Woods Hole Oceanographic Institution

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

The Long Term Upper Ocean Study
(LOTUS)

Cruise Summary and Hydrographic Data Report
ENDEAVOR 97
April 1983

by

Richard P. Trask and Melbourne G. Briscoe

October 1983

Technical Report

Prepared for the Office of Naval Research
under Contract N00014-76-C-0197; NR 083-400.

Approved for public release; distribution unlimited.

WOODS HOLE, MASSACHUSETTS 02543

WHOI-83-33

The Long Term Upper Ocean Study
(LOTUS)

Cruise Summary and Hydrographic Data Report
ENDEAVOR 97
April 1983

by

Richard P. Trask
and
Melbourne G. Briscoe

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

October 1983

Technical Report

Prepared for the Office of Naval Research under Contract N00014-76-C-0197; NR 083-400.

Approved for Distribution:

N. P. Fofonoff

N. P. Foforoff, Chairman
Department of Physical Oceanography

ABSTRACT

ENDEAVOR cruise number 97 (8-19 April, 1983) was the ninth scheduled cruise to the Long Term Upper Ocean Study (LOTUS) area centered at 34°N, 70°W. During the cruise three LOTUS moorings (a near-surface and two subsurface moorings) deployed eleven months earlier were recovered and replaced by a nearly identical set of moorings. The new array will remain in the water during the final year of LOTUS field work. The LOTUS surface mooring, scheduled to be recovered during ENDEAVOR 97, had been partially recovered one month earlier after the mooring parted and drifted off station. The lower portion of the surface mooring which went to the bottom when the mooring failed was successfully recovered during ENDEAVOR 97. A new surface mooring replacing the one that parted and a C. S. Draper Labs profiling current meter mooring were also set during the cruise.

Non-mooring work included deploying three satellite tracked drifter buoys and completing five CTD stations in the LOTUS area. Several intercomparisons between shipborne meteorological sensors and similar sensors on the LOTUS surface buoy and the drifter buoys were made. An XBT section was also completed along 70°W between 40°N and 34°N.

Part I of this report is a summary of the major cruise activities and part II presents the hydrographic data (CTD and XBT) collected during the cruise.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

The moorings set during ENDEAVOR cruise number 97 were designed, prepared and deployed by the WHOI Buoy Group, composed of personnel from the Physical Oceanography Department and the Ocean Structures and Moorings Section of the Ocean Engineering Department.

We are grateful for the skill of Captain John Tate and the personnel of the R/V ENDEAVOR. The expertise of Captain Emerson Hiller and the cooperation displayed by the personnel of the R/V KNORR greatly simplified the untimely recovery of the LOTUS-4 surface mooring. We sincerely thank Nancy Pennington who was responsible for organizing the graphics displayed in this report and for her review of the text.

This work was supported by the Office of Naval Research under Contract No. N00014-76-C-0197, NR 083-400.

Introduction

The main purpose of ENDEAVOR cruise 97 was to recover the Long Term Upper Ocean Study (LOTUS) moored array located in the vicinity of 34°N, 70°W, and to deploy a nearly identical array as a continuation of the two year long LOTUS field program (Briscoe and Trask, 1983). The recovery of the moored array produced the first year of current meter data from the LOTUS site thus marking the mid-point in the field program.

Figure 1 shows the LOTUS area (33°-35°N, 69°-71°W) relative to the Gulf Stream, the east coast of the United States and Bermuda. The site is in the mid-ocean away from the direct influences of topography and the Gulf Stream, in the path of hurricanes and Gulf Stream rings and at the edge of the region of eighteen degree water formation and high eddy kinetic energy.

The deployment of the moored array during ENDEAVOR 97 was the third of four science deployments planned for the LOTUS experiment. The first science deployment designated LOTUS-3 occurred in May 1982 and consisted of a surface mooring, a near-surface mooring and two subsurface moorings. Details of that deployment can be found in Trask and Briscoe (1983). The LOTUS surface mooring is replaced every six months whereas the near-surface and subsurface moorings are replaced once a year. In October-November 1982 the surface mooring deployed in May was replaced by a nearly identical surface mooring which was designated as LOTUS-4 (Trask and Briscoe, 1983). During ENDEAVOR 97 approximately eleven months after the original deployment the entire moored array was replaced. Part I of this report summarizes the major cruise events including the mooring work and the deployment of three satellite tracked drifter buoys. Part II presents the CTD stations and XBT section made during the cruise.

Following each LOTUS cruise a report of similar content to this will be issued. With the recovery of the entire moored array during ENDEAVOR 97 a data report presenting the moored current meter and thermistor chain data will be available. Table 1 gives the nominal contents and publication dates of the LOTUS report series.

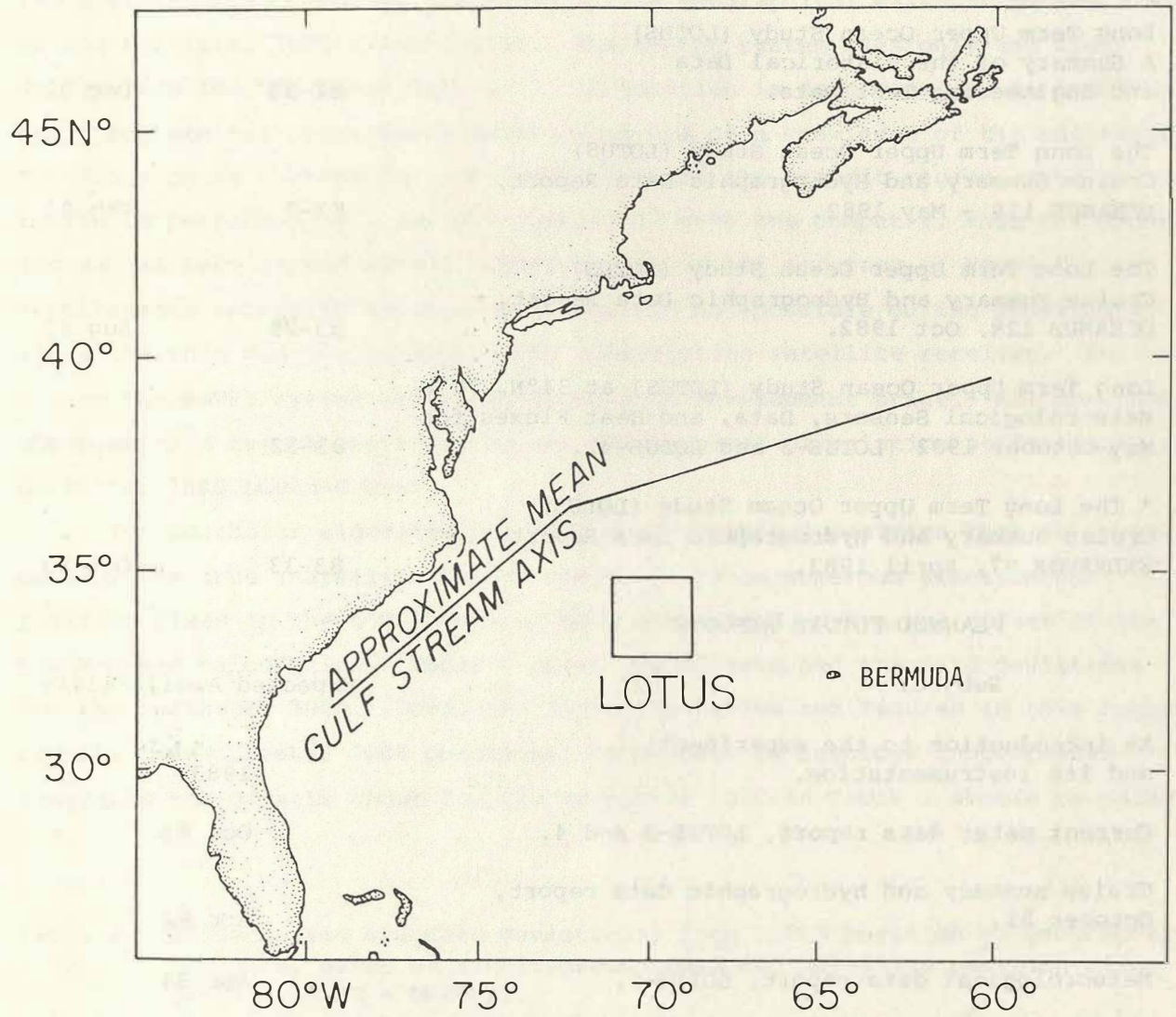

Figure 1. The location of the Long Term Upper-Ocean Study (LOTUS) area.

Table 1. LOTUS-related WHOI Technical Reports.

PRESENTLY AVAILABLE REPORTS

Title	WHOI No.	Date
Long Term Upper Ocean Study (LOTUS) A Summary of the Historical Data and Engineering Test Data.	82-53	Dec 82
The Long Term Upper Ocean Study (LOTUS) Cruise Summary and Hydrographic Data Report, OCEANUS 119 - May 1982.	83-7	Feb 83
The Long Term Upper Ocean Study (LOTUS) Cruise Summary and Hydrographic Data Report, OCEANUS 129, Oct 1982.	83-29	Aug 83
Long Term Upper Ocean Study (LOTUS) at 34°N, 70°W Meteorological Sensors, Data, and Heat Fluxes for May-October 1982 (LOTUS-3 and LOTUS-4).	83-32	Sept 83
* The Long Term Upper Ocean Study (LOTUS) Cruise Summary and Hydrographic Data Report, ENDEAVOR 97, April 1983.	83-33	Oct 83

PLANNED FUTURE REPORTS

Subject	Expected Availability
An introduction to the experiment and its instrumentation.	1983
Current meter data report, LOTUS-3 and 4.	Oct 83
Cruise summary and hydrographic data report, October 83.	Apr 84
Meteorological data report, LOTUS-5.	Apr 84
Cruise summary and hydrographic data report, April 84.	Oct 84
Meteorological data report, LOTUS-6.	Oct 84
Current meter data report, LOTUS-5 and 6.	Oct 84
A summary of the LOTUS experiment.	Jan 85

---

* This report.

Navigation

During ENDEAVOR 97 two systems of navigation, both based on LORAN C, were utilized. Positions from the more conventional system which has been used during previous LOTUS cruises are based on the geographical calculation performed by the Northstar 7000 LORAN-C unit. The second system uses only the time delays from the Northstar 7000 unit. A position is determined by an independent geographical calculation which makes use of a knowledge of the additional secondary phase factors for the LOTUS area and the transit region. The calculation is performed by a Hewlett-Packard 85 desk top computer, thus the second system has been termed NAV85. Confirmation of the accuracy of NAV85 through simultaneous satellite derived positions was not possible during ENDEAVOR 97 since the ship was not equipped with a navigation satellite receiver. For this reason the NAV85 system continues to be in a development stage. All positions shown in this report are based on the geographical calculation performed by the Northstar 7000 LORAN-C unit.

The Northstar algorithm provides a geographical position that is southeast of the true (satellite based) position. From numerous simultaneous position fixes in the LOTUS area we have determined an average offset of the LORAN-based calculation. Table 2 shows the offsets and standard deviations for the Northstar 7000. Positions listed in Tables and Figures in this report are all the Northstar 7000 positions; to convert to absolute geographical positions the offsets shown for the Northstar 7000 in Table 2 should be added.

Table 2. Offsets (and standard deviations) from LORAN position to geographical position, based on simultaneous LORAN and satellite position fixes (GEOG = LORAN + OFFSET).

	OFFSET (S.D.)		OFFSET (S.D.)	
UNIT	North	West	Range [km]*	Bearing
Northstar 7000	1.07' (.15)	1.24' (.16)	2.76' (.32)	316° (4)

* 1 km = .54 nautical miles.

PART I

Cruise Summary

ENDEAVOR 97

April 1983

Cruise number 97 of the R/V ENDEAVOR left Woods Hole on 8 April 1983 bound for the LOTUS area, i.e. the vicinity of 34°N, 70°W. The trip was the ninth* in a series of cruises planned for the LOTUS experiment. The cruise was twelve days long with the ENDEAVOR returning to Woods Hole on 19 April.

During the cruise the LOTUS near-surface and two subsurface moorings were recovered in their entirety along with approximately the lower 3400 m of the LOTUS surface mooring which had parted on 18 February 1983. The upper portion of the surface mooring containing the surface buoy and most of the instrumentation was recovered 236 kilometers west-southwest of its anchor position by the R/V KNORR on 10 March 1983. Details of the premature recovery of the LOTUS-4 surface buoy appear in Appendix I.

Upon arriving in the LOTUS area the remaining instrumentation and backup buoyancy from the parted surface mooring (mooring number 770) were recovered and a new surface mooring (mooring number 787) was deployed. The near-surface mooring (mooring number 766), east intermediate mooring (mooring number 765) and south intermediate mooring (mooring number 764) were recovered and replaced by moorings 788, 789 and 790 respectively, which were nearly identical to their recovered counterparts. Each mooring was recovered and replaced before attempting another recovery. This deployment of the LOTUS moored array has been designated as LOTUS-5.

Prior to the recovery of mooring 765 three test releases on the mooring were interrogated in order to evaluate their performance after one year. The test releases were then redeployed for an additional year on mooring 789. Upon arriving at the deployed anchor position of mooring 764 the release did not respond to interrogation. An attempt however was made to fire the release. A faint warble from the radio on the mooring was detected approximately 20 minutes later indicating that the mooring had come to the surface. A series of ship maneuvers and relative radio signal intensities indicated that the

---

* This does not include ship-of-opportunity work to the LOTUS area.

mooring was to the southwest of its deployed anchor position. The distance between the deployed anchor position and the final recovery site of 764 was 22 km. Since the mooring could not drift this far in the time period between firing the release and recovering the mooring it is therefore assumed that the mooring dragged its anchor sometime during the deployment period. An attempt will be made to determine the approximate time when the mooring moved after examining the current meter records.

Additional mooring work in the LOTUS area consisted of setting a C. S. Draper Labs-M.I.T. profiling current meter (PCM) mooring in cooperation with C. Eriksen of MIT. Figure 2 is a chart of a section of the LOTUS area showing the location of the four LOTUS moorings and the PCM mooring following ENDEAVOR cruise 97. Mooring diagrams appear in Figure 3. The instrument depths shown in Figure 3 are design depths, actual depths may vary slightly. Table 3 summarizes the mooring deployment times and positions.

Non-mooring work included the deployment of three satellite tracked drifter buoys in cooperation with W. Large (NCAR). Each drifter has a two meter tower on which are mounted several meteorological sensors which measure wind speed and direction, air temperature and relative humidity. Sea surface temperature is measured by a thermistor in contact with the buoy hull. Ten subsurface temperature measurements are made by a 125 meter long electromechanical cable that hangs below the drifter. Nine of the ten temperature measurements are made above 50 meters depth and the tenth is made at 100 meters. This particular sampling scheme was chosen in order to monitor the establishment and destruction of the daily thermocline as well as the establishment of the seasonal thermocline in response to strong surface heating.

Also at 100 m there is a hydrophone which measures ambient acoustic noise at three frequencies between 4 and 15 kilohertz. These signals will be used to infer wind stress and speed at the surface and also to tell when it is raining.

Tracking and data acquisition are achieved with an ARGOS satellite based data collection system. The data collected by the drifter buoy is transmitted via satellite to the National Environmental Satellite Service (NESS) center in Maryland and then to the ARGOS processing center in France where a position is computed, the data is processed and put on tape. The information is then transmitted back to Maryland where the most recent data can be accessed by telephone.

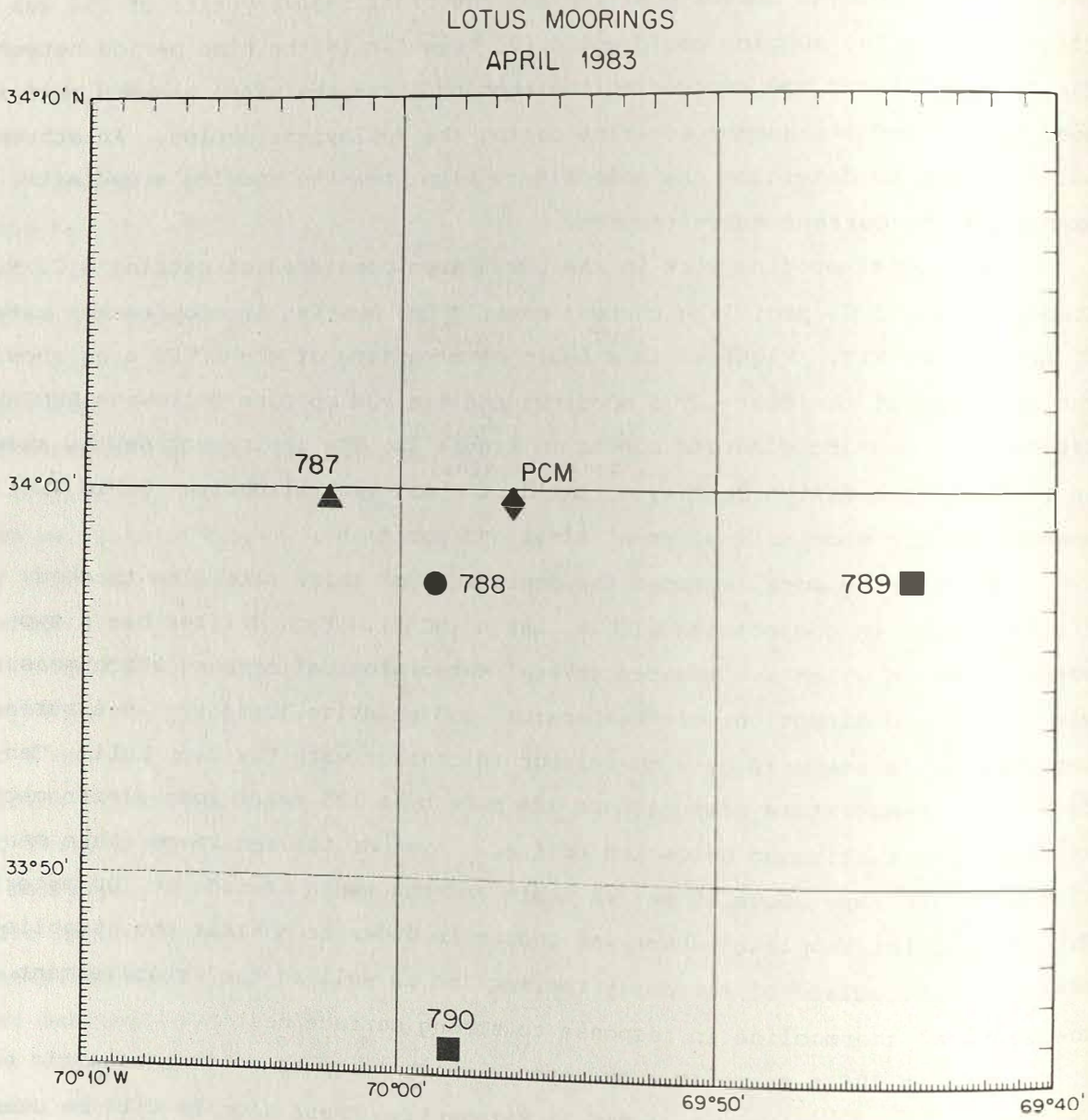

Figure 2. A chart of a section of the LOTUS area showing the location of the LOTUS surface mooring (▲), near-surface mooring (●), and subsurface moorings (■) following ENDEAVOR cruise 97.

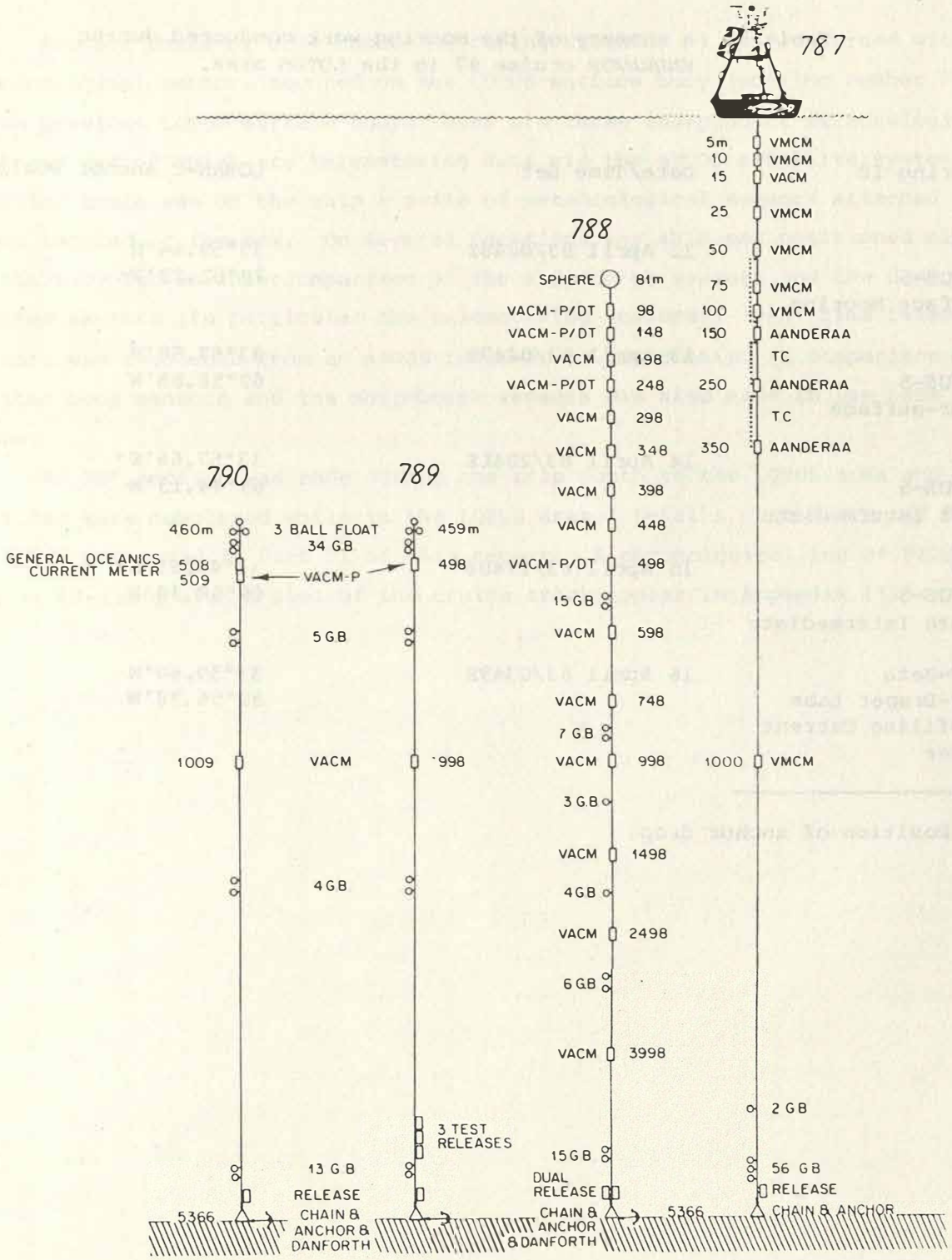

Figure 3. Mooring diagrams of the four LOTUS moorings set during ENDEAVOR 97. The instrument depths shown are design depths, actual depths may vary slightly.

Table 3. A summary of the mooring work conducted during ENDEAVOR cruise 97 in the LOTUS area.

Mooring ID	Date/Time Set	LORAN-C Anchor Position
787 LOTUS-5 Surface Mooring	12 April 83/0048Z	33°59.64'N 70°02.22'W
788 LOTUS-5 Near-surface	13 April 83/0447Z	33°57.58'N 69°58.88'W
789 LOTUS-5 East Intermediate	14 April 83/2041Z	33°57.66'N* 69°44.13'W
790 LOTUS-5 South Intermediate	15 April 83/1740Z	33°45.65'N* 69°58.38'W
PCM-Zeta MIT-Draper Labs Profiling Current Meter	16 April 83/0349Z	33°59.60'N 69°56.38'W

* Position of anchor drop.

Another phase of work conducted during ENDEAVOR 97 was concerned with the meteorological sensors mounted on the LOTUS surface buoy (mooring number 787). As on previous LOTUS surface buoys there are three independent meteorological packages two of which are telemetering data via the ARGOS satellite system. In addition there was on the ship a suite of meteorological sensors attached to a tower located at the bow. On several occasions the ship was positioned close to the buoy for an intercomparison of the ship-borne sensors and the buoy mounted sensors (in particular the telemetering sensors). Real time telemetered data was available from an ARGOS receiver on board ship. A comparison of drifter buoy sensors and the ship-borne sensors was also made in the same manner.

An XBT section was made during the trip south to the LOTUS area and 5 CTD stations were completed while in the LOTUS area. Details of the XBT and CTD work are presented in Part II of this report. A chronological log of ENDEAVOR cruise 97 along with a plot of the cruise track appear in Appendix II.

PART II

Hydrographic Data

a. CTD Data

Five CTD station were made in the LOTUS area (Figure 4) during ENDEAVOR cruise 97. The CTD measurements were made by a Neil Brown Instrument Systems internal recording conductivity-temperature-depth profiler (CTD/IR). Mechanical and operational details of the LOTUS CTD/IR are found in Trask (1981).

CTD stations 1 and 4 were made in close proximity to the east and south subsurface moorings respectively. Stations 2 and 3 were made to the north and west of the moored array respectively. Station 5 consists of a series of shallow yo-yos (several down and up profiles) between the surface and 202 meters in the vicinity of the PCM mooring. These short profiles were made at approximately the same time and over the same depth range that the PCM instrument was designed to operate.

Stations 2 and 3 are slightly shallower than planned due to a combination of winch problems, large wire angles and early messenger drops. A summary of the CTD/IR stations taken during ENDEAVOR cruise 97 appear in Table 4.

Calibration and preliminary data processing procedures are found in Briscoe and Trask (1983); a brief summary follows.

Data Presentation

The CTD/IR data are presented in two forms, tabular listings and graphical profiles. The profiles are reproductions of the original computer plots. Included here are profiles of potential temperature, salinity, Brunt Väisälä frequency, and potential density referenced to the surface (Figures 5-9). Full depth profiles as well as profiles of the upper 750 meters are presented. In addition a potential temperature-salinity diagram is presented for each station. The listings of data (Tables 5-9) include the above parameters plus sigma-t, potential temperature gradient, dynamic height, and sound speed, all at standard pressures as well as at the design depths of the instrumentation on the moorings.

The heading of the tabular listing includes the ship name (EN = ENDEAVOR) and cruise number, CTD number, year, year day, time, the latitude and longitude (LORAN-7000 position) of the CTD station when it started and the water depth at

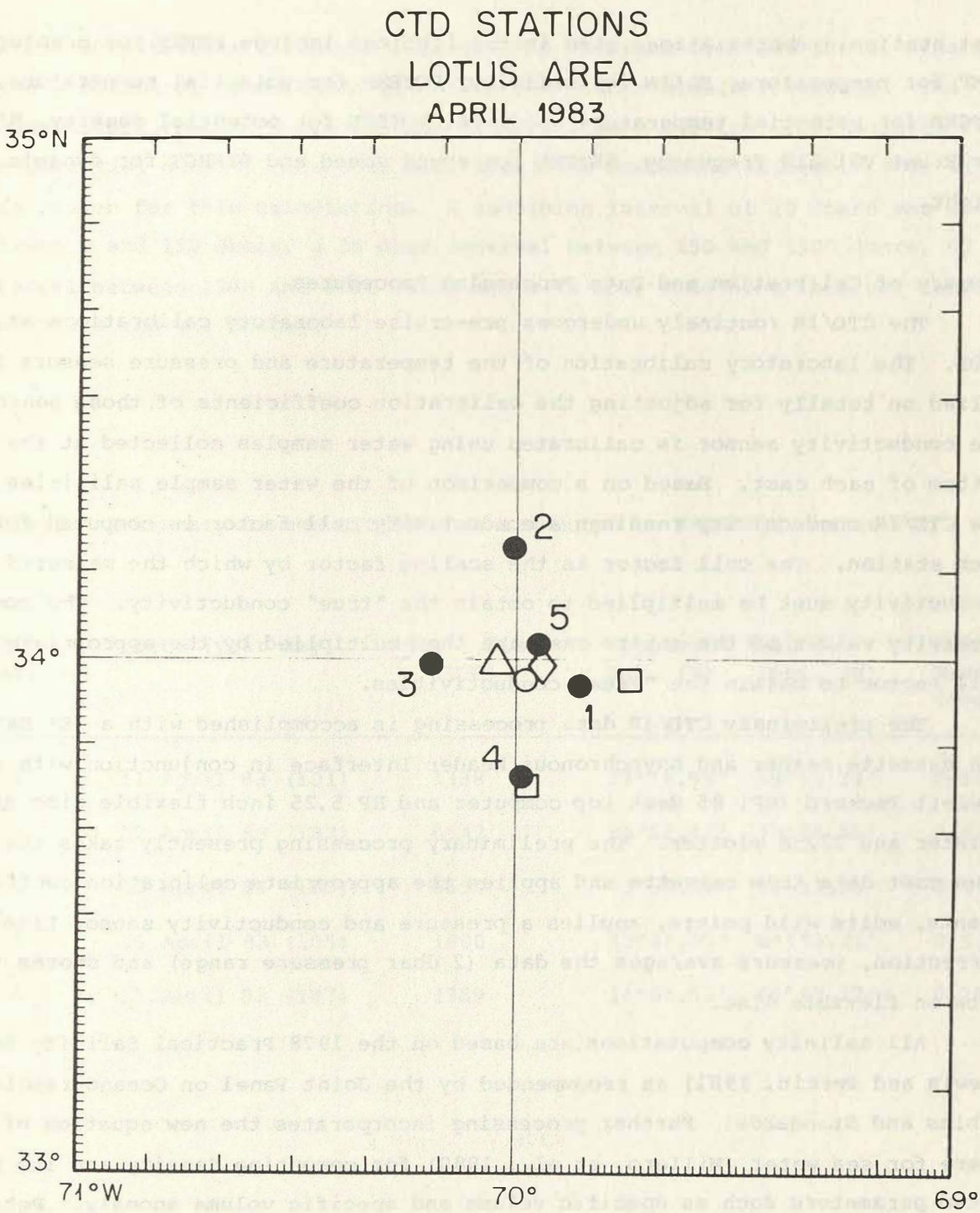

Figure 4. Chart of the LOTUS area showing the locations of the CTD/IR stations (●) made during ENDEAVOR 97 and their proximity to the LOTUS surface mooring (Δ), near-surface mooring (O), and subsurface moorings (□).

that station. Abbreviations used in the listings include PRESS for pressure, TEMP for temperature, SALIN for salinity, POTEMP for potential temperature, POTGRD for potential temperature gradient, POTDEN for potential density, BR-V for Brunt Väisälä frequency, SSPEED for sound speed and DYNHGT for dynamic height.

Summary of Calibration and Data Processing Procedures

The CTD/IR routinely undergoes pre-cruise laboratory calibrations at WHOI. The laboratory calibration of the temperature and pressure sensors is relied on totally for adjusting the calibration coefficients of those sensors. The conductivity sensor is calibrated using water samples collected at the bottom of each cast. Based on a comparison of the water sample salinities and the CTD/IR conductivity readings a conductivity cell factor is computed for each station. The cell factor is the scaling factor by which the measured conductivity must be multiplied to obtain the "true" conductivity. The conductivity values of the entire cast are then multiplied by the appropriate cell factor to obtain the "true" conductivities.

The preliminary CTD/IR data processing is accomplished with a SEA DATA 12A cassette reader and Asynchronous Reader Interface in conjunction with a Hewlett Packard (HP) 85 desk top computer and HP 5.25 inch flexible disc drive, printer and 7225B plotter. The preliminary processing presently takes the raw down cast data from cassette and applies the appropriate calibration coefficients, edits wild points, applies a pressure and conductivity sensor time lag correction, pressure averages the data (2 dbar pressure range) and stores the data on flexible disc.

All salinity computations are based on the 1978 Practical Salinity Scale (Lewis and Perkin, 1981) as recommended by the Joint Panel on Oceanographic Tables and Standards. Further processing incorporates the new equation of state for sea water (Millero, et al., 1980) for computing density and its related parameters such as specific volume and specific volume anomaly. Potential temperature at a reference pressure is computed using a fourth order Runge Kutta integration algorithm (Fofonoff, 1977) which uses the Bryden (1973) polynomial for adiabatic lapse rate. Sound speed calculations are based on the algorithms of Chen and Millero (1977). These algorithms are the basis of

further computations which yield quantities of sigma-t, sigma-theta, dynamic height, potential temperature gradients and Brunt-Väisälä frequency. The Brunt-Väisälä frequency calculation incorporates a sliding least squares fit to the potential density data over user specified smoothing windows. Four windows were chosen for this calculation. A smoothing interval of 10 dbars was used between 0 and 150 dbars, a 30 dbar interval between 150 and 1500 dbars, 62 dbar interval between 1500 and 3500 dbars and a 90 dbar smoothing interval between 3500 dbars and the bottom.

Table 4: A summary of the CTD/IR work conducted on ENDEAVOR cruise 97.

CTD Station	Date (year day)	Start Time (UTC)	Deployed Position Lat. (N)	Long. (W)	Pressure Range (dbar)
1	11 April 83 (101)	1338	33°56.99'	69°51.22'	0-5088
2	12 April 83 (102)	0542	34°12.43'	70°00.51'	0-4710
3	13 April 83 (103)	0634	33°59.14'	70°11.19'	0-4908
4	15 April 83 (105)	1800	33°46.25'	69°59.21'	0-5306
5	17 April 83 (107)	1359	34°01.53'	69°57.12'	0-202

Table 5: Listing of CTD data and derived quantities for station 1.

EN097 CTD 001 1983 101 1338Z 33 56.99N 69 51.22W corrD: 5366m

PRESS dbar	TEMP °C	SALIN psu	POTEMP °C	POTGRD m°C/db	SIGMA-t kg/m**3	POTDEN kg/m**3	BR-V cph	SSPEED m/s	DYNHGT dyn m
2.	19.993	36.381	19.993	0.00	25.834	25.819	0.00	1523.0	0.0000
6.	19.985	36.412	19.984	3.10	25.860	25.845	3.75	1523.1	.0088
10.	19.984	36.423	19.982	2.18	25.869	25.854	2.50	1523.2	.0176
16.	19.979	36.435	19.976	-.87	25.879	25.865	1.82	1523.3	.0303
20.	19.978	36.435	19.974	-.58	25.880	25.865	1.07	1523.3	.0387
26.	19.970	36.436	19.965	1.59	25.882	25.868	.54	1523.4	.0519
30.	19.971	36.436	19.966	.72	25.882	25.868	-.86	1523.5	.0597
36.	19.969	36.436	19.962	3.88	25.883	25.869	1.53	1523.6	.0726
50.	19.916	36.446	19.907	13.15	25.904	25.891	3.06	1523.7	.1025
66.	19.762	36.457	19.750	7.15	25.953	25.941	2.15	1523.5	.1365
76.	19.734	36.459	19.720	1.13	25.962	25.950	1.18	1523.6	.1568
100.	19.607	36.482	19.588	16.90	26.014	26.003	3.77	1523.7	.2063
126.	19.377	36.508	19.354	14.03	26.093	26.084	3.28	1523.5	.2589
150.	19.160	36.528	19.133	18.95	26.165	26.156	2.88	1523.3	.3049
200.	18.839	36.529	18.803	6.82	26.248	26.242	1.91	1523.3	.3991
250.	18.705	36.527	18.660	4.99	26.281	26.277	1.17	1523.7	.4908
300.	18.642	36.528	18.588	.18	26.298	26.296	1.32	1524.4	.5825
350.	18.491	36.526	18.429	23.74	26.335	26.335	2.08	1524.7	.6733
400.	18.277	36.536	18.206	9.01	26.396	26.399	1.72	1525.0	.7631
450.	18.005	36.514	17.927	4.77	26.447	26.451	1.77	1525.0	.8509
500.	17.791	36.491	17.704	1.01	26.482	26.489	1.41	1525.2	.9371
550.	17.515	36.445	17.420	7.30	26.515	26.523	1.95	1525.1	1.0230
600.	17.220	36.395	17.118	4.12	26.549	26.558	1.86	1525.0	1.1081
650.	16.357	36.236	16.251	8.81	26.632	26.642	2.24	1523.1	1.1906
700.	15.769	36.135	15.656	58.35	26.691	26.701	2.68	1522.0	1.2706
750.	14.726	35.961	14.611	13.51	26.790	26.799	2.83	1519.3	1.3466
800.	13.729	35.805	13.612	19.99	26.883	26.892	2.37	1516.8	1.4181
900.	11.220	35.448	11.104	43.52	27.102	27.106	2.91	1509.5	1.5478
1000.	9.223	35.224	9.107	-11.14	27.277	27.277	2.95	1503.8	1.6565
1100.	7.299	35.116	7.187	8.67	27.488	27.484	2.30	1498.1	1.7455
1200.	6.210	35.083	6.096	11.37	27.611	27.606	2.21	1495.5	1.8175
1300.	5.474	35.064	5.357	13.10	27.690	27.683	1.86	1494.2	1.8793
1400.	5.097	35.059	4.974	2.62	27.732	27.725	1.00	1494.3	1.9347
1500.	4.755	35.038	4.626	.68	27.755	27.749	.88	1494.6	1.9875
1600.	4.540	35.028	4.404	1.45	27.771	27.765	.79	1495.3	2.0387
1800.	4.241	35.012	4.090	.33	27.791	27.786	.66	1497.4	2.1389
2000.	4.002	35.004	3.835	1.64	27.810	27.807	.64	1499.8	2.2375
2200.	3.816	35.000	3.632	.89	27.827	27.824	.69	1502.4	2.3342
2400.	3.571	34.985	3.371	.07	27.840	27.838	.68	1504.7	2.4293
2500.	3.507	34.986	3.298	1.59	27.847	27.846	.69	1506.1	2.4763
2600.	3.397	34.980	3.179	.24	27.853	27.852	.64	1507.3	2.5229
2800.	3.205	34.967	2.971	1.33	27.861	27.862	.62	1509.9	2.6152
3000.	3.055	34.956	2.803	1.85	27.867	27.868	.70	1512.6	2.7068
3200.	2.866	34.946	2.597	.39	27.876	27.878	.57	1515.2	2.7968
3400.	2.719	34.938	2.431	1.61	27.883	27.886	.58	1518.0	2.8857
3600.	2.592	34.930	2.286	.15	27.888	27.892	.55	1520.9	2.9735
3800.	2.503	34.923	2.178	.56	27.889	27.895	.50	1523.9	3.0607
4000.	2.427	34.918	2.081	.74	27.892	27.900	.46	1527.0	3.1483
4200.	2.368	34.913	2.000	.25	27.893	27.902	.32	1530.2	3.2362
4400.	2.341	34.908	1.950	.15	27.891	27.902	.27	1533.6	3.3252
4600.	2.329	34.904	1.915	.12	27.889	27.901	.22	1537.0	3.4159
4800.	2.320	34.901	1.881	.25	27.888	27.902	.23	1540.4	3.5084
5000.	2.313	34.897	1.850	.08	27.885	27.901	.29	1543.8	3.6029

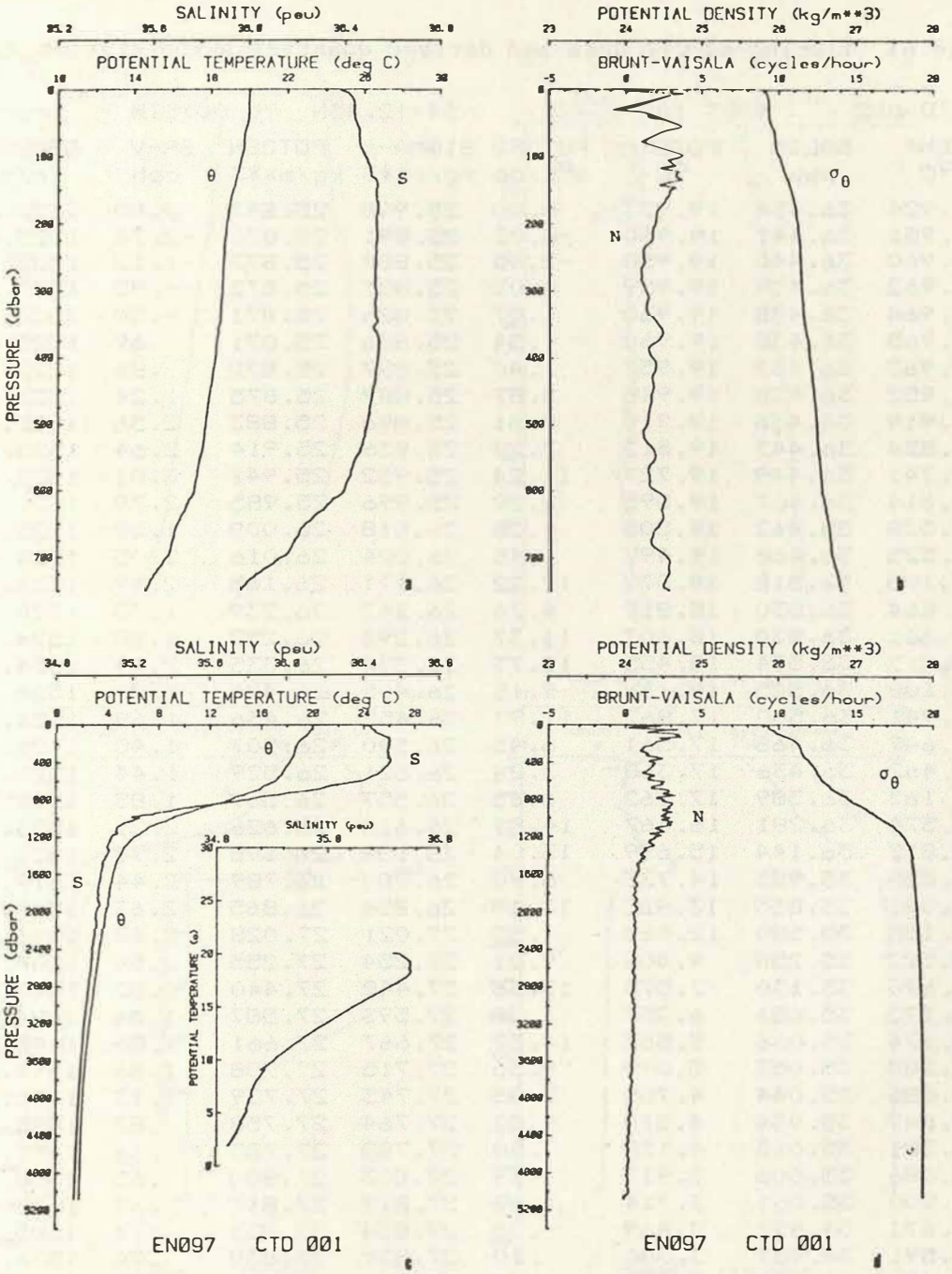

Figure 5. CTD station 1. Profiles of potential temperature (θ) and salinity (S), and Brunt-Väisälä frequency (N) and potential density (σ_θ) for the upper 750 m (a and b respectively) and for the entire cast (c and d respectively). θ-S diagram included in c.

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-83-33	2.	3. Recipient's Accession No.

4. Title and Subtitle

The Long Term Upper Ocean Study (LOTUS)
Cruise Summary and Hydrographic Data Report
ENDEAVOR 97 April 1983

5. Report Date: October 1983

6.

7. Author(s): Richard P. Trask and Melbourne G. Briscoe

8. Performing Organization Rept. No. WHOI-83-33

9. Performing Organization Name and Address

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C) N00014-76-C-0197;
(G) NR 083-400

12. Sponsoring Organization Name and Address

Office of Naval Research
Environmental Sciences Directorate
Arlington, VA 22217

13. Type of Report & Period Covered: Technical

14.

15. Supplementary Notes

This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept. WHOI-83-33.

16. Abstract (Limit: 200 words)

ENDEAVOR cruise number 97 (8-19 April, 1983) was the ninth scheduled cruise to the Long Term Upper Ocean Study (LOTUS) area centered at 34°N, 70°W. During the cruise three LOTUS moorings (a near-surface and two subsurface moorings) deployed eleven months earlier were recovered and replaced by a nearly identical set of moorings. The new array will remain in the water during the final year of LOTUS field work. The LOTUS surface mooring, scheduled to be recovered during ENDEAVOR 97, had been partially recovered one month earlier after the mooring parted and drifted off station. The lower portion of the surface mooring which went to the bottom when the mooring failed was successfully recovered during ENDEAVOR 97. A new surface mooring replacing the one that parted and a C. S. Draper Labs profiling current meter mooring were also set during the cruise.

Non-mooring work included deploying three satellite tracked drifter buoys and completing five CTD stations in the LOTUS area. Several intercomparisons between shipborne meteorological sensors and similar sensors on the LOTUS surface buoy and the drifter buoys were made. An XBT section was also completed along 70°W between 40°N and 34°N.

Part I of this report is a summary of the major cruise activities and part II presents the hydrographic data (CTD and XBT) collected during the cruise.

17. Document Analysis a. Descriptors

1. LOTUS
2. Hydrographic Data
3. Sargasso Sea

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement:	19. Security Class (This Report)	21. No. of Pages
Approved for public release; distribution unlimited.	Unclassified	46
	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

MANDATORY DISTRIBUTION LIST

FOR UNCLASSIFIED TECHNICAL REPORTS, REPRINTS, AND FINAL REPORTS PUBLISHED BY OCEANOGRAPHIC CONTRACTORS OF THE OCEAN SCIENCE AND TECHNOLOGY DIVISION OF THE OFFICE OF NAVAL RESEARCH

(Revised October 1983)

1 *Deputy Under Secretary of Defense*
(Research and Advanced Technology)
Military Assistant for Environmental Science
Room 3D129
Washington, DC 20301

Office of Naval Research
800 North Quincy Street
Arlington, VA 22217

3 *Attn: (Code applicable to Program) **

1 *Attn: Code 420C*

2 *Attn: Code 102C*

Commanding Officer
Naval Research Laboratory
Washington, DC 20375

6 *Attn: Library Code 2627*

1 *Attn: Library Code 2620, Mr. Peter Imhof*

12 *Defense Technical Information Center*
Cameron Station
Alexandria, VA 22314
Attn: DCA

Commander
Naval Oceanographic Office
NSTL Station
Bay St. Louis, MS 39522

1 *Attn: Code 8100*

1 *Attn: Code 6000*

1 *Attn: Code 3300*

1 *NODC/NOAA*
Code D781
Wisconsin Avenue, N.W.
Washington, DC 20235

Applicable Codes: 422 (PO); 422CB (Chem/Bio); 422CS (Coastal); 425 (G&G); 425AR (Arctic); 421 (OE); 421SP (Ships); 425OA (Ocean Acoustics); 425UA (Underwater Acoustics)

Table 6: Listing of CTD data and derived quantities for station 2.1

EN097 CTD 002 1983 102 0542Z 34 12.43N 70 00.51W corrD: 5391m

PRESS dbar	TEMP °C	SALIN psu	POTEMP °C	POTGRD m°C/db	SIGMA-t kg/m**3	POTDEN kg/m**3	BR-V cph	SSPEED m/s	DYNHGT dyn m
2.	19.924	36.454	19.923	0.00	25.908	25.893	0.00	1522.9	0.0000
6.	19.951	36.441	19.950	-6.021	25.891	25.876	-2.741	1523.0	.0083
10.	19.960	36.440	19.958	-2.051	25.888	25.873	-1.131	1523.1	.0168
16.	19.962	36.439	19.959	-.03	25.887	25.872	-.921	1523.2	.0289
20.	19.964	36.438	19.960	.07	25.886	25.871	-.501	1523.3	.0378
26.	19.965	36.438	19.960	.54	25.886	25.871	.69	1523.4	.0507
30.	19.963	36.439	19.957	.40	25.887	25.872	.86	1523.5	.0593
36.	19.952	36.438	19.945	2.87	25.889	25.875	1.24	1523.5	.0719
50.	19.919	36.436	19.910	5.81	25.896	25.883	2.56	1523.7	.1016
66.	19.824	36.443	19.812	3.29	25.926	25.914	2.64	1523.7	.1359
76.	19.741	36.449	19.727	11.24	25.952	25.941	3.01	1523.6	.1570
100.	19.614	36.461	19.595	8.29	25.9961	25.985	2.791	1523.7	.2065
126.	19.528	36.462	19.505	-.38	26.0181	26.009	1.021	1523.9	.2595
150.	19.525	36.468	19.497	1.48	26.0241	26.016	2.051	1524.3	.3079
200.	19.108	36.518	19.072	17.22	26.1711	26.165	2.771	1524.0	.4077
250.	18.864	36.530	18.819	4.76	26.2421	26.239	1.731	1524.2	.5014
300.	18.661	36.530	18.607	11.37	26.2951	26.293	1.881	1524.4	.5945
350.	18.517	36.534	18.455	12.73	26.3341	26.335	2.041	1524.8	.6855
400.	18.208	36.525	18.138	9.15	26.4051	26.408	1.80	1524.8	.7750
450.	17.941	36.500	17.8621	11.97	26.4521	26.456	1.68	1524.8	.8623
500.	17.647	36.468	17.5611	6.451	26.5001	26.507	1.431	1524.7	.9482
550.	17.462	36.436	17.3681	3.281	26.5211	26.529	1.44	1525.0	1.0330
600.	17.1631	36.389	17.0621	6.651	26.5571	26.567	1.851	1524.9	1.11731
650.	16.5741	36.281	16.4671	14.87	26.6151	26.626	2.211	1523.8	1.2005
700.	15.8121	36.144	15.6991	13.04	26.6881	26.698	2.741	1522.1	1.2809
750.	14.8501	35.9831	14.735	6.90	26.7801	26.789	2.441	1519.8	1.35691
800.	14.0411	35.8551	13.9221	11.17	26.856	26.865	2.631	1517.8	1.4300
900.	12.1851	35.5801	12.0631	.55	27.0211	27.028	2.481	1513.0	1.5642
1000.	9.522	35.2581	9.404	9.01	27.2541	27.255	2.591	1504.9	1.6791
1100.	7.690	35.1301	7.575	13.36	27.4421	27.440	2.821	1499.6	1.7733
1200.	6.372	35.0861	6.257	1.28	27.5931	27.587	1.861	1496.1	1.84821
1300.	5.674	35.0661	5.555	14.52	27.6671	27.661	1.861	1495.0	1.91231
1400.	5.203	35.0531	5.079	9.36	27.715	27.708	1.56	1494.7	1.9705
1500.	4.886	35.0441	4.755	3.86	27.7451	27.739	1.131	1495.1	2.02501
1600.	4.647	35.0341	4.510	.57	27.764	27.758	.821	1495.8	2.0775
1800.	4.281	35.0131	4.128	.58	27.7881	27.783	.661	1497.6	2.1793
2000.	4.086	35.0061	3.917	-.34	27.803	27.800	.65	1501.1	2.2791
2200.	3.900	35.0011	3.714	1.67	27.819	27.817	.641	1502.7	2.37781
2400.	3.671	34.9911	3.469	-.38	27.8341	27.833	.711	1505.1	2.4751
2500.	3.591	34.9871	3.380	.10	27.8391	27.839	.741	1506.5	2.5234
2600.	3.497	34.9831	3.278	.29	27.8461	27.846	.671	1507.7	2.5710
2800.	3.315	34.9721	3.079	2.38	27.8541	27.855	.741	1510.4	2.6659
3000.	3.1441	34.9601	2.890	.38	27.861	27.864	.501	1513.0	2.75941
3200.	2.9901	34.9491	2.718	.47	27.8671	27.870	.46	1515.8	2.85261
3400.	2.8541	34.9411	2.563	.33	27.8731	27.877	.501	1518.6	2.9446
3600.	2.7111	34.9321	2.402	.44	27.8791	27.884	.53	1521.4	3.0363
3800.	2.5931	34.9251	2.265	.29	27.8831	27.890	.611	1524.3	3.12701
4000.	2.4931	34.9181	2.145	.53	27.887	27.895	.501	1527.3	3.21711
4200.	2.4221	34.9111	2.053	.25	27.8871	27.897	.431	1530.5	3.30711
4400.	2.3731	34.9071	1.9821	.01	27.888	27.898	.401	1533.7	3.39771
4600.	2.3391	34.9011	1.924	.32	27.8861	27.898	.32	1537.0	3.48941

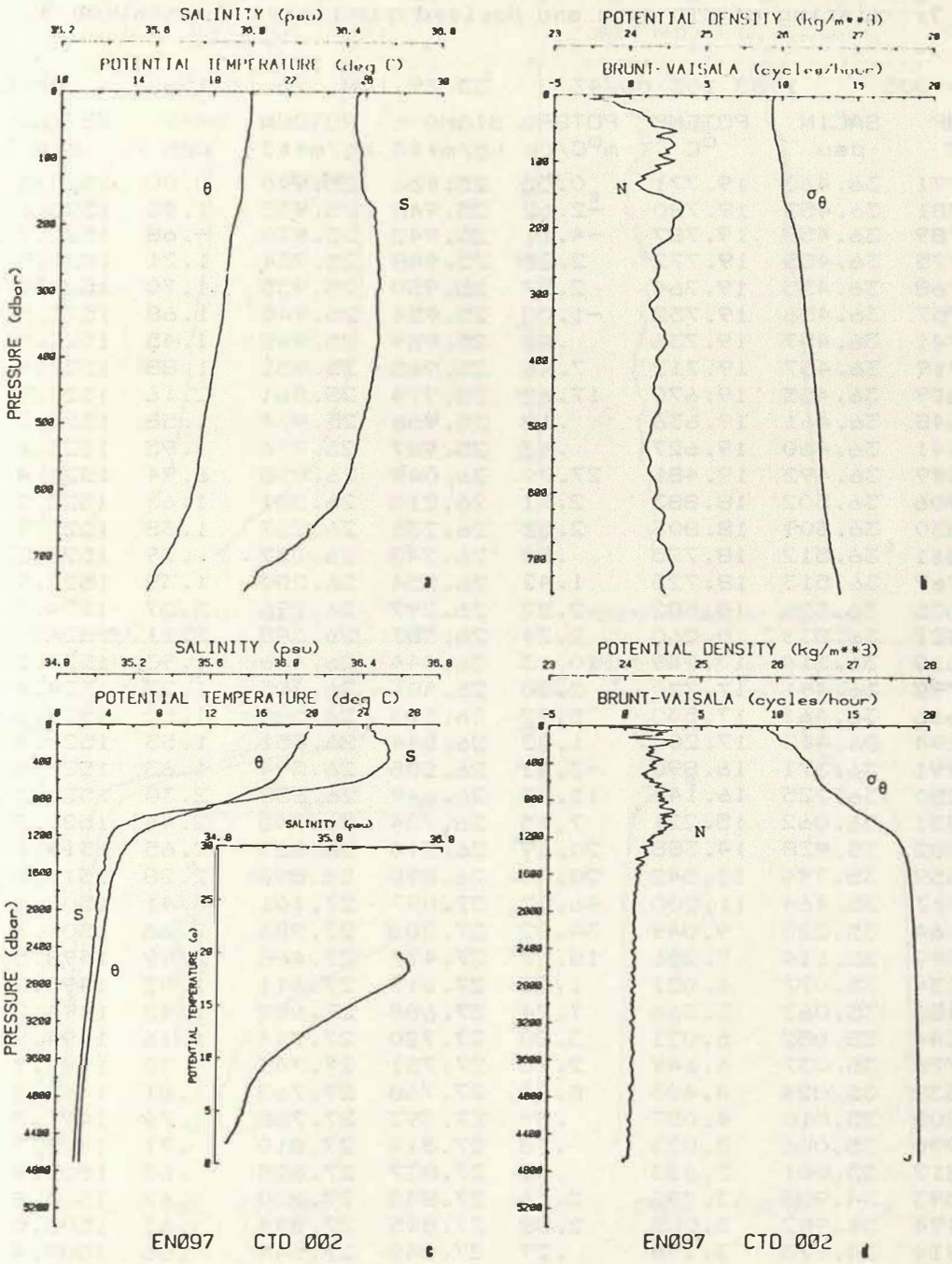

Figure 6. CTD station 2. Profiles of potential temperature (θ) and salinity (S), and Brunt-Väisälä frequency (N) and potential density (σ_θ) for the upper 750 m (a and b respectively) and for the entire cast (c and d respectively). θ-S diagram included in c.

Table 7: Listing of CTD data and derived quantities for station 3.

EN097 CTD 003 1983 103 0634Z 33 59.14N 70 11.19W corrD: 5366m

PRESS dbar	TEMP °C	SALIN psu	POTEMP °C	POTGRD m°C/db	SIGMA-t kg/m**3	POTDEN kg/m**3	BR-V cph	SSPEED m/s	DYNHGT dyn m
2.	19.771	36.463	19.771	0.00	25.956	25.940	0.00	1522.5	0.0000
6.	19.781	36.457	19.780	-2.12	25.948	25.933	-1.98	1522.6	.0082
10.	19.789	36.455	19.787	-4.11	25.945	25.930	-.68	1522.7	.0167
16.	19.775	36.455	19.772	2.28	25.948	25.934	1.21	1522.7	.0286
20.	19.768	36.455	19.764	2.57	25.950	25.935	1.70	1522.8	.0369
26.	19.757	36.456	19.752	-1.00	25.954	25.940	1.68	1522.9	.0490
30.	19.741	36.457	19.736	.88	25.959	25.945	1.45	1522.9	.0574
36.	19.719	36.457	19.712	7.46	25.965	25.951	1.88	1522.9	.0703
50.	19.679	36.455	19.670	17.62	25.974	25.961	2.16	1523.0	.0983
66.	19.648	36.461	19.636	.18	25.986	25.974	.58	1523.2	.1313
76.	19.641	36.460	19.627	.43	25.987	25.976	.95	1523.4	.1521
100.	19.499	36.492	19.481	27.79	26.049	26.038	6.94	1523.4	.2013
126.	18.906	36.502	18.883	2.71	26.210	26.201	1.67	1522.2	.2503
150.	18.830	36.509	18.803	2.52	26.235	26.227	1.38	1522.4	.2945
200.	18.811	36.512	18.775	.88	26.243	26.237	.79	1523.2	.3872
250.	18.769	36.513	18.725	1.42	26.254	26.250	1.39	1523.9	.4790
300.	18.635	36.526	18.582	2.52	26.297	26.296	2.27	1524.3	.5727
350.	18.321	36.533	18.260	2.24	26.383	26.383	2.11	1524.3	.6620
400.	18.019	36.514	17.949	10.13	26.444	26.446	1.93	1524.2	.7495
450.	17.798	36.491	17.720	2.80	26.481	26.485	1.23	1524.4	.8353
500.	17.616	36.461	17.530	5.72	26.503	26.509	1.52	1524.6	.9203
550.	17.294	36.412	17.200	1.22	26.544	26.551	1.53	1524.4	1.0044
600.	16.991	36.371	16.890	-3.91	26.585	26.594	1.63	1524.3	1.0880
650.	16.250	36.225	16.144	13.93	26.649	26.658	2.30	1522.7	1.1693
700.	15.331	36.062	15.221	7.15	26.734	26.743	2.44	1520.5	1.2475
750.	14.502	35.928	14.388	20.39	26.814	26.823	2.65	1518.6	1.3219
800.	13.659	35.794	13.542	28.40	26.890	26.898	2.28	1516.5	1.3935
900.	11.317	35.464	11.200	46.02	27.097	27.101	3.41	1509.9	1.5236
1000.	9.164	35.223	9.049	34.52	27.286	27.286	2.68	1503.6	1.6310
1100.	7.399	35.114	7.286	18.27	27.472	27.468	2.99	1498.5	1.7200
1200.	6.134	35.077	6.021	1.88	27.617	27.611	1.92	1495.2	1.7919
1300.	5.483	35.063	5.366	7.24	27.688	27.682	1.42	1494.2	1.8532
1400.	5.144	35.052	5.021	3.20	27.720	27.714	1.16	1494.5	1.9097
1500.	4.778	35.037	4.649	2.15	27.751	27.745	.90	1494.7	1.9635
1600.	4.539	35.024	4.403	8.74	27.768	27.762	.81	1495.3	2.0150
1800.	4.208	35.010	4.057	.39	27.793	27.788	.74	1497.3	2.1153
2000.	3.990	35.006	3.823	.78	27.814	27.810	.71	1499.7	2.2133
2200.	3.817	35.001	3.633	.88	27.827	27.825	.67	1502.4	2.3096
2400.	3.593	34.988	3.393	2.16	27.840	27.838	.67	1504.8	2.4047
2500.	3.494	34.982	3.285	2.58	27.845	27.844	.63	1506.0	2.4517
2600.	3.414	34.978	3.196	.27	27.849	27.849	.56	1507.4	2.4985
2800.	3.247	34.967	3.012	.96	27.857	27.858	.62	1510.1	2.5920
3000.	3.062	34.955	2.809	-.28	27.865	27.866	.60	1512.7	2.6841
3200.	2.908	34.945	2.638	.89	27.871	27.874	.67	1515.4	2.7754
3400.	2.746	34.934	2.458	1.74	27.877	27.881	.62	1518.1	2.8655
3600.	2.639	34.930	2.332	.72	27.883	27.888	.51	1521.1	2.9546
3800.	2.536	34.922	2.209	.57	27.886	27.893	.51	1524.1	3.0435
4000.	2.456	34.917	2.109	-.08	27.889	27.896	.41	1527.2	3.1321
4200.	2.403	34.912	2.034	.12	27.890	27.899	.26	1530.4	3.2213
4400.	2.366	34.906	1.974	.39	27.888	27.899	.32	1533.7	3.3114
4600.	2.341	34.901	1.926	.19	27.886	27.898	.32	1537.0	3.4031
4800.	2.325	34.898	1.886	.08	27.885	27.899	.17	1540.4	3.4961

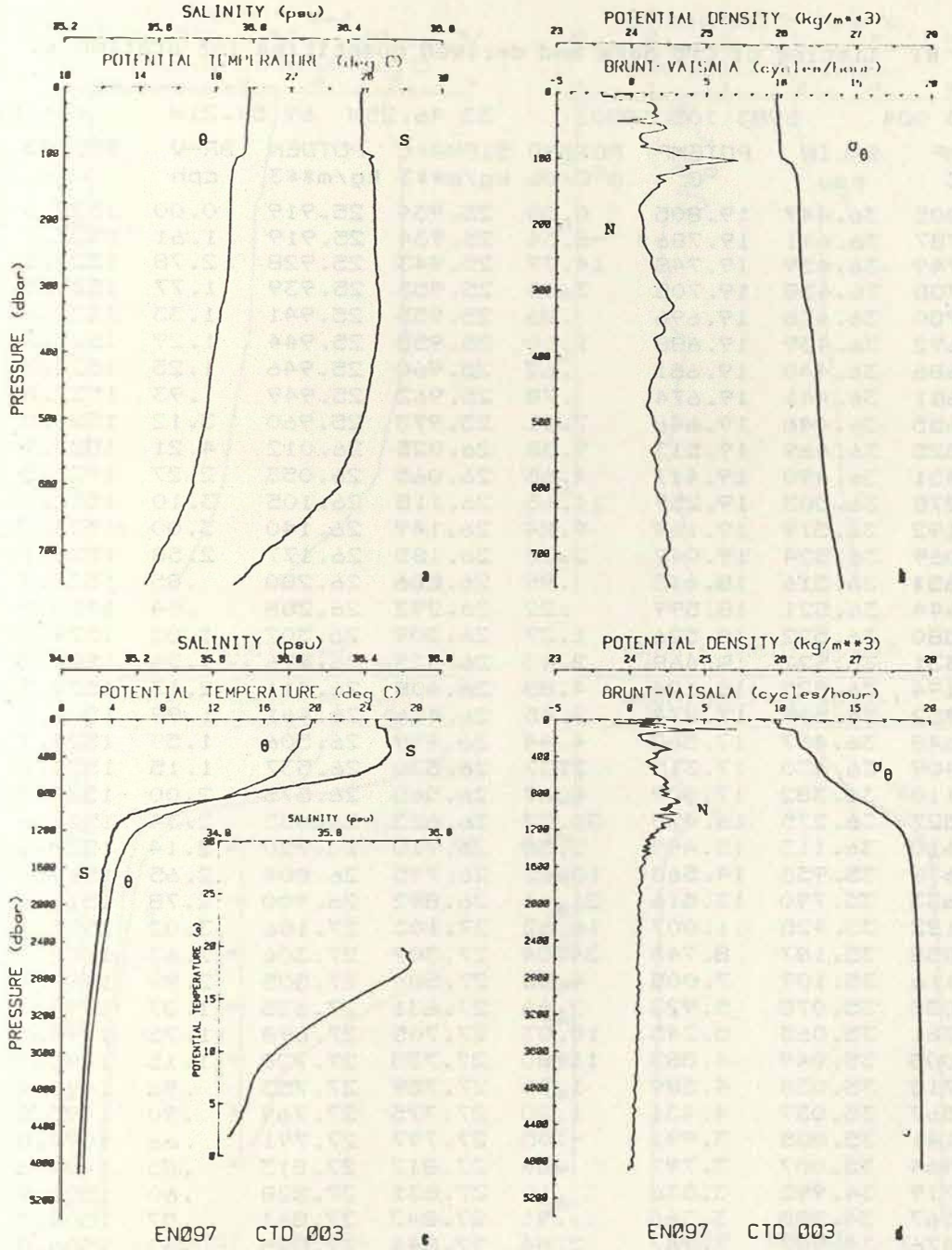

Figure 7. CTD station 3. Profiles of potential temperature (θ) and salinity (S), and Brunt-Väisälä frequency (N) and potential density (σ_θ) for the upper 750 m (a and b respectively) and for the entire cast (c and d respectively). θ-S diagram included in c.

Table 8: Listing of CTD data and derived quantities for station 4.

EN097 CTD 004 1983 105 1800Z 33 46.25N 69 59.21W corrD: 5373m

PRESS dbar	TEMP °C	SALIN psu	POTEMP °C	POTGRD m°C/db	SIGMA-t kg/m**3	POTDEN kg/m**3	BR-V cph	SSPEED m/s	DYNHGT dyn m
2.	19.805	36.447	19.805	0.00	25.934	25.919	0.00	1522.6	0.0000
6.	19.787	36.441	19.786	-6.34	25.934	25.919	1.61	1522.6	.0078
10.	19.749	36.439	19.748	14.77	25.943	25.928	2.78	1522.5	.0161
16.	19.708	36.438	19.705	3.64	25.953	25.939	1.77	1522.5	.0280
20.	19.700	36.438	19.696	.86	25.955	25.941	1.33	1522.6	.0368
26.	19.692	36.439	19.688	1.00	25.958	25.944	1.29	1522.7	.0493
30.	19.686	36.440	19.681	.62	25.960	25.946	1.25	1522.7	.0572
36.	19.681	36.441	19.674	.78	25.962	25.949	.93	1522.8	.0698
50.	19.655	36.446	19.646	7.21	25.973	25.960	3.12	1523.0	.0982
66.	19.525	36.469	19.513	9.38	26.025	26.012	4.21	1522.9	.1308
76.	19.431	36.490	19.417	4.65	26.065	26.053	2.27	1522.8	.1507
100.	19.278	36.503	19.259	11.65	26.115	26.105	3.10	1522.8	.1977
126.	19.192	36.519	19.169	9.84	26.149	26.140	3.00	1523.0	.2480
150.	19.069	36.524	19.042	2.20	26.185	26.177	2.58	1523.1	.2936
200.	18.651	36.516	18.615	.99	26.286	26.280	.85	1522.7	.3842
250.	18.644	36.521	18.599	.22	26.292	26.288	.94	1523.5	.4754
300.	18.580	36.522	18.526	1.37	26.309	26.307	1.02	1524.2	.5668
350.	18.531	36.527	18.469	2.43	26.325	26.326	1.34	1524.9	.6577
400.	18.194	36.525	18.124	4.88	26.408	26.411	2.13	1524.7	.7478
450.	17.952	36.509	17.874	3.45	26.456	26.461	1.98	1524.8	.8348
500.	17.648	36.467	17.562	4.44	26.499	26.506	1.59	1524.7	.9205
550.	17.409	36.430	17.315	2.37	26.530	26.537	1.15	1524.8	1.0053
600.	17.110	36.382	17.009	4.67	26.565	26.575	2.00	1524.7	1.0900
650.	16.527	36.275	16.420	31.57	26.622	26.632	2.34	1523.6	1.1725
700.	15.610	36.113	15.499	3.58	26.710	26.720	2.14	1521.5	1.2521
750.	14.678	35.953	14.563	10.62	26.795	26.804	2.65	1519.2	1.3283
800.	13.633	35.790	13.516	21.41	26.892	26.900	2.78	1516.4	1.3997
900.	11.122	35.425	11.007	16.62	27.103	27.106	3.02	1509.2	1.5282
1000.	8.858	35.187	8.745	34.04	27.307	27.306	2.63	1502.4	1.6338
1100.	7.116	35.109	7.005	4.55	27.509	27.505	2.99	1497.4	1.7210
1200.	6.035	35.078	5.923	2.66	27.631	27.625	1.87	1494.8	1.7897
1300.	5.361	35.065	5.245	10.03	27.705	27.698	1.72	1493.7	1.8491
1400.	5.005	35.049	4.883	11.80	27.735	27.728	1.15	1493.9	1.9038
1500.	4.718	35.038	4.589	1.76	27.759	27.753	.96	1494.4	1.9559
1600.	4.567	35.037	4.431	1.20	27.775	27.769	.90	1495.5	2.0068
1800.	4.141	35.005	3.991	-.05	27.797	27.791	.66	1497.0	2.1056
2000.	3.964	35.007	3.797	.66	27.817	27.813	.83	1499.6	2.2021
2200.	3.719	34.992	3.536	.10	27.831	27.828	.60	1501.9	2.2968
2400.	3.567	34.988	3.366	.91	27.842	27.841	.57	1504.7	2.3909
2500.	3.476	34.982	3.267	2.84	27.846	27.845	.63	1506.0	2.4376
2600.	3.398	34.979	3.181	1.48	27.852	27.852	.58	1507.3	2.4842
2800.	3.223	34.968	2.988	.61	27.860	27.861	.58	1510.0	2.5768
3000.	3.054	34.957	2.802	.48	27.867	27.869	.51	1512.6	2.6685
3200.	2.891	34.947	2.621	1.55	27.874	27.877	.68	1515.3	2.7591
3400.	2.736	34.937	2.449	-.14	27.881	27.884	.52	1518.1	2.8485
3600.	2.635	34.932	2.328	.64	27.886	27.891	.52	1521.1	2.9371
3800.	2.525	34.925	2.199	.94	27.889	27.896	.46	1524.0	3.0253
4000.	2.440	34.919	2.093	-.10	27.892	27.899	.43	1527.1	3.1133
4200.	2.387	34.913	2.018	.13	27.892	27.901	.30	1530.3	3.2017
4400.	2.353	34.909	1.962	.04	27.891	27.902	.25	1533.6	3.2910
4600.	2.335	34.903	1.920	.12	27.888	27.901	.26	1537.0	3.3821
4800.	2.327	34.901	1.888	.09	27.887	27.901	.21	1540.4	3.4747
5000.	2.321	34.897	1.858	.27	27.884	27.900	.22	1543.9	3.5695
5200.	2.309	34.893	1.821	.00	27.882	27.900	.28	1547.3	3.6660

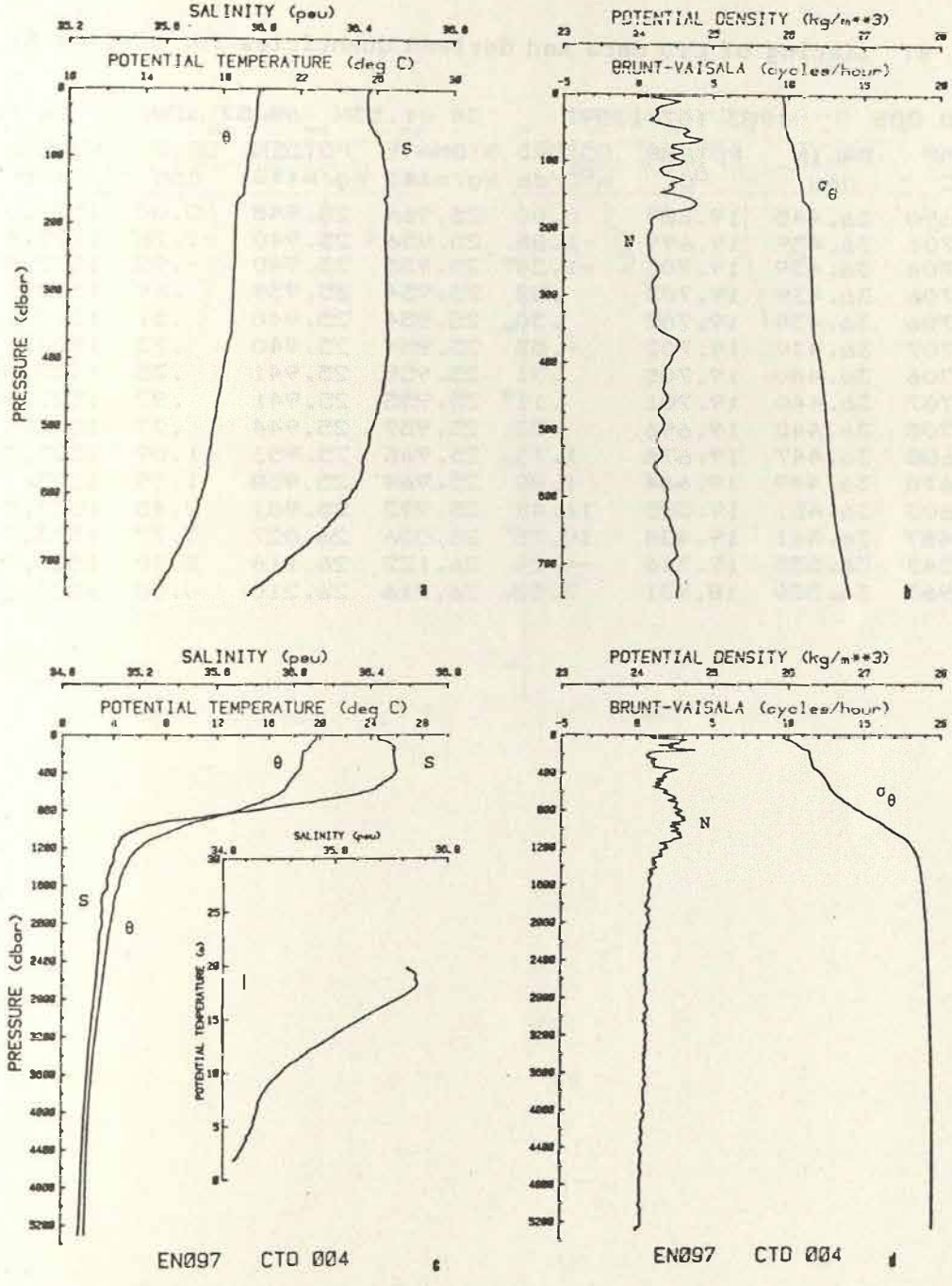

Figure 8. CTD station 4. Profiles of potential temperature (θ) and salinity (S), and Brunt-Väisälä frequency (N) and potential density (σ_θ) for the upper 750 m (a and b respectively) and for the entire cast (c and d respectively). θ-S diagram included in c.

Table 9: Listing of CTD data and derived quantities for station 5.

EN097 CTD 005 1983 107 1359Z 34 01.53N 69 57.12W corrD: 5366m

PRESS dbar	TEMP °C	SALIN psu	POTEMP °C	POTGRD m°C/db	SIGMA-t kg/m**3	POTDEN kg/m**3	BR-V cph	SSPEED m/s	DYNHGT dyn m
3.	19.690	36.445	19.689	0.00	25.964	25.948	0.00	1522.3	0.0000
6.	19.701	36.439	19.699	-1.85	25.956	25.940	-1.78	1522.4	.0079
10.	19.704	36.439	19.703	-1.24	25.955	25.940	-.92	1522.4	.0157
16.	19.706	36.439	19.703	.52	25.954	25.939	.69	1522.5	.0280
20.	19.706	36.439	19.702	.30	25.954	25.940	.51	1522.6	.0355
26.	19.707	36.439	19.702	-.53	25.954	25.940	.73	1522.7	.0479
30.	19.706	36.440	19.700	.71	25.955	25.941	.35	1522.8	.0563
36.	19.707	36.440	19.701	.11	25.955	25.941	.97	1522.9	.0689
50.	19.705	36.442	19.696	.33	25.957	25.944	.77	1523.1	.0981
66.	19.688	36.447	19.676	1.73	25.965	25.953	1.09	1523.3	.1309
76.	19.678	36.449	19.664	1.80	25.969	25.958	1.09	1523.5	.1518
100.	19.603	36.453	19.585	11.49	25.992	25.981	2.45	1523.7	.2011
126.	19.457	36.461	19.434	10.75	26.036	26.027	3.77	1523.7	.2546
150.	19.343	36.535	19.316	-4.28	26.122	26.114	2.90	1523.9	.3021
200.	18.967	36.530	18.931	7.58	26.216	26.210	0.00	1523.6	.3981

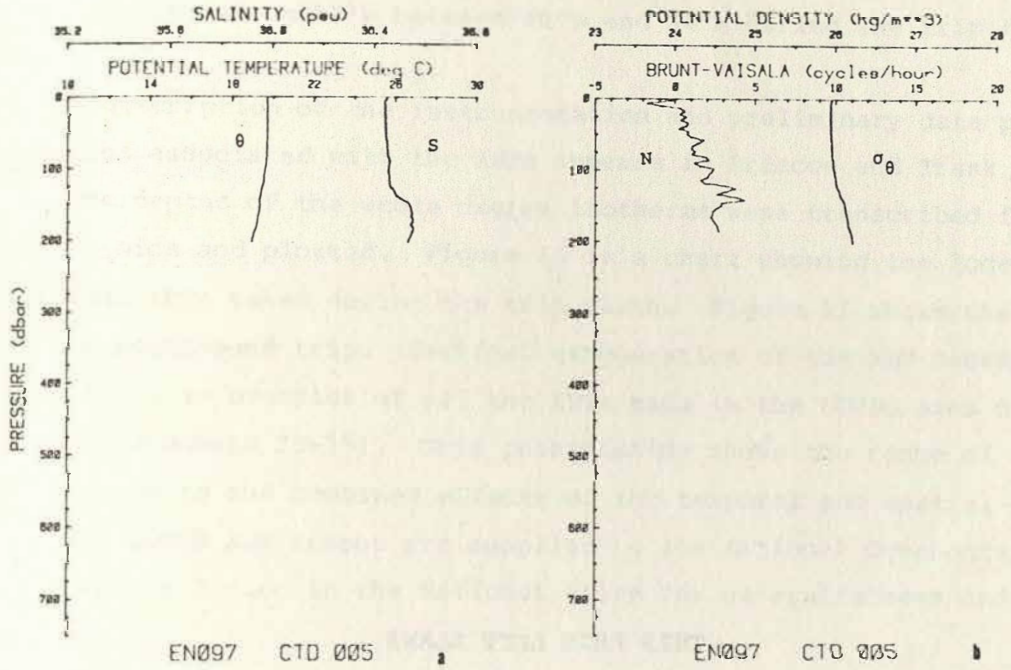

Figure 9. CTD station 5. Profiles of potential temperature (θ) and salinity (S), and Brunt-Väisälä frequency (N) and potential density (σ_θ) for the upper 202 m.

THIS PAGE LEFT BLANK

INTENTIONALLY

b. XBT Data

Expendable bathythermograph data were collected approximately every 20 km (i.e., hourly) along 70°W between 40°N and 34°N during the trip to the LOTUS area.

A description of the instrumentation and preliminary data processing procedures associated with the XBTs appears in Briscoe and Trask (1983).

The depths of the whole degree isotherms were transcribed from the strip chart records and plotted. Figure 10 is a chart showing the location of individual XBTs taken during the trip south. Figure 11 shows the XBT section from the southbound trip. Vertical exaggeration of the XBT sections is 1:463. Figure 12 is an overplot of all the XBTs made in the LOTUS area during ENDEAVOR cruise 97 (numbers 29-35). This presentation shows the range of temperatures observed due to the combined effects of the temporal and spatial variations.

All LOTUS XBT traces are supplied to the National Oceanographic Data Center for inclusion in the National files for general access and usage.

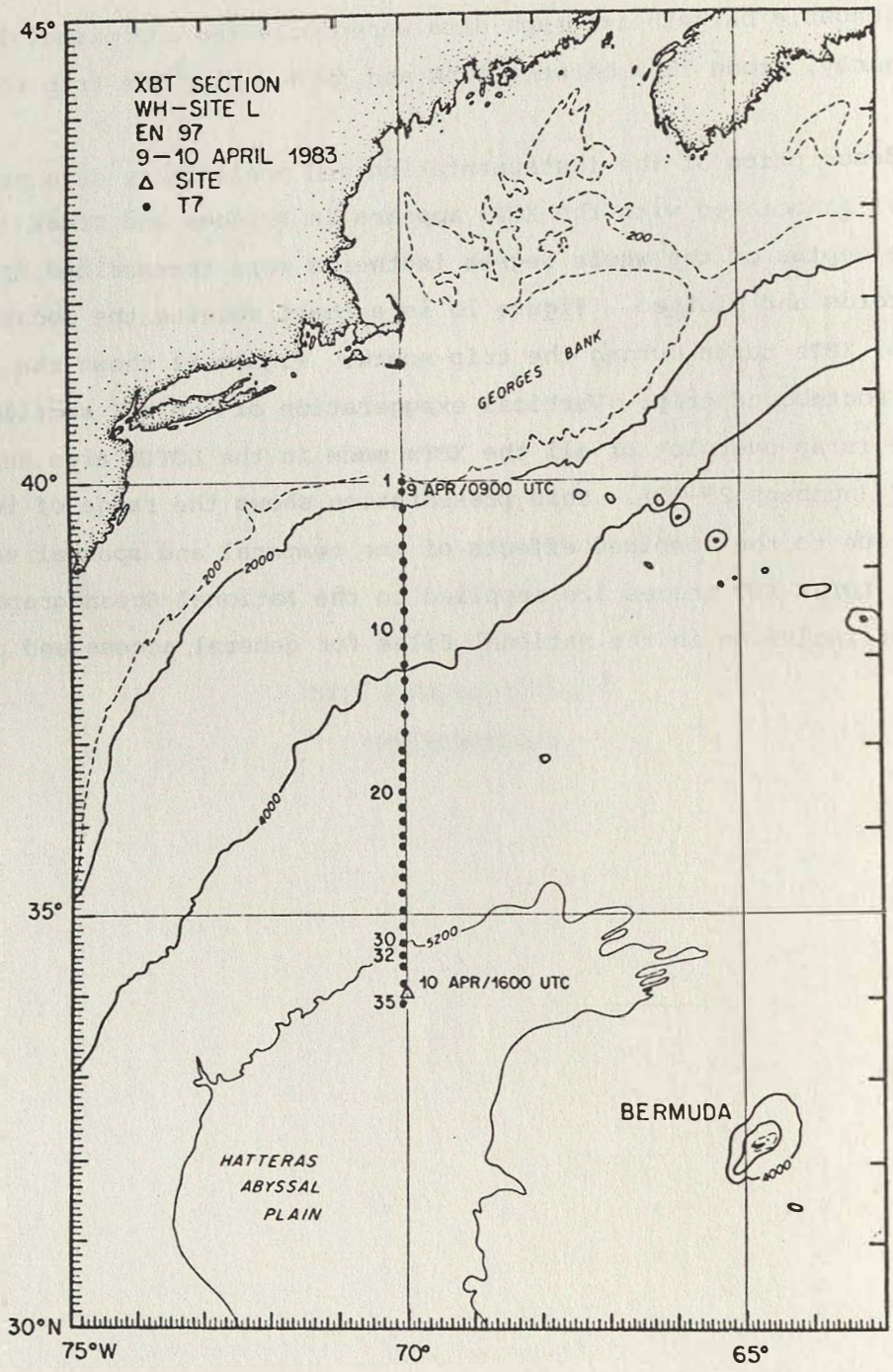

Figure 10. Chart showing the location of individual XBTs taken during the trip south to the LOTUS area.

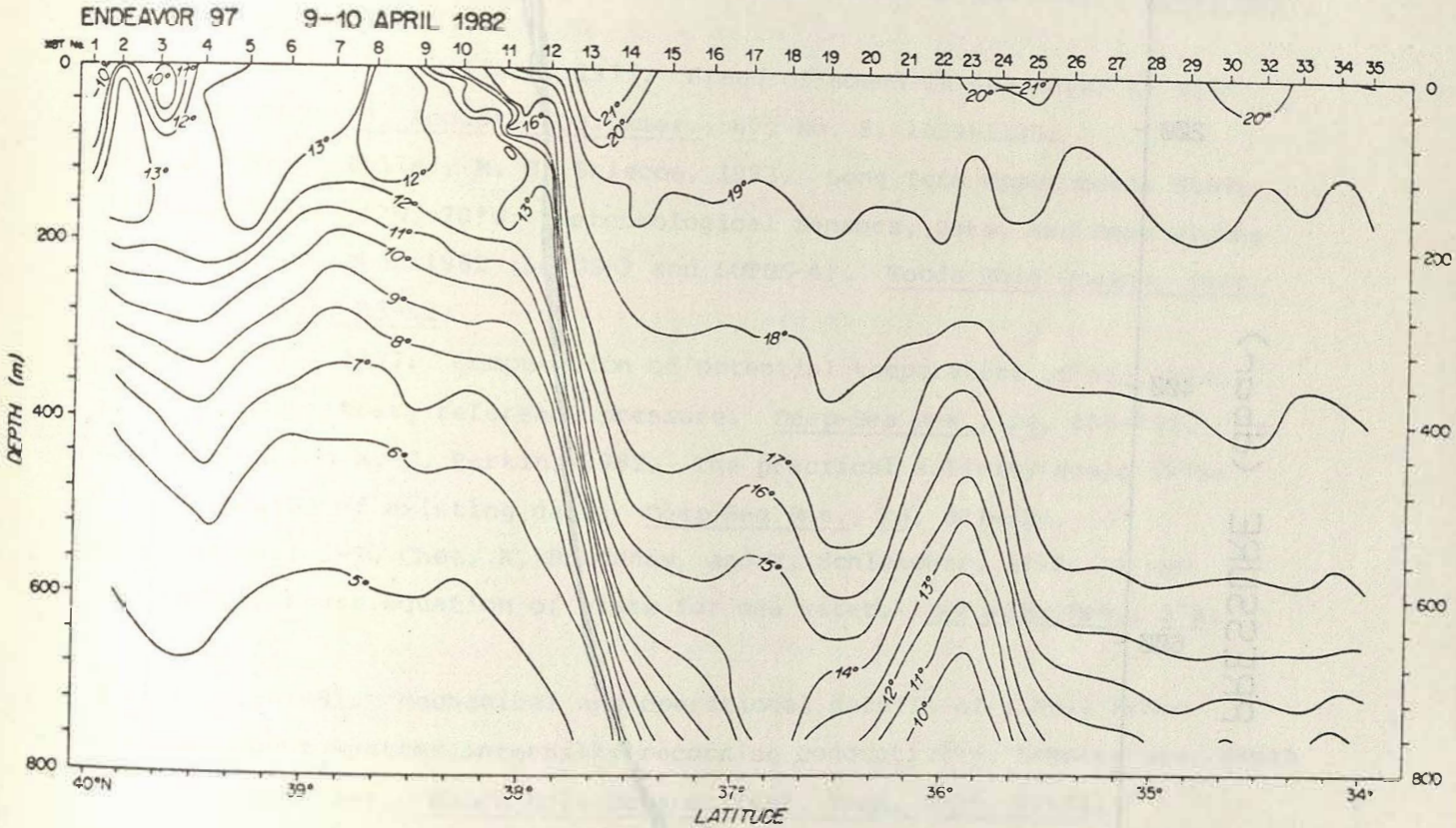

Figure 11. XBT section from the southbound trip along 70°W between 40°N and 34°N.

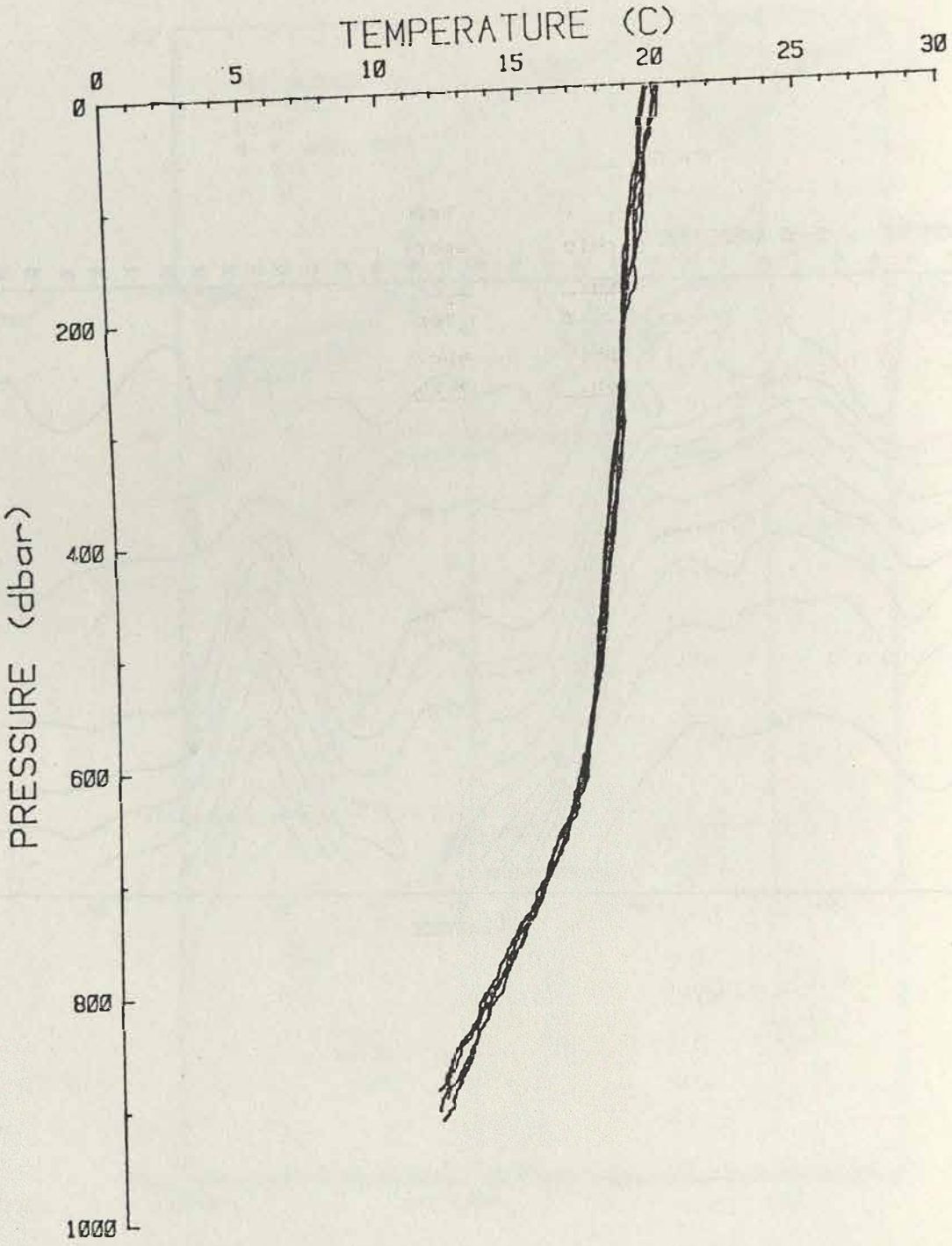

Figure 12. An overplot of all the XBTs taken in the LOTUS area during ENDEAVOR cruise 97.

References

Briscoe, M. G., and R. P. Trask, 1983. The Long Term Upper Ocean Study (LOTUS), An introduction to the experiment and its instrumentation. Woods Hole Oceano. Inst. Tech. Rept., in preparation.

Bryden, H. L., 1973. New polynomials for thermal expansion, adiabatic temperature gradient and potential temperature of sea water. Deep-Sea Res., 20, 401-408.

Chen, C-T., and F. J. Millero, 1977. Speed of sound in sea water at high pressures. J. Acoust. Soc. Amer., 62, No. 5, 1129-1135.

Deser, C., R. A. Weller, M. G. Briscoe, 1983. Long Term Upper Ocean Study (LOTUS) at 34°N, 70°W: Meteorological Sensors, Data, and Heat Fluxes for May-October 1982 (LOTUS-3 and LOTUS-4). Woods Hole Oceano. Inst. Tech. Rept. 83-32.

Fofonoff, N. P., 1977. Computation of potential temperature of sea water for an arbitrary reference pressure. Deep-Sea Res., 24, 489-491.

Lewis, E. L., and R. G. Perkin, 1981. The practical salinity scale 1978: conversion of existing data. Deep-Sea Res., 28, 307-328.

Millero, F. J., C-T. Chen, A. Bradshaw, and K. Schleicher, 1980. A new high pressure equation of state for sea water. Deep-Sea Res., 27A, 255-264.

Trask, R. P., 1981. Mechanical and operational details of a Neil Brown Instrument Systems internally recording conductivity, temperature, depth (CTD) profiler. Woods Hole Oceano. Inst. Tech. Rept. 81-74.

Trask, R. P., M. G. Briscoe, and N. J. Pennington, 1982. Long Term Upper Ocean Study (LOTUS), A summary of the historical data and engineering test data. Woods Hole Oceano. Inst. Tech. Rept. 82-53.

Trask, R. P., M. G. Briscoe, 1983. The Long Term Upper Ocean Study (LOTUS) Cruise summary and hydrographic data report OCEANUS 119 - May 1982. Woods Hole Oceano. Inst. Tech. Rept. 83-7.

Trask, R. P., M. G. Briscoe, 1983. The Long Term Upper Ocean Study (LOTUS) Cruise summary and hydrographic data report OCEANUS 129 - October 1982. Woods Hole Oceano. Inst. Tech. Rept. 83-29.

APPENDIX I

Recovery of LOTUS-4

The LOTUS-4 surface mooring parted on the 18th of February 1983 after being on station for 110 days. The failure was detected when the mooring tensions transmitted from the buoy via the ARGOS satellite based data collection system dropped from typical values of 2500 pounds down to 1500 pounds and when the buoy position as determined by ARGOS indicated that the buoy had moved off station and was drifting to the southwest. The tension readings made at the apex of the rigid bridle were an indication of what portion of the mooring hung below the buoy. Based on a knowledge of instrument and wire rope weights the 1500 pound tension values indicated that the mooring had probably failed below most of the intrumentation in the vicinity of the 5/16" wire rope (Figure A-1). With 1500 pounds suspended from the rigid bridle the buoy remained stable with little chance of flipping over. In the upright position the buoy could continue to transmit information and be tracked.

The buoy and the upper portion of the mooring drifted to the west southwest at an average rate of 11 km/day. Figure A-2 shows the track the buoy followed as it drifted from its moored position to the final recovery site at 33°49.26'N, 72°32.53'W. The R/V KNORR recovered the surface buoy and the suspended instrumenation on the 10th of March while steaming from Barbados to Woods Hole (Cruise 99, Leg 6). Recovery of the mooring revealed that the failure had occurred at approximately 1000 meters depth in the second 500 meter shot of 5/16" wire rope as had been suspected.

Determination of the cause of the failure was essential in order that the necessary precautions could be taken with the other LOTUS surface moorings that followed. Based on the configuration of the wire rope at the time of recovery and on a review of the setting procedures, a probable cause of the failure was determined. The sequence of events which led to the failure are outlined below.

During the LOTUS-4 deployment the buoy was placed in the water and the upper 350 meters of the mooring were deployed rather slowly as in previous deployments since a number of current meters had to be shackled in place and the Aanderaa thermistor chains attached to the mooring cable. Once this upper

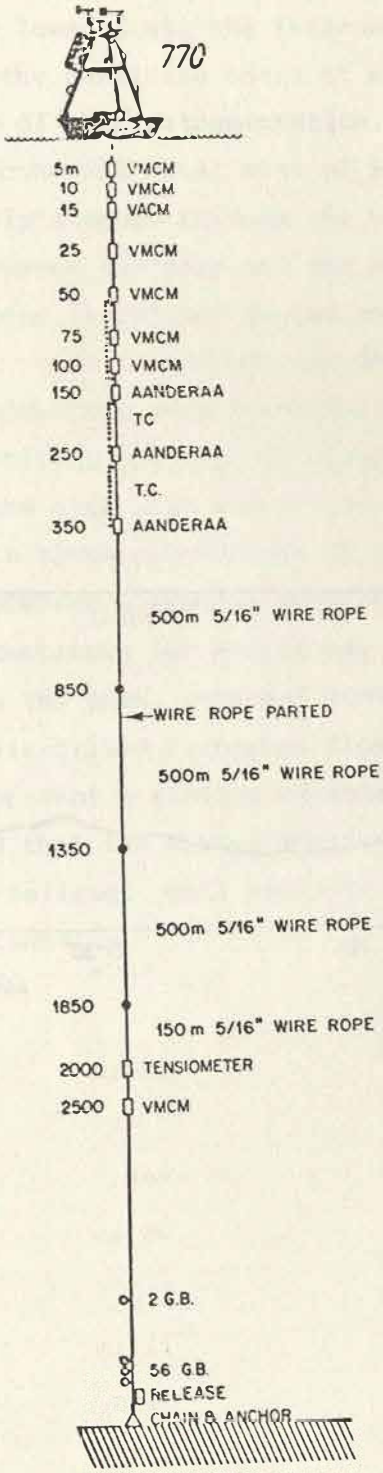

Figure A_1: Mooring diagram of the LOTUS-4 surface mooring.

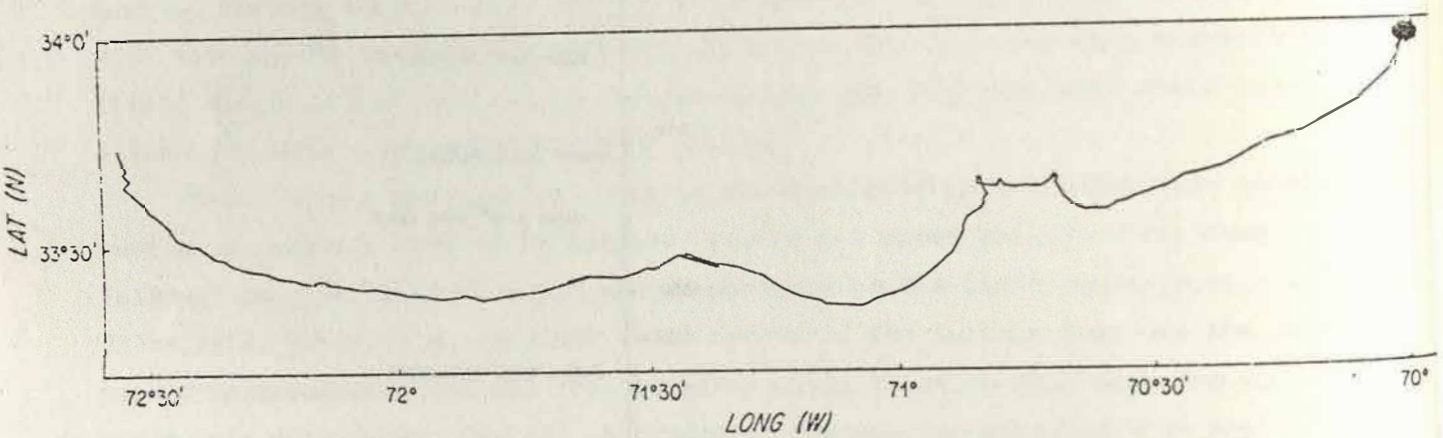

Figure A-2. The track the LOTUS-4 surface buoy followed as it drifted from its moored position to the final recovery site.

instrumentation was in the water the 5/16" wire rope followed. The first 500 m shot of 5/16" wire rope essentially lowered all the instrumentation so that it hung directly below the buoy while the remaining shots of wire formed a catenary between the ship and the bottom of the instrumentation. The problem occurred during the deployment of the second 500 meter shot of 5/16" wire rope. The mooring payout rate exceeded the ship's speed through the water which did not allow the mooring to stretch out between the ship and the buoy. Instead the wire rope appears to have crossed over itself and fouled on a shackle pin at the bottom of the first 500 m shot. Once the anchor was deployed the tension in the mooring line prevented the wire rope from freeing itself. Kinks and twists in the recovered wire rope which presumably occurred when the tension increased at anchor drop weakened the wire rope and led to its failure after 110 days. In subsequent deployments close attention will be paid to payout rates and ship speeds in order to prevent a similar occurrence.

We have discovered that the Institute für Meerskunde in Kiel, Germany, has had similar deployment problems (W. Zenk, personal communication, 1983); they are testing a solution using air-filled fisherman floats along the wire rope to keep it surfaced and thus prevent a kinking catenary.

In retrospect, we are pleased that the kinked mooring lasted through 110 days of a winter deployment before failing. This suggests the mooring design is probably adequate for the conditions.

APPENDIX II

CHRONOLOGICAL SUMMARY

ENDEAVOR-097

8-19 APRIL 1983

(all times UTC=EST+5)

8 April - Day 98

2245Z : Preparing to leave dock at Woods Hole.

9 April - Day 99

0100Z : Science meeting in main lab.
0205Z : Some problems with the NAV85 program, including memory overflow, Error 110, and bad parameters.
0820Z : First XBT in hourly section along 70°W, nominal.
0830Z : Commence echo sounding to get bathymetry under the XBT section.
1530Z : Fire and boat drill.
1850Z : XBT's and Error 110 on NAV85 continue.
1900Z : Compared WHOI and URI bucket temperatures:

Lab readout	:	20.3°C (at 5 m depth)
URI bucket	:	19.0
WHOI bucket	:	20.3

(MGB note: Surface variable during this period; should not use these results as definitive.)

10 April - Day 100

1420Z : Changed NAV85 ASF's to LOTUS area values, i.e. 2.25 and 2.29 for x and y; had been using the Woods Hole values of 3.79, 1.51. NAV85 did not accept the new values; had to Reinitialize.
1700Z : Near 770 (LOTUS-4) anchor. Trying to talk to the release. Drift 1.3-1.5 kts to 350-360°T, wind 12-14 kts from the South.
1724Z : Release fired; balls should surface on port quarter.
1827Z : Balls in sight.
1855Z : Some confusion on where the balls are; acoustics not in agreement.
1926Z : Problem was our acoustics were sometimes transponding on the old, nearby, PCM release.
1928Z : Maneuvering for the balls.
1938Z : Balls and release aboard. Hauling 770 remains.
2124Z : 770's deep VMCM aboard. Some mud on it but otherwise it looks good.
2146Z : Cut the wire rope after recovering the tensiometer, because several wuzzles were showing up. The bitter end wasn't worth it.
2239Z : Decision to launch and recover two of the NCAR drifters tonight.

11 April - Day 101

0110Z : Drifter 1866 over at 34°01.76'N, 69°55.95'W, with 2s flash rate strobe on it.
0212Z : Heavy rain put LORAN off air, system back up at 0234.
0215Z : Second drifter, 1867, launched with 1s flash rate strobe on it. Approximate position 34°02.1'N, 69°56.3'W.
0333Z : Release tests in progress; steaming on wire.
0447Z : Release tests completed. Move to drifters.
0503Z : H/T. Drifters about 1/2 mile ahead.
0735Z : Wind making it difficult to keep the drifters and the wind on the bow.
1010Z : Have installed 400 MHz RDF antenna on the flying bridge.
1131Z : RDF'ing on the drifters works well. Excellent signals at 1 1/2 miles, pretty good bearings on the beam and astern, perhaps 20° errors on the bow.
1137Z : Overnight the drifters made 0.6-0.8 kts to about 345°T, with kinks and whorls.
1150Z : Close by the drifters, taking pictures, at 34°08.7'N, 69°58.8'W.
1155Z : Bow between the two drifters, at 34°08.784'N, 69°58.63'W.
1156Z : Calculated starting point and target for setting LOTUS-5, based on wind 15-25 kts from 270°T, and setting 0.6-0.8 kts to 350°T.
1230Z : Decision (with Clay and Simoneau) to wait out weather before setting LOTUS-5.
1338Z : CTD No. 1 underway east of Site L (34°N, 70°W).
1448Z : Messengers away.
1507Z : Double ping detected.
1631Z : CTD on board and secured.
1808Z : On station for setting LOTUS-5. Checking drift.
1855Z : Buoy in water. Knocked off Payne's humidity sensor at launch; crane whip caught it.
2056Z : Spoke with Clayt Collins via WHOI SSB on 6 MHz, arranged thru URI who called WHOI to have them call us. His last ARGOS position for drifters 1866 and 1867 was at 1255Z, during our keeping station on them.

12 April - Day 102

0048Z : Anchor over for mooring 787 (LOTUS-5). Range/bearing to surface float 2.78 miles at 103°T.
0248Z : All power off on ship for a few minutes.
0542Z : CTD station No. 2 underway north of Site L.
0708Z : Messenger drop.
0734Z : Winding problems with winch.
1107Z : CTD on board and secured.
1415Z : Release fired for 766 recovery.
1441Z : ARGOS positions for LOTUS-5 from Clayt Collins via KXC713: 102/0722Z; 34.005 N, 70.054 W.
1533Z : Top sphere aboard.
1950Z : Dual release aboard; recovery of 766 complete.

2130Z : Standing by 787 (LOTUS-5) to intercompare buoy and shipborne meteorological sensors.

2319Z : Winds about 20 kts from 270°T (assume ship will set 0.7 kts to 090°T), ship drift about 0.4 kts to 146°T; implies current is 0.6 kts to 236°T. Will start setting 788 eight miles ENE of desired anchor position, which allows 4 hours at 2 kts over the bottom.

13 April - Day 103

0040Z : Commencing launch of 788.

0447Z : Anchor over.

0519Z : Radio off.

0526Z : Anchor on bottom.

0639Z : CTD No. 3 underway West of Site L.

0932Z : CTD on board and secured.

1022Z : Intercomparison meteorological data with LOTUS-5.

1300Z : Secure from anemometer calibrations.

1329Z : Test releases on hydro wire (two lowerings).

1643Z : Steam SW to dump wire from Pengo.

1930Z : Commence acoustic survey of release positions on 787, 788.

2206Z : Survey complete. Move to prospective PCM site for bathymetry survey.

14 April - Day 104

0005Z : Bottom survey at PCM site complete. Uncorrected depth 5302 m, or 5363 m corrected by 5 m transducer depth plus 56 m "Mathews" correction.

0023Z : Ship drift is to SW, wind is from NNW, therefore current set is to WSW, so commence drifter deployment two miles South of 787 (LOTUS-5).

0110Z : Drifter 1869 in water.

0118Z : Drifter 1868 (with light) in water.

0208Z : Drifting with the drifters.

0340Z : Meteorological sensor intercomparison with LOTUS-5.

0750Z : Proceeding to mooring 765 to interrogate test releases.

1016Z : Tests complete; standing by 765.

1259Z : Released 765.

1305Z : Top ball-cluster on surface nearby.

1412Z : Communication with Keith Bradley via ATS; requested 2030Z SSB schedule with Clayt Collins on KXC713 for latest drifter positions from ARGOS.

1541Z : Mooring 765 aboard. Prepare for new intermediate mooring deployment.

1738Z : Top ball-cluster in water for deployment of mooring 789.

2041Z : Anchor in.

2054Z : ARGOS positions for 1868 and 1869 from 14/0103Z from Clayt via KXC713. (NOTE: this is before we deployed them.)

2112Z : Radio float off. Steam for 764 site.

2224Z : Ham radio contact with Clayt Collins (W1HLL) on 3866 kHz (with relay help of A1lW) to obtain NASA/Goddard positions for drifters at 1952Z.

2310Z : Nothing heard from 764 release interrogation.
2311Z : Fired 764 release. Put extra eyes on bridge to watch for balls/light. Kenwood TS430S in lab tuned to 26.995 MHz.
2323Z (approx.) : Scott Worrilow hears faint warble on lab radio.

15 April - Day 105

0012Z : Performed slow circular pattern with ship to use directionality of the antenna pattern from the 18V vertical connected to the TS430S; directionality caused by antenna location on the port after side of the bridge and wheelhouse. Bridge radio (Drake MSR-2) unable to hear the warble on 26.995 MHz. Strongest signal to SW confirms suggestion from Clara Deser and Peter Clay based on early June 1982 SW excursion of LOTUS-3 surface buoy.
0033Z : Steaming West to keep signal on port side of ship.
0041Z : Bob Reid gives port beam indication from OAR RDF loop. Course change to 180°T.
0044Z : George Tupper hears faint pinger on PGR. Radio signal not heard on this southerly course.
0059Z : Going to slow and circle the ship again.
0104Z : Radio signal strongest on a ship heading of 270°T and weakest at 150°T.
0113Z : Acoustics give 7.51 km slant range.
0121Z : Steady on 225°T.
0125Z : Range 6.1 km.
0133Z : Range 4.72 km.
0140Z : Range 3.50 km.
0143Z : Light seen on starboard bow.
0155Z : 1 km range.
0213Z : Ship's searchlight on top ball-cluster. Commence pickup.
0434Z : Release on board. No work planned overnight.
1305Z : Steaming for position to start setting 790; dumped wire off Pengo enroute.
1406Z : Commence setting 790.
1740Z : Anchor in. Move nearby for CTD station.
1803Z : CTD No. 4 underway near 790 (South of Site L).
2044Z : KXC713 radio information from Clayt; NASA positions for drifters 1868 and 1869 as of 15/1941Z.
2111Z : CTD on deck and secured. Steam to PCM site.
2211Z : Near LOTUS-5 checking ship drift.
2339Z : Commence setting PCM, 6 miles West of anchor target.

16 April - Day 106

0349Z : Anchor in.
0436Z : Anchor on bottom.
0445Z : Acoustic survey start.
0533Z : Survey completed: begin search for drifters 1868 and 1869. Will go West just south of 34°00'N, as far as 71°00'W, based on NASA positions.

1202Z : From Clayt on 7225 kHz; position from NASA for LOTUS-5 at 15/1941Z is 18 miles West and 4.5 miles South of actual position. We decide to continue search for drifters. ARGOS system is down (in Washington, D.C.), and it is Saturday so NASA is not working (but their fixes are wrong, anyway).

1815Z : Still no new fixes from Clayt; continuing search.

2304Z : Bad weather forecast for overnight and tomorrow. Have moved current meters from their rack in the fantail into the main lab. Will deploy the third drifter here at 34°00'N, 70°30'W.

2355Z : Drifter in water.

17 April - Day 107

0030Z : Comparison of shipborne meteorological sensors with drifter.

0205Z : Move to LOTUS-5 position.

0649Z : Near LOTUS-5.

0900Z : Commence anemometer calibrations.

1225Z : Moving to PCM site to obtain a shallow CTD station for conductivity intercomparison.

1258Z : Clayt on 7230 kHz; ARGOS back up and gives drifter positions for 107/0131Z.

1326Z : We were searching too far South; apparently the wind had shifted and was influencing their drift.

1359Z : Commence CTD shallow station No. 5 to be simultaneous with PCM 1400Z profile.

1432Z : CTD on deck and secured after a 3-cycle yo-yo to 200 m. Begin steaming toward drifters.

1645Z : Another fix from Clayt via 40 m band; for 107/0802Z.

1710Z : We work out a probable arrival at the drifters of 1900Z, and predict their location for that time.

1900Z : Blips on RDF radio, starboard bow.

1930Z : Close by drifter 1869; signals all ok, but wind sensors are broken off.

1950Z : Close by drifter 1868; no data being received from its thermistor chain.

2008Z : Will recover 1868 and move its tower to another drifter for redeployment.

2145Z : New drifter in.

2150Z : Head for home via 71°W for a XBT section for Narragansett Fisheries.

18 April - Day 108

1455Z : In Gulf Stream. Captain reports bad weather ahead. Decide to cancel Fisheries' XBT section due to probable bad conditions on deck during the night.

19 April - Day 109

1354Z : All fast WHOI dock. Commence unloading.

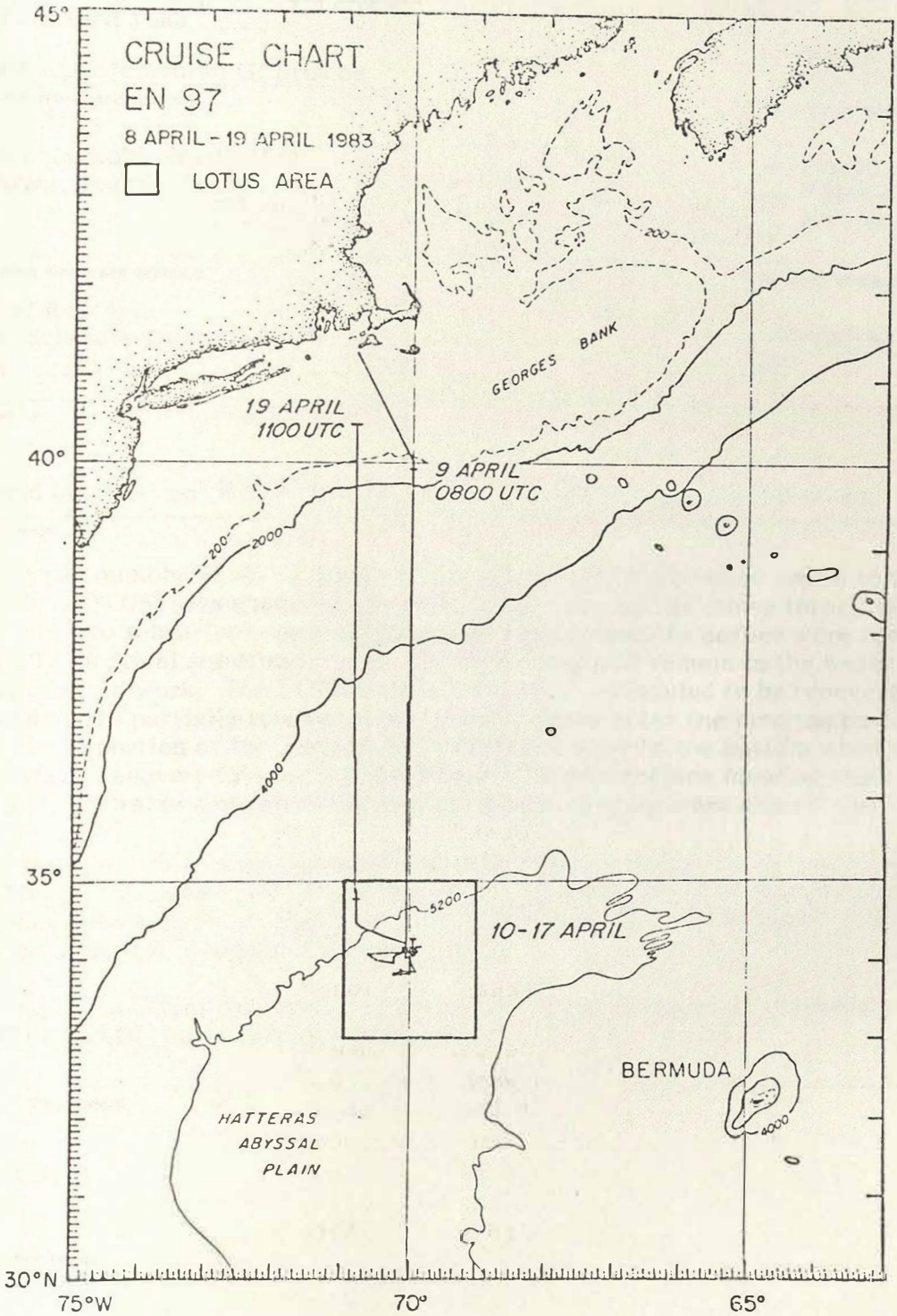

Figure A-3. Cruise track of ENDEAVOR cruise number 97.