Woods Hole Oceanographic Institution

Technical Report
May 1995

WHOI-95-07
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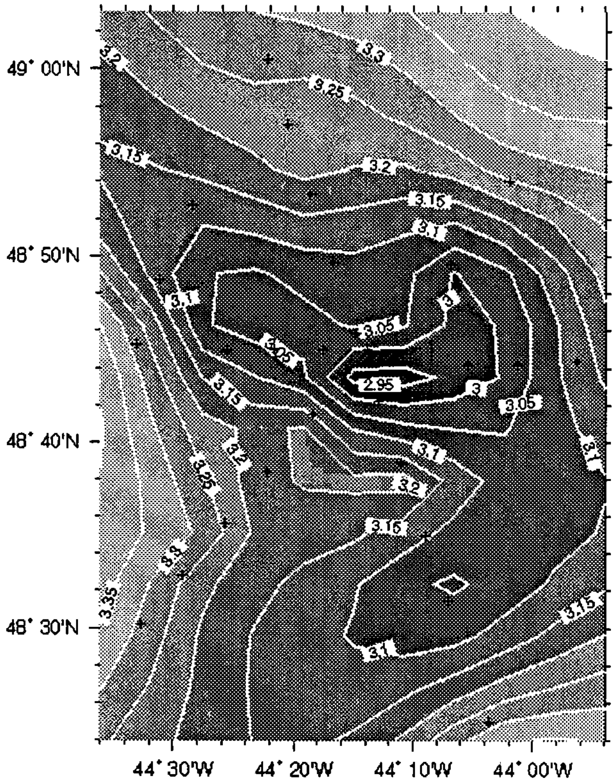
Hydrographic Data from *Endeavor* 223: Formation and Spreading of the Shallow Component of the North Atlantic Deep Western Boundary Curent



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Abstract

In March-April, 1991, a 34-day hydrographic cruise aboard R V *Endeavor* was undertaken to investigate the formation of the shallow component of the North Atlantic Deep Western Boundary Current (DWBC). Forty-seven stations were occupied, including 4 crossings of the DWBC. Five of the stations comprise a detailed CTD/XBT survey taken in the region of a lens of newly ventilated water. Two additional stations were occupied in the central part of the Labrador Sea. Dissolved Oxygen, Nitrate, Nitrite, Phosphate, Silicate, and Chlorofluorocarbons (CFC) F-11 and F-12 were measured at all stations. F-113 measurements were taken in the latter part of the cruise and Tritium and Helium were measured at selected stations. An acoustic transport float (POGO) was deployed at each station to measure average velocity directly over the upper 1000-1500 meters. The shipboard Acoustic Doppler Current Profiler (ADCP) measured upper layer currents throughout the cruise. Eighty-four XBTs were taken. 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. Tritium and Helium data are listed in an appendix.

Introduction

In March-April 1991, a 34-day hydrographic cruise aboard R V *Endeavor* was undertaken to investigate the formation and subsequent spreading of the shallow component of the North Atlantic Deep Western Boundary Current (DWBC). West of the Grand Banks, this component of the DWBC is in the depth range 700 - 1200 m with potential temperatures of 4 - 6° C and potential density σ_θ ~27.68 kg/m^3. This water mass is characterized most readily by a core of high Chlorofluorocarbons (indicative of recently ventilated water) and anomalously fresh salinity relative to the interior water. The boundary-intensified CFC signal is present all the way to the equator where it splits into two cores, one progressing eastward along the equator and the other progressing farther southward along the western boundary. The precise origin of this water mass is still under question.

The purpose of this cruise was to determine the geographical area of formation, investigate the dynamics of formation, and quantify the downstream entrainment and spreading as the water mass progresses equatorward in the shallow DWBC. A further objective was to study the downstream evolution of the two deeper components of the DWBC, the Labrador Sea water and Norwegian--Greenland Sea overflow water.

The experiment was scheduled in late winter specifically to investigate water mass formation. Unfavorable weather conditions made completion of all planned sections impossible; however, 47 stations were successfully occupied. Five of the stations comprise a detailed CTD/XBT survey taken in the region of a lens of newly ventilated water. In all, 4 crossings of the DWBC were completed. Two additional stations were occupied in the central part of the Labrador Sea in order to compare "classical" Labrador Sea water with the shallow DWBC water.

Data Collection

CTD

Using satellite SST images collected just prior to the cruise, the approximate location of the Gulf Stream/North Atlantic Current was determined. Section 1, consisting of 10 stations, was started to the north of the Gulf Stream front. Sections 2 (11 stations) and 3 (14 stations) extended into the North Atlantic Current. Within Section 3, a detailed survey consisting of 5 CTD stations and 30 XBT casts was carried out around a lens of newly ventilated shallow DWBC water. The existence of this lens was recognized since its characteristics (high CFC, low salinity) matched those of a similar feature identified in data from Section 2. Section 4 is a short section (4 stations) across the DWBC south of Cape Farewell. Figures 1 and 3 show the station positions. They are listed in Table 1.

A Neil Brown CTD, mounted on a 24 place 10-liter bottle rosette, was used. The CTD was equipped with a Beckmann oxygen sensor. The sensor was replaced after station 35 when it became clear that the CTD oxygens were not agreeing sufficiently with the bottle sample oxygens. The new sensor performed reliably.

At-sea processing was done on *Endeavor*'s shipboard workstation, a VAXSTATION 3600. Data were acquired using the MicroVAX CTD acquisition program WHOI AQUI89 Version 1.0 (Allen, 1992).

With the exception of the small-scale survey, where measurements were taken to 1000 m, all CTD casts were occupied to the bottom. All casts produced complete down-cast traces. Forty-six of forty-seven produced complete up-cast traces. Due to an error in the processing program, station 1 had to be specially reprocessed after the cruise to salvage the data, but the uptrace was not salvageable.

Water Samples

At each station, water samples were collected using Scripps-type 10-liter Niskin bottles. All bottles were equipped with plastic-coated springs and baked O-rings to reduce contamination of the CFCs. Typically, twenty-four samples were collected per station, though at shallow stations fewer samples were collected. Measurements of salinity, dissolved oxygen, nutrients, and CFCs F-11 and F-12 were routinely carried out. Measurements of CFC F-113 were made from station 25 through the end of the cruise. Dr. William Smethie of Lamont-Doherty Earth Observatory (LDEO) oversaw sampling and analysis of the CFCs. Tritium and Helium were collected at most stations, typically at 6-12 levels, in collaboration with Dr. William Jenkins of WHOI.

Salinity

Salinity was measured using a standard AUTOSAL located in *Endeavor's* special-purpose laboratory, which has the best temperature control of any working location on the ship. This task was handled by the Scripps Institution of Oceanography (SIO) shipboard operations group, and upon completion of the cruise the data were in preliminary form.

Oxygen

Oxygen was measured using a Winkler system operated by the SIO shipboard operations group. The concentrations were determined using the Winkler (1888) titration method and to the standards described by Culverson (1991).

Chlorofluorocarbons (CFCs)

The chlorofluorocarbons, F-11, F-12, and F-113 were measured on air and water samples. Water samples were collected in syringes and stored in a sink continuously flushed with clean surface seawater until analysis, which was within 12 hours of collection. Air samples were collected by pumping air from the bow of the ship during transits between stations to insure a good headwind across the sample intake and thus avoid contamination with the ship's air. An aliquot of dried air was sampled with a calibrated loop and injected into the CFC analysis system.

Water and air samples were analyzed using a purge-and-trap technique to isolate the CFCs from water and air, followed by gas chromatographic analysis using a Shimadzu 8A gas chromatograph with an electron capture detector. Two CFC analysis systems and two different chromatographic methods were used on this cruise. At the beginning of the cruise, both CFC systems used the same chromatographic method. CFCs from water or air samples were trapped on a unibeads 2s trap at -70° C. The trap was then heated to 100°C and the contents backflushed into a gas chromatograph with a precolumn and main column packed with Porasil B and a post column packed with molecular sieve 5A. The molecular sieve 5A column separates nitrous oxide from F-12 and is valved out of the gas stream before F-11 elutes from the main column; the precolumn prevents long retention time compounds from entering the main column. Details of the procedure are described by Smethie et al. (1988). This method is good for F-11 and F-12, but it does not separate F-113 from methyl iodide, a naturally occurring halocarbon. A method was developed in the laboratory prior to this cruise to separate F-113 from both methyl iodide and methyl bromide, another naturally occurring halocarbon, as well as provide good analyses for F-11 and F-12. This was accomplished by replacing the main column of Porasil B with a column of 20% SP2100 on Supelcoport. Other than this change, both methods are essentially the same. A detailed description of the new method is given by Smethie (submitted). This new method was used on CFC analysis system 1 during the latter half of the cruise.

CFC calibrations were performed by analyzing different size loops of a gas with known CFC concentrations. 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). The average difference between the best fit equation and the calibration points for system 1 was 1.1% for F-11, 1.4% for F-12, and 2.0% for F-113. The average difference for system 2 was 1.8% for F-11 and 2.1% for F-12.

The F-11 and F-12 concentrations are on the SIO 1986 scale and the F-113 concentration is on the 1992 NOAA Climate Monitoring and Diagnostics Laboratory scale. Two standards were used for F-11 and F-12, #1173 and #8335. Standard #8335 was also used for F-113. Standard #8335 was prepared by Doug Wallace at Brookhaven National Laboratory. It was calibrated at Lamont for F-11 and F-12 relative to Standard #1173 which had previously been analyzed for F-11 and F-12 on the SIO 1986 scale by Ray Weiss's Laboratory at Scripps Institution of Oceanography. It was also calibrated at Lamont for F-113 relative to Standard #2415 which was analyzed and provided to us by the NOAA Climate Monitoring and Diagnostics Laboratory.

Blanks for all three CFCs were measured throughout the cruise and corrections made for these blanks. The stripper blank for F-11 and F-12 was generally less than 0.01 pmol/kg. There was a consistent F-113 blank that averaged 0.036 pmol/kg. It was not possible to determine the Niskin bottle sampling blank because there was no zero CFC water. At two stations, duplicate Niskin bottles were tripped at the same depths and one bottle sampled several hours after the first bottle. The differences between these bottles ranged from zero to barely greater than the analytical precision. F-11 and F-12 bottle blanks were assumed to be 0.005 pmol/kg based on historical data for 10-liter Niskin bottles and the F-113 blank was assumed to be zero.

The precision of the CFC measurements was determined by making duplicate measurements and was different for different methods and systems. The precision for the various stations is summarized in Table 2.

To compare the results between systems 1 and 2, 24 duplicate samples were taken from various stations and analyzed on both systems. The differences between the F-11 analyses averaged about 1% which is within the error of the measurement. However, there appeared to be a systematic difference between the two systems for F-12 with system 2 being about 4% higher than system 1. The cause for this apparent systematic difference has not been determined and no correction for this has been made in the data presented in this report.

Air samples were analyzed in replicates of 4 to 6. The average standard deviation was 0.8% for F-12, 0.6% for F-11 and 1.6% for F-113. There appeared to be no difference between air samples measured with system 1 or system 2. Atmospheric concentrations are presented in Table 3.

Nutrients

The measurement of nutrients was handled by the SIO shipboard operations group. Silicate, Phosphate, Nitrate, and Nitrite were measured on an auto-analyzer located in the special purpose lab.

POGO

At the end of each CTD cast, POGO, an acoustic transport float (see Rossby et al., 1991), was deployed to measure the upper layer transport. The depth of the POGO float varied by station, typically 1000 - 1500 m. Data were processed on board using software written by T. Rossby's group at University of Rhode Island. Mean speed and bearing were computed (Table 4); the associated vectors are shown in figure 2.

XBT

Eighty-four Sippican T-7 XBTs were deployed; eight were unsuccessful due to software failure and one due to probe failure. One test station was taken. Twelve XBTs were taken en route to CTD station 11 to locate the edge of the North Atlantic Current. Thirty-one XBTs were taken as part of the detailed survey (CTD stations 37 - 41), and 26 additional XBTs were taken en route to the Labrador Sea stations (42 - 43). Northeast of the detailed survey area, five XBTs were deployed to help identify the edge of the North Atlantic Current. The locations are listed in Table 5 and shown in figures 1 and 3. The cover figure shows a lateral map of temperature at 500 m from the detailed survey.

At-Sea Data Processing

For each station, salinity, oxygen, F-11, silicate, and potential vorticity were plotted versus depth, potential temperature and potential density. Bottle salinity and oxygen were over-plotted with the corresponding CTD measurements. Using the bottle data, CTD calibration coefficients were updated as necessary during the cruise. After each transect was completed, vertical sections of potential temperature, salinity, potential density, dissolved oxygen, F-11 and silicate were prepared. Bottom depth was digitized from the line scan recorder.

Plotting entire transects was critical to locating regions of newly formed water. An example can be seen in Figure 25, which shows clearly, at station 15, an anomalously cold and fresh patch of newly formed shallow DWBC water, characterized by high CFC and oxygen concentration. This feature is not as evident when viewed as an isolated vertical profile.

Post-cruise processing of bottle salinity and oxygen data was performed at SIO. CFC data were processed at LDEO, and tritium/helium at Woods Hole Oceanographic Institution (WHOI).

CTD Calibration and Processing

Laboratory calibrations of the CTD pressure, temperature and conductivity sensors were performed at the WHOI calibration facility. Bottle conductivity calibration was performed at WHOI by M. Cook using the WHOI CTD data processing system and the coefficients listed in Table 6.

The calibrated CTD profiles were interpolated to a regular pressure grid with an increment of 2 db. Preliminary editing was performed and WHOI's binary CTD format files were prepared for use in the final processing stage.

CTD Oxygen

It was discovered that the oxygen sensor used through station 35 was not performing properly. The signs of failure were subtle, and it was hoped some of the data could be saved. This did not prove to be possible, and ultimately, it was necessary to discard all CTD oxygen data for stations 2-35 and use only the bottle oxygen data for those stations. The sensor was replaced and produced good quality oxygen traces for the rest of the stations.

Final Processing and Data Quality Control

CTD

Final processing of CTD and water sample data was performed by T. McKee at WHOI. Data were plotted and reviewed for spikes. Several stations required a small amount of further editing. Final data were archived in the standard binary file format compatible with WHOI hydrographic data analysis software.

Water Sample

Final salinity, dissolved oxygen, and nutrient data, when received from SIO and LDEO, were merged with calibrated uptrace temperatures and pressures into WOCE format (Culverson, 1991). These were plotted and reviewed for spikes, which were removed from the data set. Each salinity profile was over-plotted with the corresponding 2 db CTD profile versus depth and potential temperature. During this process, it became evident that the uptrace CTD profiles were a more useful measure of the quality of the bottle data. This is because the strong variability in this part of the North Atlantic, in combination with the ship's drift, often caused the uptrace profile (whence the bottles were tripped) to be noticeably different from the down-trace in the upper part of the water column. Therefore, the CTD profiles presented in this report show the uptrace as well. The final edited water sample ascii data were also converted to standard binary file format for compatibility with WHOI hydrographic data analysis software.

XBT

Using URI technical services processing software, raw XBT data were converted to depth and temperature profiles. Data were edited at WHOI by D. Torres, using an algorithm which eliminated data points where the vertical temperature gradient was greater than .5 ° C per meter. After editing, the XBT profiles were interpolated onto a regular 5 meter grid, from 5 to 825 meters.

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 (0 - 1000 m) and the lower plot showing the deeper water (1000 m - bottom). Symbols denote the bottle measurements. The solid line is the CTD down-trace. The finely dashed line shows the CTD uptrace. Oxygen and F-11 from water samples are plotted as a function of pressure and are divided into two plots showing upper and deeper water. Since oxygen data from the CTD was only available for the last 12 stations, only bottle oxygens are shown. Plots are presented by section and are arranged in onshore to offshore order rather than in numerical order.

Part 2 contains vertical sections of potential temperature, salinity, and potential density 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. These are a composite of uptrace CTD pressure, temperature and salinity along with bottle salinity, oxygen, nutrients, and CFCs. Calculations of depth, potential temperature (theta), and potential density (sigma 0, sigma 1.5, sigma 2.0, sigma 3.0, sigma 4.0) are included. The chemical data (silicate, phosphate, nitrite, and nitrate) have not been edited to the same degree as the plotted data. If tritium and helium were sampled at that station, it is noted in the header. Missing or edited data appear as blanks in the listing.

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

Acknowledgements

We are most grateful to Captain Tom Tyler and the crew of the *Endeavor* for their efforts to make this a successful experiment. The POGO floats were built and tested by Jim Fontaine and Mike Mulroney of URI. Maggie Cook calibrated and processed the CTD and water sample data. This work was supported by the National Science Foundation under grant number 90-18409.

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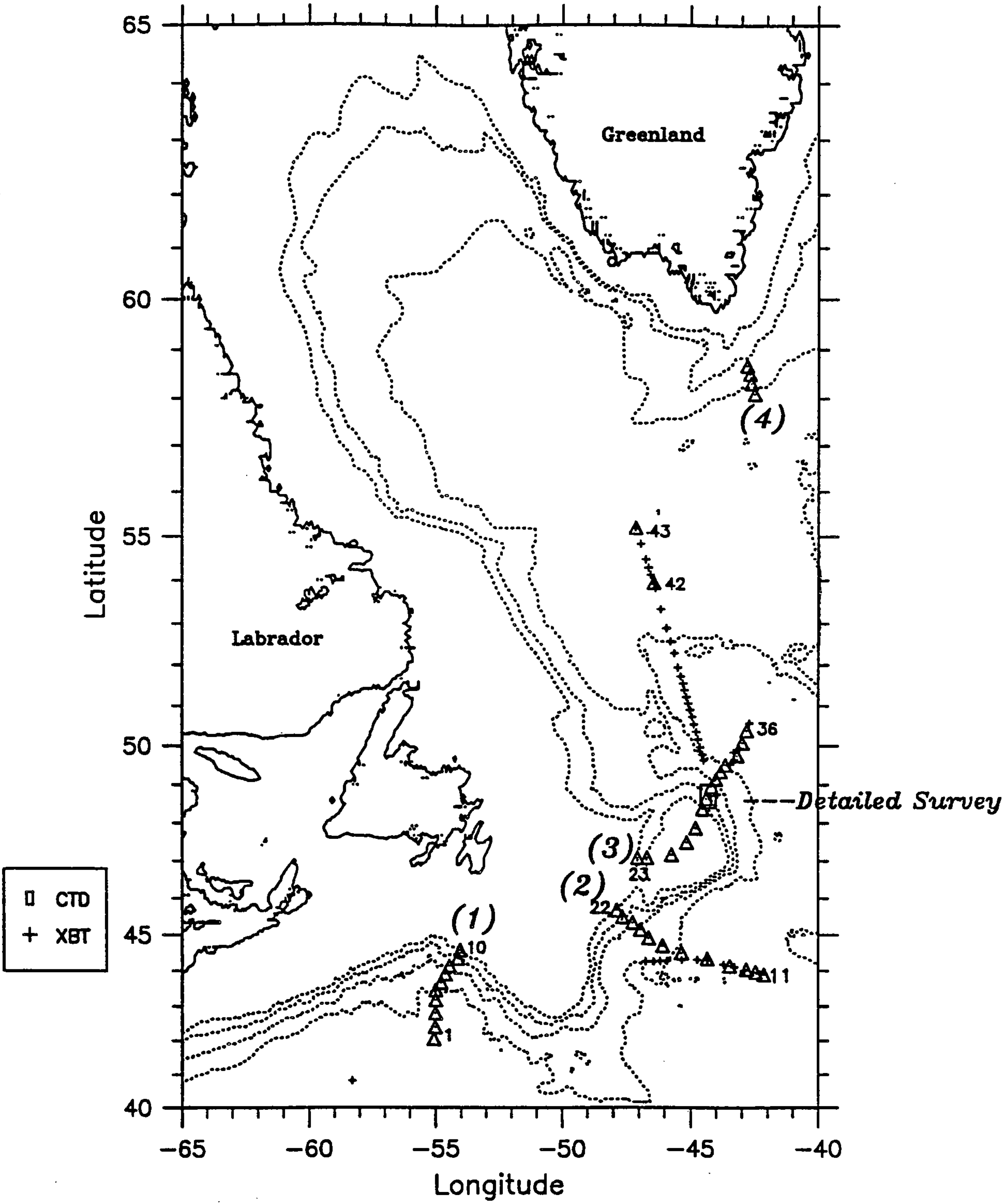

Figure 1. Location of CTD stations (Δ) and XBT drops (+). The large square indicates the region of a detailed XBT/CTD survey around a lens of newly ventilated water (see Fig. 3.)

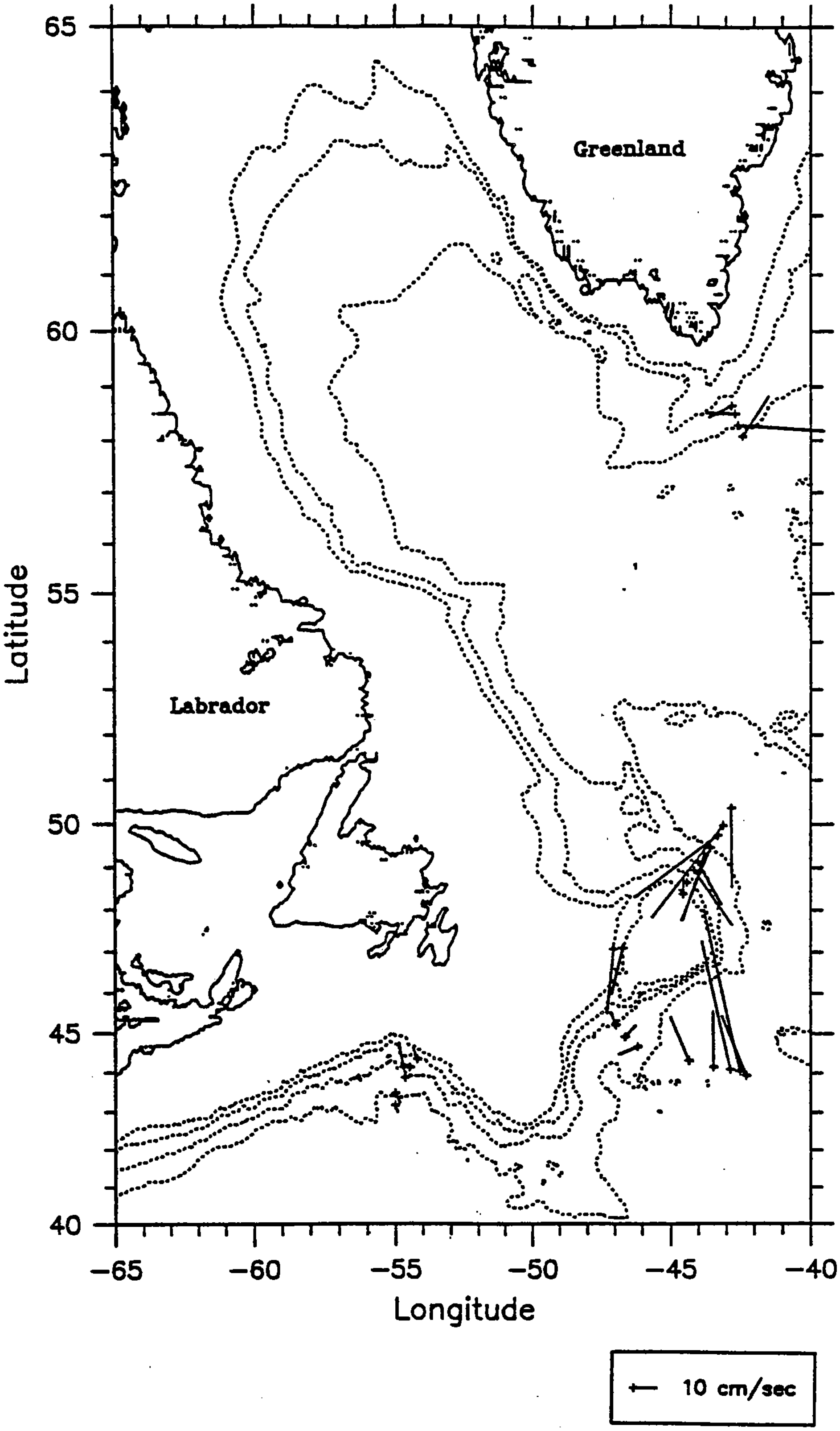

Figure 2. Mean velocities from POGO floats.

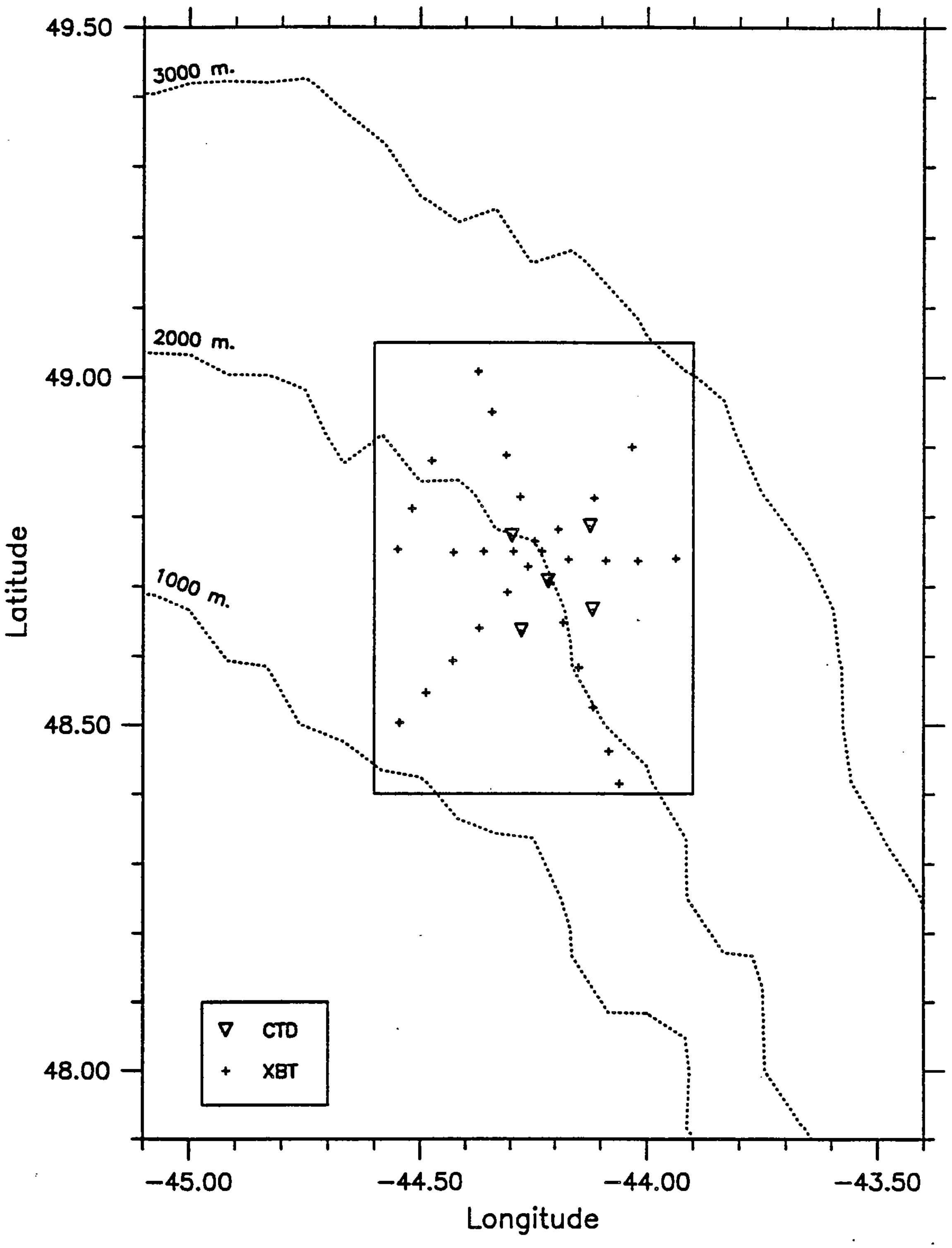

Figure 3. Map showing locations of CTDs and XBTs taken as part of the detailed survey.

Table 1. Dates, Positions, and Bottom depths for *Endeavor* 223 hydrographic stations.

Endeavor 223 Station Dates and Positions

Station Number	Date GMT	Time	Latitude °N		Longitude °W		Depth m
1	91/03/26	1955	42	02.58	55	04.08	4670
2	91/03/28	317	42	23.66	55	1.28	4482
3	91/03/28	1248	42	47.71	55	0.40	4406
4	91/03/28	2035	43	10.12	55	0.05	4258
5	91/03/29	242	43	27.10	54	59.90	3998
6	91/03/29	918	43	39.80	54	47.82	3723
7	91/03/29	1533	43	54.14	54	38.00	3362
8	91/03/29	2130	44	7.83	54	28.15	2673
9	91/03/30	303	44	20.65	54	8.00	2275
10	91/03/30	854	44	34.00	54	3.01	1430
11	91/04/01	1355	43	53.50	42	9.33	4774
12	91/04/01	2035	43	58.00	42	28.10	4778
13	91/04/02	233	44	2.40	42	50.00	4883
14	91/04/02	1008	44	8.04	43	28.02	4795
15	91/04/02	1854	44	20.17	44	21.05	4728
16	91/04/03	835	44	30.15	45	20.90	4146
17	91/04/03	1742	44	41.92	46	4.94	3733
18	91/04/04	120	44	54.96	46	36.82	3565
19	91/04/04	648	45	8.94	46	56.13	3398
20	91/04/04	1325	45	20.28	47	14.60	2857
21	91/04/04	2137	45	29.93	47	38.27	2011
22	91/04/05	342	45	40.60	47	51.86	1248
23	91/04/10	133	47	4.96	47	2.93	1118
24	91/04/10	518	47	5.20	46	40.50	984
25	91/04/10	1130	47	10.16	45	44.05	278
26	91/04/10	1518	47	29.06	45	9.04	233
27	91/04/10	1833	47	52.04	44	47.91	278
28	91/04/10	2218	48	22.05	44	32.17	905
29	91/04/11	218	48	38.20	44	23.27	1623
30	91/04/11	715	48	57.03	44	10.96	2395
31	91/04/11	1134	49	8.06	43	59.98	3220
32	91/04/11	1635	49	19.96	43	49.17	3899
33	91/04/12	23	49	30.45	43	37.65	4013
34	91/04/12	1157	49	44.95	43	10.25	4237
35	91/04/13	1413	50	4.08	42	58.44	4270
36	91/04/13	2313	50	22.89	42	48.09	4263
37	91/04/17	448	48	42.51	44	13.02	1837
38	91/04/17	800	48	47.21	44	7.45	1966
39	91/04/17	1059	48	46.41	44	17.83	1802
40	91/04/17	1330	48	38.19	44	16.55	1678
41	91/04/17	1625	48	40.00	44	7.14	1931
42	91/04/19	330	53	57.01	46	25.79	3616
43	91/04/19	1344	55	12.02	47	8.06	3591
44	91/04/20	1419	58	18.57	42	38.35	2897
45	91/04/20	1825	58	30.06	42	41.09	2621
46	91/04/20	2218	58	39.82	42	48.03	2330
47	91/04/21	433	58	4.94	42	29.87	3140

Table 2. Summary of CFC precision for *Endeavor* 223 stations.

System	**Method**	**Stations**	**F-12**	**F-11**	**F-113**
1	Porasil B	1 - 16	0.003 *pmol/kg* or 0.6% (n=21)	0.005 *pmol/kg* or 0.6% (n=21)	
1	SP2100	30, 32, 34 35, 37, 39 42 - 47	0.017 *pmol/kg* or 2.2% (n=20)	1.0% (n=20)	0.019 *pmol/kg* *(n=18)*
2	Porasil B	17 - 29, 31 33, 36, 38 39, 40, 41	2.4% (n=17)	1.9% (n=20)	

Table 3. Atmospheric concentrations of CFCs measured on *Endeavor* 223.

Date	Station Number	Latitude °N	Longitude °W	F-12 pptv	F-11 pptv	F-113 pptv	System
91/03/30	9-10	44 25′	53 35′	504.7 +1.8	272.1 ±3.6		1
91/03/31	10-11	44 19′	45 45′	500.6 +4.2	269.9 ±2.2		1
91/04/02	14-15	44 19′	44 18′	489.7 +1.7	272.7 ±1.4		1
91/04/04	20-21	45 27′	47 38′	491.5 +3.0	268.0 ±1.6		2
91/04/10	24-25	47 16′	45 30′	509.1 +3.1	270.5 ±0.8		2
91/04/13	35-36	50 09′	42 58′	488.5 +3.1	269.8 ±3.3	81.6 ±2.8	1
91/04/15	36-37	50 21′	42 18′	484.0 +4.2	266.2 ±0.5	82.1 ±2.5	1
91/04/16	36-37	48 27′	44 18′	492.9 +4.9	270.8 ±0.9	82.0 ±0.6	1
91/04/19	43-44	55 56′	46 16′	494.2 +4.9	271.1 ±1.0	83.9 ±0.3	1
91/04/21	after 47	59 58′	37 52′	495.4 +9.1	270.8 ±1.3	85.5 ±0.5	1

Table 4. Surface and Mean Current Data from POGO Floats.

Endeavor 223 POGO Data

CTD #	POGO #	Latitude °N		Longitude °W		Mean Speed cm/s	Mean Bearing °T	Surface Speed cm/s	Surface Bearing °T	Depth (m)
4	2	43	10.01	55	00.58	2.5	156	12.6	242	1049
5	3	43	28.61	55	01.21	3.8	144	39.0	029	1040
7	5	43	52.81	54	38.65	11.3	345	5.6	266	1058
8	6	44	08.52	54	28.76	4.1	283	21.2	313	1512
9	7	44	20.59	54	12.66	4.0	333	31.8	316	1521
11	8	43	56.40	42	17.02	21.6	330	83.8	315	1512
12	9	44	02.90	42	30.78	52.0	342	84.3	331	1521
13	10	44	05.15	42	51.12	41.7	342	104.1	348	1512
14	11	44	09.43	43	26.87	17.4	359	74.0	43	1521
15	12	44	18.78	44	21.02	16.0	329	27.7	105	1512
17	13	44	40.31	46	10.00	8.8	253	8.9	291	1503
18	14	44	54.72	46	37.02	5.9	52	2.4	301	1530
19	15	45	12.52	46	58.28	4.2	332	47.6	292	1485
23	16	47	03.31	47	03.09	19.5	188	93.5	183	533
24	17	47	05.23	46	42.55	14.7	200	24.4	148	533
28	18	48	22.65	44	33.35	4.3	004	12.3	295	542
29	19	48	39.21	44	24.63	1.4	274	8.4	266	1022
30	20	48	56.19	44	09.67	23.5	133	54.3	100	1485
31	21	49	07.80	44	00.43	16.0	140	3.5	153	1512
32	22	49	19.46	43	46.63	21.7	207	24.2	207	1467
33	23	49	27.34	43	33.51	25.0	212	95.8	348	1530
34	24	49	44.73	43	18.85	41.0	244	78.7	279	1547
35	25	49	58.10	43	06.91	41.4	230	75.4	233	1512
36	26	50	22.39	42	49.43	22.8	179	55.0	193	1512
37	27	48	41.26	44	13.02	18.7	137	53.5	131	1031
38	28	48	47.03	44	07.25	19.2	150	68.2	166	1004
39	29	48	46.40	44	17.65	24.4	133	44.0	216	1022
40	30	48	38.26	44	16.00	11.5	174	33.2	197	1040
41	31	48	40.14	44	06.45	18.8	157	90.1	104	1022
44	32	58	17.35	42	35.61	37.9	092	34.4	090	1521
45	33	58	30.07	42	40.84	13.0	271	24.0	195	1467
46	34	58	39.21	42	48.70	10.5	255	19.9	049	1512
47	35	58	04.59	42	25.33	14.7	051	36.3	078	1494

Table 5. Dates, Times and Positions for XBT Drops.

XBT	Date	Time GMT	Latitude °N	Longitude °W	Comment
001	26 Mar 91	----	40 48.9	58 18.3	Test cast
002	31 Mar 91	1956	44 16.1	46 44.1	En route to CTD station 11
003	31 Mar 91	2107	44 16.3	46 25.4	"
004	31 Mar 91	2207	44 16.9	46 10.0	"
005	31 Mar 91	2309	44 17.3	45 54.3	"
006	01 Apr 91	0125	44 18.6	45 20.6	"
007	01 Apr 91	0330	44 18.5	44 44.3	"
008	01 Apr 91	0515	44 18.5	44 20.3	"
009	01 Apr 91	0730	44 11.2	43 42.3	"
010	01 Apr 91	0900	44 06.1	43 17.0	"
011	01 Apr 91	1035	44 01.0	42 54.1	"
012	01 Apr 91	1200	43 57.8	42 32.6	"
013	01 Apr 91	1300	43 55.1	42 17.9	"
014	12 Apr 91	0800	49 31.1	43 26.2	En route to CTD station 34
015	12 Apr 91	0901	49 39.1	43 16.7	"
016	12 Apr 91	2054	49 50.2	43 18.3	En route to CTD station 35
017	12 Apr 91	2145	49 56.5	43 05.1	"
018	14 Apr 91	0610	50 34.2	42 42.6	En route to CTD station 36
019	16 Apr 91	1220	48 54.0	44 02.0	Detailed Survey
028	16 Apr 91	1324	48 49.6	44 06.9	"
029	16 Apr 91	1404	48 46.9	44 11.7	"
030	16 Apr 91	1427	48 43.7	44 15.7	"
031	16 Apr 91	1447	48 41.5	44 18.4	"
032	16 Apr 91	1505	48 38.4	44 22.2	"
033	16 Apr 91	1525	48 35.6	44 25.7	"
034	16 Apr 91	1545	48 32.8	44 29.2	"
035	16 Apr 91	1605	48 30.2	44 32.7	"
036	16 Apr 91	1815	48 24.9	44 03.6	"
037	16 Apr 91	1830	48 27.7	44 05.0	"
038	16 Apr 91	1854	48 31.5	44 07.0	"
039	16 Apr 91	1916	48 35.0	44 08.9	"
040	16 Apr 91	1937	48 38.9	44 11.0	"
041	16 Apr 91	2001	48 42.2	44 12.9	"
042	16 Apr 91	2022	48 45.9	44 14.8	"
043	16 Apr 91	2045	48 49.7	44 16.7	"
044	16 Apr 91	2106	48 53.3	44 18.6	"
045	16 Apr 91	2128	48 57.0	44 20.5	"
046	16 Apr 91	2150	49 00.5	44 22.3	"
047	16 Apr 91	2255	48 52.8	44 28.5	"
048	16 Apr 91	2321	48 48.7	44 31.1	"
049	16 Apr 91	2341	48 45.2	44 33.0	"
050	17 Apr 91	0010	48 44.9	44 25.6	"
051	17 Apr 91	0025	48 45.0	44 21.6	"
052	17 Apr 91	0040	48 45.0	44 17.6	"
053	17 Apr 91	0055	48 45.0	44 13.8	"
054	17 Apr 91	0109	48 44.3	44 10.3	"
056	17 Apr 91	0130	48 44.2	44 05.4	"
057	17 Apr 91	0145	48 44.2	44 01.2	"