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UPPER OCEAN TEMPERATURE, SALINITY AND DENSITY IN THE VICINITY OF ARCTIC DRIFT STATION FRAM I, MARCH TO MAY, 1979

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A program designed to measure temperature and conductivity in the upper 270 m of the Arctic Ocean within a 150-km radius of Drift Station FRAM I is described, and data in the form of profiles of temperature, salinity, and density as functions of depth are presented for each of 104 casts made with a portable, self-contained conductivity-temperature-depth instrument. Seventy-five of the casts were made away from the ice station at sites reached by helicopter. Details of sampling procedure, instrument calibration, and data organization are given.

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PREFACE

This report was prepared by Miles G. McPhee, Snow and Ice Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory. The study was funded by Office of Naval Research MIPR - N0001480MP00004 - 1 Oct. 1979.

Help with the field program by A. Gill and T. Manley under the direction of K. Hunkins of LDGO was much appreciated, as was the excellent flight support provided by the Glace helicopter crew, and general logistic support under the direction of A. Heiberg, Polar Science Center, University of Washington. T. Manley kindly provided data necessary for instrument calibration.

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by

Miles G. McPhee

INTRODUCTION

From 11 March to 13 May 1979, a drifting research station named FRAM I was maintained on pack ice northwest of Spitzbergen for the purpose of conducting oceanographic, geophysical, and geological studies in a little-explored part of the Arctic Basin. During the project, the station drifted in an area bounded by latitudes 83° and 85°N and longitudes 6° and 11°W. Details of camp drift, underlying bathymetry, and gravity are given by Hunkins et al. (1979).

From an oceanographic standpoint, the region in which FRAM I drifted was of special interest for a number of reasons. First, there was a notable lack of available hydrographic data: only one previous U.S. station (ARLIS II) had traversed the area, and few primary (i.e. station) data are accessible from the Soviet North Pole stations that passed nearby. Second, the area is one in which cold, relatively fresh water of the Transpolar Drift Stream, which flows across the North Pole and then south along the east coast of Greenland, interacts with warmer, more saline water of Atlantic origin flowing north through Fram Strait in the West Spitzbergen current. Most of the sensible oceanic heat reaching the Arctic Basin enters by this route, but our knowledge of how and where the heat reaches the surface is sketchy. Third, the overall static stability of the water column was thought to be considerably less here than in the western and central parts of the basin, thus posing the possibility of direct interaction between near-surface and deep waters, triggered by freezing at the surface. Finally, there was evidence from previous drift stations in the western and central Arctic of features with abrupt horizontal variation in density and temperature properties of the water column above levels of about 300 m. Prior sampling had been limited to the drift trajectories of the manned stations; it was clear that to understand such phenomena would require sampling over a larger area.

The oceanographic program at FRAM I included plans for using the camp's helicopter along with a portable conductivity-temperature-depth (CTD) instrument to sample the upper ocean within about 150 km of the station's drift track. Salinity and density data were calculated from the conductivity, temperature, and depth measurements. This report presents the results of this project.

INSTRUMENTATION

A lightweight, self-contained CTD unit manufactured by Ocean Data Equipment Company (ODEC), Middletown, Rhode Island (Model 202 Digital CSTD) was chosen for the project (Fig. 1). The instrument, which had originally

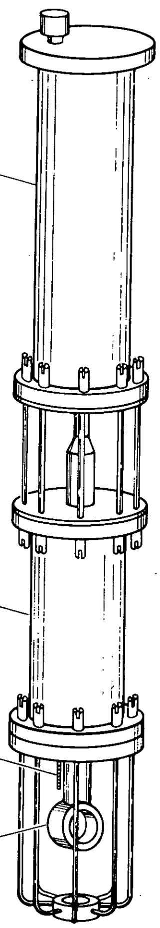

Figure 1. ODEC Model 202 Digital CSTD.

been developed specifically for work under arctic conditions, consists of sensors attached to a pressure case containing sensor electronics connected to a second pressure case containing batteries and a high-density cassette recorder. The whole unit is lowered through the water column, making a conducting cable to the surface unnecessary.

The package also includes a portable field tape reader which, via microprocessor computation, directly converts the recorded digitized sensor data and displays conductivity, temperature, depth, and salinity in engineering units. The tape reader was particularly useful during our helicopter operations as it allowed us to check each cast shortly after it was completed and, if need be, examine the data more thoroughly in order to choose the next appropriate sampling site. The same unit was later used to read the tapes through a serial interface into the Prime computing system at the Cold Regions Research and Engineering Laboratory.

The manufacturer's sensor specifications are shown in Table 1. The sampling rate can be varied from 200 ms to 1 s for all sensors; the fastest rate was used on all casts. The unit was calibrated at the Northwest Regional Calibration Center in Bellevue, Washington, shortly before the field project. However, comparison with measurements made with a CTD manufactured by Plessy, used by the Lamont-Doherty Geological Observatory (LDGO) and calibrated with bottle samples, indicated a discrepancy in the calibrated readouts. This will be discussed in more detail below.

Table 1. Specifications for the ODEC Model 202 Digital CSTD.

Parameter	Range	Accuracy
Conductivity	0 to 55 mS cm^{-1}	$\pm$ 0.02 mS cm^{-1}
Temperature	-2 to 23°C	$\pm$ 0.01°C
Depth	0 to 300 m	$\pm$ 1 m
Salinity*	0 to 40 o/oo	$\pm$ 0.03 o/oo

*computed from conductivity, temperature, depth.

The CTD was lowered by its own weight on Kevlar cable (1200-lb test) from a lightweight aluminum winch. For reeling in the instrument, the winch was coupled to a 1/2-inch electric drill powered by a portable gasoline generator. The ascent rate was nearly constant.

The position of the main camp (FRAM I) was determined accurately by SATNAV navigation (Hunkins et al. 1979). The positions of remote sites were determined by the helicopter's OMEGA navigation gear. Discrepancies in the OMEGA determinations were checked at the main camp by Yngve Kristoffersen of the Norwegian Polar Institute, who provided Figure 2, showing OMEGA's results offset relative to those of SATNAV. Errors were systematically to the east, with magnitudes mostly less than 2 km. Since our objective was to look mainly at horizontal gradients in CTD structure, no attempt was made to correct the OMEGA readings. In one case, a series of closely spaced sampling stations was made in a line centered on the camp; for these positions the helicopter was flown on one heading with range (up to 30 km) determined by a radar ranging system.

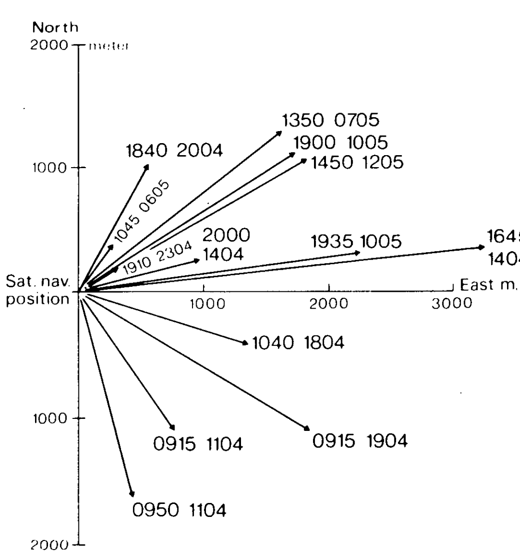

Figure 2. Direction and distance of the errors in the OMEGA navigation system relative to the SATNAV system at FRAM I. Time (GMT), day, month are indicated next to each determination. (Figure courtesy of Y. Kristoffersen, NPI).

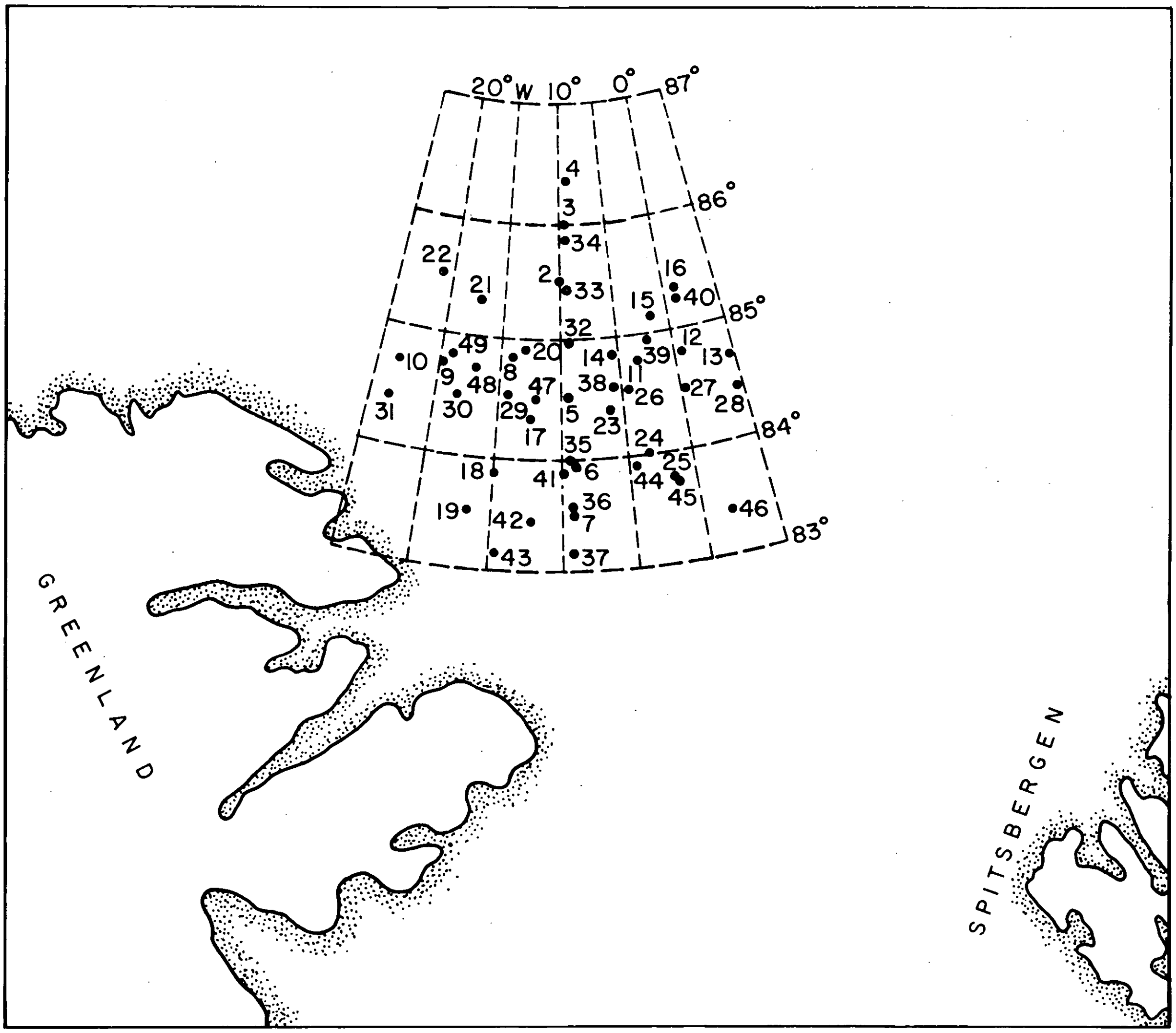

Figure 3. Coverage obtained by the large-scale survey, indicated by sampling site numbers. This survey comprised eight transects, each about 300 km long, sampled between late March and early May 1979.

SAMPLING

The sampling strategy was to perform a large-scale survey whose dimensions were limited by safe helicopter range and to look for anomalous features embedded in the mesoscale structure that would be explored in more detail. The actual operation followed this plan closely. Coverage for the large-scale array is shown in Figure 3. Eight transects about 300 km long, each with seven casts (including one at FRAM I), were made at various times during the six weeks from late March to early May.

A cast made during a north-south transect on 17 April was obviously different from adjacent profiles, so this region was sampled using a much closer spacing (typically 20 km) over the next few days in a series of 27 casts referred to as the "small-scale survey" (Fig. 4).

Casts away from camp were made by landing the helicopter near thin ice, chopping a small hole, lowering the instrument to about 270 m, and

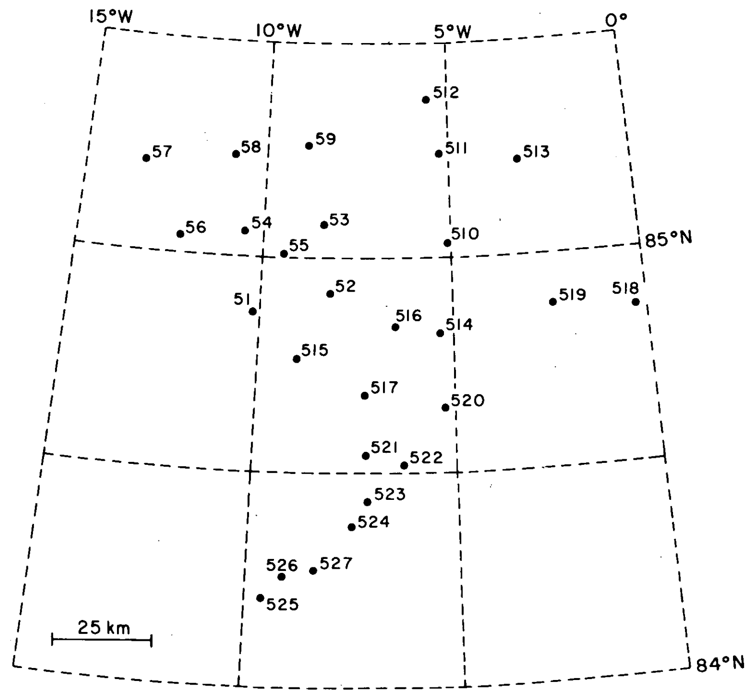

Figure 4. Sampling sites in the small-scale survey, 2 April 1979 to 25 April 1979.

raising it using the electric drill. In the helicopter before departure, the tape was removed from the recorder pressure case, and the data were verified using the field tape reader. Each cast normally required 30-35 minutes on the surface.

In addition to casts away from camp, 32 casts were made at FRAM I, both to provide a central point in the linear transects and to serve as calibration checks against the LDGO Plessy CTD.

Overall, the ODEC CTD performed well, although minor repairs were required on a couple of occasions.

CALIBRATION

Comparison of the LDGO Plessy and ODEC CTD data showed that the ODEC instrument was calibrated so that salinities computed by the microprocessor program were about 0.2 o/oo high, and temperatures were about 0.15°C high. (Plessy values, having been calibrated to bottle samples, were taken as correct.) A calibration run in which the ODEC and Plessy instruments were lowered together indicated an average salinity difference of about 0.23 o/oo, but with no obvious depth dependence. We therefore decided to use mixed-layer properties to determine conductivity and temperature corrections on days when both ODEC and Plessy casts were made at FRAM I.

For most of the project, variations in mixed-layer properties occurred slowly, if at all. Mixed-layer salinity and temperature values, as calculated from the ODEC output using cold water formulas developed by Perkin and Walker (1971), were compared with the Plessy values when casts were made by both instruments within a few hours at FRAM I on days when a clearly defined mixed layer existed. There were 16 such comparisons more or less evenly spaced throughout the project. Differences in salinity and temperature were then analyzed for time dependence using standard regression techniques. The results showed a slight but significant drift in temperature difference, but no significant time dependence for salinity (conductivity) differences. From the analysis, the following corrections to ODEC conductivity and temperature readings were ascertained to provide the closest correspondence between the two instruments:

$$\Delta C = -0.140 \quad mS \cdot cm^{-1}$$

$$\Delta T = (4.02 \times 10^{-4} t + 0.026)°C$$

where t is time in Julian days of 1979.

The corrections were checked for consistency by performing a regression analysis of the difference between freezing point temperature and mixed-layer temperature against time for all ODEC casts (including all remote sites). It was found that without the specified time correction, this difference exhibited a significant correlation with time. When the correction determined by the ODEC/Plessy comparison was applied, the correlation vanished. Since it was difficult to see why departure of the mixed-layer temperature from its freezing point should vary with time, this was taken as confirmation that instrument drift occurred in the ODEC thermometer, and that the correction applied was in fact the proper one.

In addition to the calibrations described above, two other effects were apparent when downward casts were compared with upward casts. First, for casts made at exposed, remote locations (as opposed to those made from the warm hut at FRAM I), values for temperature and conductivity near the surface were often much lower on the down cast than on the up cast. This problem (which was anticipated) probably occurred because the sensors became cold during setup and were enveloped in a thin film of ice when submerged in water at its freezing point. As the sensors fell to levels where the water temperature was slightly above freezing, the film melted and subsequent readings measured true water properties. We found after some testing that letting the instrument soak near the surface did not improve the down cast performance. When operating from the helicopter, it was difficult to keep the instrument warm until it was in the water; therefore, we compared several up and down casts made from the warm hut and determined that properties measured on the up cast were representative as long as the instrument spent some time in water above the freezing point.

The second effect is shown by Figure 5a. A hysteresis in conductivity and temperature occurs such that similar values on up and down casts are separated vertically by a few meters. If the instrument has passed through a zone where gradients are uniform, this behavior indicates that the sensor response lags behind the pressure (depth) response by some time interval. For example, if the measured temperature at depth d_o is T_m, then the actual temperature is

$$T_o = T_m + \frac{\partial T}{\partial t} \Delta_T$$

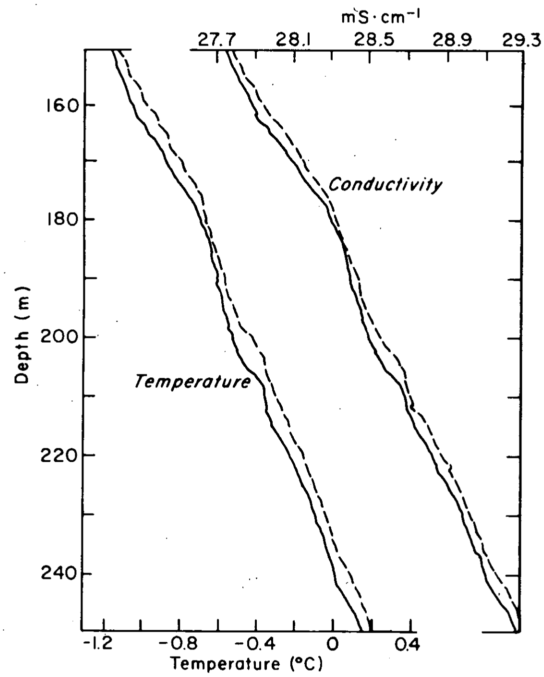

Figure 5a. Profiles from the down (solid line) and up (dashed line) legs of a typical cast showing hysteresis due to a lag in sensor response.

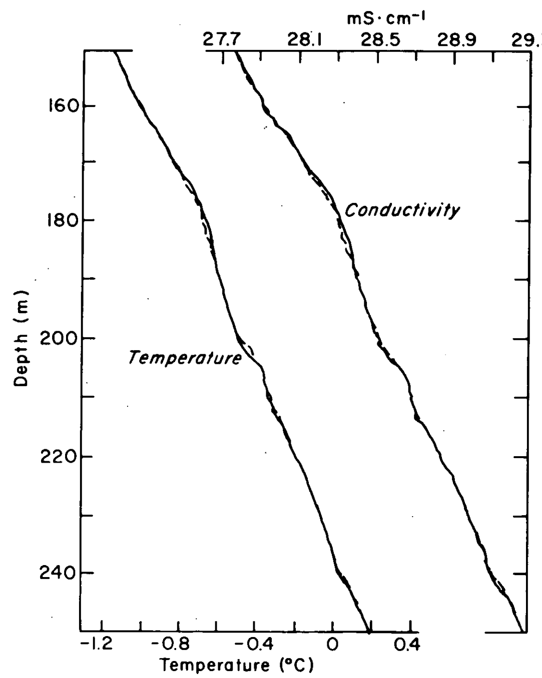

Figure 5b. Profiles adjusted to compensate for time lag.

where Δ_T is the time that the temperature sensor lags behind the pressure, which is assumed to be constant. The time rate of change of temperature is related to the descent rate w by

$$\frac{\partial T}{\partial t} = w \frac{\partial T}{\partial z} \quad .$$

Over a segment in which $\partial T/\partial z$ is constant and the descent rate w_d and ascent rate w_u are known, we have

$$\Delta_T = \left(1 \bigg/ \frac{\partial T}{\partial z}\right) \left\{ \frac{\overline{T_{mu} - T_{md}}}{w_d - w_u} \right\}$$

where $\overline{T_{mu} - T_{md}}$ is the average difference between measured temperature at the same level on up and down casts. In this way, time lags calculated over the linear portion of the profile can be used to correct sensor output with respect to depth. Figure 5b shows the corrected profiles for the casts of Figure 5a using time lags calculated over the same depth interval.

In practice, it was found from analyzing a number of casts in this way that the conductivity and temperature lags were similar (about 4.5 s). Since the ascent rate was uniform (0.5 m s^{-1}), a downward depth correction of 2.2 m was applied to all up casts, and these were taken as the correct profiles.

DATA

At the rate of one sample each 200 ms, there were approximately 10 samples per meter during ascent. For data handling ease, these were averaged in 1-m bins. Plots of profiles from all casts are shown in Appendix A.

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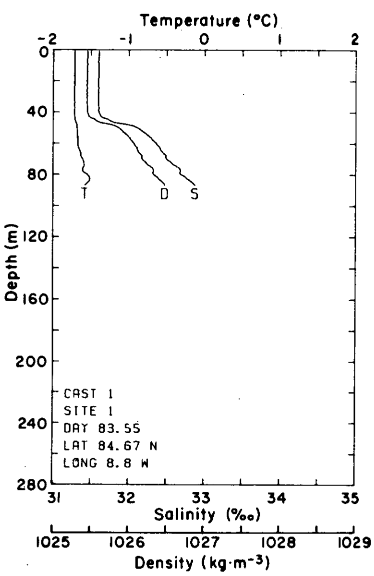
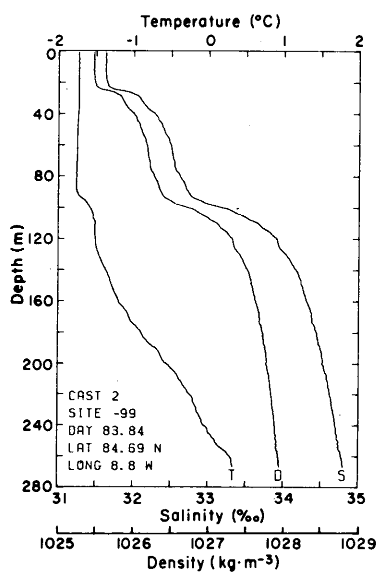
Hunkins, K., T. Manley and W. Teimann (1979) Observations of position, ocean depth, ice rotation, magnetic declination and gravity taken at the FRAM I drifting ice station. CV-1-79 Technical Report No. 1, Lamont-Doherty Geological Observatory, Columbia University, New York.

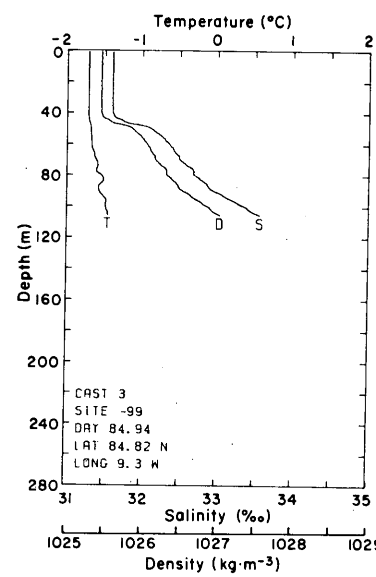
Perkin, R.G. and E.R. Walker (1971) Salinity calculations from *in situ* measurements. Pacific Marine Science Report No. 71-1, Marine Sciences Branch, Department of the Environment, Victoria, British Columbia.

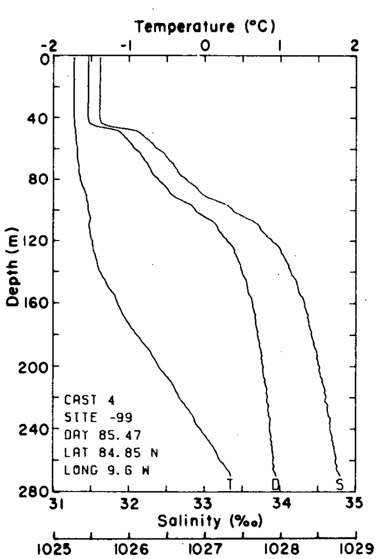
APPENDIX A: PROFILES OF TEMPERATURE, SALINITY AND DENSITY
(At Atmospheric Pressure)

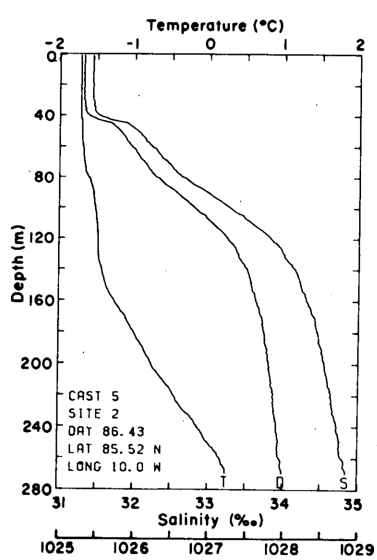
Coordinates are in degrees (e.g. 84.25 = 84°15') and time is in Julian days of 1979 (e.g. 85.25 = 0600 GMT on 26 March 1979). All sites labeled -99 refer to casts made at FRAM I, sites 2-49 refer to casts of the large-scale array (Fig. 3), and all sites with prefix "5" (i.e. sites 51-527) are part of the small-scale survey (Fig. 4). Cast numbers are sequenced chronologically. Density (kg m^{-3}) refers to the density of a parcel of water brought adiabatically to surface (atmospheric) pressure, calculated from σ_t (the specific density anomaly) according to a standard formula provided by J.D. Smith, Department of Oceanography, University of Washington, Seattle, Washington. All profiles from upward casts are adjusted for sensor lag.

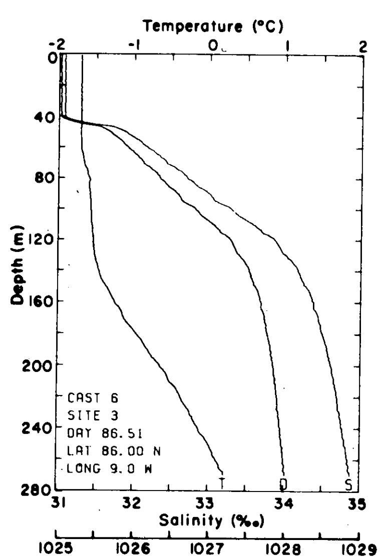


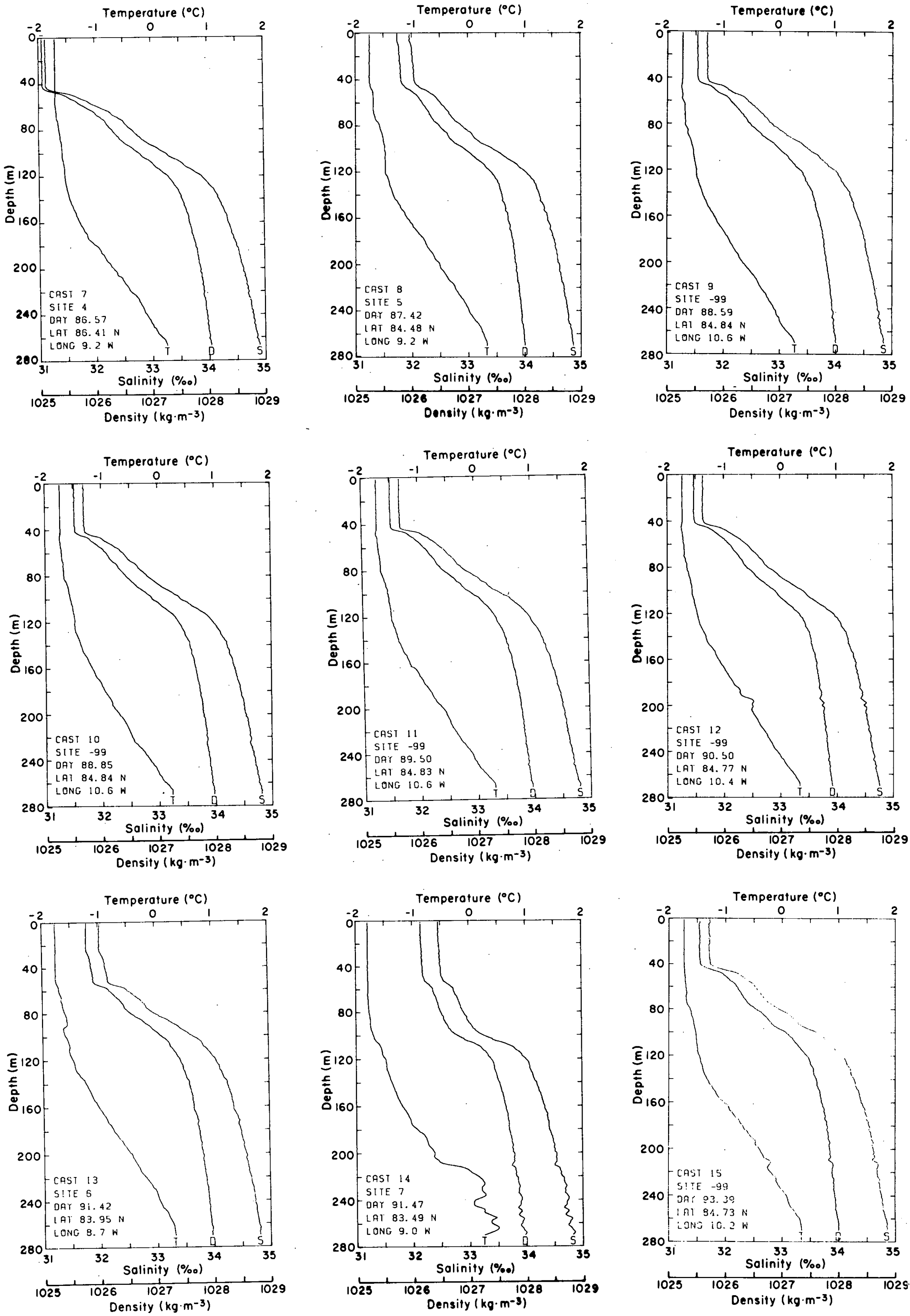




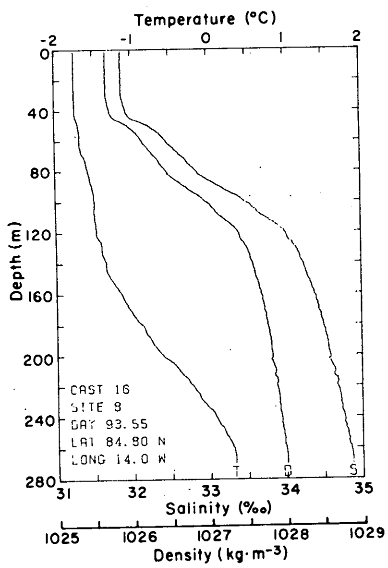


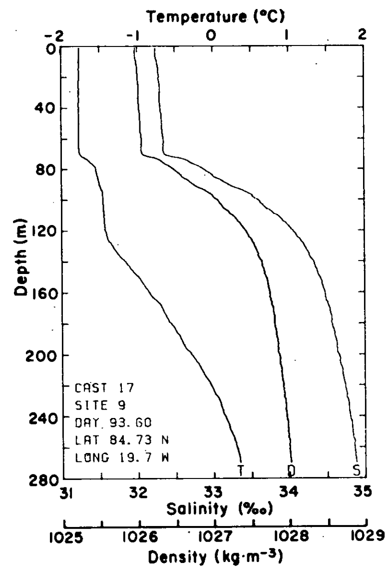


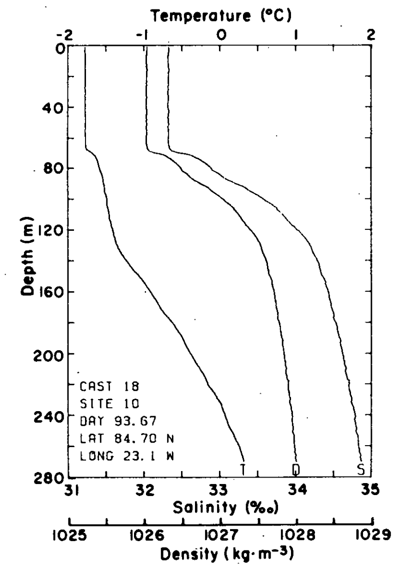


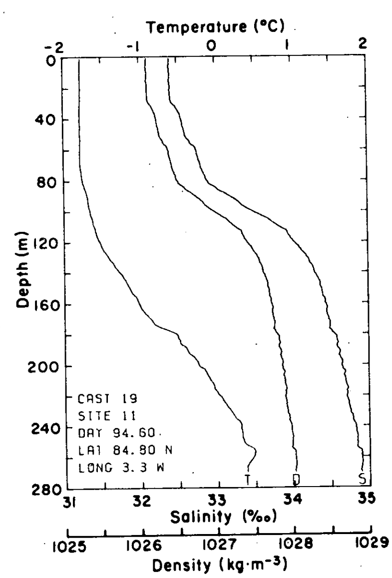


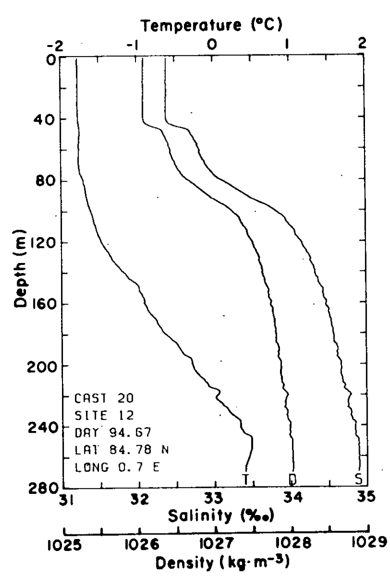
Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
Salinity (‰)
31 32 33 34 35
Density (kg·m⁻³)
1025 1026 1027 1028 1029
T D S
CAST 7
SITE 4
DAY 86.57
LAT 86.41 N
LONG 9.2 W
CAST 8
SITE 5
DAY 87.42
LAT 84.48 N
LONG 9.2 W
CAST 9
SITE -99
DAY 88.59
LAT 84.84 N
LONG 10.6 W
CAST 10
SITE -99
DAY 88.85
LAT 84.84 N
LONG 10.6 W
CAST 11
SITE -99
DAY 89.50
LAT 84.83 N
LONG 10.6 W
CAST 12
SITE -99
DAY 90.50
LAT 84.77 N
LONG 10.4 W
CAST 13
SITE 6
DAY 91.42
LAT 83.95 N
LONG 8.7 W
CAST 14
SITE 7
DAY 91.47
LAT 83.49 N
LONG 9.0 W
CAST 15
SITE -99
DAY 93.39
LAT 84.73 N
LONG 10.2 W

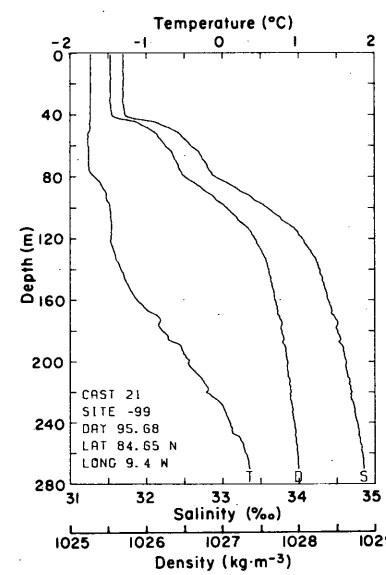

Temperature (°C)
Depth (m)
CAST 16
SITE 8
DAY 93.55
LAT 84.90 N
LONG 14.0 W
T D S
Salinity (‰)
Density (kg·m⁻³)

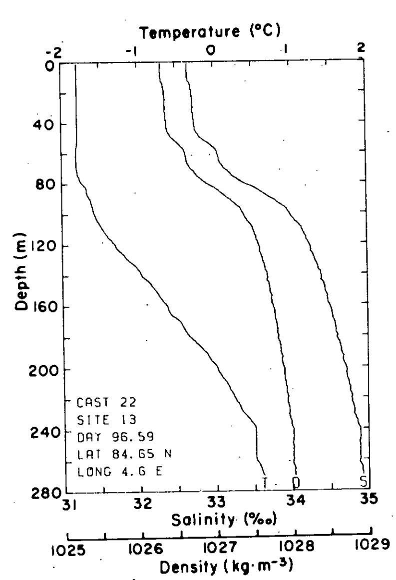

Temperature (°C)
Depth (m)
CAST 17
SITE 9
DAY 93.60
LAT 84.73 N
LONG 19.7 W
T D S
Salinity (‰)
Density (kg·m⁻³)

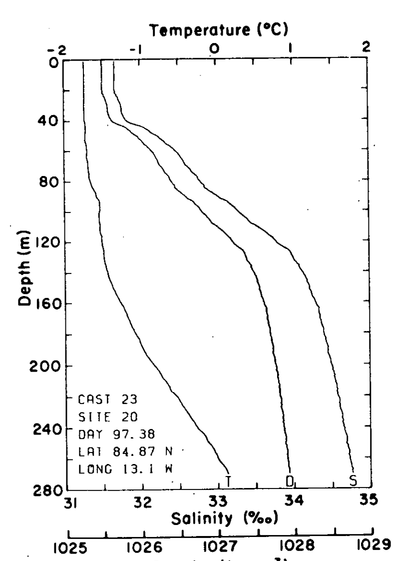

Temperature (°C)
Depth (m)
CAST 18
SITE 10
DAY 93.67
LAT 84.70 N
LONG 23.1 W
T D S
Salinity (‰)
Density (kg·m⁻³)

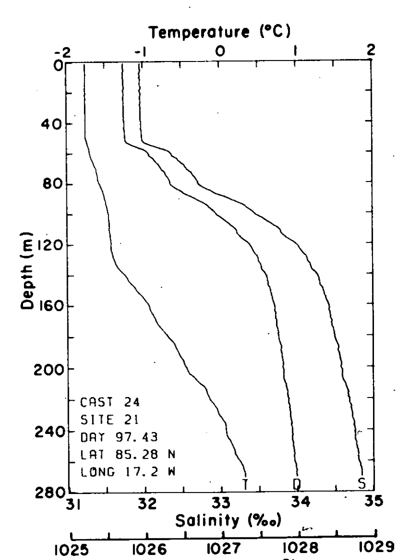

Temperature (°C)
Depth (m)
CAST 19
SITE 11
DAY 94.60
LAT 84.80 N
LONG 3.3 W
T D S
Salinity (‰)
Density (kg·m⁻³)


Temperature (°C)
Depth (m)
CAST 20
SITE 12
DAY 94.67
LAT 84.78 N
LONG 0.7 E
T D S
Salinity (‰)
Density (kg·m⁻³)


Temperature (°C)
Depth (m)
CAST 21
SITE -99
DAY 95.68
LAT 84.65 N
LONG 9.4 W
T D S
Salinity (‰)
Density (kg·m⁻³)


Temperature (°C)
Depth (m)
CAST 22
SITE 13
DAY 96.59
LAT 84.65 N
LONG 4.6 E
T D S
Salinity (‰)
Density (kg·m⁻³)


Temperature (°C)
Depth (m)
CAST 23
SITE 20
DAY 97.38
LAT 84.87 N
LONG 13.1 W
T D S
Salinity (‰)
Density (kg·m⁻³)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Depth (m)
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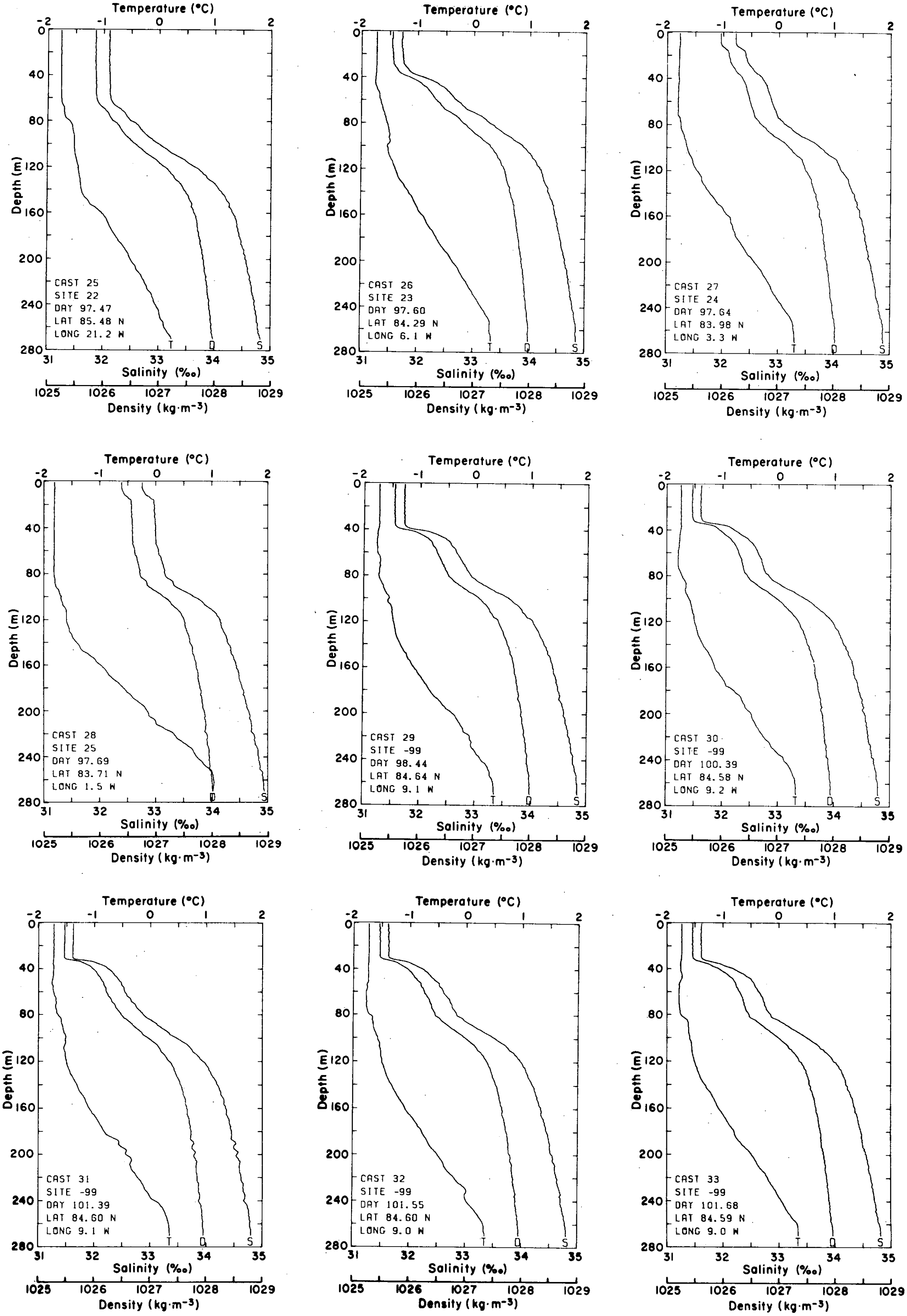
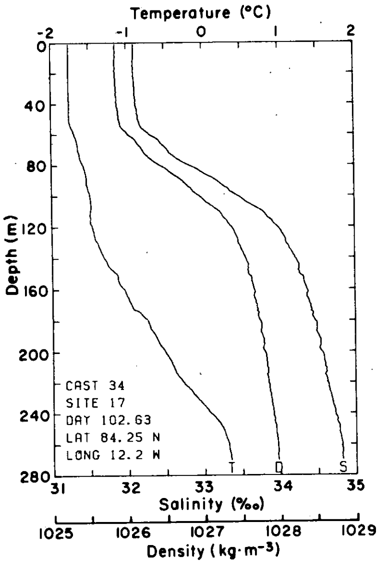
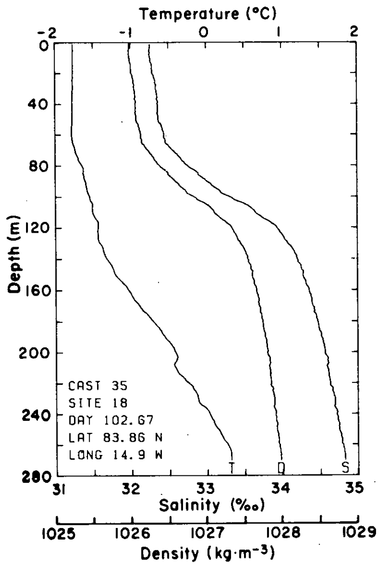
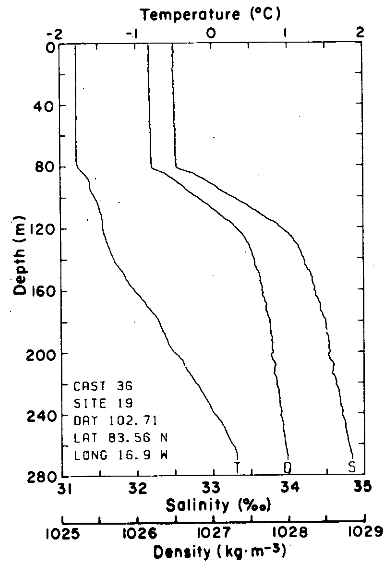
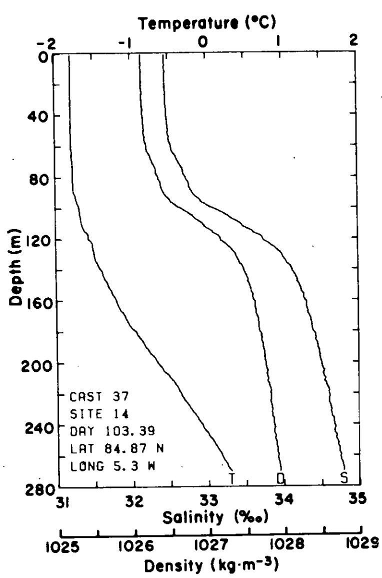
SITE 21
DAY 97.43
LAT 85.28 N
LONG 17.2 W
T D S
Salinity (‰)
Density (kg·m⁻³)

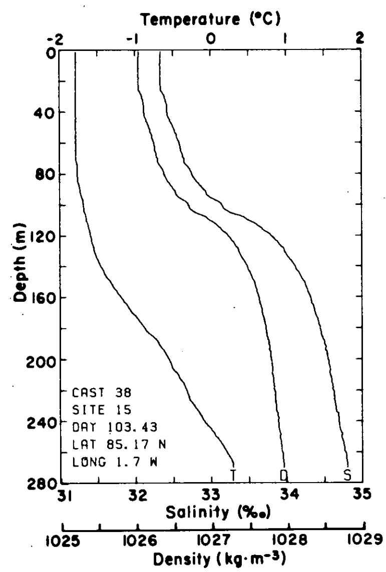

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
T D S
CAST 25
SITE 22
DAY 97.47
LAT 85.48 N
LONG 21.2 W
CAST 26
SITE 23
DAY 97.60
LAT 84.29 N
LONG 6.1 W
CAST 27
SITE 24
DAY 97.64
LAT 83.98 N
LONG 3.3 W
CAST 28
SITE 25
DAY 97.69
LAT 83.71 N
LONG 1.5 W
CAST 29
SITE -99
DAY 98.44
LAT 84.64 N
LONG 9.1 W
CAST 30
SITE -99
DAY 100.39
LAT 84.58 N
LONG 9.2 W
CAST 31
SITE -99
DAY 101.39
LAT 84.60 N
LONG 9.1 W
CAST 32
SITE -99
DAY 101.55
LAT 84.60 N
LONG 9.0 W
CAST 33
SITE -99
DAY 101.68
LAT 84.59 N
LONG 9.0 W

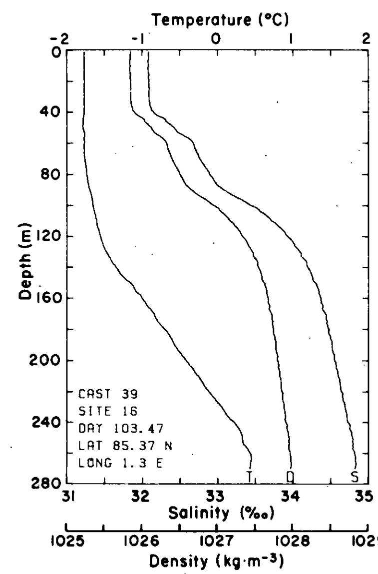

Temperature (°C)
Depth (m)
CAST 34
SITE 17
DAY 102.63
LAT 84.25 N
LONG 12.2 W
T
D
S
Salinity (‰)
Density (kg·m⁻³)

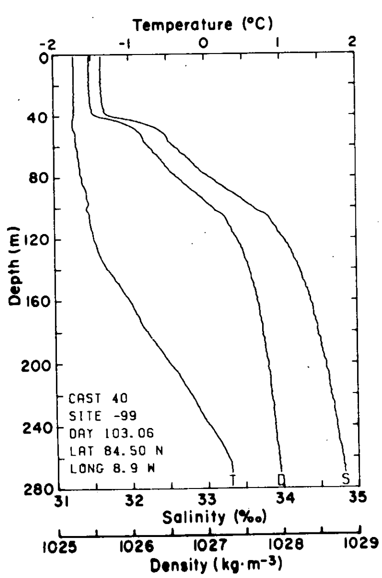

Temperature (°C)
Depth (m)
CAST 35
SITE 18
DAY 102.67
LAT 83.86 N
LONG 14.9 W
T
D
S
Salinity (‰)
Density (kg·m⁻³)

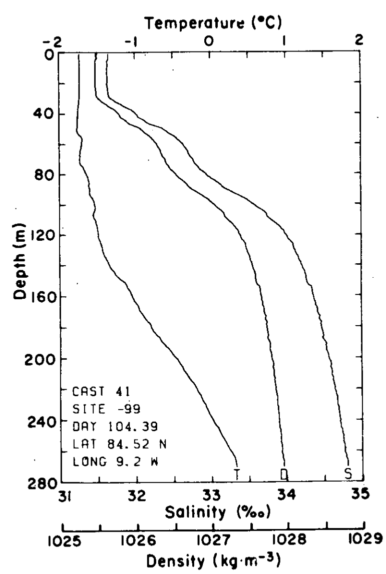

Temperature (°C)
Depth (m)
CAST 36
SITE 19
DAY 102.71
LAT 83.56 N
LONG 16.9 W
T
D
S
Salinity (‰)
Density (kg·m⁻³)

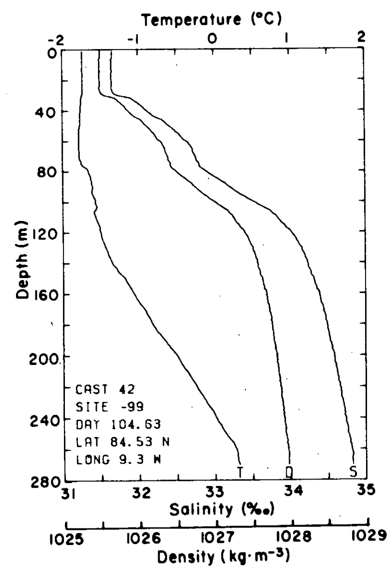

Temperature (°C)
Depth (m)
CAST 37
SITE 14
DAY 103.39
LAT 84.87 N
LONG 5.3 W
T
D
S
Salinity (‰)
Density (kg·m⁻³)

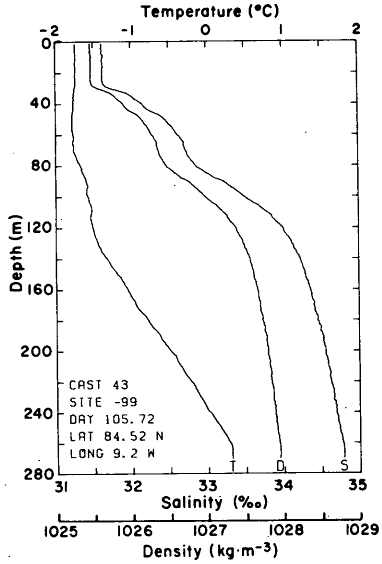

Temperature (°C)
Depth (m)
CAST 38
SITE 15
DAY 103.43
LAT 85.17 N
LONG 1.7 W
T
D
S
Salinity (‰)
Density (kg·m⁻³)

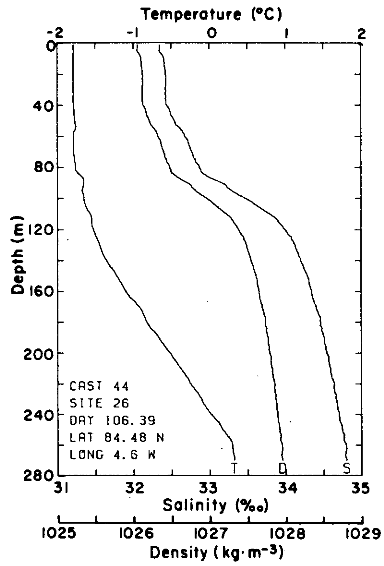

Temperature (°C)
Depth (m)
CAST 39
SITE 16
DAY 103.47
LAT 85.37 N
LONG 1.3 E
T
D
S
Salinity (‰)
Density (kg·m⁻³)

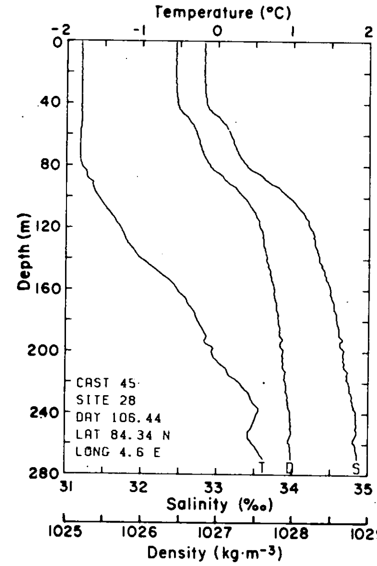

Temperature (°C)
Depth (m)
CAST 40
SITE -99
DAY 103.06
LAT 84.50 N
LONG 8.9 W
T
D
S
Salinity (‰)
Density (kg·m⁻³)

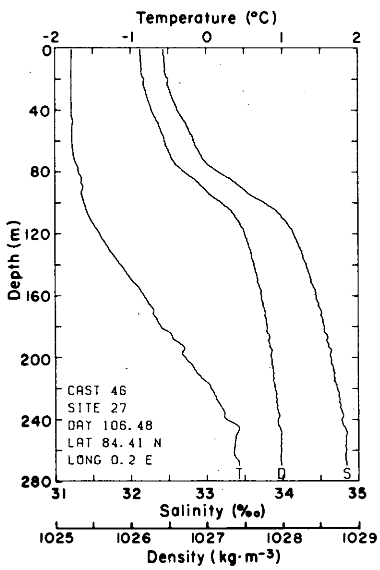

Temperature (°C)
Depth (m)
CAST 41
SITE -99
DAY 104.39
LAT 84.52 N
LONG 9.2 W
T
D
S
Salinity (‰)
Density (kg·m⁻³)

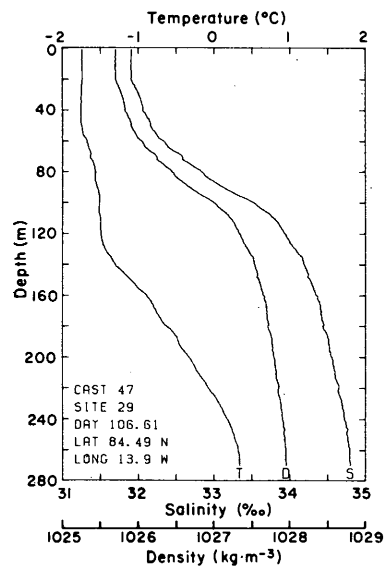

Temperature (°C)
Depth (m)
CAST 42
SITE -99
DAY 104.63
LAT 84.53 N
LONG 9.3 W
T
D
S
Salinity (‰)
Density (kg·m⁻³)

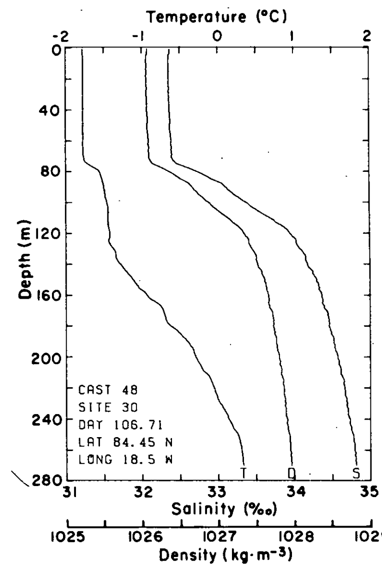

Temperature (°C)
Depth (m)
CAST 43
SITE -99
DAY 105.72
LAT 84.52 N
LONG 9.2 W
T D S
Salinity (‰)
Density (kg·m⁻³)

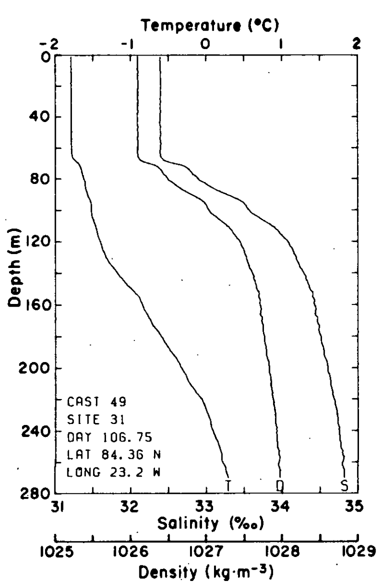

Temperature (°C)
Depth (m)
CAST 44
SITE 26
DAY 106.39
LAT 84.48 N
LONG 4.6 W
T D S
Salinity (‰)
Density (kg·m⁻³)

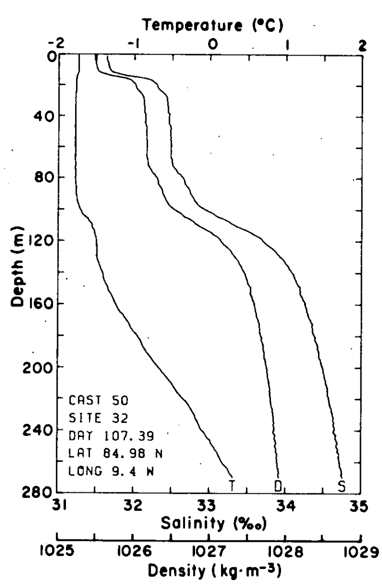

Temperature (°C)
Depth (m)
CAST 45
SITE 28
DAY 106.44
LAT 84.34 N
LONG 4.6 E
T D S
Salinity (‰)
Density (kg·m⁻³)

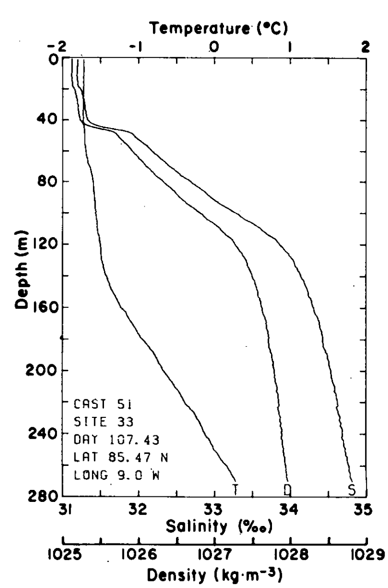

Temperature (°C)
Depth (m)
CAST 46
SITE 27
DAY 106.48
LAT 84.41 N
LONG 0.2 E
T D S
Salinity (‰)
Density (kg·m⁻³)

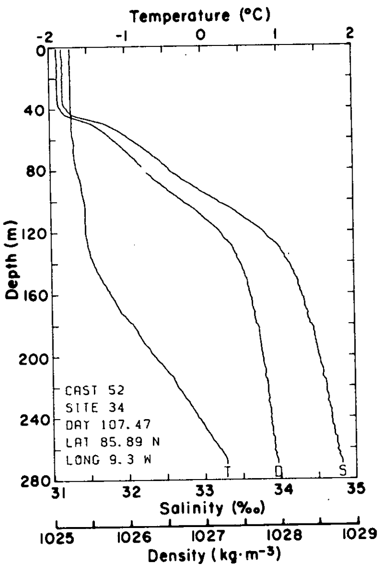

Temperature (°C)
Depth (m)
CAST 47
SITE 29
DAY 106.61
LAT 84.49 N
LONG 13.9 W
T D S
Salinity (‰)
Density (kg·m⁻³)

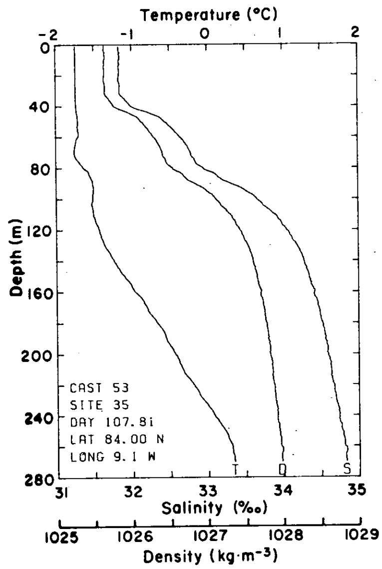

Temperature (°C)
Depth (m)
CAST 48
SITE 30
DAY 106.71
LAT 84.45 N
LONG 18.5 W
T D S
Salinity (‰)
Density (kg·m⁻³)

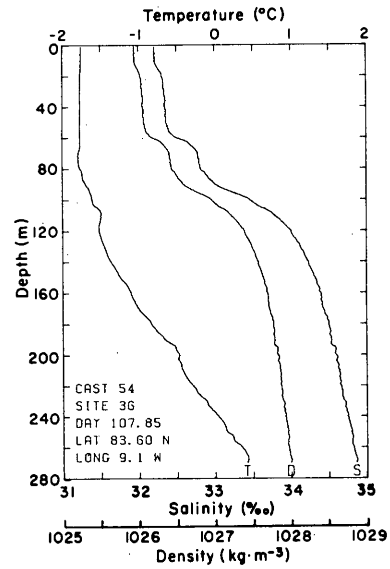

Temperature (°C)
Depth (m)
CAST 49
SITE 31
DAY 106.75
LAT 84.36 N
LONG 23.2 W
T D S
Salinity (‰)
Density (kg·m⁻³)

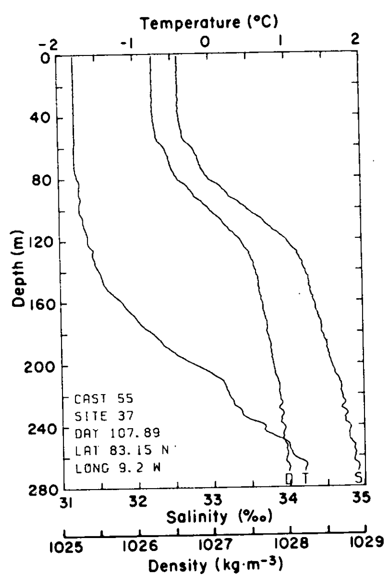

Temperature (°C)
Depth (m)
CAST 50
SITE 32
DAY 107.39
LAT 84.98 N
LONG 9.4 W
T D S
Salinity (‰)
Density (kg·m⁻³)

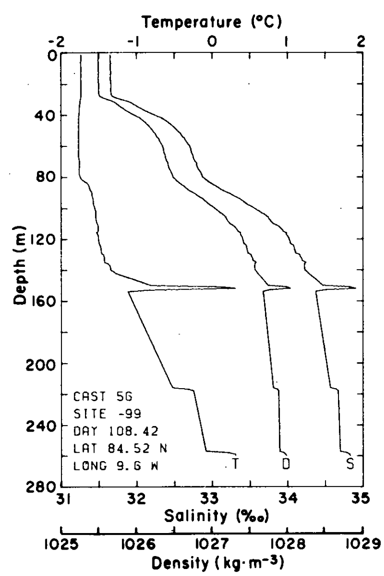

Temperature (°C)
Depth (m)
CAST 51
SITE 33
DAY 107.43
LAT 85.47 N
LONG 9.0 W
T D S
Salinity (‰)
Density (kg·m⁻³)

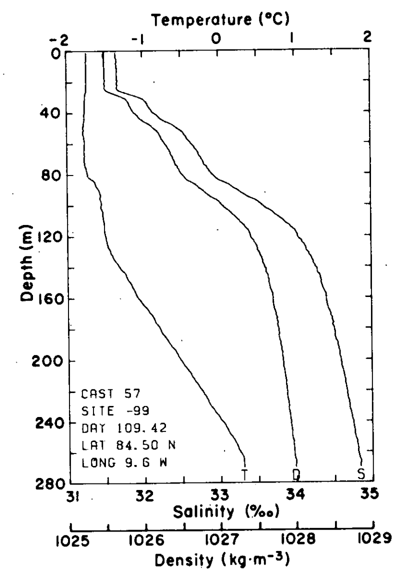

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 52
SITE 34
DAY 107.47
LAT 85.89 N
LONG 9.3 W
T
D
S

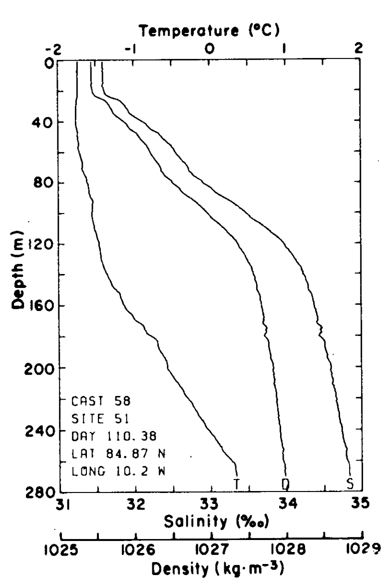

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 53
SITE 35
DAY 107.81
LAT 84.00 N
LONG 9.1 W
T
D
S

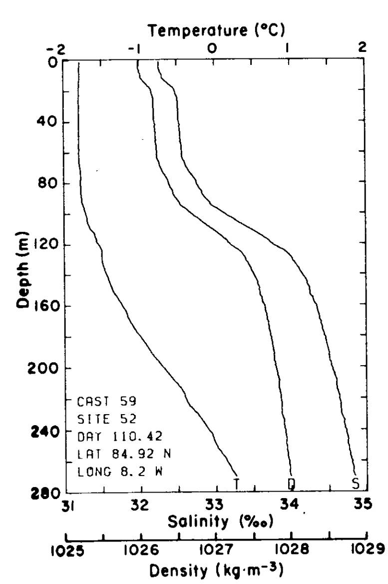

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 54
SITE 36
DAY 107.85
LAT 83.60 N
LONG 9.1 W
T
D
S

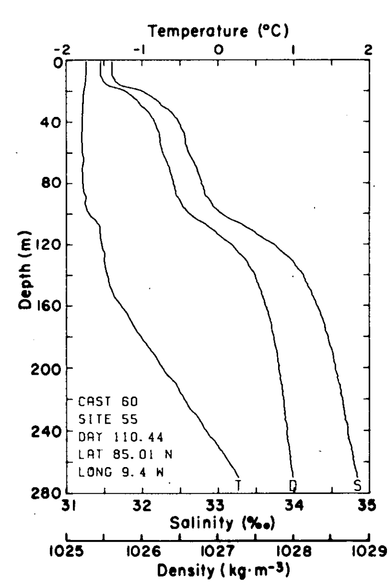

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 55
SITE 37
DAY 107.89
LAT 83.15 N
LONG 9.2 W
D
T
S

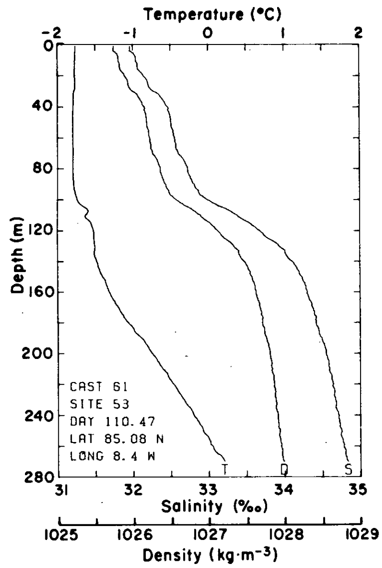

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 56
SITE -99
DAY 108.42
LAT 84.52 N
LONG 9.6 W
T
D
S

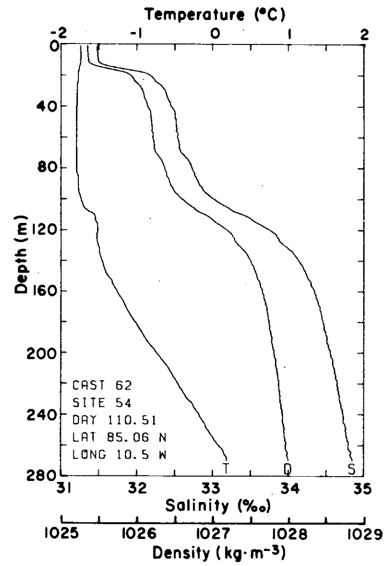

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 57
SITE -99
DAY 109.42
LAT 84.50 N
LONG 9.6 W
T
D
S

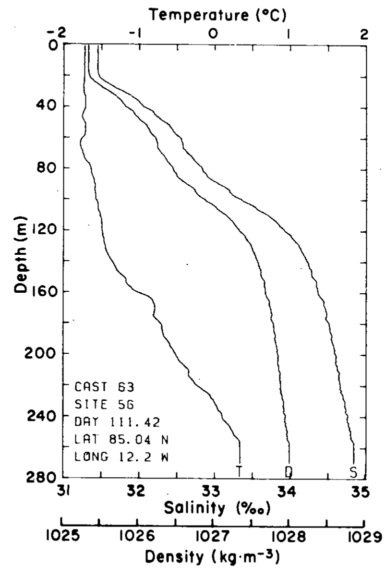

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 58
SITE 51
DAY 110.38
LAT 84.87 N
LONG 10.2 W
T
D
S

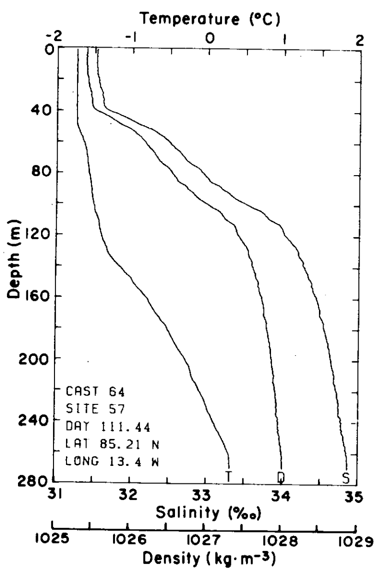

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 59
SITE 52
DAY 110.42
LAT 84.92 N
LONG 8.2 W
T
D
S

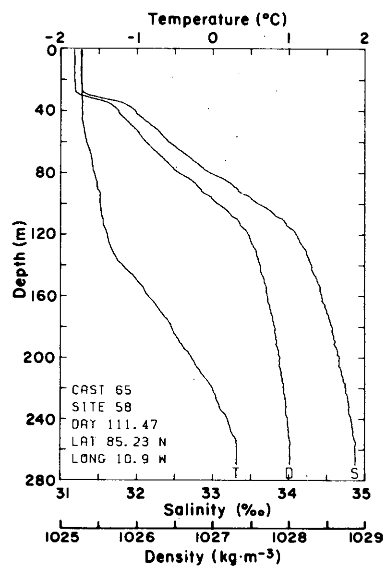

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 60
SITE 55
DAY 110.44
LAT 85.01 N
LONG 9.4 W
T
D
S

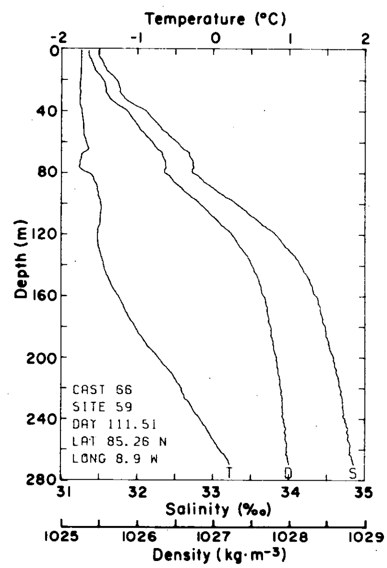

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 61
SITE 53
DAY 110.47
LAT 85.08 N
LONG 8.4 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density ($kg \cdot m^{-3}$)

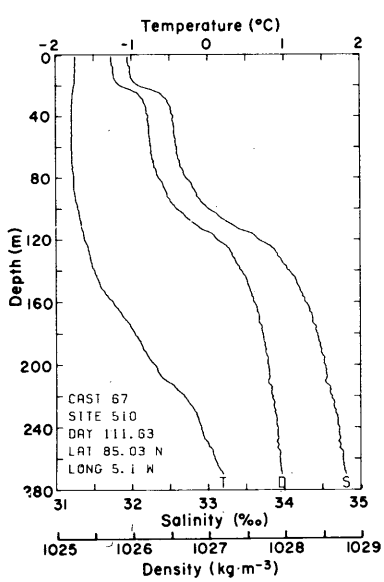

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 62
SITE 54
DAY 110.51
LAT 85.06 N
LONG 10.5 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density ($kg \cdot m^{-3}$)

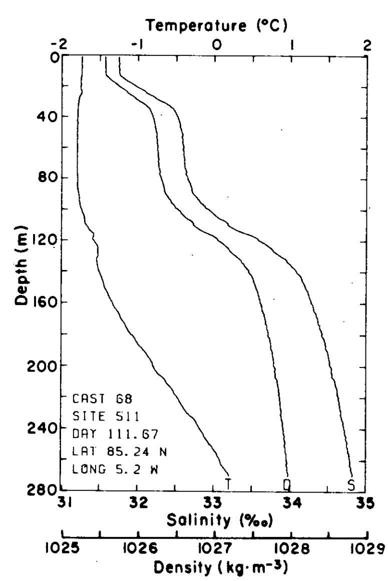

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 63
SITE 56
DAY 111.42
LAT 85.04 N
LONG 12.2 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density ($kg \cdot m^{-3}$)

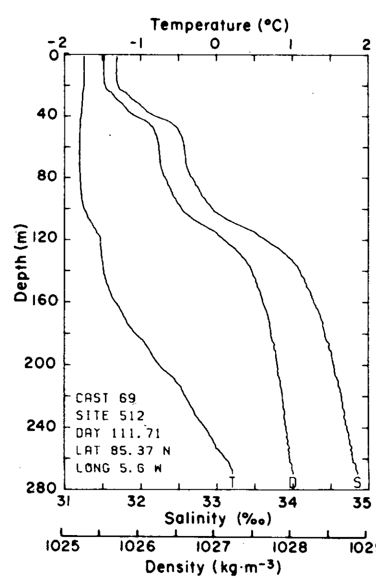

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 64
SITE 57
DAY 111.44
LAT 85.21 N
LONG 13.4 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density ($kg \cdot m^{-3}$)

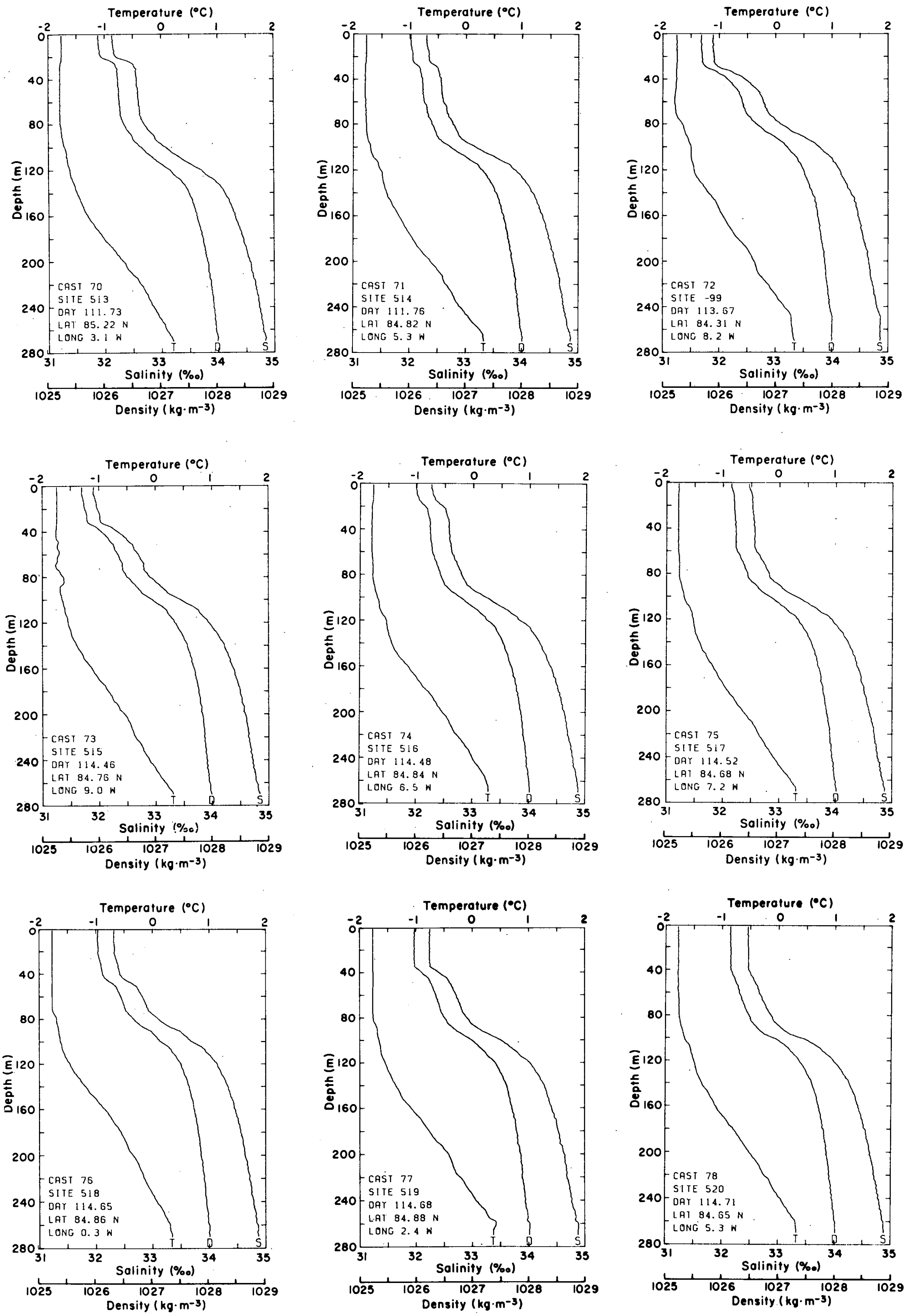

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 65
SITE 58
DAY 111.47
LAT 85.23 N
LONG 10.9 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density ($kg \cdot m^{-3}$)

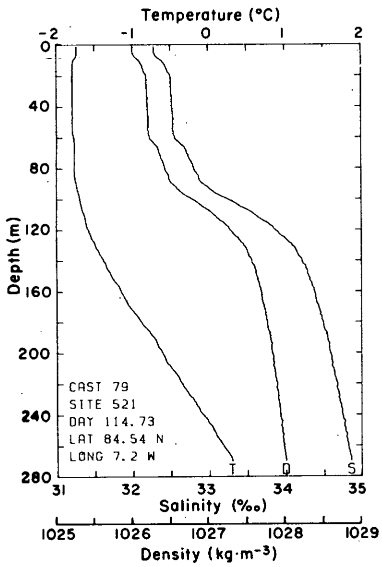

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 66
SITE 59
DAY 111.51
LAT 85.26 N
LONG 8.9 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density ($kg \cdot m^{-3}$)

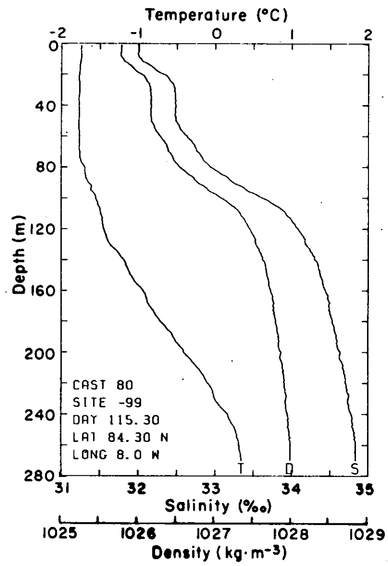

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 67
SITE 510
DAY 111.63
LAT 85.03 N
LONG 5.1 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density ($kg \cdot m^{-3}$)

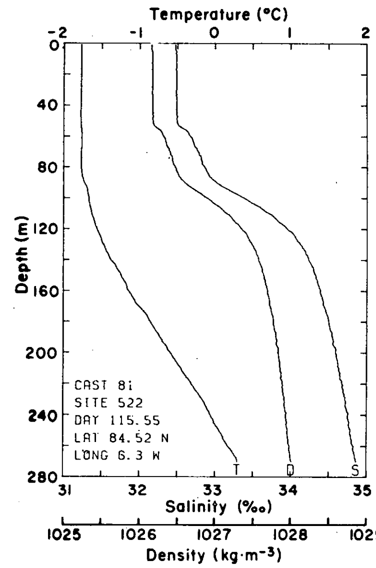

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 68
SITE 511
DAY 111.67
LAT 85.24 N
LONG 5.2 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density ($kg \cdot m^{-3}$)

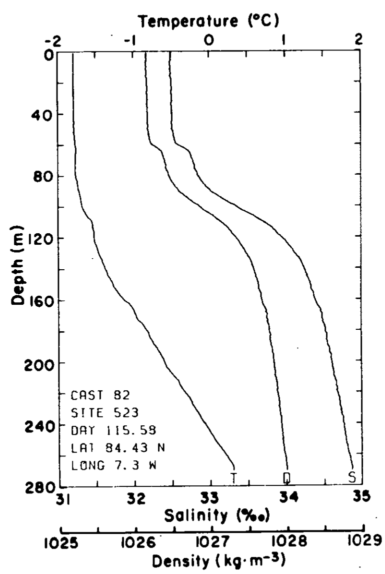

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 69
SITE 512
DAY 111.71
LAT 85.37 N
LONG 5.6 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density ($kg \cdot m^{-3}$)

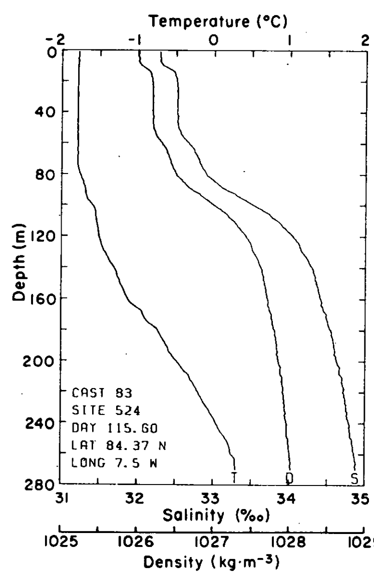

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
T
D
S
CAST 70
SITE 513
DAY 111.73
LAT 85.22 N
LONG 3.1 W
CAST 71
SITE 514
DAY 111.76
LAT 84.82 N
LONG 5.3 W
CAST 72
SITE -99
DAY 113.67
LAT 84.31 N
LONG 8.2 W
CAST 73
SITE 515
DAY 114.46
LAT 84.76 N
LONG 9.0 W
CAST 74
SITE 516
DAY 114.48
LAT 84.84 N
LONG 6.5 W
CAST 75
SITE 517
DAY 114.52
LAT 84.68 N
LONG 7.2 W
CAST 76
SITE 518
DAY 114.65
LAT 84.86 N
LONG 0.3 W
CAST 77
SITE 519
DAY 114.68
LAT 84.88 N
LONG 2.4 W
CAST 78
SITE 520
DAY 114.71
LAT 84.65 N
LONG 5.3 W

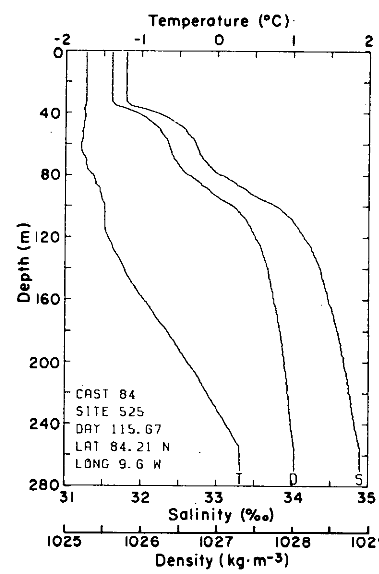

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 79
SITE 521
DAY 114.73
LAT 84.54 N
LONG 7.2 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density (kg·m⁻³)

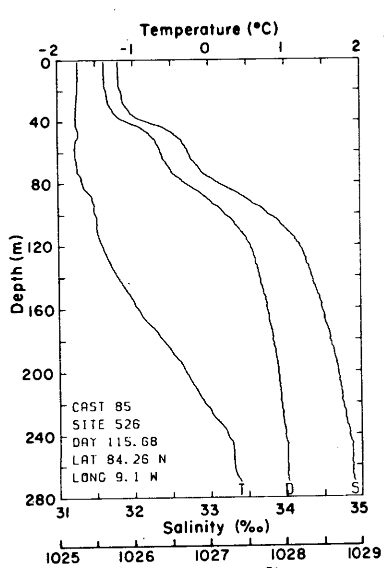

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 80
SITE -99
DAY 115.30
LAT 84.30 N
LONG 8.0 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density (kg·m⁻³)

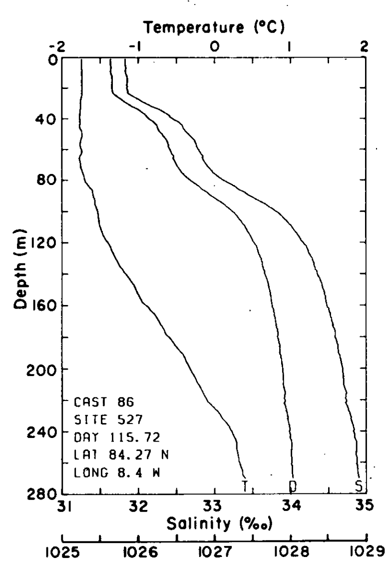

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 81
SITE 522
DAY 115.55
LAT 84.52 N
LONG 6.3 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density (kg·m⁻³)

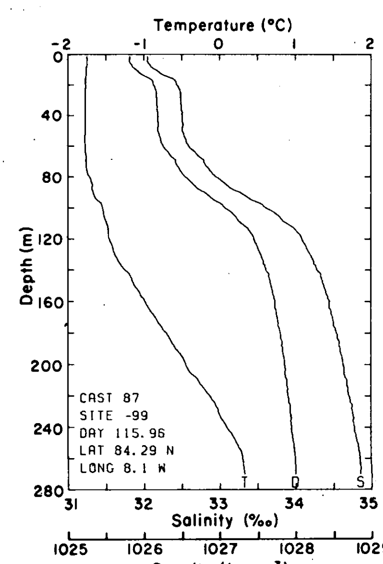

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 82
SITE 523
DAY 115.59
LAT 84.43 N
LONG 7.3 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density (kg·m⁻³)

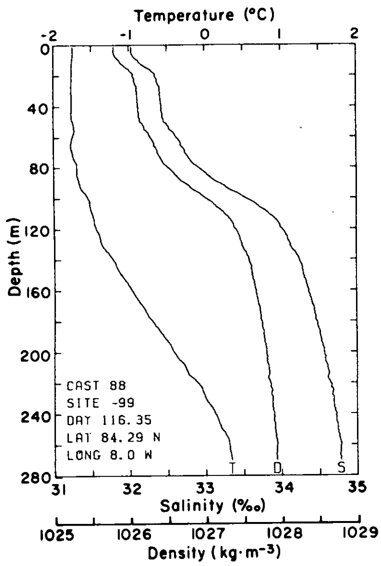

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 83
SITE 524
DAY 115.60
LAT 84.37 N
LONG 7.5 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density (kg·m⁻³)

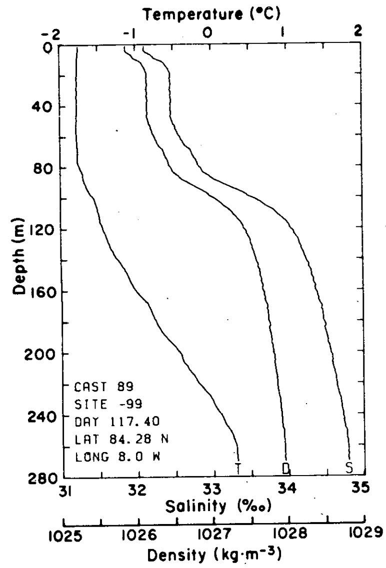

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 84
SITE 525
DAY 115.67
LAT 84.21 N
LONG 9.6 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density (kg·m⁻³)

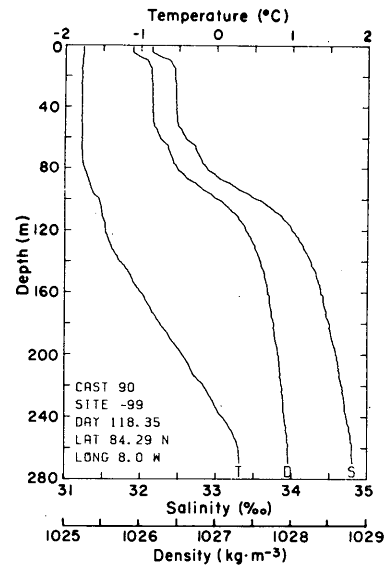

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 85
SITE 526
DAY 115.68
LAT 84.26 N
LONG 9.1 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density (kg·m⁻³)

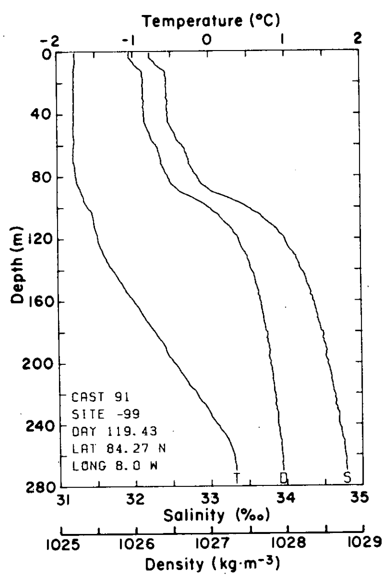

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 86
SITE 527
DAY 115.72
LAT 84.27 N
LONG 8.4 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density (kg·m⁻³)

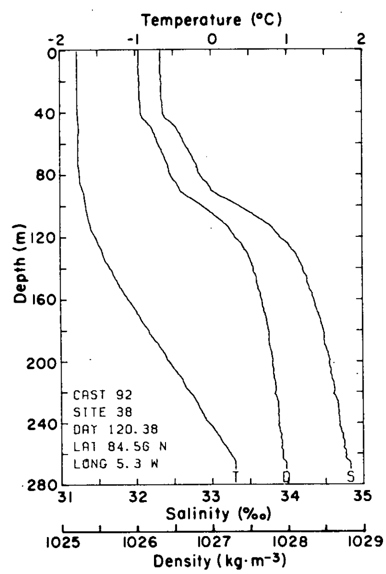

Temperature (°C)
-2 -1 0 1 2
Depth (m)
0 40 80 120 160 200 240 280
CAST 87
SITE -99
DAY 115.96
LAT 84.29 N
LONG 8.1 W
T D S
31 32 33 34 35
Salinity (‰)
1025 1026 1027 1028 1029
Density (kg·m⁻³)

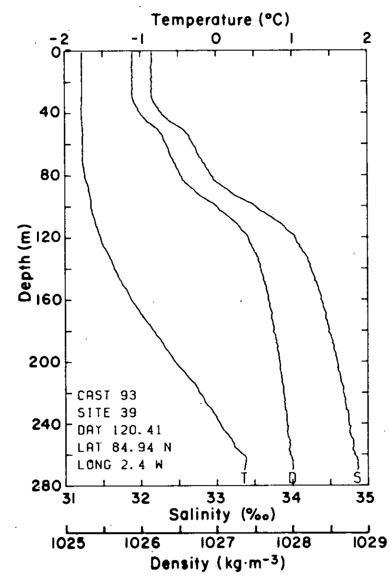

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 88
SITE -99
DAY 116.35
LAT 84.29 N
LONG 8.0 W
T
D
S

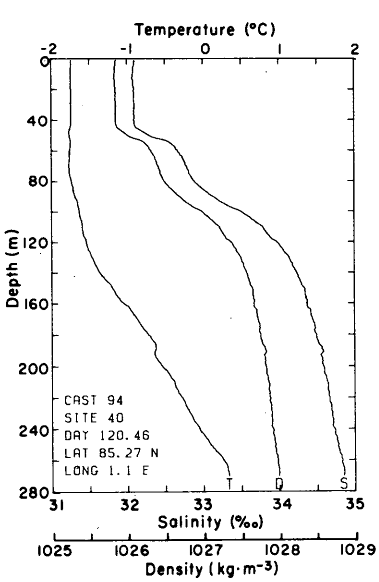

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 89
SITE -99
DAY 117.40
LAT 84.28 N
LONG 8.0 W
T
D
S

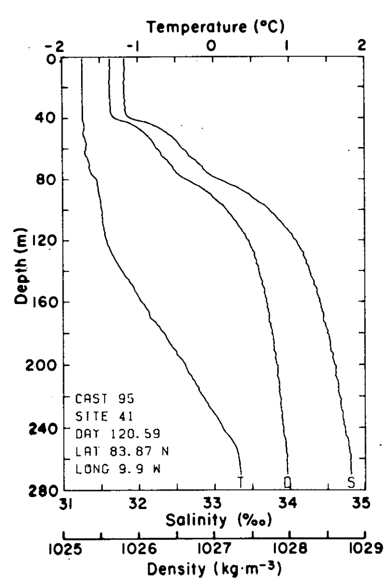

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 90
SITE -99
DAY 118.35
LAT 84.29 N
LONG 8.0 W
T
D
S

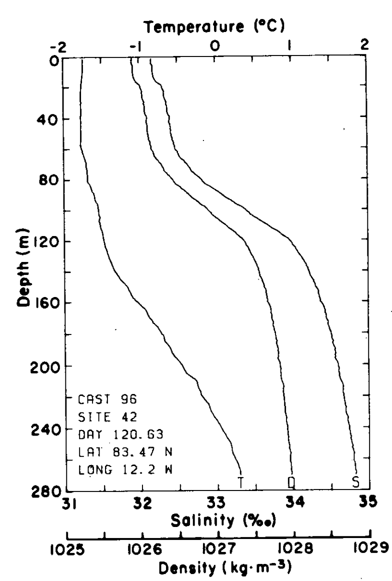

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 91
SITE -99
DAY 119.43
LAT 84.27 N
LONG 8.0 W
T
D
S

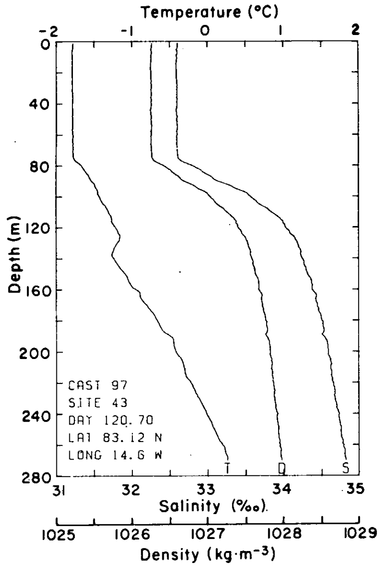

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 92
SITE 38
DAY 120.38
LAT 84.56 N
LONG 5.3 W
T
D
S

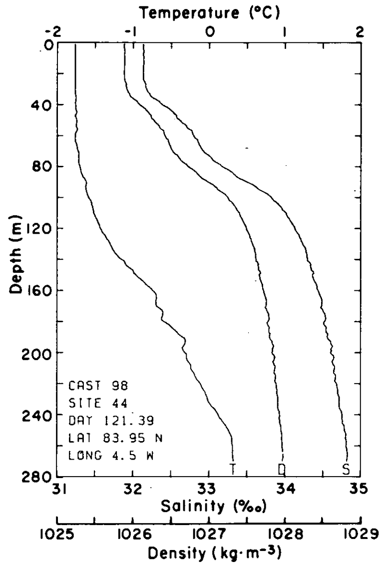

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 93
SITE 39
DAY 120.41
LAT 84.94 N
LONG 2.4 W
T
D
S

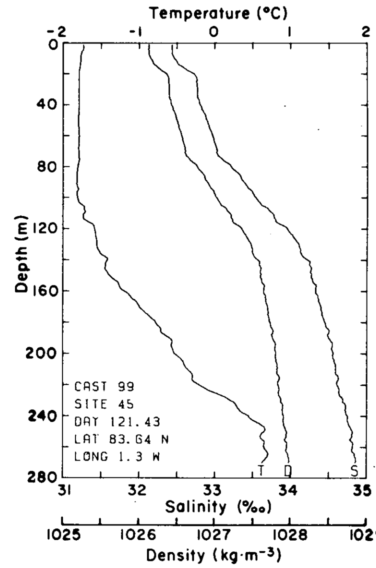

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 94
SITE 40
DAY 120.46
LAT 85.27 N
LONG 1.1 E
T
D
S

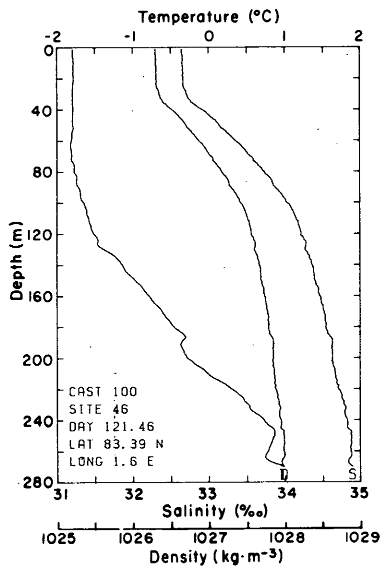

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 95
SITE 41
DAY 120.59
LAT 83.87 N
LONG 9.9 W
T
D
S

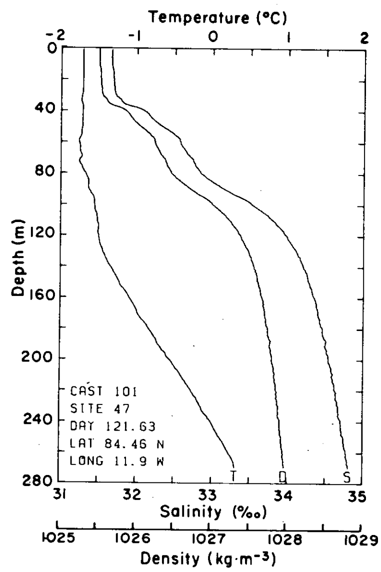

Temperature (°C)
Depth (m)
Salinity (‰)
Density (kg·m⁻³)
CAST 96
SITE 42
DAY 120.63
LAT 83.47 N
LONG 12.2 W
T
D
S

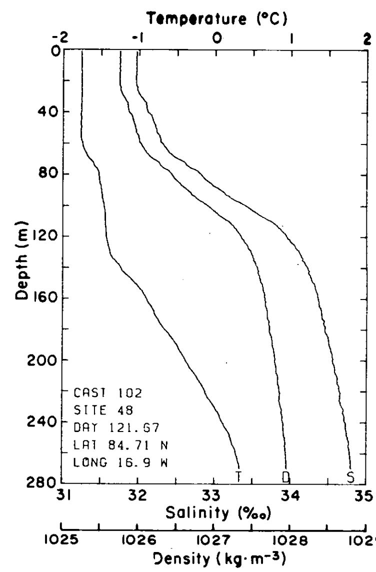


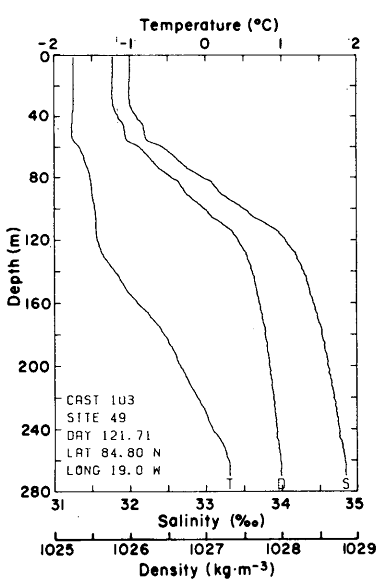


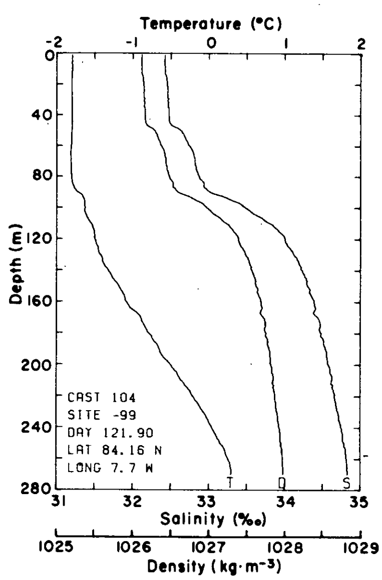












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