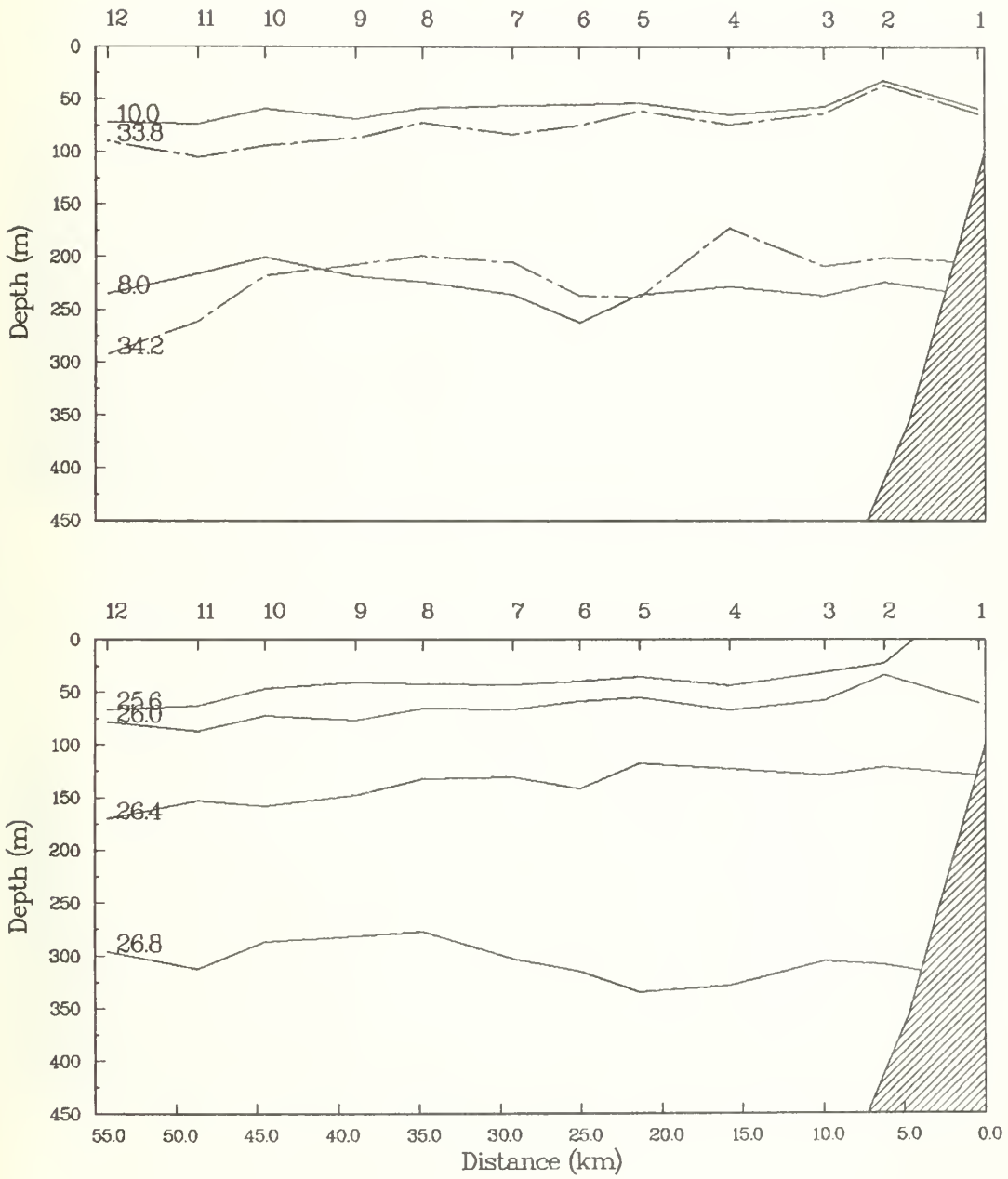


Figure 47.

4/23/79

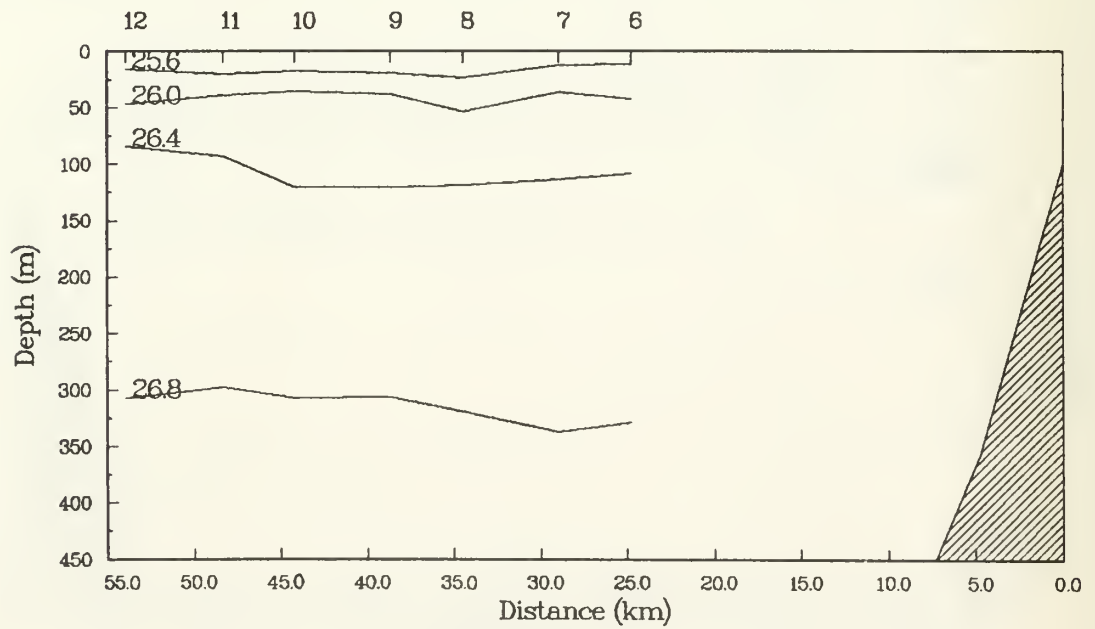
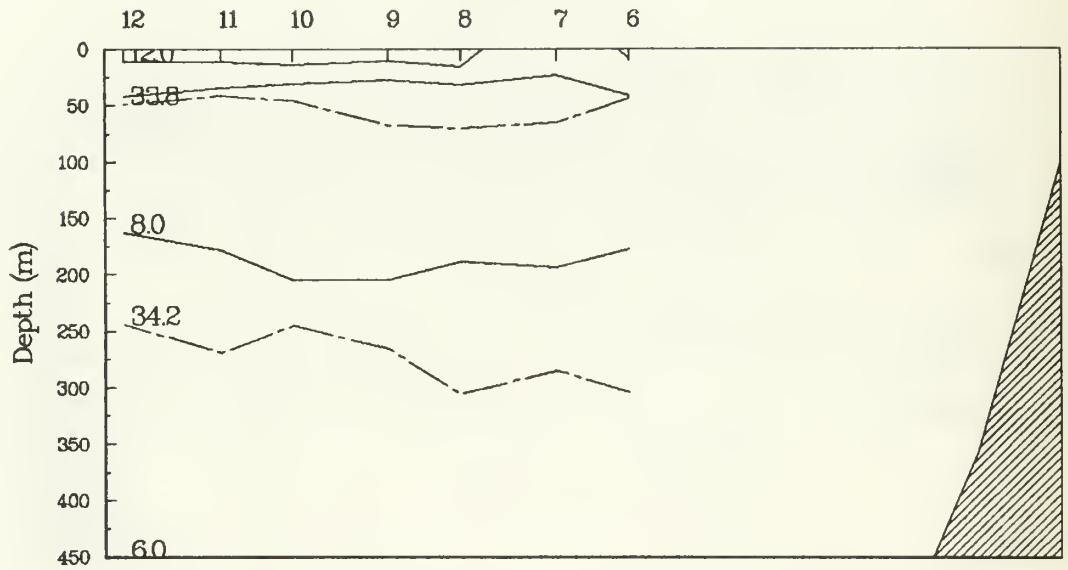


Figure 48.

7/8/79

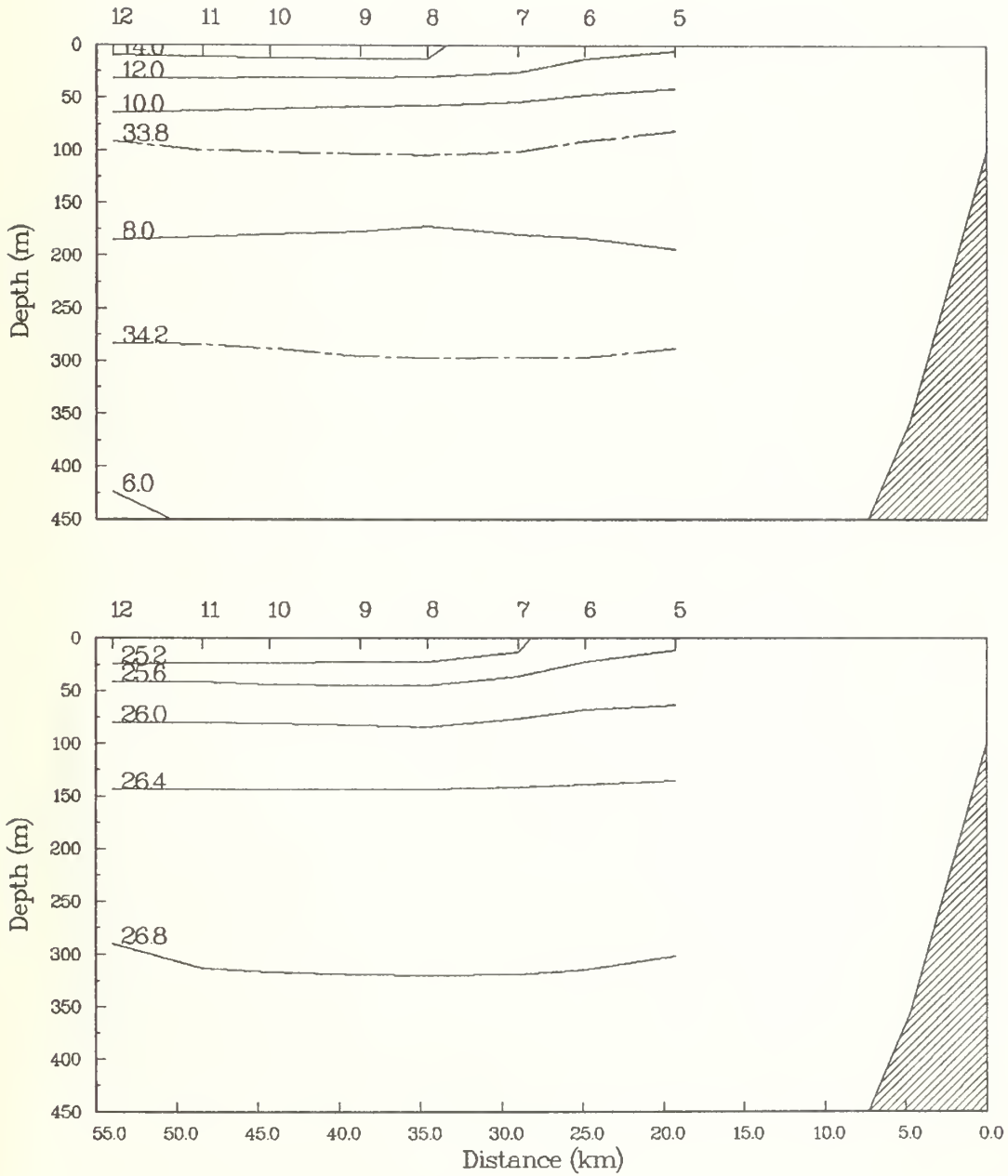


Figure 49.

7/23/79

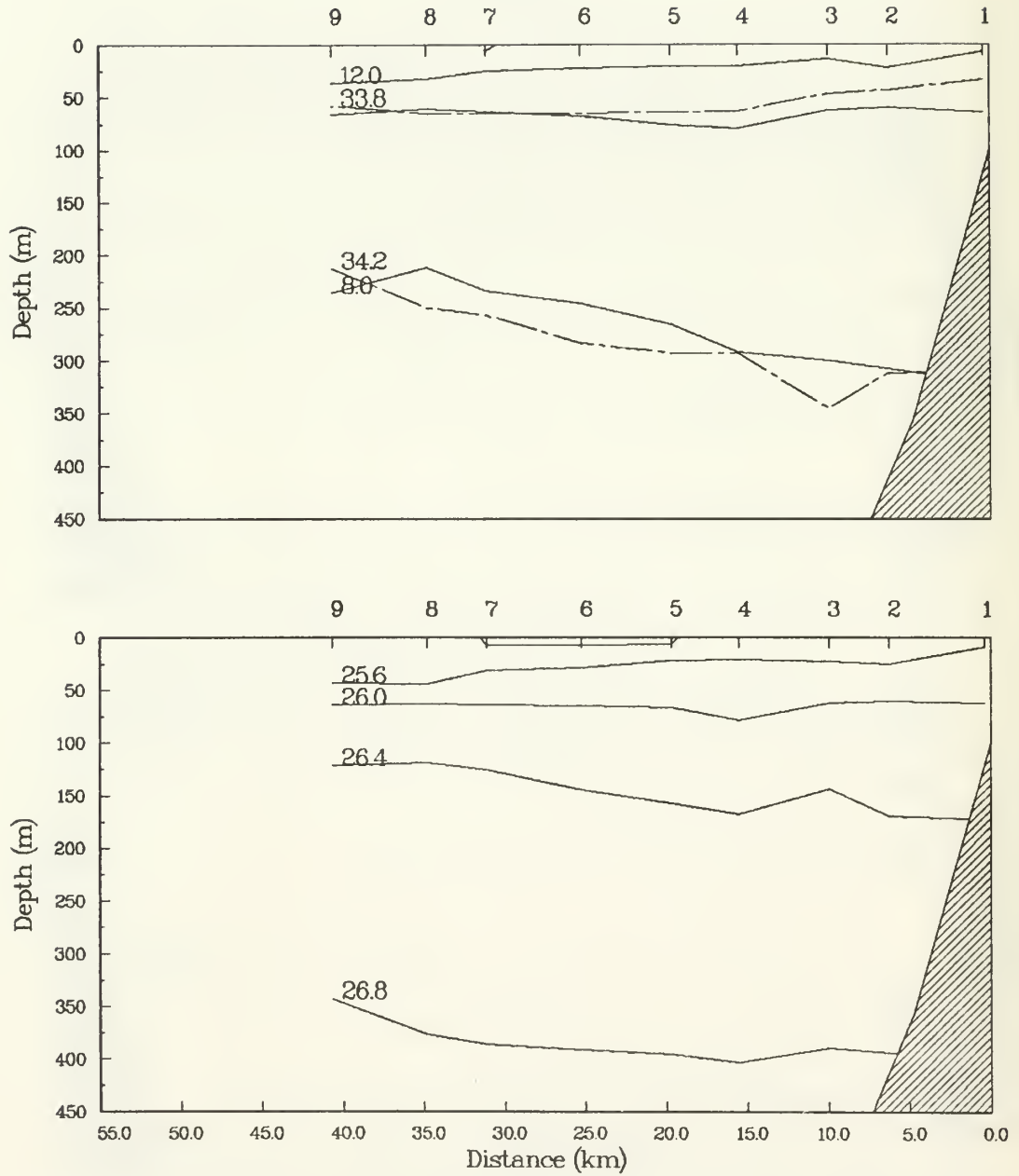


Figure 50.

9/23/79

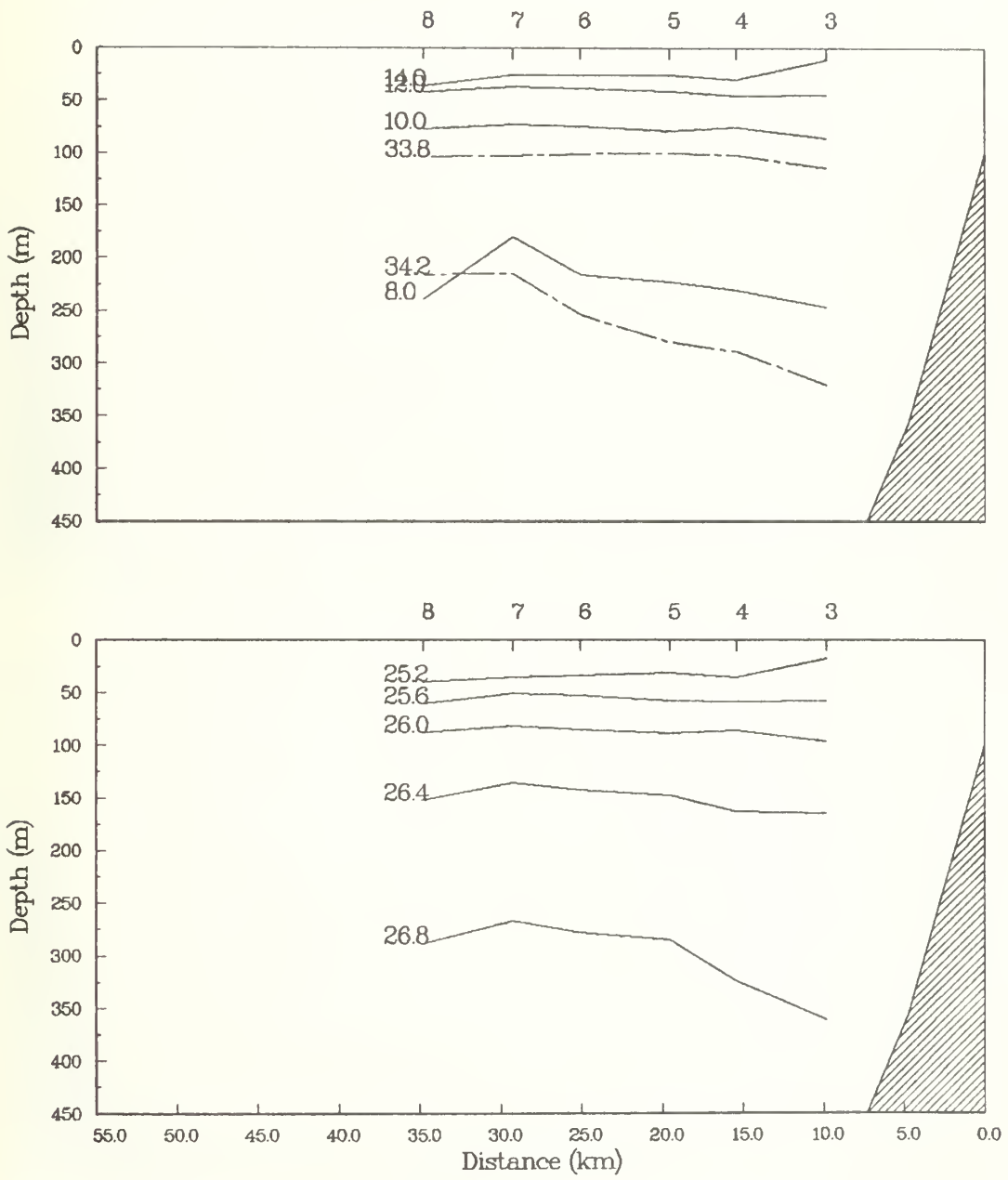


Figure 51.

2/12/80

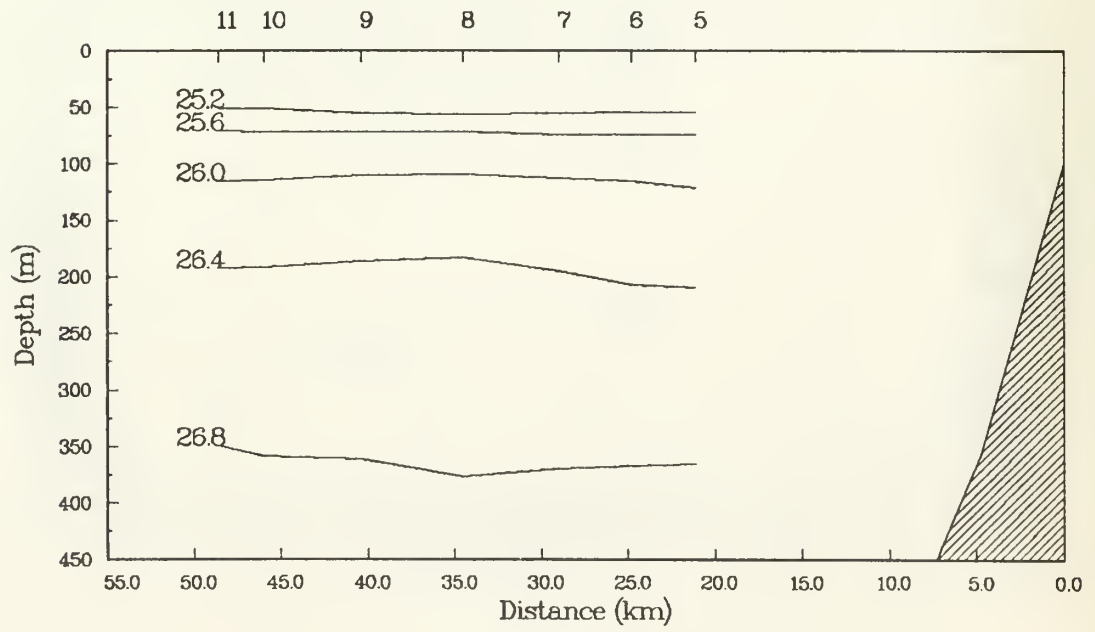
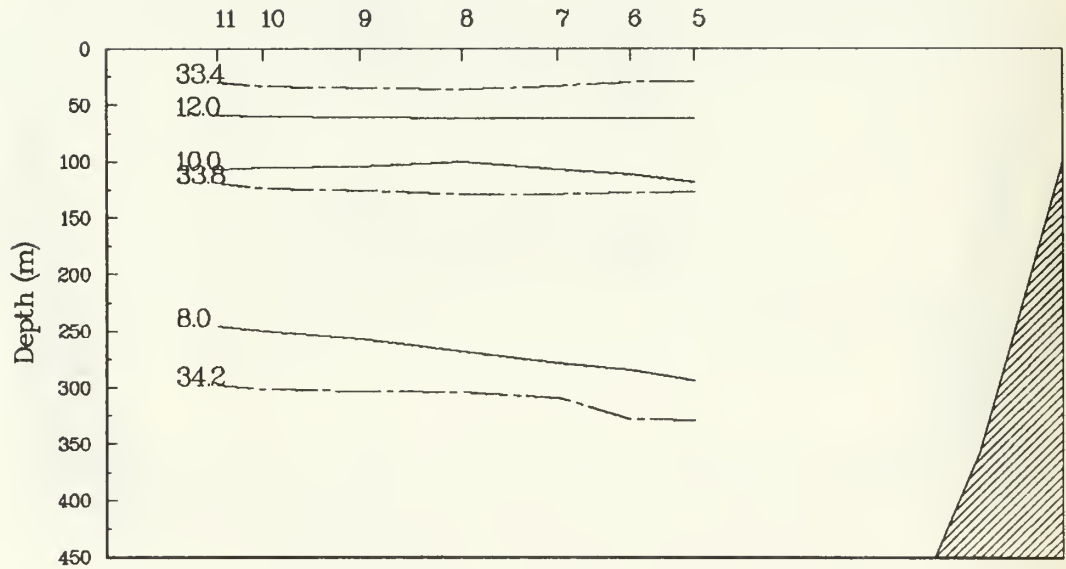


Figure 52.

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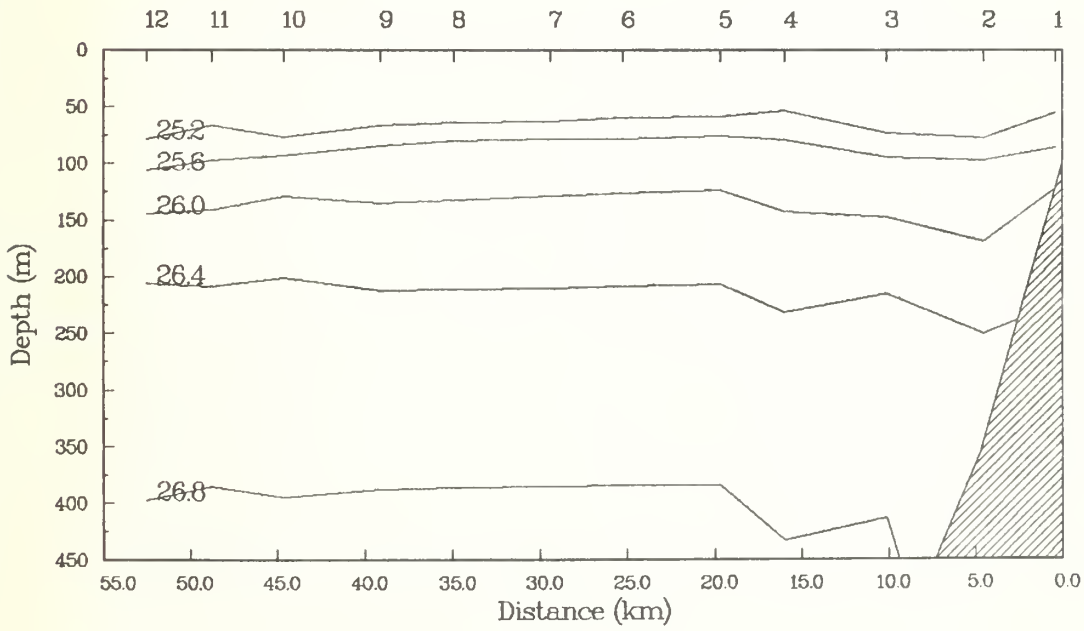
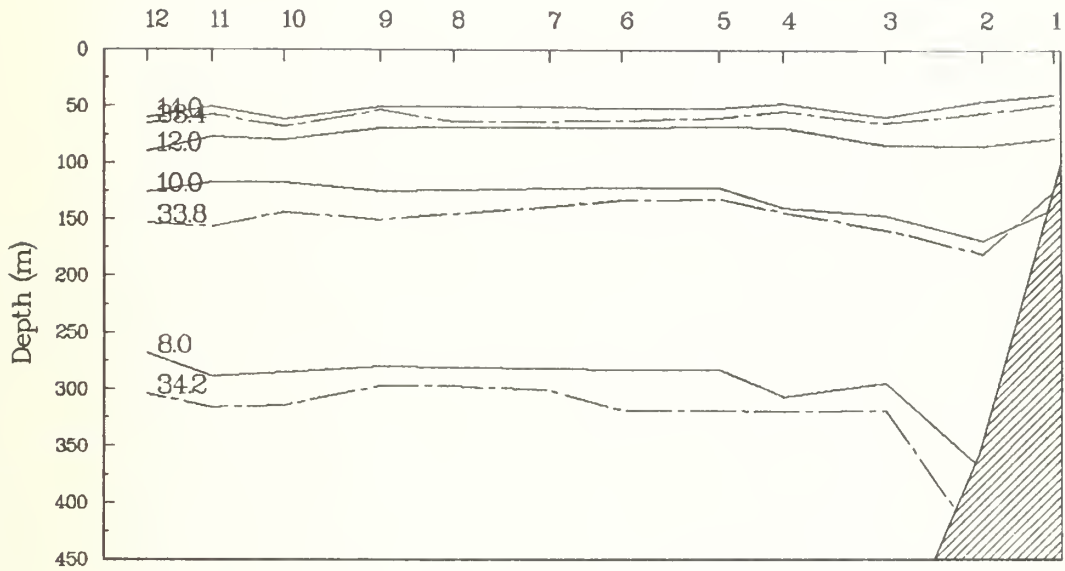


Figure 53.

4/7/80

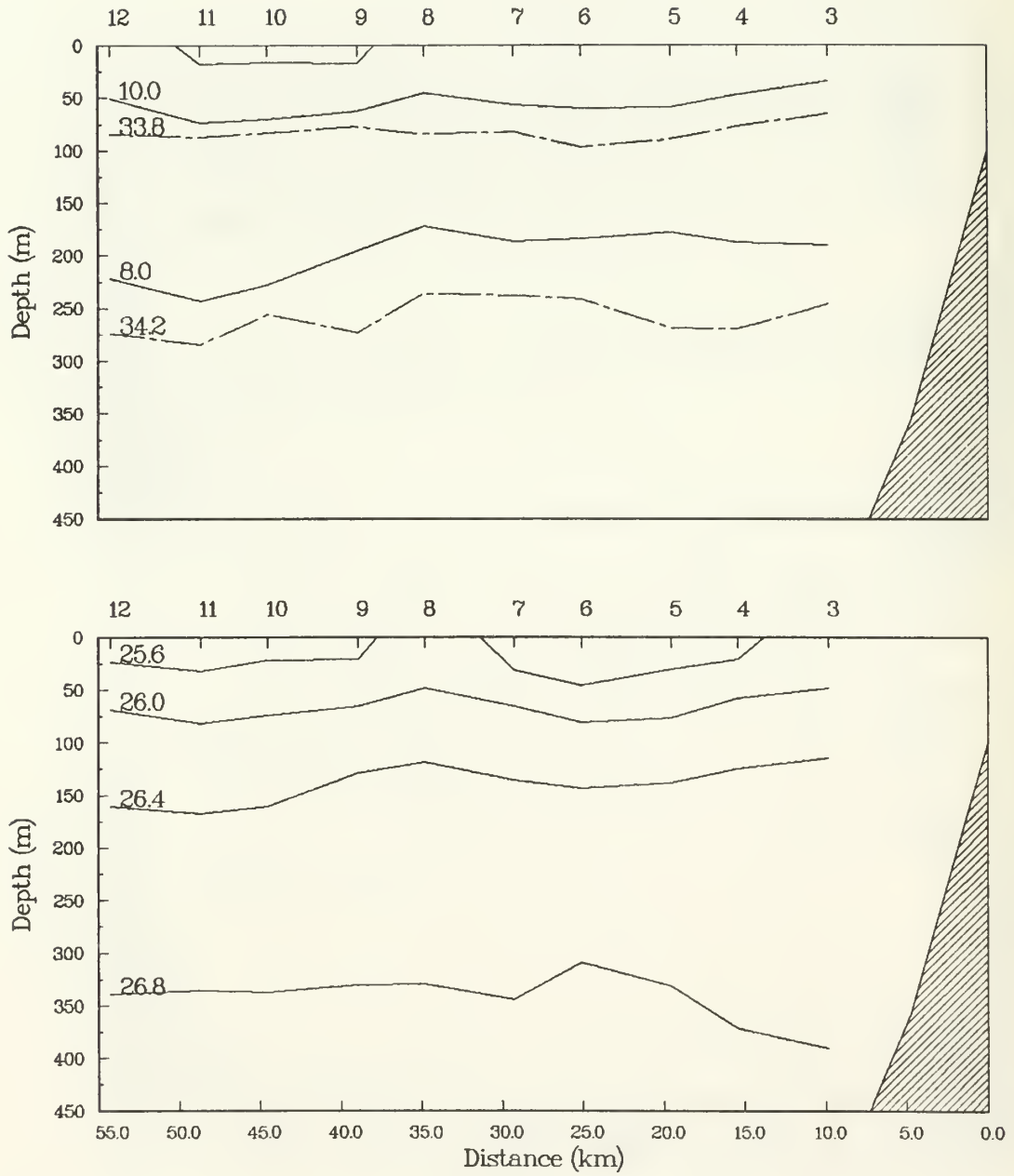


Figure 54.

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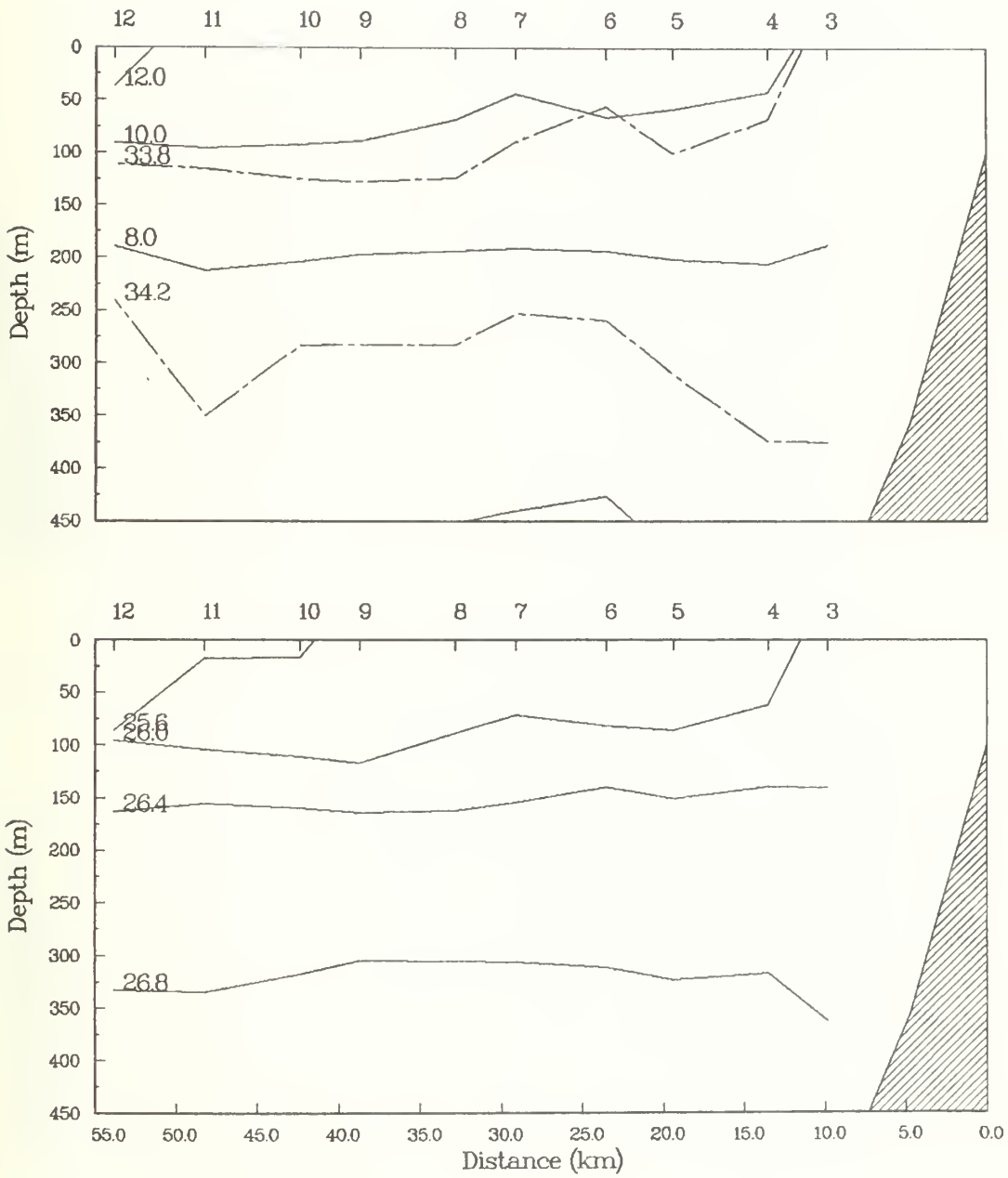


Figure 55.

6/26/80

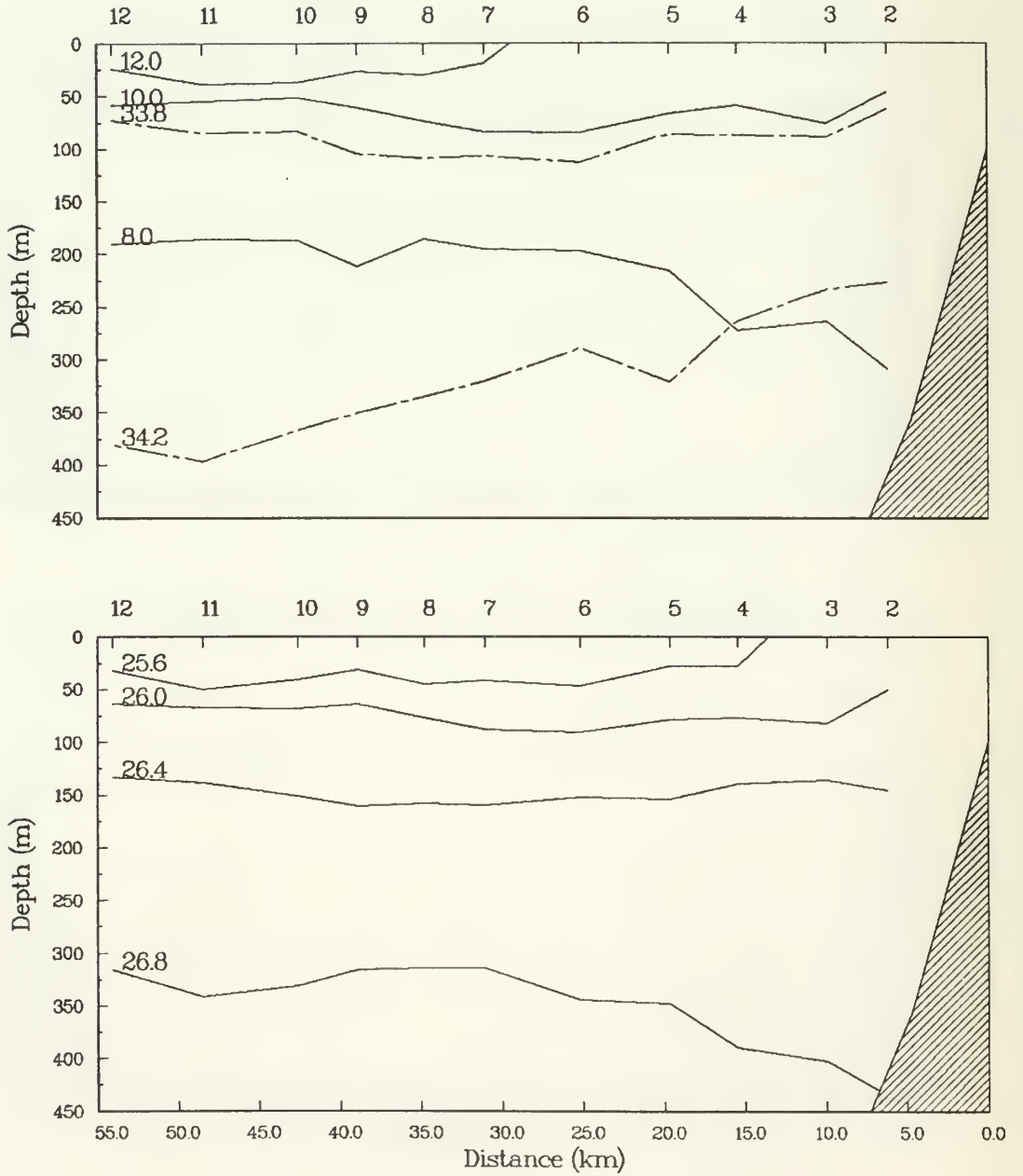
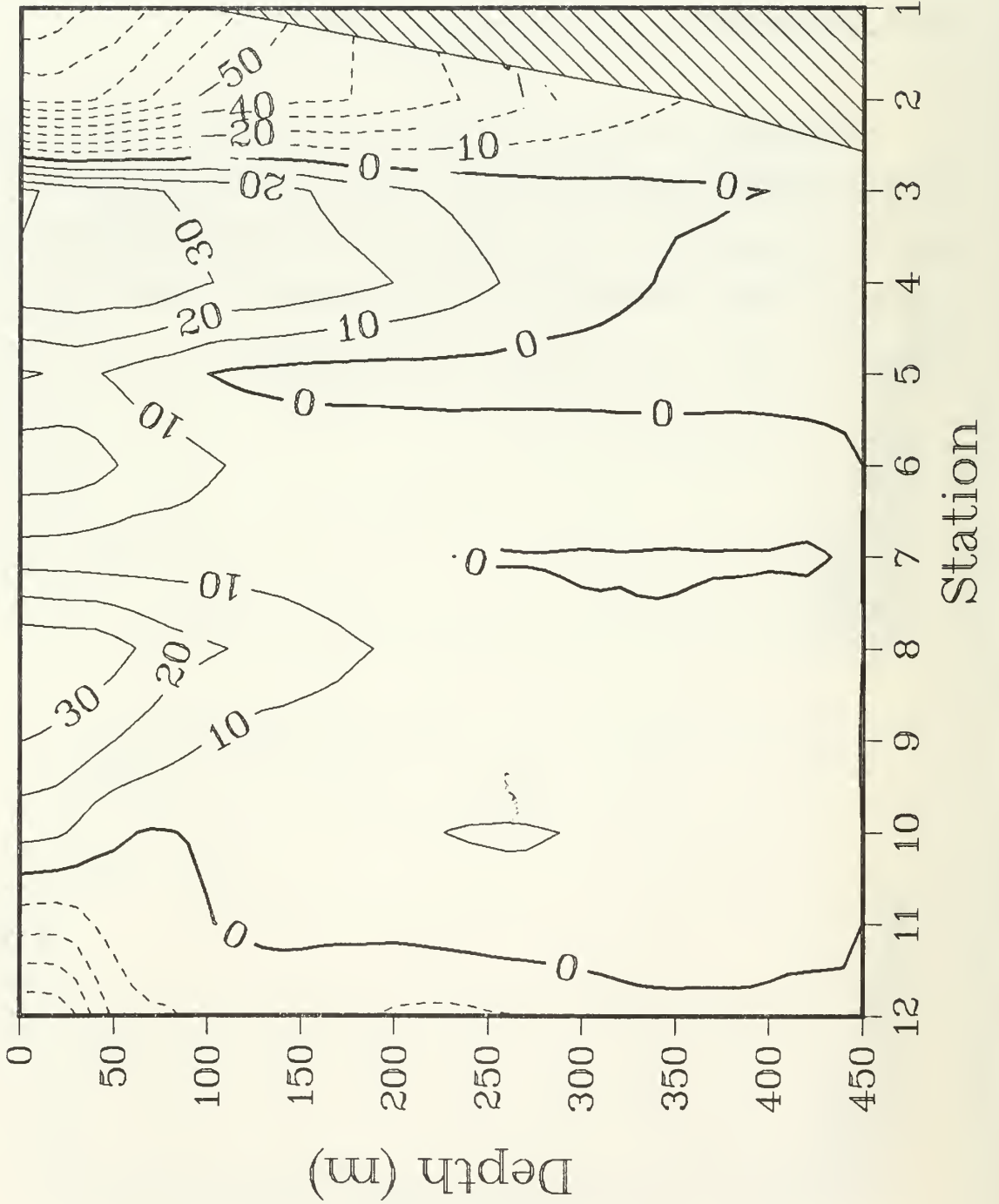


Figure 56.

Data Presentation - Geostrophic Velocities

Alongshore geostrophic velocities for each cruise are contoured at 10 cm/s intervals (Figures 57-74), with solid lines indicating positive (poleward) geostrophic flow and dashed lines indicating negative (equatorward) flow. The stippled areas indicate missing data, and the bottom slope is also shown.

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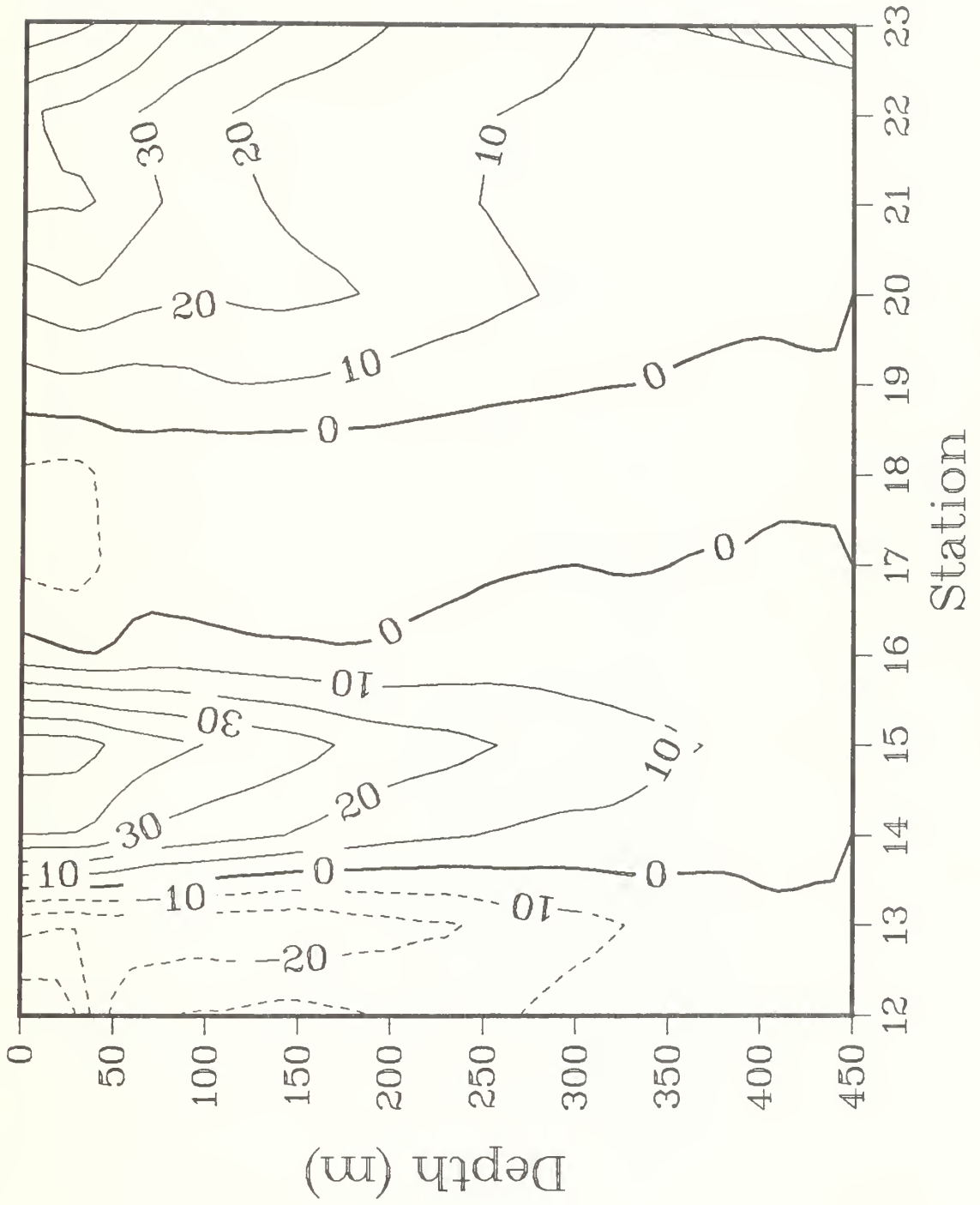


Figure 58.

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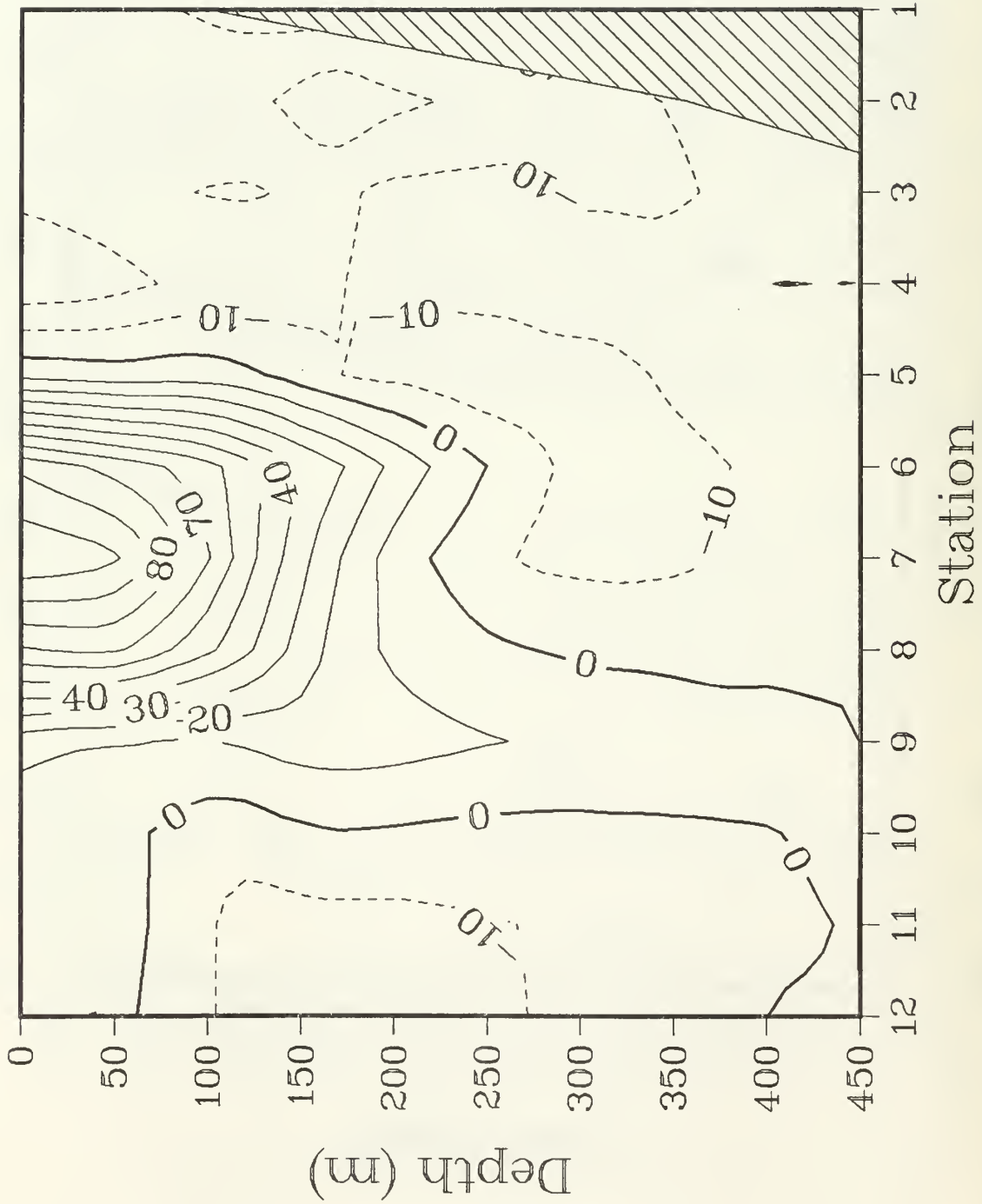


Figure 59.

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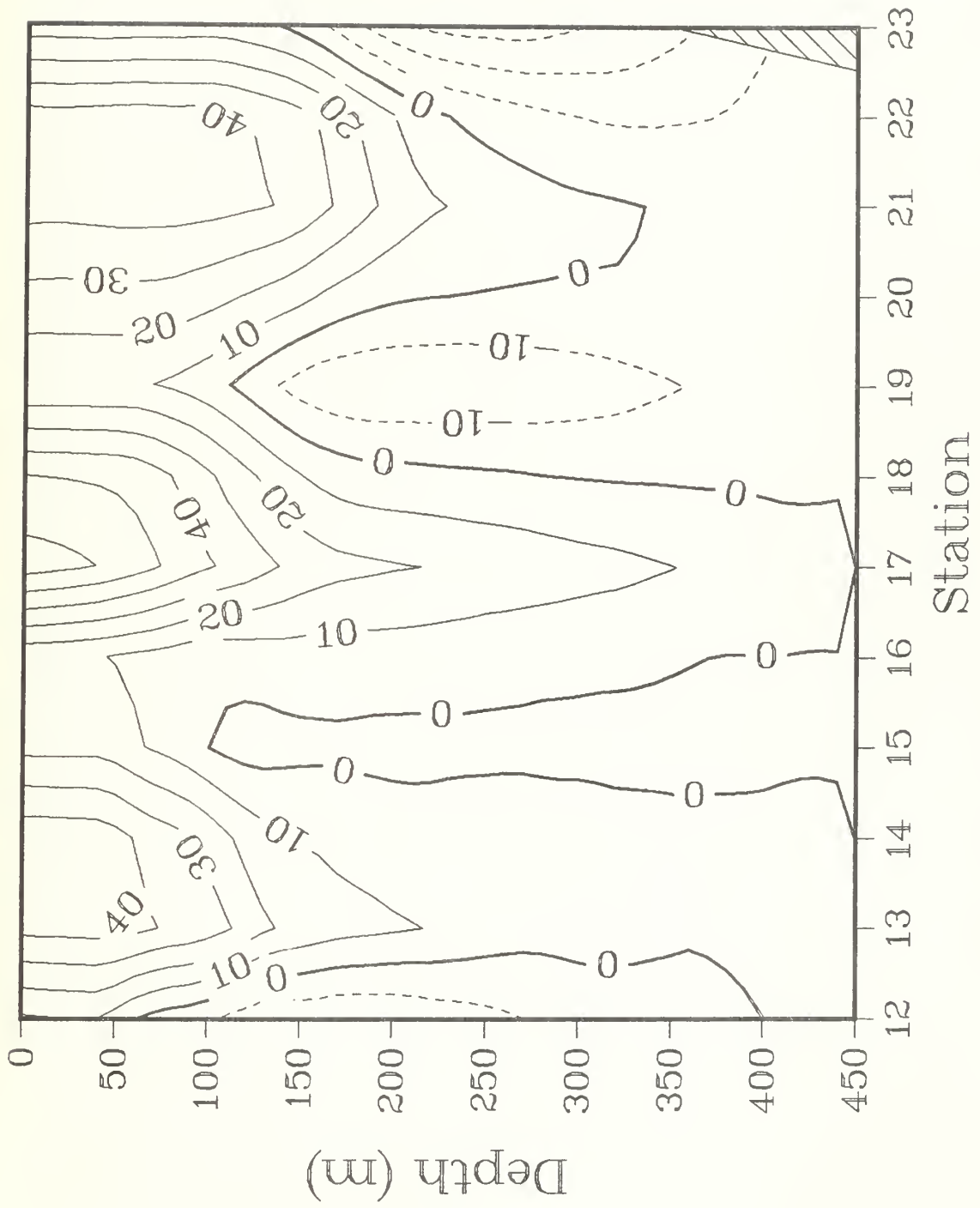


Figure 60.

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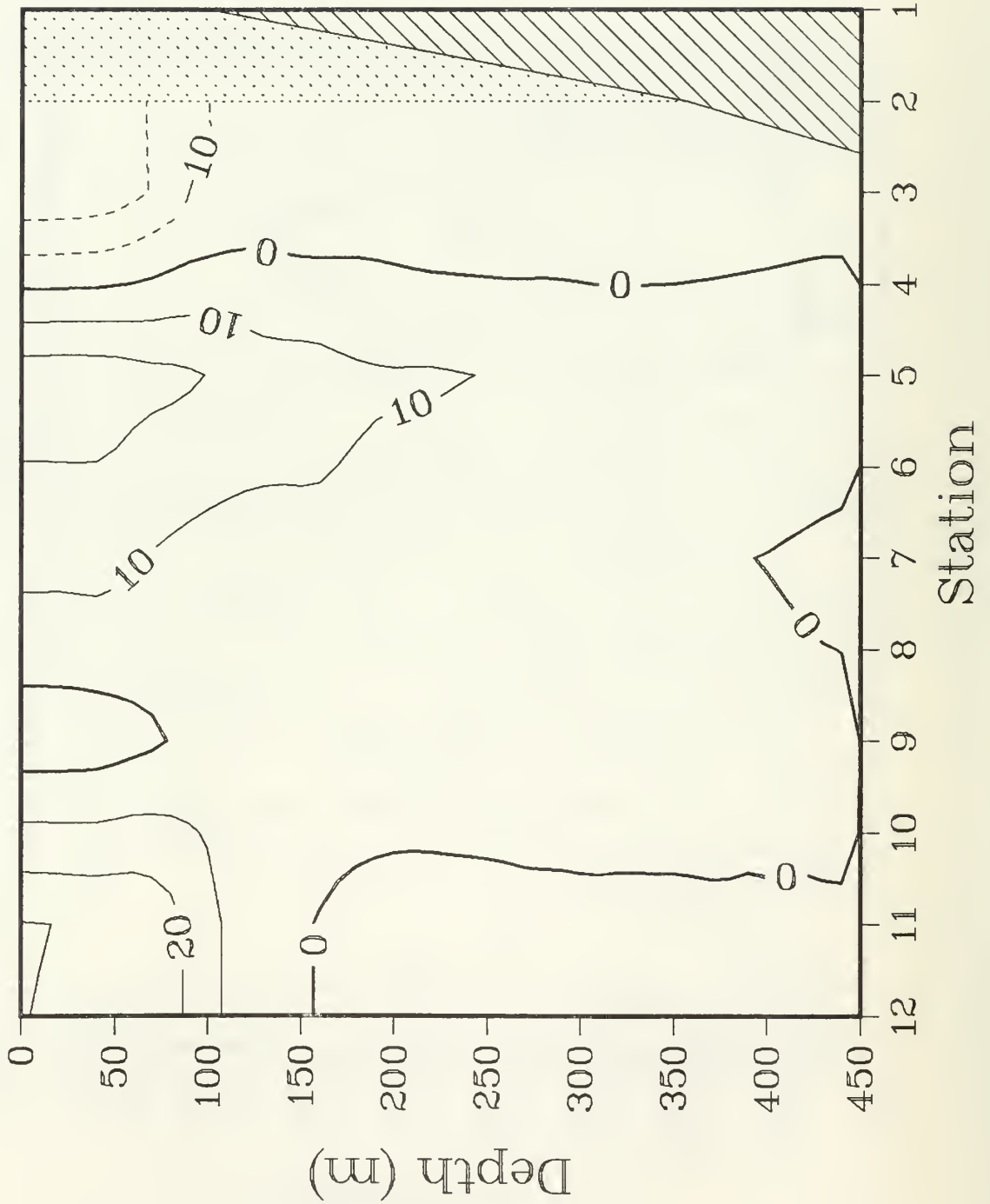


Figure 61.

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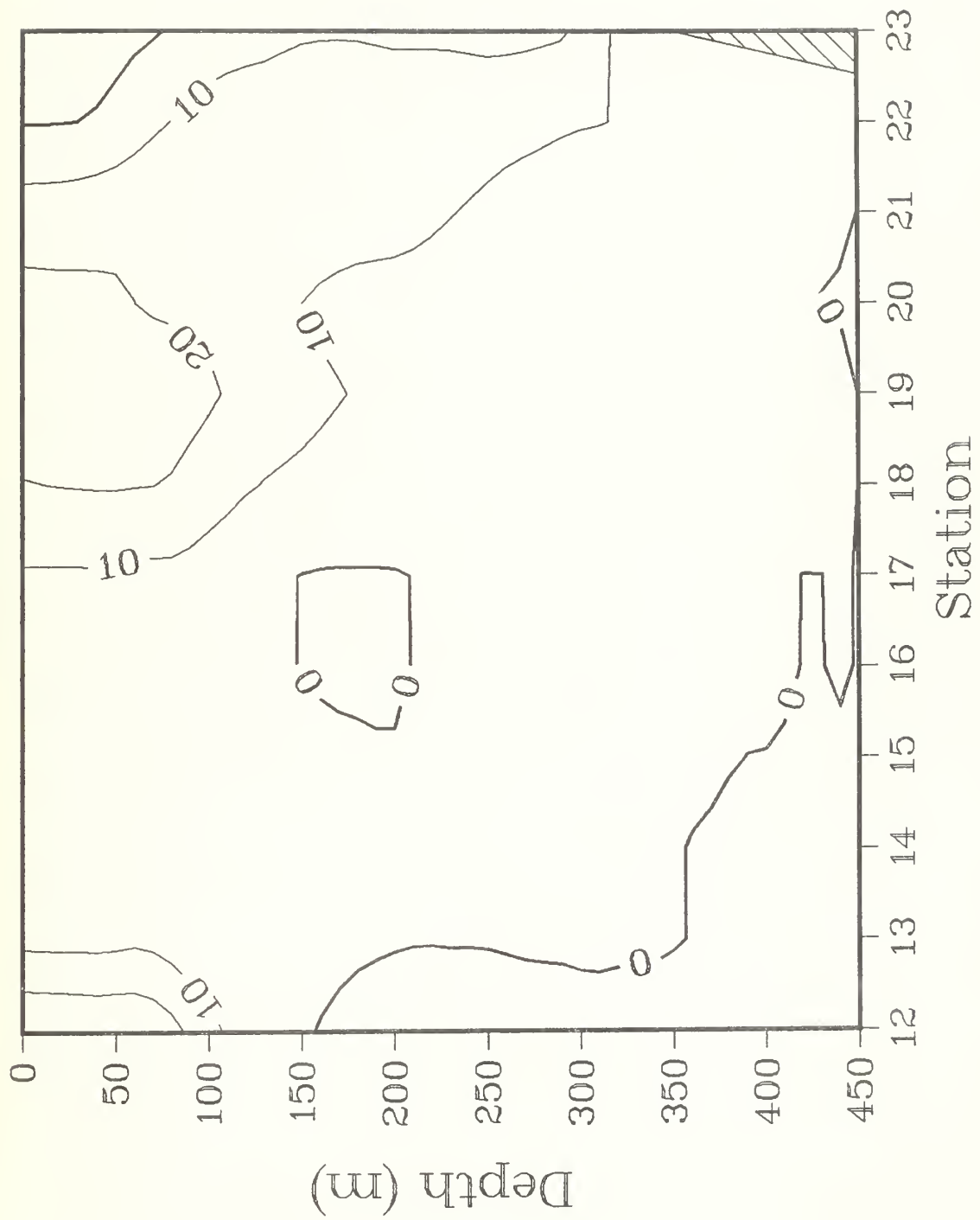


Figure 62.

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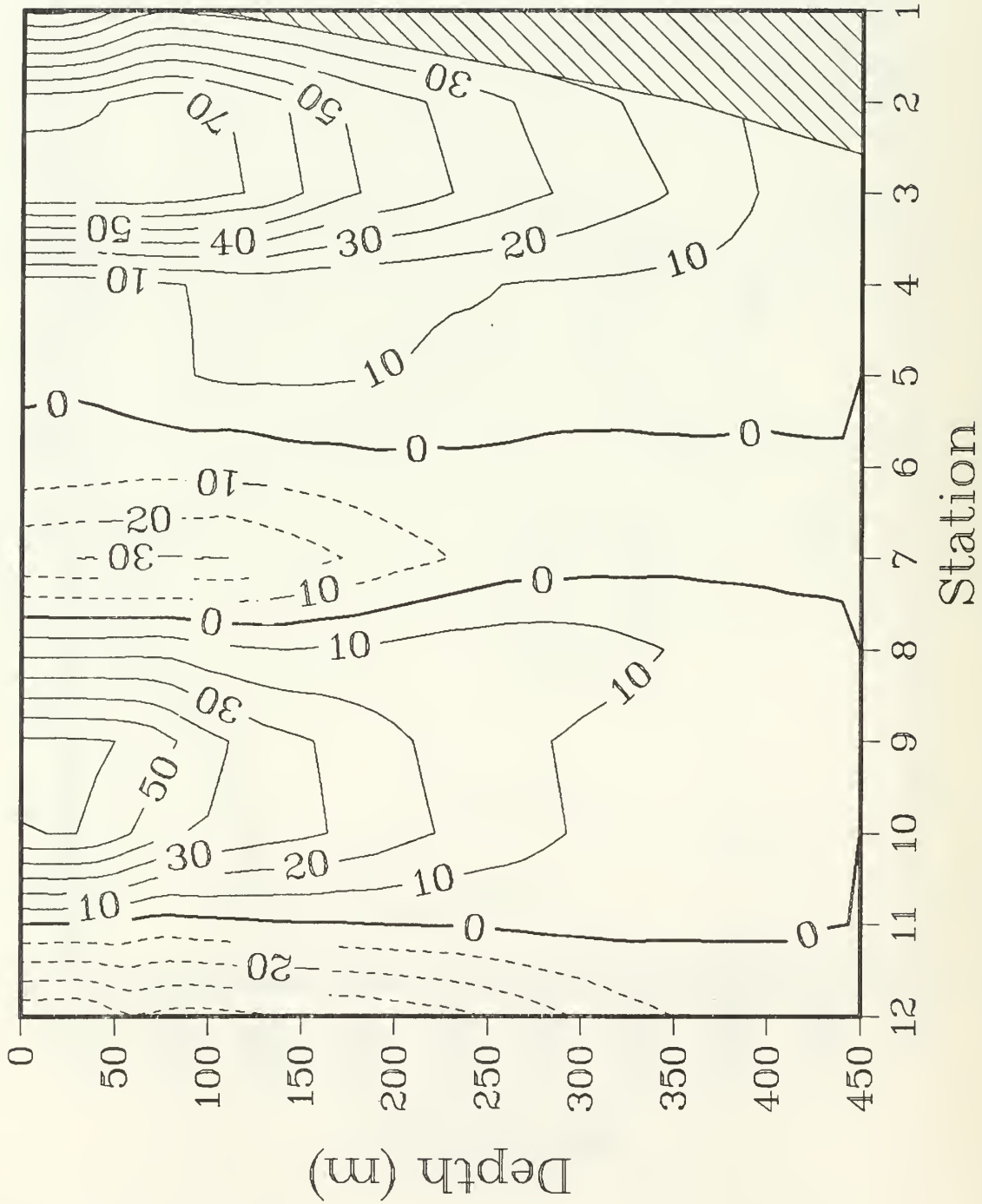


Figure 63.

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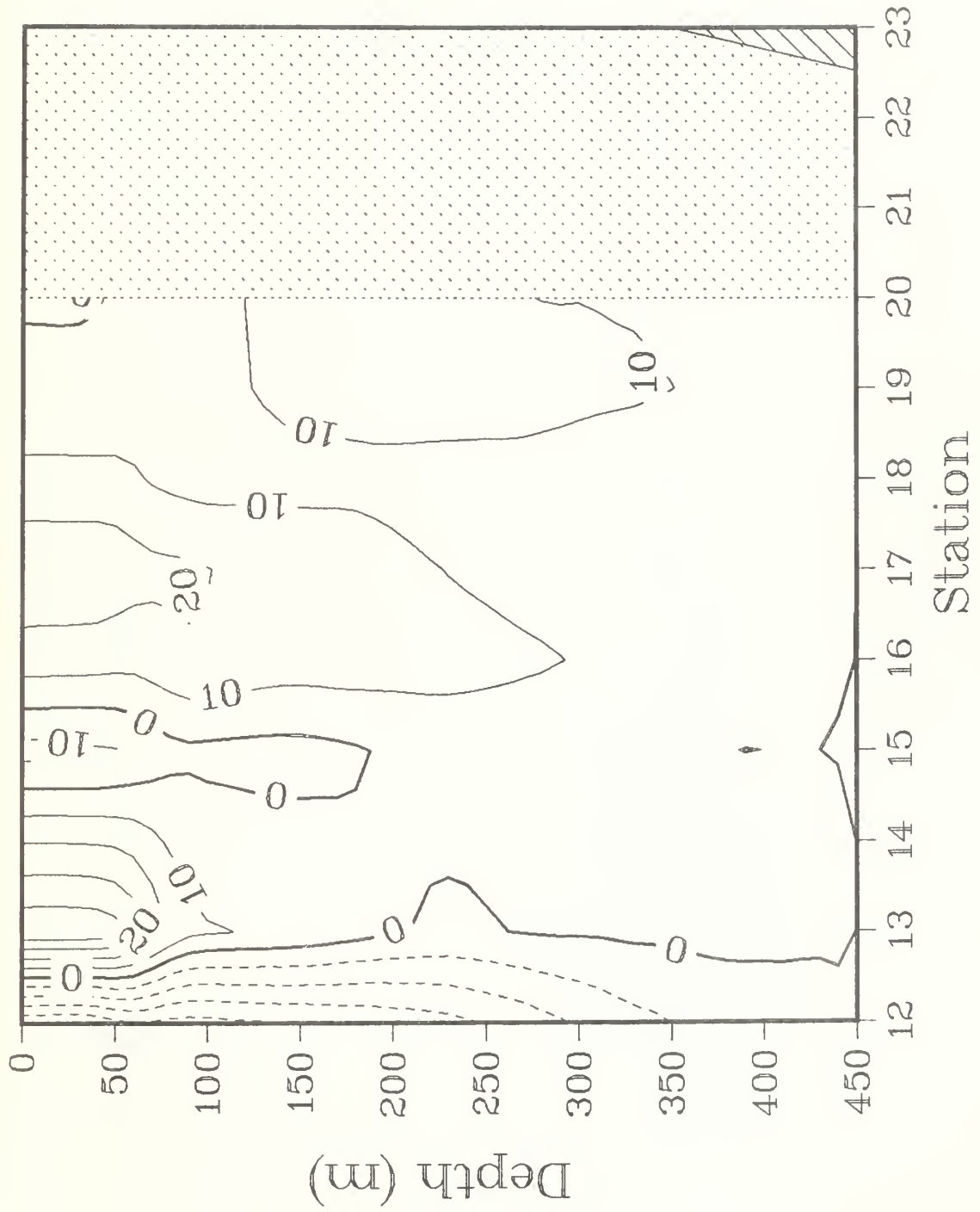


Figure 64.

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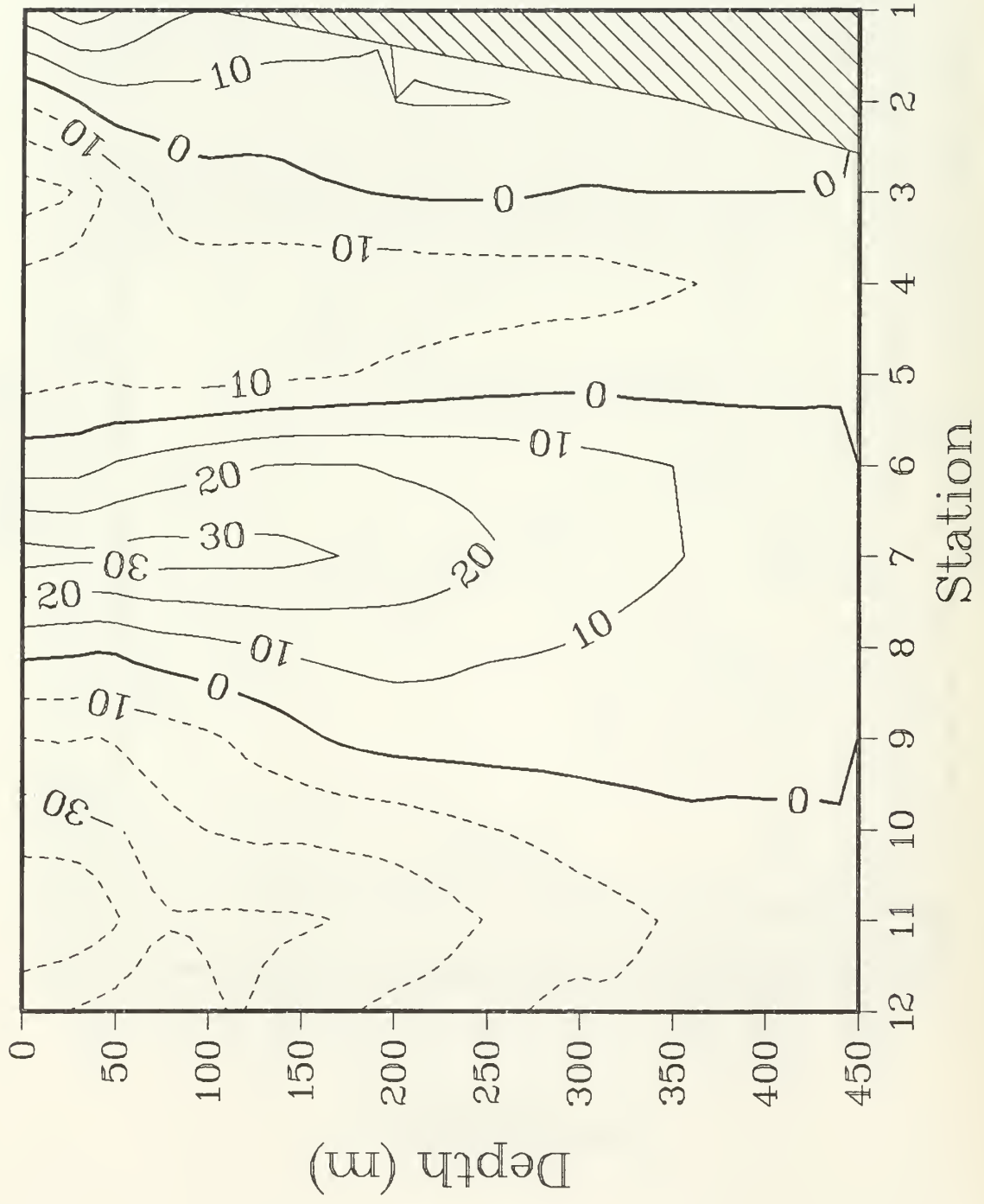


Figure 65.

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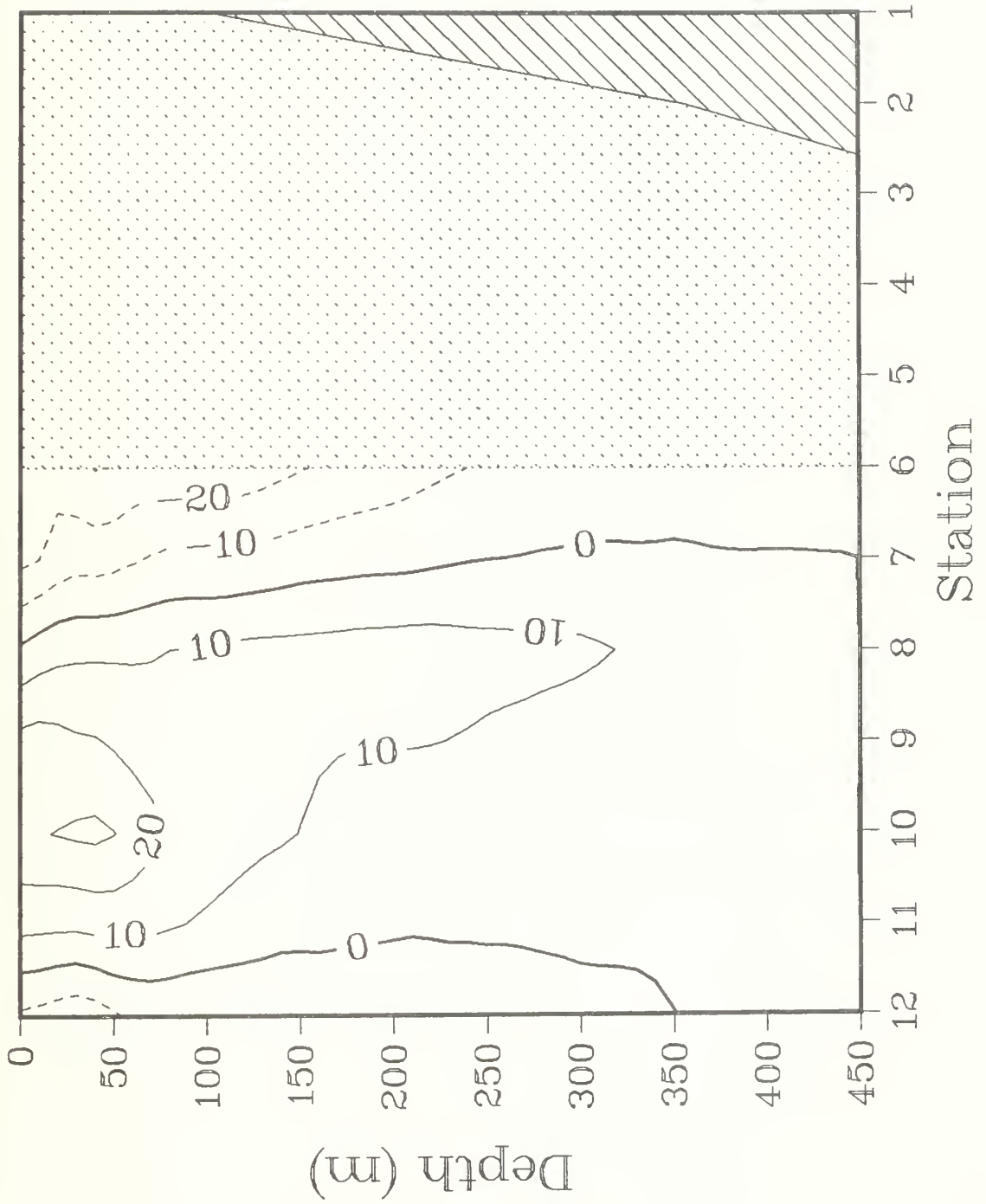


Figure 66.

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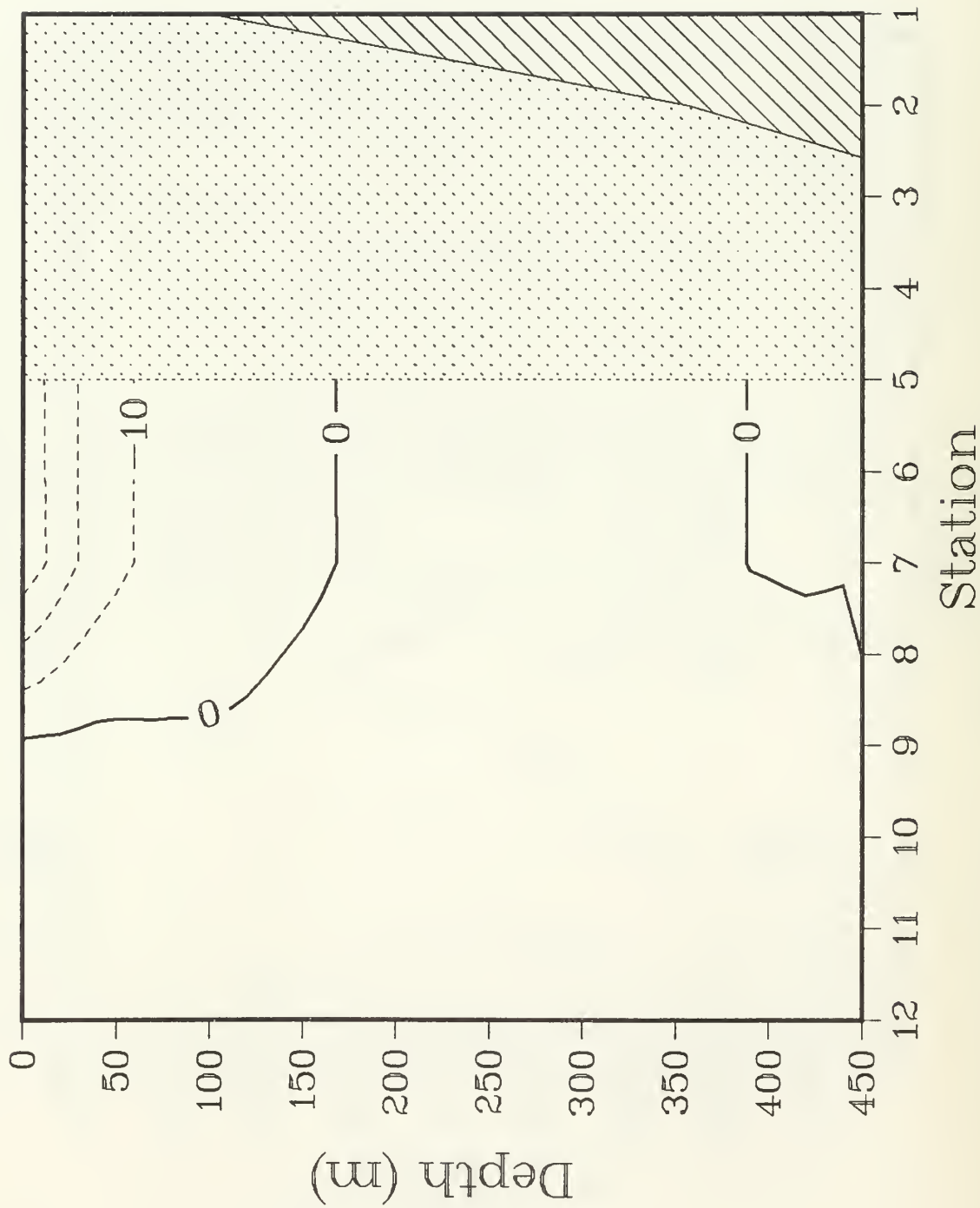


Figure 67.

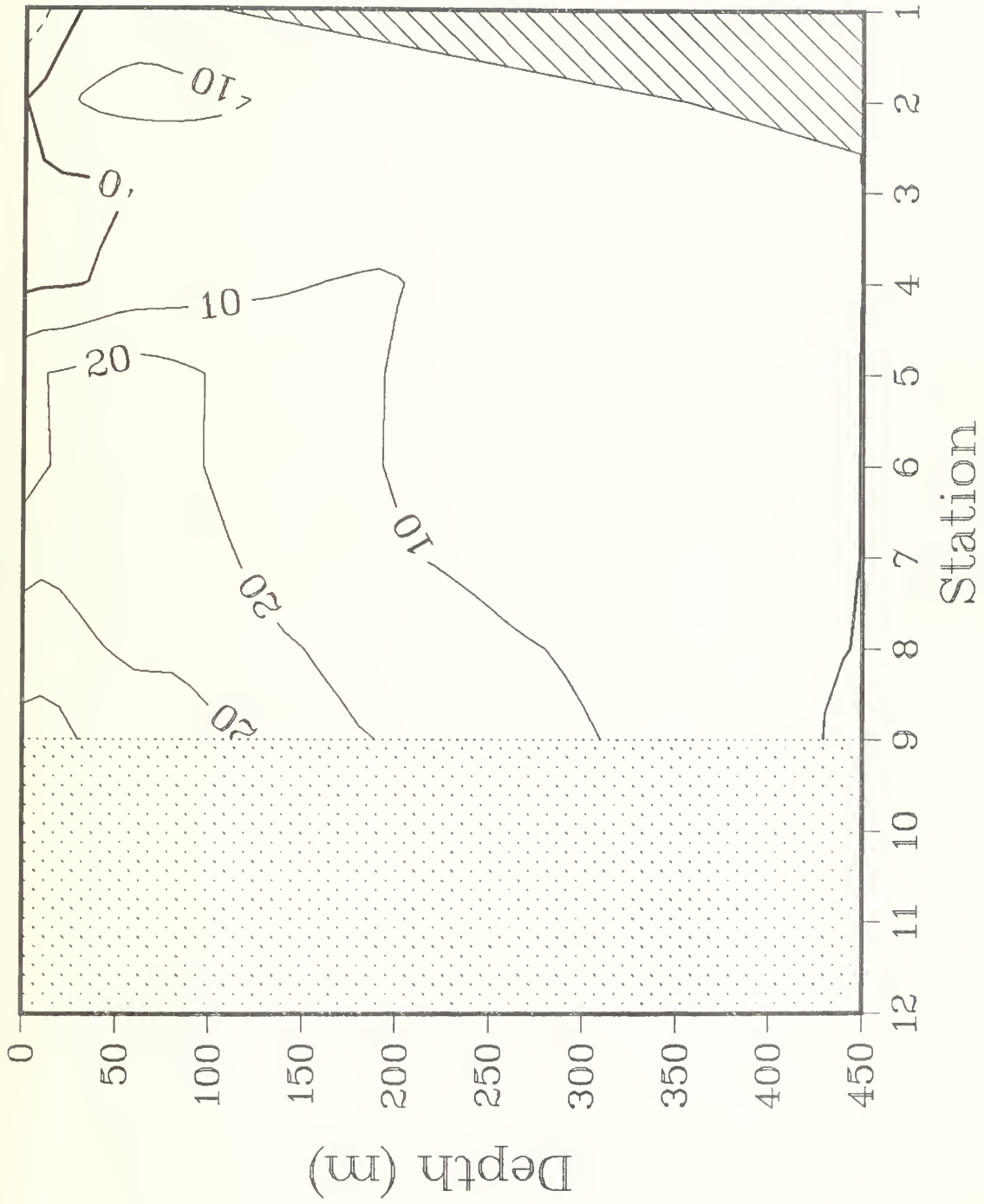


Figure 68.

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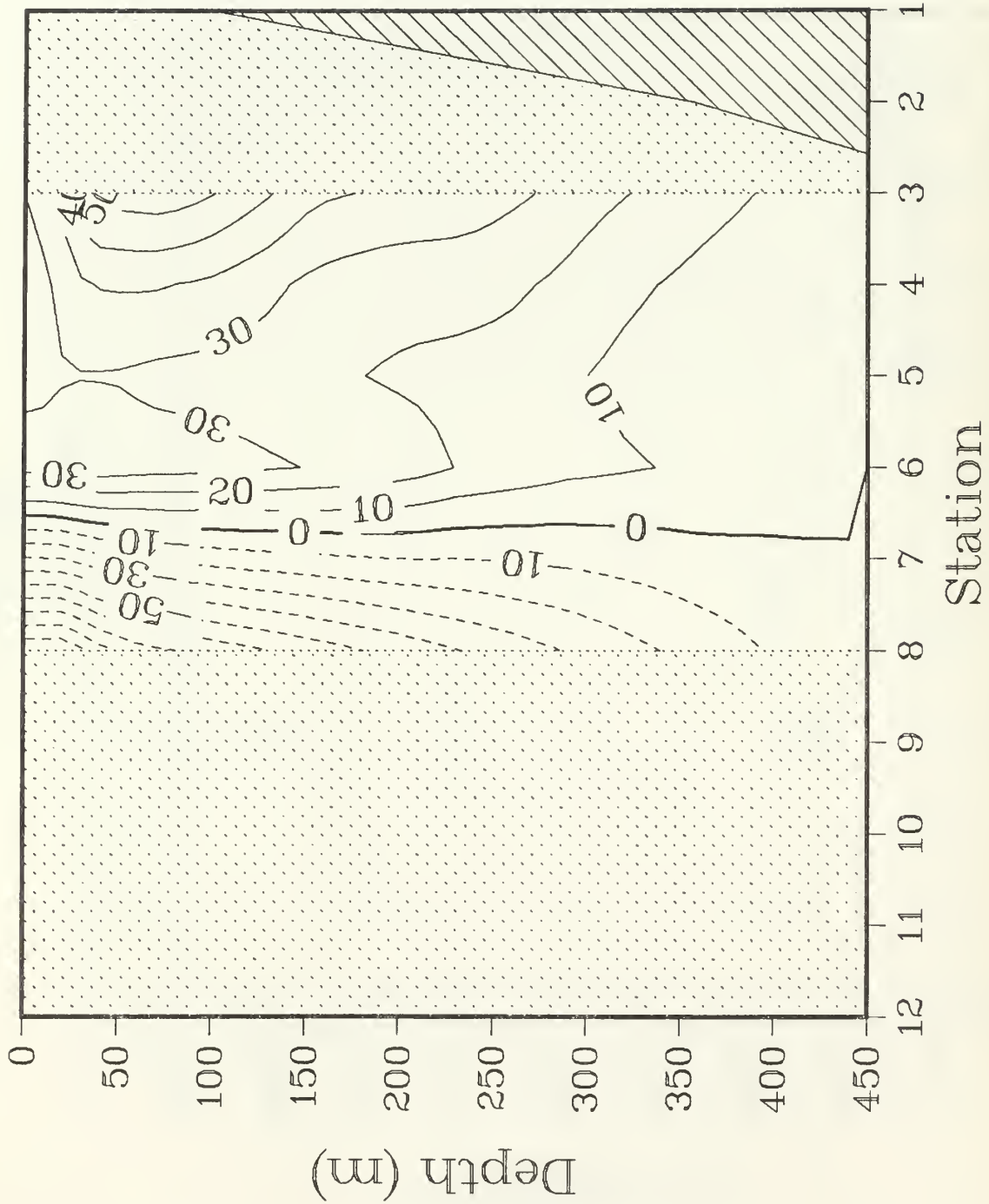


Figure 69.

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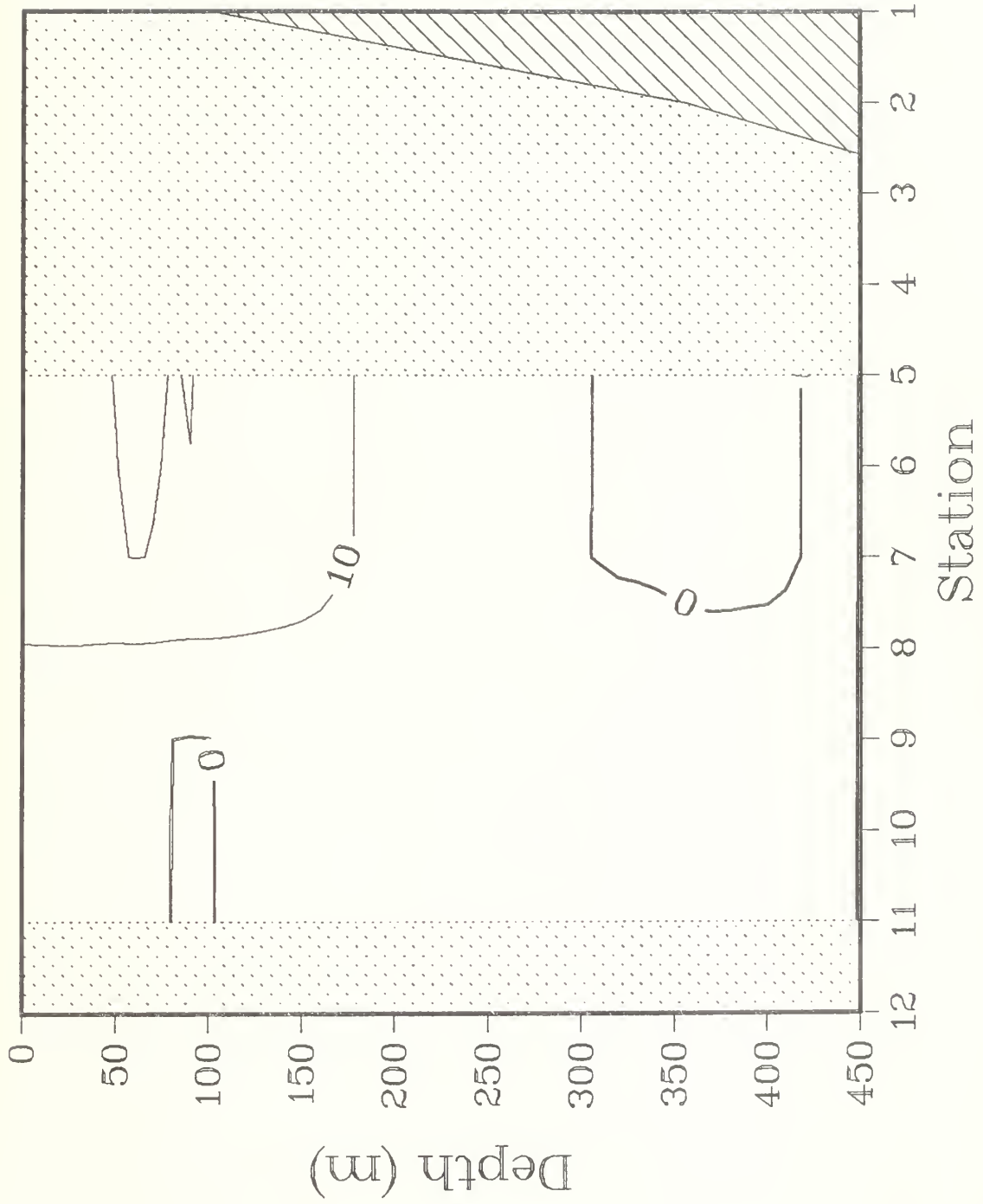


Figure 70.

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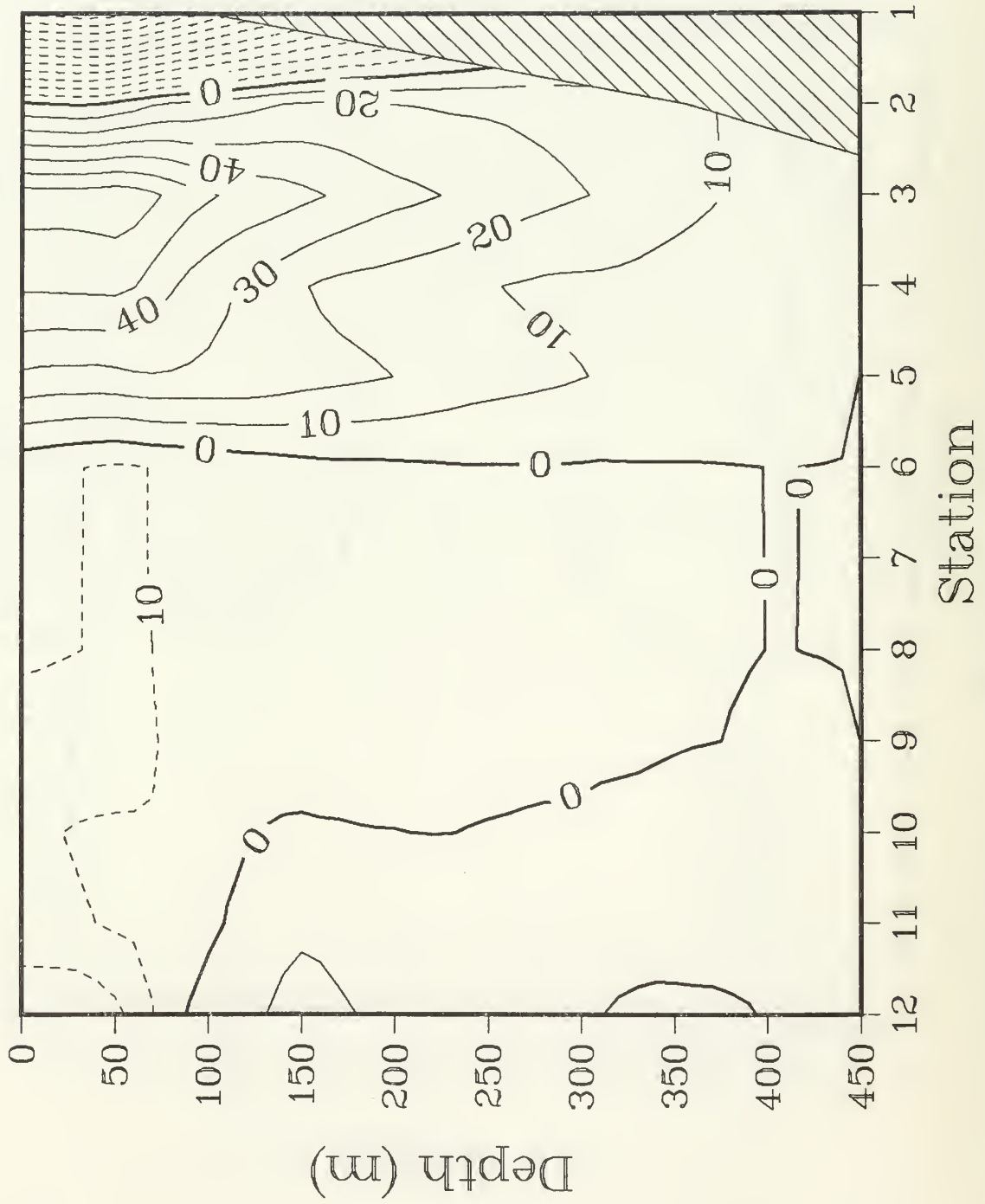


Figure 71.

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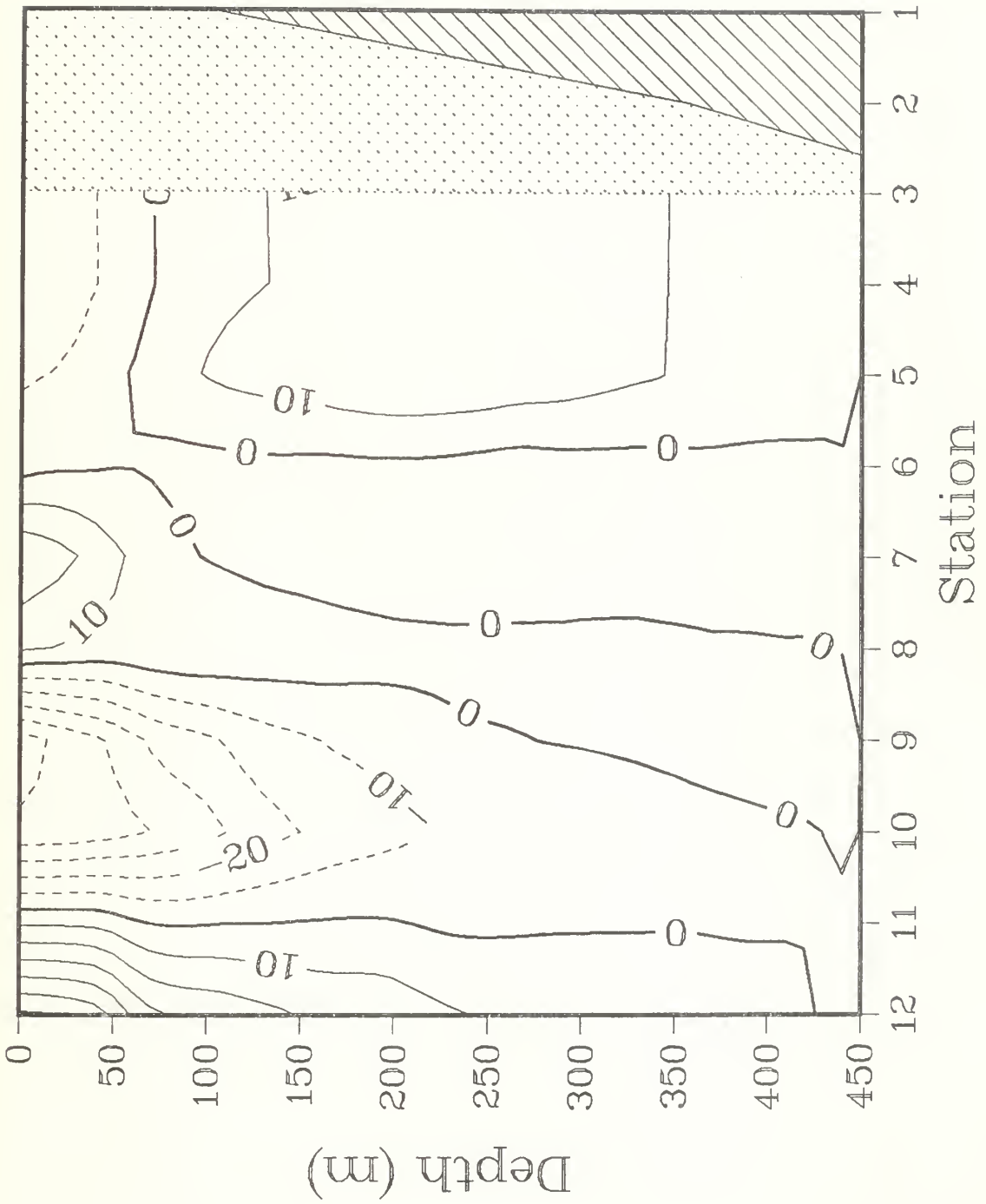


Figure 72.

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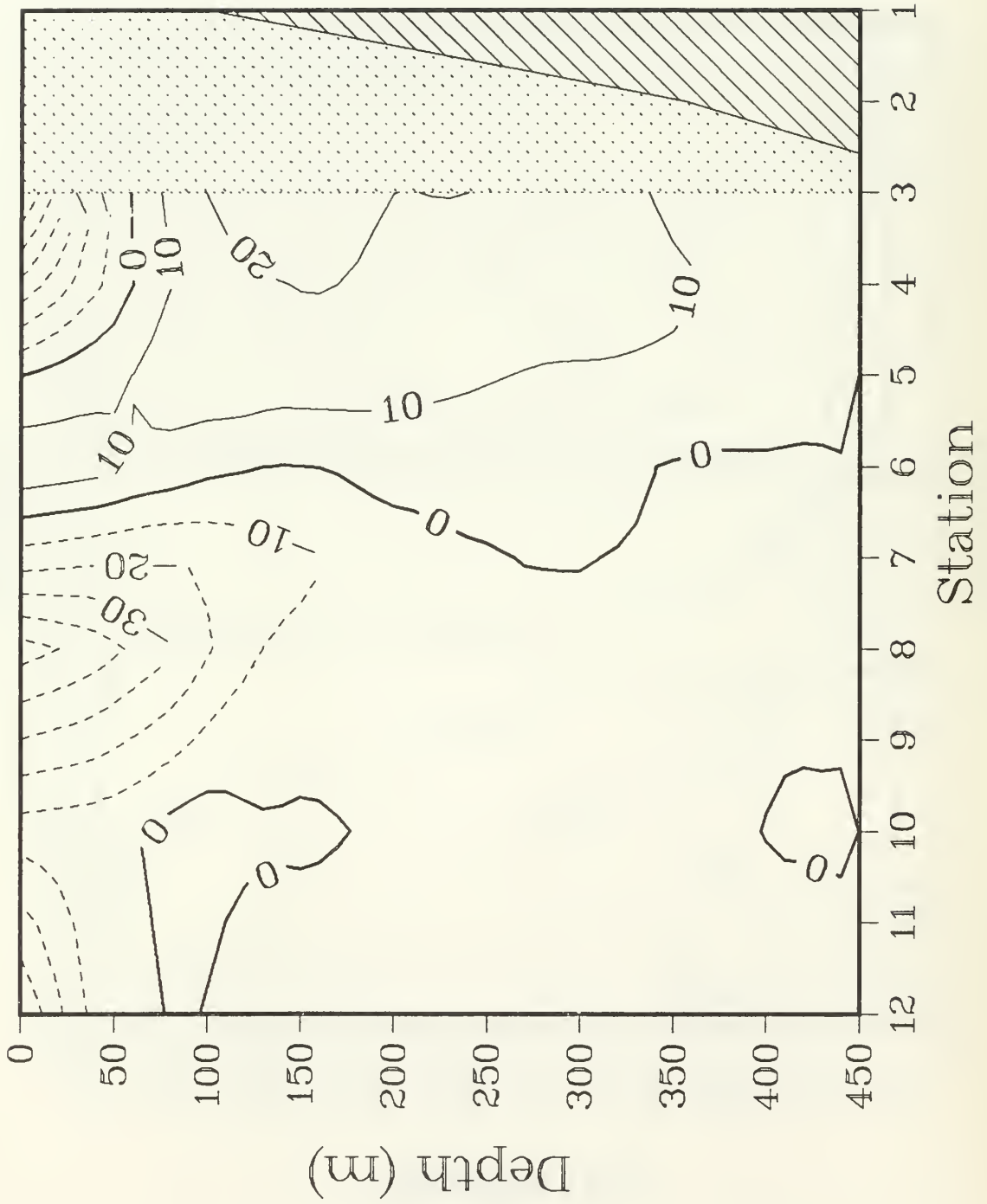


Figure 73.

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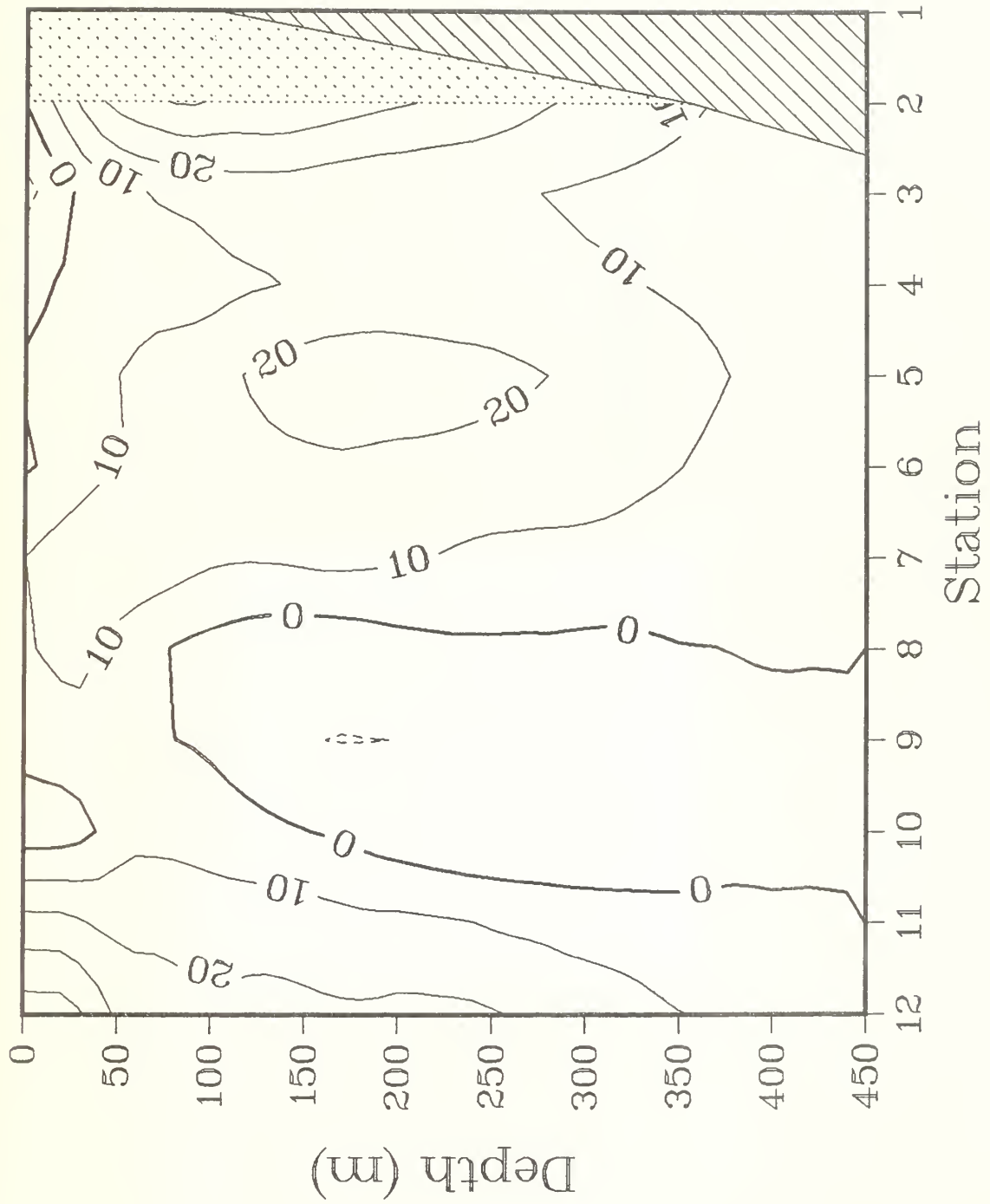


Figure 74.

Acknowledgements

For their work in data acquisition, the authors are indebted to the captain and crew of R/V Acania of the Naval Postgraduate School and to Dr. Stevens P. Tucker, Mr. Jerrold Norton, LT Keith Coddington (USGS) and LCDR Robert Harrod (USN). Mr. Norton also contributed in the data processing phase. This study was sponsored by the National Aeronautics and Space Administration and by the Bureau of Land Management.

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856 Hydrographic data from the
H92 slope waters off central
1984 California, 26 November
1978 - 26 June 1980.

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