Woods Hole Oceanographic Institution

WHOI-92-23

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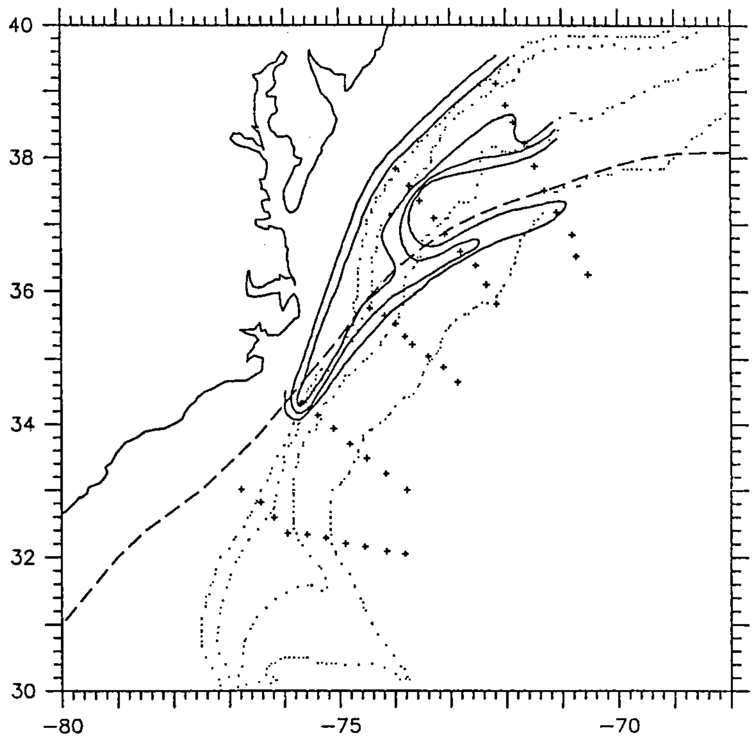
Hydrographic Data from Endeavor 214:

A Study of the Gulf Stream—Deep Western Boundary Current Crossover



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Theresa K. McKee
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and

William M. Smethie, Jr.
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May 1992

Technical Report

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Hydrographic Data from Endeavor 214: A Study of the Gulf Stream-Deep Western Boundary Current Crossover

by

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Approved for Distribution:

James Luyten, Chairman
Department of Physical Oceanography

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Cover Figure: Lateral distribution of F-11 in the density layer σ_θ= 27.40 – 27.73 kg/m^3, which corresponds to the upper extreme of the deep western boundary current (DWBC). The dashed line is the mean north wall of the Gulf Stream. At this shallow level, all of the high-CFC DWBC water is entrained by the subsurface Gulf Stream, forming an offshore tongue.

3 List of Participants

Woods Hole Oceanographic Institution

Robert S. Pickart	co-Principal Investigator
Amy Bower	CTD/POGO watch stander
Sara Gille	CTD watch stander
Elise Berliner	CTD watch stander
Barry Klinger	Oxygen Measurements

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Sandy Fontanna	CTD watch stander
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Erik Fields	CTD/ADCP watch stander
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Jan Szelag	CTD hardware technician
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Scripps Insitution of Oceanography

Doug Masten	Nutrient measurements

4 Abstract

In late June, 1990, a 17-day cruise aboard R/V ENDEAVOR was undertaken to investigate the manner in which the Deep Western Boundary Current (DWBC) crosses under the Gulf Stream. Forty-four CTD casts, comprising five sections, were made along with bottle measurements of Dissolved Oxygen, Nitrate, Nitrite, Phosphate, Silica, F-11, and F-12. An acoustic transport float (POGO) was deployed at each station to obtain a measurement of the upper layer transport. The shipboard Acoustic Doppler Current Profiler (ADCP) measured currents throughout the cruise. This report presents vertical profiles and sections of the bottle and CTD data, a vector map of the average POGO currents, and listings of the bottle data.

5 Introduction

As the Gulf Stream leaves the continental shelf near Cape Hatteras and flows into deeper water, it crosses the equatorward flowing Deep Western Boundary Current (DWBC). The DWBC consists of three separate water mass components, which together span the water column from approximately 800 m to the bottom. At present, it is not understood just how the "crossover" occurs, particularly for the shallowest DWBC component which should encounter significant Gulf Stream flow to the northeast.

In June–July 1990 a hydrographic survey of the Gulf Steam – DWBC crossover was completed aboard R/V ENDEAVOR. The co-principal investigators were Robert Pickart from Woods Hole Oceanographic Institution (WHOI) and William Smethie from Lamont-Doherty Geological Observatory. The survey consisted of five sections across the continental slope, spanning the crossover region. Measurements of various chemical properties were carried out, as well as measurements of upper layer currents using acoustic transport floats. The main objective of the experiment was to determine the kinematics of the crossover, in particular to determine if water from the DWBC recirculates with the Gulf Stream. Ultimately, analysis of the data will contribute to a better understanding of how the two currents dynamically influence one another.

The hydrographic survey was carried out during the multi-year Gulf Stream Synoptic Ocean Prediction (SYNOP) experiment. During SYNOP, a line of bottom current meters was maintained from October, 1987 through August, 1990 across the DWBC at the Gulf Stream crossover. Our central section coincided with this current meter line. Although the hydrographic survey was not formally part of SYNOP, the concurrent data complement one other and will strengthen the respective analyses.

This report documents the CTD, water sample and acoustic float data collected during the 17-day hydrographic survey. The instrumentation and data processing are described, then the data are plotted as vertical profiles and vertical sections. Finally, water sample data listings are included.

6 Data Collection

6.1 CTD

Five sections were occupied (Figure 1): two upstream of the crossover (Sections 1 and 2), one at the crossover (Section 3), and two downstream (Sections 4 and 5). A total of 44 casts were made – 41 bottom casts plus three additional 1500 m casts on the last Section (Table 1). At each section an attempt was made to cross both the DWBC and the Gulf Stream. However, the Gulf Stream was not completely crossed on the southern two sections (where it is still near the continental shelf).

CTD operations during the cruise were handled by the Marine Technical Services Group from the University of Rhode Island (URI). A single Neil Brown Mark III CTD (no. 1088), mounted on a 24 10-liter bottle rosette, was used. The CTD was equipped with a Beckmann oxygen sensor; however, the oxygen current contained random jumps that could not be fixed. During the cruise it was thought that this was a software problem. Unfortunately, it was later determined that the probe was faulty, making the oxygen data unusable.

For 43 out of 44 stations, the CTD gave complete data return. The exception was station 12 which had no data deeper than 2335 m, where the CTD failed; the last 625 m were lost.

Table 1. **Hydrographic Station Dates, Positions, and Bottom Depths.**

Station Number	Date (yymmdd)	Time (GMT)	Latitude (° N)		Longitude (° W)		Depth (m)
1	90/06/24	1901	32	2.94	73	49.46	5062
2	90/06/25	0658	32	5.52	74	9.43	4833
3	90/06/25	1502	32	9.49	74	33.05	4618
4	90/06/25	2106	32	12.16	74	54.04	4313
5	90/06/26	0239	32	17.18	75	15.08	3933
6	90/06/26	0750	32	20.05	75	35.29	3377
7	90/06/26	1421	32	21.39	75	56.41	2660
8	90/06/26	2011	32	35.22	76	11.03	2117
9	90/06/27	1000	32	49.01	76	25.46	1129
10	90/06/27	1511	33	0.44	76	46.95	614
11	90/06/27	2352	34	19.49	75	41.20	1149
12	90/06/28	0503	34	8.33	75	23.55	2953
13	90/06/28	1019	33	56.17	75	6.54	3296
14	90/06/28	1541	33	42.02	74	49.13	3750
15	90/06/28	2058	33	28.91	74	30.81	4180
16	90/06/29	0322	33	15.03	74	10.03	4510
17	90/06/29	1014	33	0.15	73	47.17	4823
18	90/06/29	2350	34	39.11	72	52.06	4494
19	90/06/30	0539	34	52.52	73	7.28	4295
20	90/06/30	1122	35	2.37	73	23.65	4014
21	90/06/30	2324	35	13.00	73	41.00	3653
22	90/06/30	2217	35	20.32	73	48.97	3330
23	90/07/01	0427	35	31.60	73	59.02	3026
24	90/07/01	1139	35	38.51	74	10.97	2644
25	90/07/01	1701	35	45.02	74	27.17	1949
26	90/07/02	0758	37	49.88	73	58.40	1000*(est.)*
27	90/07/02	1205	37	34.40	73	44.18	2049
28	90/07/02	1624	37	21.06	73	32.74	2454
29	90/07/02	2056	37	5.56	73	17.54	2885
30	90/07/03	0304	36	51.13	73	5.60	3148
31	90/07/03	1017	36	34.91	72	48.67	3416
32	90/07/03	1816	36	22.74	72	32.24	3685
33	90/07/04	0115	36	5.93	72	20.90	3894
34	90/07/04	0727	35	48.96	72	10.20	4055
35	90/07/04	1816	36	15.01	70	32.29	4407
36	90/07/05	0135	36	31.18	70	44.73	4354
37	90/07/05	0915	36	50.66	70	49.39	4256
38	90/07/05	1412	37	11.01	71	5.69	4093
39	90/07/06	0032	37	30.51	71	18.57	3807
40	90/07/06	0543	37	52.17	71	29.04	3229
41	90/07/06	1039	38	12.84	71	39.74	2953
42	90/07/06	1502	38	31.90	71	51.89	2815
43	90/07/07	0900	38	47.00	72	0.00	2639
44	90/07/07	1629	39	6.67	72	9.69	1606

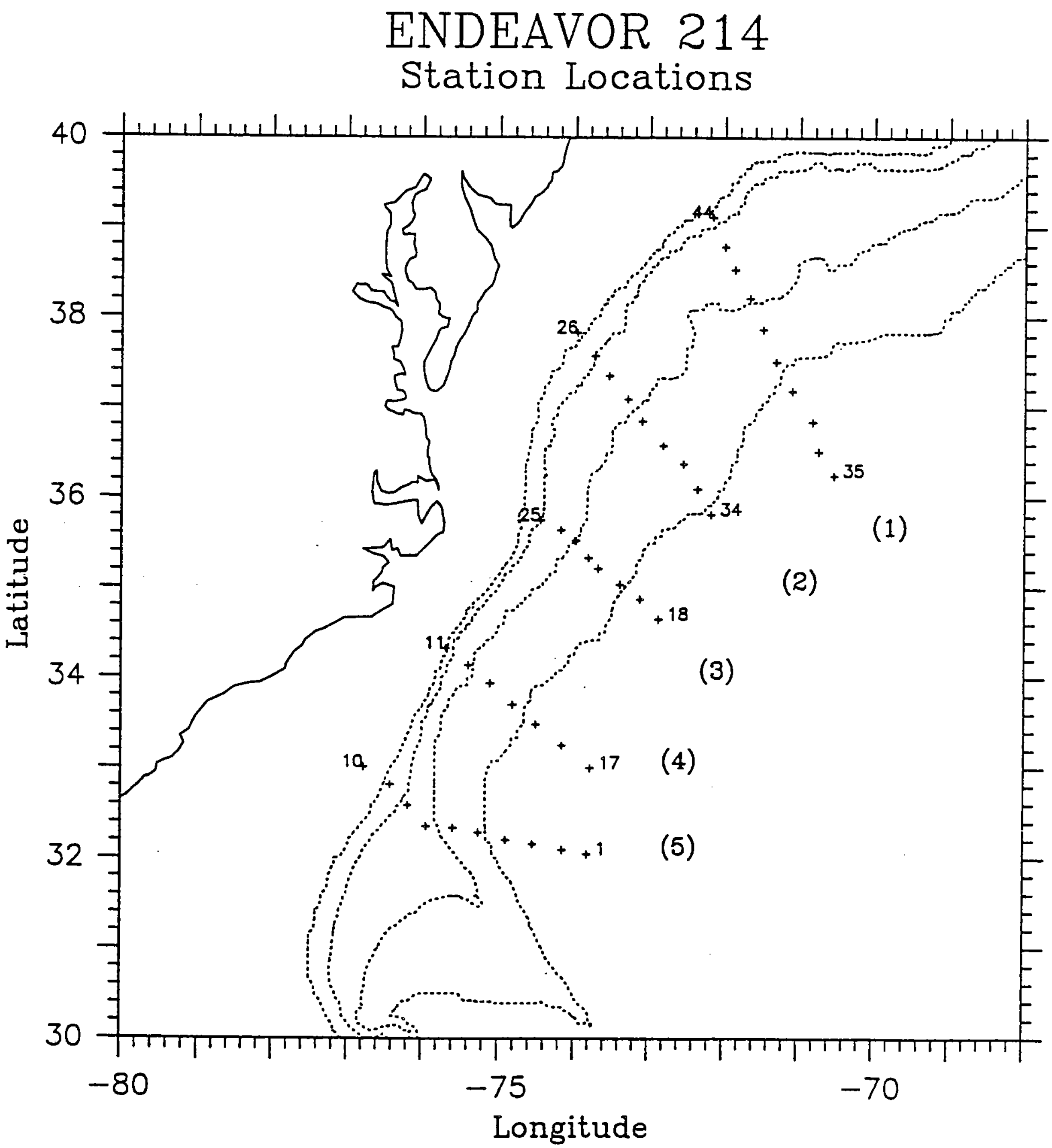

Figure 1: Map showing hydrographic station locations. Section numbers are in parentheses.

6.2 Water samples

At most stations, 24 water samples were collected using Scripps type 10-liter Niskin bottles. At some early stations 5-liter Niskin bottles were used, and 5-liter Niskin bottles were also occasionally used as replacements. All bottles were equipped with coated springs and baked O-rings to reduce contamination of the chlorofluorocarbons (CFCs) (standard Niskins were occasionally used as replacements). At shallow stations a smaller number of samples were collected. Measurements of dissolved oxygen, CFCs F-11 and F-12, and nutrients were routinely carried out. Funding for the nutrient measurements came under a separate NSF grant with M. McCartney as Principal Investigator.

6.2.1 Salinity

Salinity was measured using a standard AUTOSAL located in the ENDEAVOR's special purpose laboratory, which has the best temperature control of any working location on the ship. This task was handled by the URI Marine Technical Services Group, and upon completion of the cruise the data were in final form.

6.2.2 Oxygen

Oxygen was measured using a Winkler system operated by D. Kester's laboratory group at URI. The concentrations were determined using the Winkler (1888) titration method as modified by Carritt and Carpenter (1966).

6.2.3 Chlorofluorocarbons (CFCs)

The chlorofluorocarbons, F-11 and F-12, were measured on air and water samples. Water samples were collected using the 5- or 10-liter Niskin bottles attached to a rosette. Samples were drawn from these bottles into 100-cc glass syringes fitted with plastic valves. The samples were then stored (for no longer than 12 hours) in a sink continually flushed with clean surface seawater until analysis.

Water and air samples were analyzed using a purge and trap system interfaced to a gas chromatograph with an electron capture dectector. The method is described in detail by Smethie et al. (1988). Calibration curves were run by introducing different size sample loops of standard gas into the system. The calibration points were fit with a polynomial equation, and this equation was used to calculate the sample concentrations as described by Bullister and Weiss (1988). System blanks, stripper blanks, and sample bottle blanks were measured during the cruise, and the data have been corrected for these blanks. Stripper blanks were generally zero for F-12 and between 0.008 and 0.015 pmol/kg for F-11. Sample bottle blanks were determined by tripping two or three bottles at the same depth and sampling the bottles at 2-hour intervals to measure CFC ingrowth. The F-12 blank was zero for both the 5- and 10-liter bottles. The F-11 blank for the 10-liter bottles was 0.014 pmol/kg at the beginning of the cruise and 0.006 pmol/kg at the end of the cruise. The

F-11 blank for the 5-liter bottles was 0.034 pmol/kg at the beginning and 0.026 pmol/kg at the end. A linear drift in the blank was assumed and a correction applied to the data.

The precision of the atmospheric measurements based on replicate measurements, was ±0.4% for F-11 and F-12. The precision for water samples, based on differences between duplicate samples, was the larger of 0.004 or 0.8% for F-11 and 0.008 or 0.7% for F-12.

The fit to the calibration curves was ±1% for both F-11 and F-12. Thus the overall accuracy is about ±1.5% for both CFCs.

All concentrations are relative to the Scripps Institution of Oceanography 1986 scale.

6.2.4 Nutrients

The measurement of nutrients was handled by the Scripps Institution of Oceanography (SIO) shipboard operations group. Silicate, Phosphate, Nitrate and Nitrite were measured on an auto-analyzer located in the special purpose lab. Post-cruise data processing was performed at SIO. Since these data are not formally part of our data set, they have not been subject to the same quality control (described later in the report) as the other properties.

6.3 CFC Air Samples

CFC air samples were collected at 10 locations along the cruise track. Samples were normally collected when the ship was underway between stations to insure a headwind across the sample intake at the bow and thus avoid contamination with the ship's atmosphere. Air samples were collected by pumping air from a mast on the ship's bow to the CFC analysis system in the main laboratory of the ship. The intake was located approximately 7 meters above the sea surface. The air stream was dried by passing it over magnesium perchlorate, and 4 cc aliquots were collected from the gas stream using a calibrated loop. The volume was corrected to STP using the temperature and pressure measured at the time the sample was collected.

The results are summarized in Table 2. Concentrations for F-11 and F-12 are slightly lower for samples collected along transects 4 and 5. Samples 7 and 9 have unusually high F-12 concentrations which suggests that these samples were contaminated with the ship's atmosphere.

Table 2. **Atmospheric Concentrations of F-11 and F-12.**

Sample	Date	Station	Latitude (° N)		Longitude (° W)		F-12 (pptv)	F-11 (pptv)
1	90/06/25	2–3	32	07.3	74	19.4	481.5	259.7
2	90/06/25	4–5	32	12.1	75	00.8	484.0	258.2
3	90/06/26	6–7	32	19.6	75	49.3	484.7	264.7
4	90/06/27	11	34	18.5	75	41.2	480.8	261.9
5	90/06/28	13–14	33	44.6	74	52.2	483.8	261.4
6	90/06/29	17–18	33	11.5	73	37.2	483.1	258.7
7	90/06/30	22–23	35	23.2	73	52.6	516.9	265.3
8	90/07/04	34–35	35	55.5	71	42.7	490.2	264.2
9	90/07/05	38	37	12.4	71	00.8	523.1	271.1
10	90/07/07	44	39	13.5	72	07.9	490.7	262.9

6.4 POGO

An acoustic transport float, POGO (see Rossby et al., 1991), was deployed near the end of each CTD cast to obtain a measurement of the upper layer transport. Data were processed shortly after the cast using software written by T. Rossby's group at URI. Mean speed and bearing over a depth range of 250 m to 3000 m were computed (Table 3); the associated vectors are shown in Figure 2. Surface speed and bearing were also computed (Table 3).

6.5 XBT

While in the Gulf Stream, XBTs were taken between the CTD stations for increased resolution. These data are not included in this report.

Table 3. Surface and Mean Current Data from POGO Floats.

Station Number	Depth (m)	Surface Speed (cm/s)	Surface Bearing (° true)	Mean Speed (cm/s)	Mean Bearing (° true)
1	3044.7	10.5	1	6.4	45
2	3049.0	18.7	133	3.9	22
3	3044.7	15.7	200	2.0	131
4	3062.4	23.7	166	2.7	251
5	3000.7	14.2	11	4.2	298
6	—	—	—	—	—
7	—	—	—	—	—
8	1060.0	66.1	93	32.5	19
9	262.0	203.2	36	126.8	49
10	—	—	—	—	—
11	492.0	150.8	23	137.8	34
12	2058.3	85.2	50	36.8	30
13	2058.3	27.1	78	19.2	21
14	3083.8	24.3	207	3.5	240
15	3005.6	15.3	192	4.3	242
16	2979.5	48.5	222	13.6	242
17	1104.4	17.4	144	8.3	255
18	1078.0	43.8	127	5.7	234
19	1086.8	89.2	80	15.6	51
20	1065.7	57.4	59	32.0	35
21	900.4	83.1	57	50.1	51
22	1092.1	48.7	66	62.4	58
23	1049.9	166.0	54	86.3	57
24	1083.3	133.5	48	64.4	57
25	1072.8	74.6	56	7.0	51
26	499.5	46.8	247	9.7	38
27	1067.5	53.4	273	24.1	232
28	1072.8	23.4	286	21.7	231
29	1106.2	11.6	170	8.6	228
30	1085.1	16.7	140	5.0	163
31	1055.2	83.9	38	22.8	66
32	1081.6	206.2	51	93.0	51
33	1106.2	136.1	58	99.3	48
34	1086.8	37.7	185	47.3	62
35	1081.6	68.8	55	23.8	55
36	1078.0	63.9	97	50.7	66
37	1088.6	162.8	91	89.6	67
38	1065.7	263.6	70	96.7	78
39	1083.3	51.9	60	3.2	186
40	1042.9	25.0	181	10.1	239
41	1041.1	12.4	184	11.7	241
42	1106.2	27.3	19	18.4	212
43	1076.3	5.3	319	10.1	252
44	1049.9	42.1	278	5.1	257

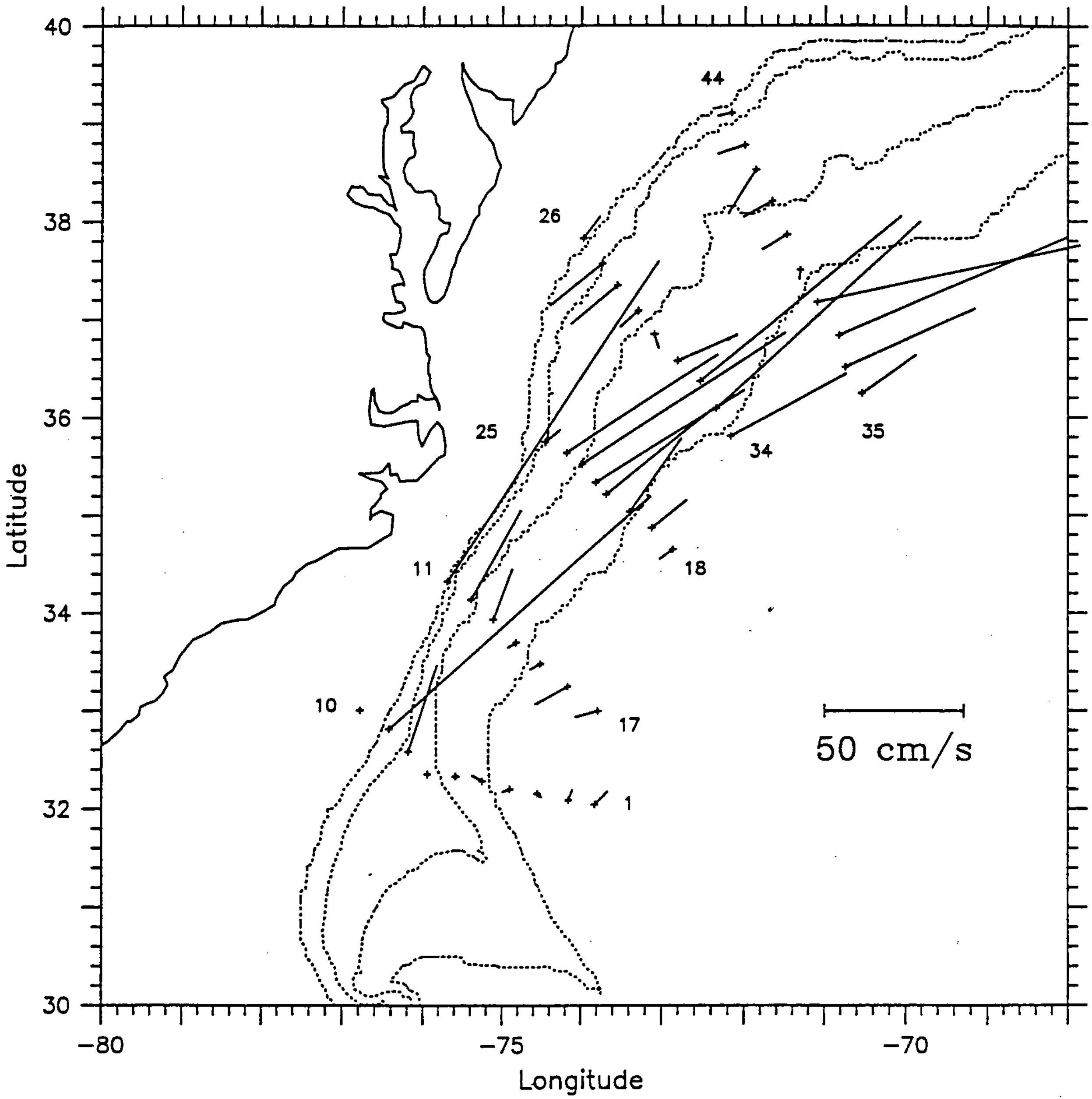

Figure 2: Map showing average POGO vectors.

7 CTD Calibration and Processing

CTD data acquisition and post-cast processing were accomplished on two MicroVAX II systems on ENDEAVOR using software written by the URI Marine Technical Services Group (for a description, see Hummon et al., 1991). By the end of the cruise, all processing steps were completed through pressure-averaging, leaving only the post-cruise calibrations to be done.

Laboratory calibrations of the CTD pressure, temperature and conductivity sensors were performed by Neil Brown Instrument Systems before and after the cruise. Based on the small amount of drift between calibrations, the pre-cruise pressure and temperature coefficients were used for the final data.

The bottle conductivity calibration was performed at WHOI by R. Pickart on a VAXstation 3100 using the water sample salinity data. Before this process was begun, a chronology of ΔS's was constructed, ΔS being the difference between the raw CTD value and water sample value at each bottle depth (Figure 3). No systematic trend over the length of the cruise was observed, and, since the dependence of ΔS on pressure was very small as well (not shown), the CTD values were calibrated as a function of conductivity only (no station trend or pressure trend included).

The bottle salinity calibration steps are summarized here:

1. Insert bottle salinity values into CTD "tag files" which contain the raw CTD variables at the bottle depths.
2. Insert upcast pressure coefficients into "header files."
3. Run the program TAGCAL to obtain calibration coefficients.
   Note: only 32 stations were used for the calibration. The following stations were not used:
   14, 30, 39, 41, 42; lower quality water sample data (Figure 3)
   16, 21, 22, 25, 33, 34, 38; bad or missing "tag files"
4. Apply conductivity coefficients to pressure averaged CTD files and compute salinities using SAL78 subroutine.

When these calibrated values were used to re-create the ΔS's, the resulting standard deviation of all values was .0040 PSU (Figure 4). The coefficients used for conductivity, pressure and temperature calibration are listed in Table 4.

A comparison was made between the deep T/S relation obtained from this data set and the standard Worthington–Metcalf curve for the western North Atlantic. The ENDEAVOR 214 data are consistently fresher between 2 and 4°C (maximum of .008 PSU fresher). It is well documented, however, that there has been a distinct freshening of the deep North Atlantic since the time the Worthington–Metcalf curve was created (e.g., M. Hall, 1991, personal communication), and our deep T/S curve is in agreement with more recent CTD surveys in this area of the North Atlantic.

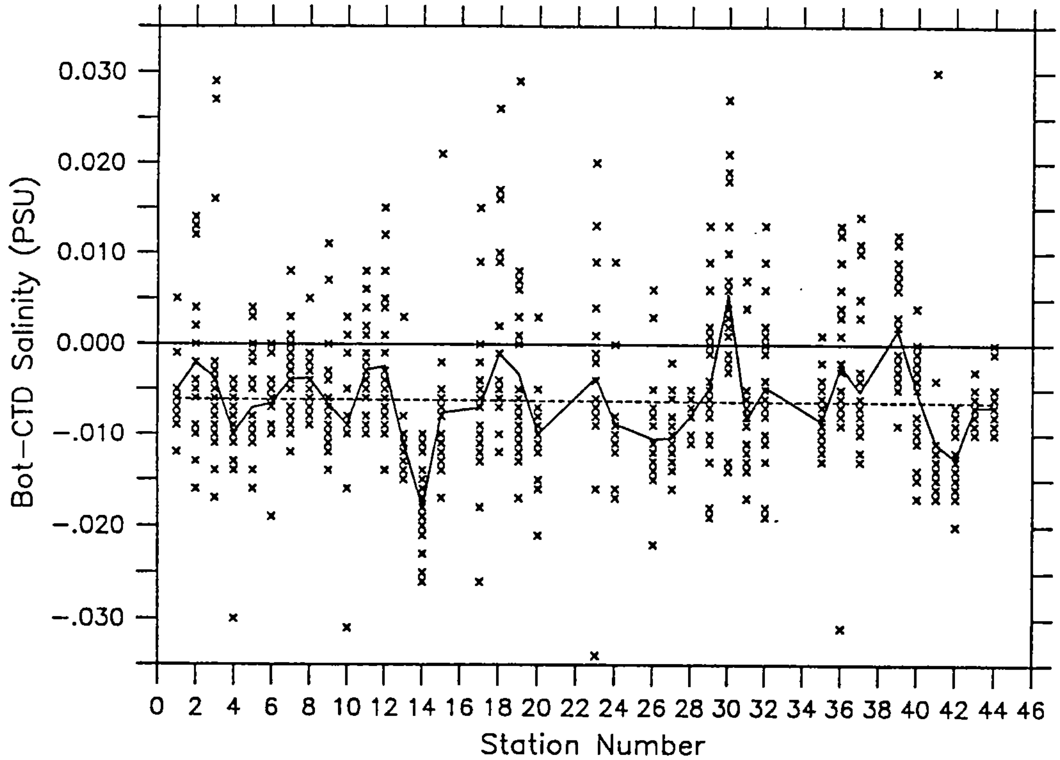

Figure 3: Plot of uncalibrated ΔS (bottle salinity – raw CTD salinity) versus station number. X's mark the ΔS. The solid line graphs the mean of each station group. The dashed line is the linear least squares fit to the mean.

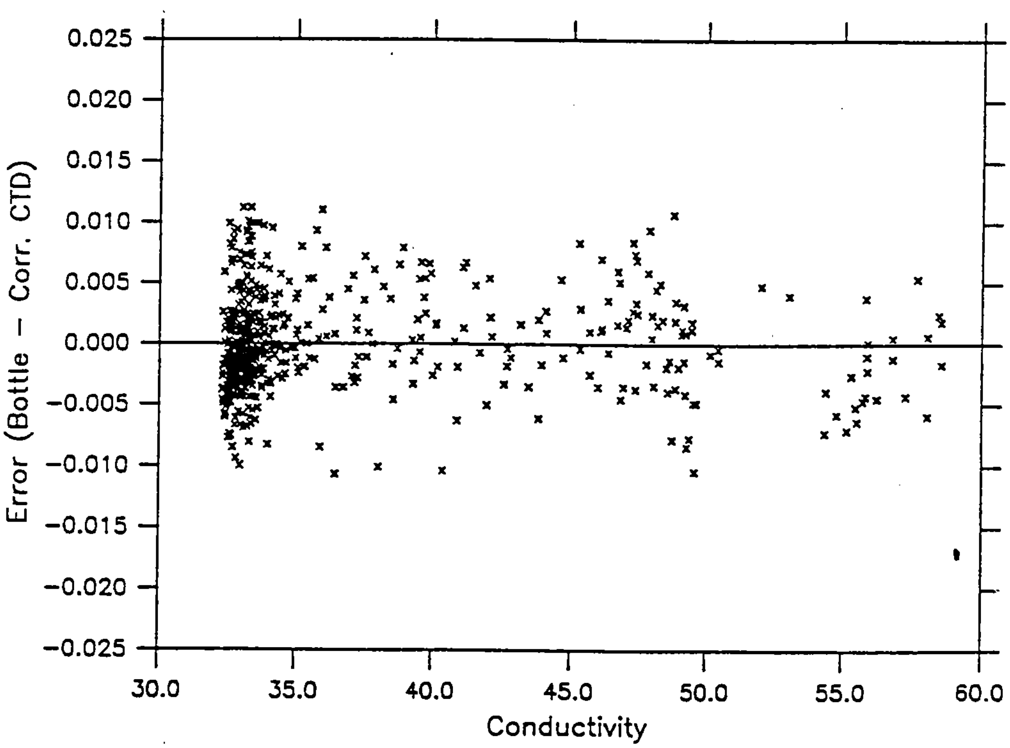

Figure 4: Plot of calibrated ΔS (bottle salinity – calibrated CTD salinity) versus conductivity.

Table 4. CTD Calibration Coefficients

PRESSURE (laboratory, pre-cruise):

upcast:	downcast:
A0 = −1.215764	A0 = −.7954182
A1 = .9987324	A1 = .9994162
A2 = .0000008356674	A2 = .0000004804482
A3 = −.00000000009893856	A3 = −.00000000006912594

TEMPERATURE (laboratory, pre-cruise):

A0 = .003269084

A1 = .9999887

A2 = .0000001020303

CONDUCTIVITY (bottle):

A0 = −.00177182

A1 = .999933

8 Final Processing and Data Quality Control

Final processing of the data took place at Woods Hole Oceanographic Institution. CTD data underwent final editing, and the different water property data were merged with calibrated CTD pressures and temperatures to form a composite bottle data set.

Edited CTD and water sample ascii data were converted to standard binary file format for compatibility with existing WHOI hydrographic data analysis software.

8.1 CTD

The calibrated CTD profiles were interpolated onto a regular pressure grid, starting at 3 db with an increment of 2 db. Several stations required a small amount of further editing (to remove isolated spikes). These edits are summarized in Table 5.

Table 5. Summary of Manually Edited CTD Files

Station	Description of edit
21	linearly interpolated over salinity and temperature spike near 1900 db
24	linearly interpolated over salinity spike near 380 db
36	linearly interpolated over salinity and temperature spike near 950 db
14, 33, 42, 44	extrapolated over <10db in order to extend the data up to the 3 db starting point

8.2 Water Sample

8.2.1 Salinity

Two methods were employed to identify bad bottle values. First, vertical traces of bottle salinity were overplotted with CTD down-trace salinity measurements on a large-scale T/S plot. Suspicious bottles could be visually identified.

Each bottle salinity was then compared with the associated calibrated CTD up-trace value (recorded at the time of the bottle measurement) and CTD down-trace value at a matching potential temperature. If the up-trace and bottle agreed, then the bottle value was deemed good. If the two disagreed, then the down-trace value was used as a check to determine whether the bottle value was indeed bad or if, in fact, the up-trace was bad. In cases where the bottle was deemed bad, the up-trace value was inserted. When all three measurements disagreed substantially, the down-trace value was inserted into the bottle data set. The final salinity data set retained 80% of the original bottle values.

Some of the bad salinities were known to be caused by sample bottle leakage. In this case, other measured properties were also bad and were removed from the data set.

8.2.2 Oxygen and CFCs

For CFCs, the F-11:F-12 ratio was calculated. Unreasonable ratios were used to identify bad data.

In addition, profiles of bottle Oxygen and F-11 versus Pressure and versus Potential Temperature were prepared and reviewed. Values of Oxygen and F-11 that did not lie on the trend were examined. Editing these was a somewhat subjective process. Extremely bad values were easily identified and removed; dubious values were compared for coherence with adjacent data, and removed if deemed unreliable.

9 Description of Plots

Part 1 contains individual vertical profiles of Salinity, Oxygen, and F-11. Salinity is plotted as a function of Potential Temperature. For each cast, there are two plots, one showing the upper water column (8–29°C) and the other showing the deeper water (0–8°C). Symbols denote the bottle measurements; the solid line is the CTD down- trace. Oxygen and F-11 are plotted as a function of pressure for the whole water column and Potential Temperature for the deeper water only. The plots are presented in geographic order (North to South and shallow to deep) rather than in station numerical order.

Part 2 contains vertical sections of Potential Temperature, Salinity, and Sigma 0, 1.5, 3.0 from the CTD, and bottle Oxygen, F-11, and Silicate. Before being contoured, the CTD data were subsampled. All data were then regridded using spline-laplacian interpolation to 50 m in the vertical, and 10 km in the horizontal. The bathymetry is the digitized output from the ship's depth recorder. For the water sample properties, crosses denote the bottle locations. All sections are drawn to a scale of 1000 m = 100 km.

Part 3 contains individual station listings of the bottle data. In addition to the measured variables Pressure, Temperature, Salinity, Oxygen, and F-11, these present Depth, Potential Temperature (Theta), and Potential Density (Sigma 0, Sigma 1.5, Sigma 2.0, Sigma 3.0, Sigma 4.0).

To give a more complete data set, uptrace CTD salinities were substituted for bad or missing bottle salinities where possible. Where the uptrace values were questionable, down-trace CTD salinities were used. Uptrace substitutions are enclosed in double brackets ({{ }}). Down-trace substitutions are enclosed in double asterisks (** **).

Other chemical data (Phosphate, Nitrite, Nitrate, and F-12) are listed as well. These have not been edited to the same degree as the plotted data. In some cases, questionable Oxygen and F-11 data are presented. These are preceded by a pound sign (#). Other missing or edited data appear as blanks in the listing.

All plots were generated using PLOTPLUS software from PLOTPLUS Graphics, Sequim, Washington.

10 Acknowledgements

We are most grateful to Captain Tom Tyler and the crew of the R/V ENDEAVOR for their hard work and patience, which made this a very successful experiment. The POGO floats were ably built and tested by Jim Fontaine, with the help of Mike Mulroney. Tom Rossby and Randy Watts graciously donated miscellaneous equipment used in the POGO floats. Mike McCartney provided helpful suggestions for quality-controlling the water sample data. Staff assistants Veta Green, Anne-Marie Michael, and Barbara Gaffron were most helpful in the preparation of the report. This work was supported by grants from the National Science Foundation and the Office of Naval Research, OCE90-09464.

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12 Figure Captions for Data Presentations

Figures 5 – 9. Bottle Salinity vs. Potential Temperature Profiles — Deep (0–8°C), Sections 1 – 5.

Figures 10 – 14. Bottle Salinity vs. Potential Temperature Profiles — Shallow (8–29°C), Sections 1 – 5.

Figures 15 – 19. Bottle Oxygen vs. Pressure Profiles, Sections 1 – 5.

Figures 20 – 24. Bottle Oxygen vs. Potential Temperature Profiles — Deep, Sections 1 – 5.

Figures 25 – 29. Bottle F-11 vs. Pressure Profiles, Sections 1 – 5.

Figures 30 – 34. Bottle F-11 vs. Potential Temperature Profiles — Deep, Sections 1 – 5.

Figure 35. Vertical Sections of CTD Potential Temperature, Salinity, and Sigma 0, 1.5, 3.0 for Section 1.

Figure 36. Vertical Sections of Bottle Oxygen, F-11, and Silicate for Section 1.

Figure 37. Vertical Sections of CTD Potential Temperature, Salinity, and Sigma 0, 1.5, 3.0 for Section 2.

Figure 38. Vertical Sections of Bottle Oxygen, F-11, and Silicate for Section 2.

Figure 39. Vertical Sections of CTD Potential Temperature, Salinity, and Sigma 0, 1.5, 3.0 for Section 3.

Figure 40. Vertical Sections of Bottle Oxygen, F-11, and Silicate for Section 3.

Figure 41. Vertical Sections of CTD Potential Temperature, Salinity, and Sigma 0, 1.5, 3.0 for Section 4.

13 Data Presentations

13.1 Part 1. Property Plots

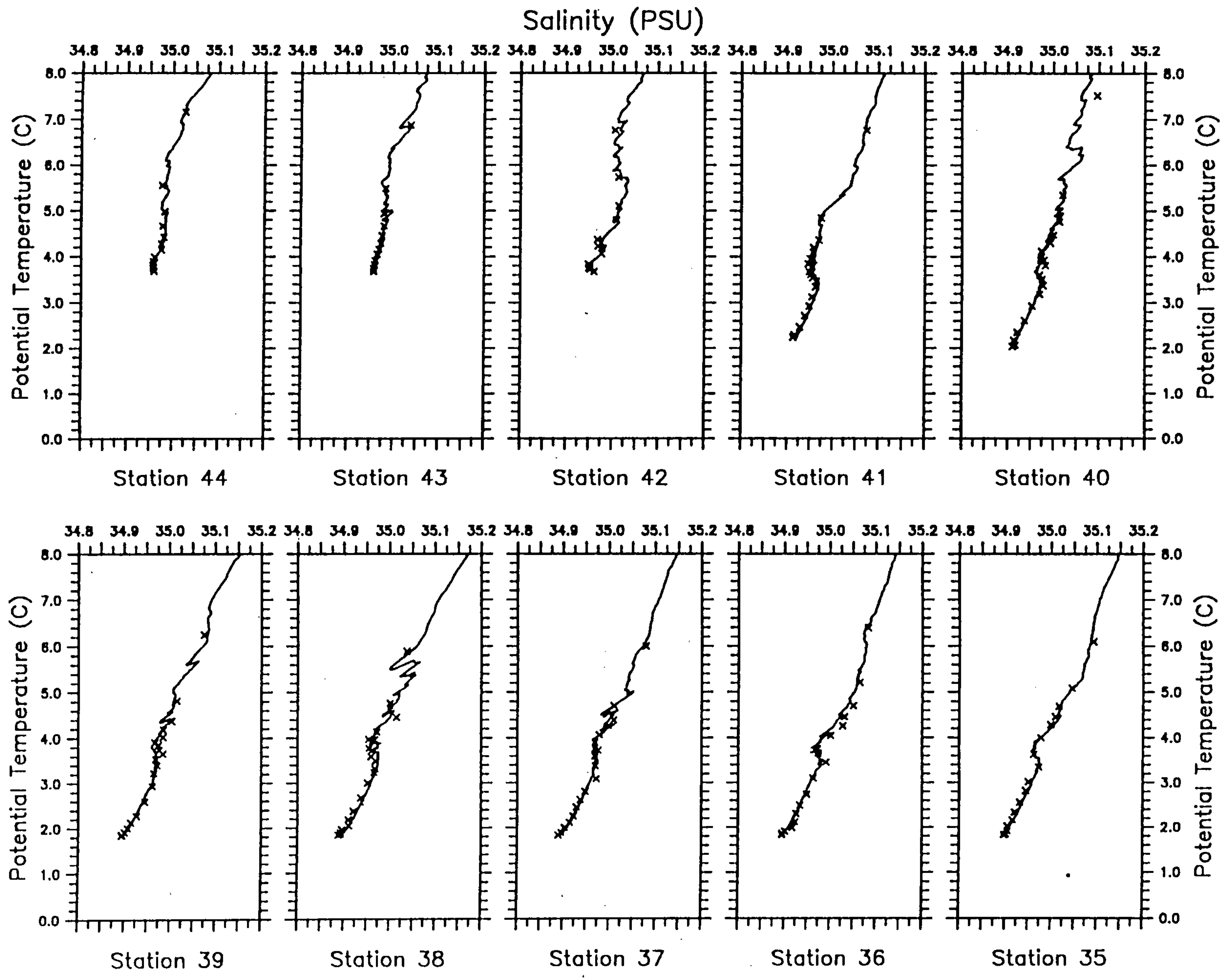

Salinity (PSU)
34.8 34.9 35.0 35.1 35.2
Potential Temperature (C)
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0
Station 44
Station 43
Station 42
Station 41
Station 40
Station 39
Station 38
Station 37
Station 36
Station 35
SECTION 1

Figure 5.

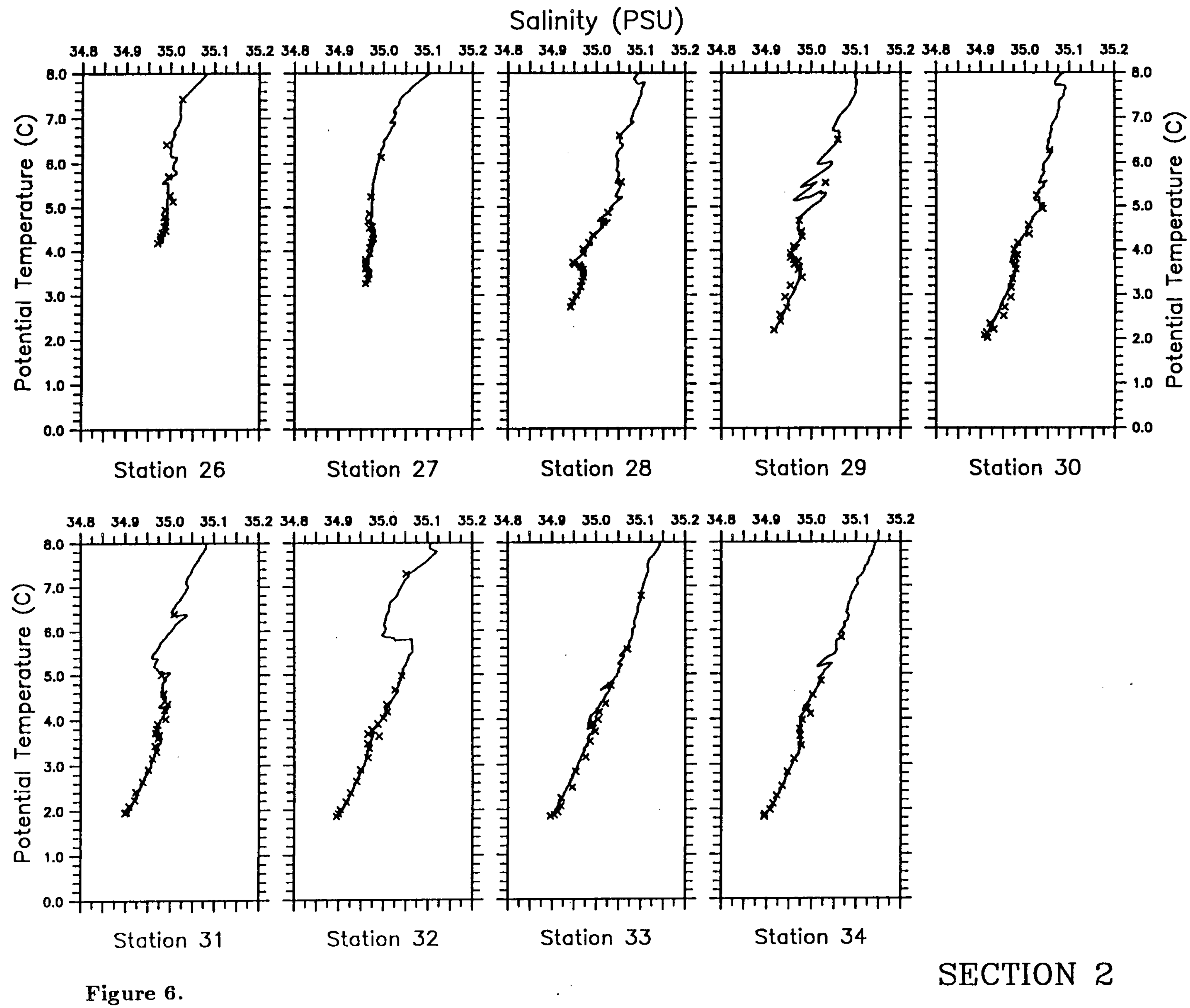
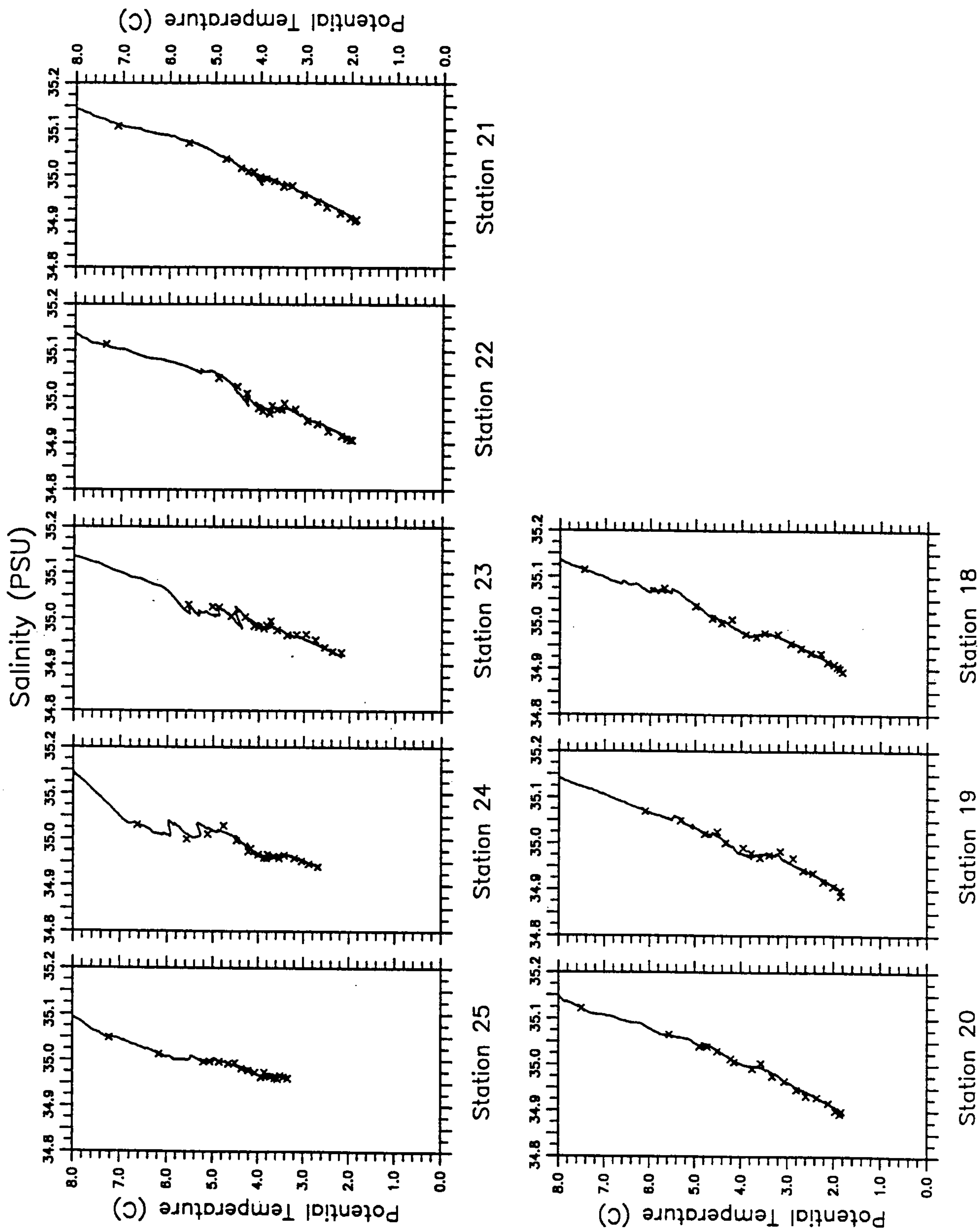

Salinity (PSU)
Potential Temperature (C)
Station 26
Station 27
Station 28
Station 29
Station 30
Station 31
Station 32
Station 33
Station 34
SECTION 2

Figure 6.



SECTION 3

Figure 7.

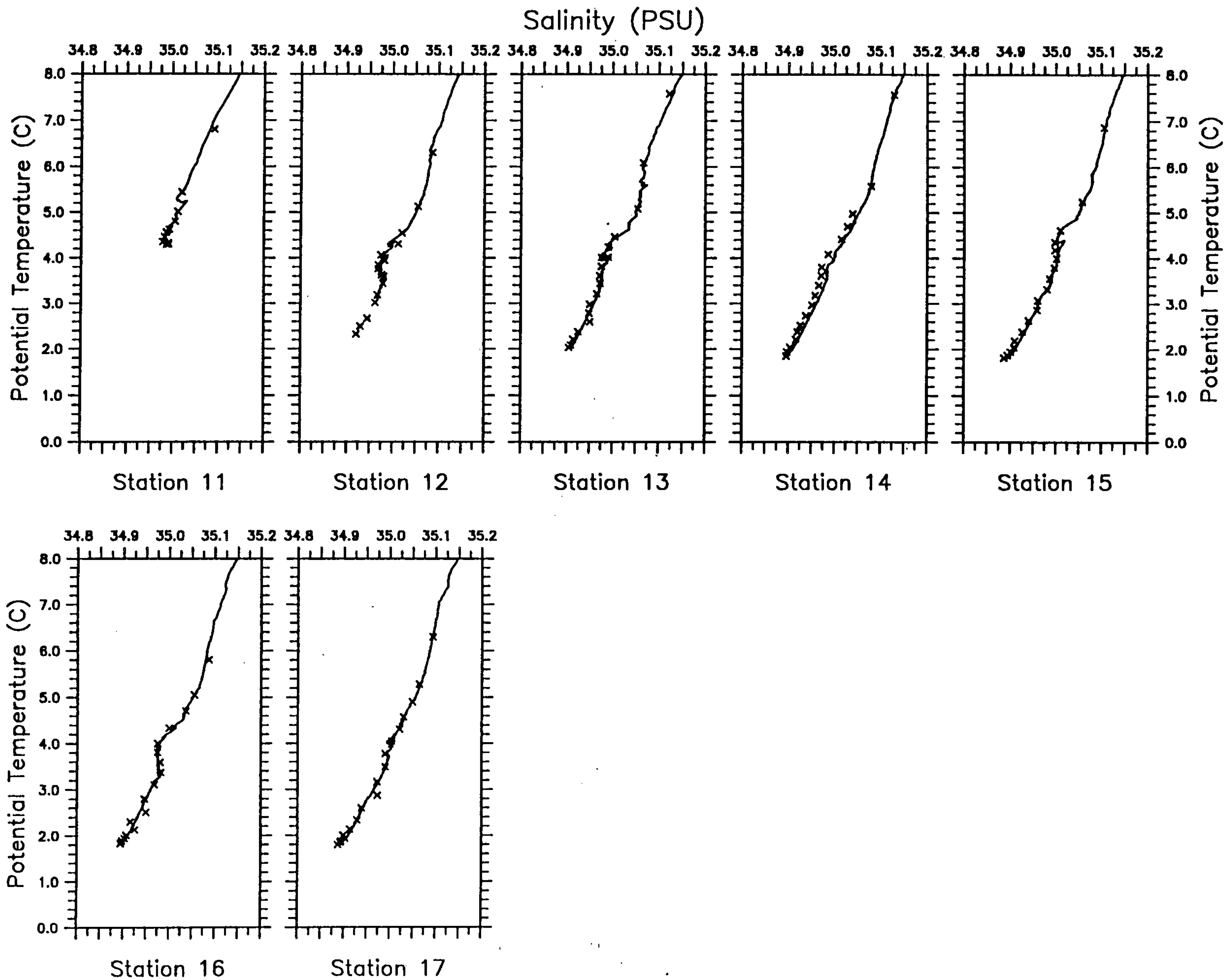


Figure 8.

SECTION 4

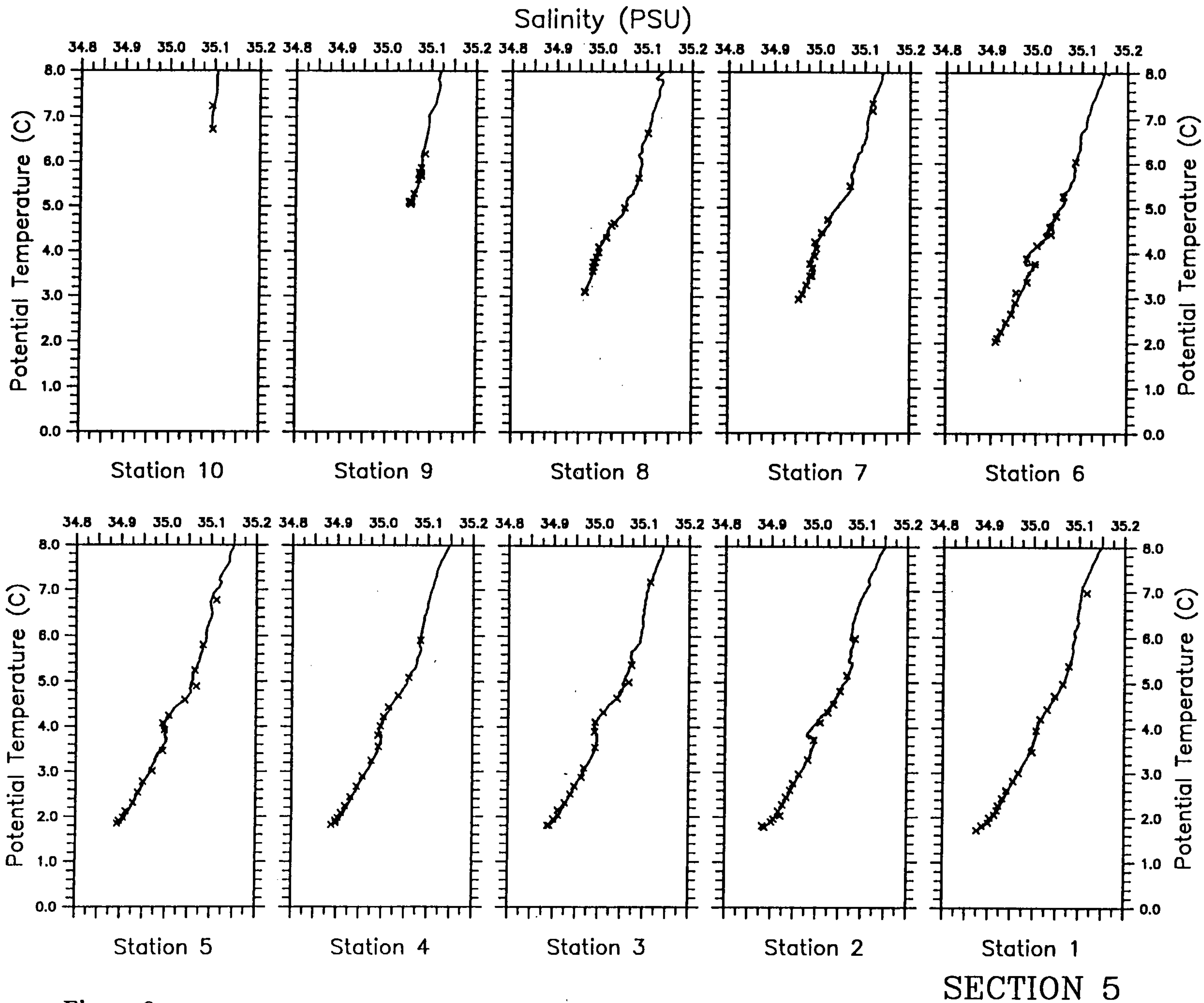

Salinity (PSU)
34.8
34.9
35.0
35.1
35.2
Potential Temperature (C)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Station 10
Station 9
Station 8
Station 7
Station 6
Station 5
Station 4
Station 3
Station 2
Station 1
SECTION 5

Figure 9.