NORDIC-91: AXBT Measurements in the Iceland-Faeroe Frontal Zone, September 1991

J. D. Boyd
Oceanography Division
Ocean Science Directorate

These working papers were prepared for the timely dissemination of information; this document does not represent the official position of NOARL.

Abstract

In September 1992, 213 deep AXBTs and 47 MK-82 SUS were dropped in the vicinity of the Iceland-Faeroe Front between Iceland and the Faeroe Islands. This technical note describes the experimental plan and the data acquisition and processing techniques used and presents the resulting data in graphical and tabular form.

Acknowledgments

The aircraft and flight crew were provided by the Naval Research Laboratory. Richard Myrick and Clark Kennedy of the Physical Oceanography Branch of the Naval Oceanographic and Atmospheric Research Laboratory (NOARL) and Robert Linzell of Neptune Sciences, Inc., participated in various phases of the data collection and analysis. Funding was provided by the Office of Naval Research, Robert Peloquin Program Manager, under Program Element 0602435N.

The mention of commercial products or the use of company names does not in any way imply endorsement by the U.S. Navy or NOARL.

Contents

Introduction	1
Experimental Plan and Operations Description	1
Navigation	2
Data Collection and Processing	2
Results	3
References	4
Appendix A. Temperature Contours at Selected Depths, 3 - 6 September 1991	9
Appendix B. Temperature and sound speed along the 7° W track, 6 September 1991	25
Appendix C. Drop Times, Positions, and Data Traces, 3 September 1991	29
Appendix D. Drop Times, Positions, and Data Traces, 4 September 1991	39
Appendix E. Drop Times, Positions, and Data Traces, 6 September 1991	49

NORDIC-91: AXBT Measurements in the Iceland-Faeroe Frontal Zone, September 1991

Introduction

An extensive joint experiment between the US Navy's Naval Oceanographic and Atmospheric Research Laboratory (NOARL, now the Naval Research Laboratory - Stennis Detachment), the NATO SACLANT Undersea Research Centre (SACLANTCEN), and the German Forschungsanstalt der Bundeswehr fuer Wasserschall und Geophysik (FWG) was scheduled to take place in September of 1991 between Iceland and the Faeroe Islands, in the vicinity of the Iceland-Faeroe Front. Extensive shipboard and aircraft environmental and acoustic measurements were planned, extending over a three week time period. Unfortunately, early in the experiment the SACLANTCEN ship the *Alliance* suffered an equipment malfunction that necessitated a return to port in the Faeroe Islands and the remainder of the experiment was canceled. Prior to cancellation, two mesoscale-resolving surveys of the area and one high resolution track were made by aircraft with AXBTs and SUS charges. This technical note summarizes the data obtained during those three flights.

Experimental Plan and Operations Description

The study area is shown in Fig. 1. The three successful flights on 3, 4, and 6 September 1991 were conducted out of Keflavik, Iceland. The first two flights resulted in a mesoscale-resolving grid over the oceanic frontal zone within the study region. As shown in Fig. 1, the flights had tracks arranged in an interleaved fashion so that each day would cover the full area at approximately half the resolution. Along-track spacing of the AXBTs ranged from 10 nmi (18.5 km) in the expected vicinity of the front to about 15 nmi (28 km) in regions expected to be less spatially variable. Between-track spacing in the frontal region was about 40 nmi (74 km), although this was approximately halved to 20 nmi (37 km) by the track arrangement in some regions. A total of 209 AXBTs were dropped on these two days, yielding 189 usable temperature versus depth profiles, 91 on 3 September and 98 on 4 September.

The third flight was part of a transmission loss experiment. Two Fleet aircraft deployed and monitored two sonobuoy arrays, while the research aircraft dropped 27 AXBTs and 47 MK-82 SUS charges along a 125 nmi (232 km) track going through one of the arrays. This was accomplished by flying the track four times. On the first run 14 AXBTs were dropped along the track at a 10 nmi (18.5 km) spacing. The aircraft turned around and reran the track a second time, dropping 24 MK 82 SUS set to go off at 90 m every 5 nmi (9.25 km). On the third run the remaining 13 AXBTs were dropped between the AXBT positions from the first run, yielding a resulting AXBT spacing of 5 nmi (9.25 km). On the final and fourth time the track was flown, the remaining 23 SUS were dropped between the earlier SUS positions, yielding a resulting SUS spacing of about 2.5 nmi (4.6 km). SUS drops were made at 200 - 300 ft; AXBT drops at 4500 ft (to improve the range for the RF data telemetry from the AXBTs in the water). Drops were arranged so that no SUS were dropped any closer than 5 nmi (9.25 km) to the sonobuoy array. Twenty four out of the twenty seven AXBTs yielded useful profiles. The

enthusiastic cooperation of the flight crew and the use of GPS navigation allowed for a very successful execution of this complicated operation. Details on the results of the transmission loss experiment are given in Kerr (1991).

Navigation

Navigation was with a NOARL-supplied Magnavox MX4400 GPS navigation system. Drop position accuracy should therefore be limited primarily by buoy drift between leaving the aircraft and hitting the ocean surface. The drop position accuracy of the AXBTs is estimated to be at least 0.25 nmi or about 0.5 km. AXBT deployments were made at altitudes of 3,500 - 4,500 ft, ground speed ranged between 215 - 250 kt, and indicated air speed lay between 200 - 240 kt, depending upon the winds at flight level. Since SUS drops were made at 200 - 300 ft, SUS drop accuracies are probably within 100 m or better.

Data Collection and Processing

All AXBTs were 800 m pre-production models manufactured by Sparton of Canada, under contract number N00163-90-C-0196. Production model NALC is 8W74. Of the 236 AXBTs deployed, 8 (3%) failed immediately and 213 yielded useable data, giving an overall failure rate from all causes of about 10%.

The data were collected and processed with the NOARL Code 331 Isis aircraft system, the organization and capabilities of which are outlined in Fig. 2. The data were initially acquired at 10 samples per second (about every 15 cm in depth) and were then filtered with a 21 point (2.1 s) median filter to remove most of the one to several point data spikes and other "glitches" that occasionally occur. The raw data were then converted to engineering units using the appropriate frequency-to-temperature and elapsed-fall-time-to depth conversion equations for the units, and the data were interpolated to 1 m resolution. A 9 point median filter was applied to the 1 m data to complete the smoothing process. The final quality check was made by an oceanographer who visually scanned the profiles to detect instances were the probes had hit bottom and to remove occasional data spikes at the beginning and ending of the profile that were not removed by the filtering processes.

The data from the first two mesoscale resolving surveys (3 and 4 September) were processed immediately after landing in order to provide a well-defined picture of the frontal conditions. Working plots of the environmental conditions in the frontal zone were produced using standard Isis gridding and contouring techniques. From these near real time results, acousticians involved in the experiment selected the site for the acoustics experiment conducted on 6 September.

Major factors in the accuracy of data from expendable probes such as the AXBT are the accuracies of the frequency-to-temperature and elapsed-fall-time-to-depth conversion equations. The U.S. Navy specifications for these equations are

$$\text{Frequency-to-temperature:} \quad T = -40.0 + 0.02778\,F$$

where F is frequency in hertz and T is temperature in degrees C, and

Elapsed-fall-time-to-depth: $z = 1.52\ t$

where z is depth in meters and t is elapsed time after probe release in seconds. The Navy standard requires the temperature accuracy to be ± 0.55 °C within the range -2 ° to 35 °, and the depth accuracy is required to be $\pm 5\%$ in depth.

While these accuracies may be adequate for certain operational requirements, they are not particularly satisfactory for research and other operational purposes. Several months prior to the NORDIC-91 experiment an AXBT calibration study had been conducted as part of the High Gain Initiative MDA Experiment. Forty eight units were dropped very close to a research vessel during the same time the vessel was making repeated high accuracy CTD (conductivity-temperature-depth) measurements. These data were used to develop improved frequency-to-temperature and elapsed-fall-time-to-depth conversion equations. All analyses presented here are based upon these equations. Full details on the calibration study will be published in a later document. For this study, four separate frequency-to-temperature equations were used, based upon the four thermistor groups represented in the AXBTs. These equations were

$$T = -40.5081 + 0.02796\ F$$
$$T = -40.7354 + 0.02809\ F$$
$$T = -40.6024 + 0.02807\ F$$
$$T = -40.4151 + 0.02794\ F.$$

The elapsed-fall-time-to-depth equation used was

$$z = 1.602\ t - 1.202 \times 10^{-4}\ t^2.$$

The calibration study found that the Sparton AXBTs had a temperature accuracy better than 0.3 °C. In depth, the accuracy was better than $\pm 5\%$ down to 300 m and ± 15 m below that.

Results

Results from the combined three days' flights are presented in Appendix A as horizontal contours of temperature for a variety of depth levels from the surface down to 700 m. The Iceland-Faeroe Front lies along the Iceland-Faeroe Ridge between Iceland and the Faeroe Islands. The front is a water mass boundary between the warmer and less dense North Atlantic waters and the colder and denser Norwegian and Iceland Sea waters. The front appears in the figures of Appendix A as a collection of bunched isotherms, although above 75 m it is quite poorly defined: a warm mixed layer caps the region and obscures the distinct water masses that are juxtaposed in the region. As a result, whenever similar conditions involving a capping mixed layer exist, remote sensing of sea surface temperature can give only an inadequate picture of the frontal zone. For example, the surface and 10 m contours suggest the frontal intensity is much stronger in the west than in the east. However, examination of the Appendix A contours from 75 m and deeper shows the frontal intensity (measured qualitatively by the tightness of the isotherm bunching) remains fairly constant.

Another feature whose signature is missing from the upper 50 m or so is a northward protrusion of warm water at around 10° W longitude and southward excursions of cooler water on either side, especially around 11° W. Such lateral oscillations of the front are frequently observed and often have short time scales on the order of days rather than months (Hopkins, 1988). This warm northward excursion has been observed quite frequently in this region and often is associated with good fishing conditions. It may also be associated with a deeper southward cold water overflow over the ridge. Most of the Arctic water passing from the Norwegian-Iceland Sea region into the Atlantic transits through the Denmark Strait between Greenland and Iceland (about 2.9 Sv) and through the Faeroe-Shetland Channel (1.1 Sv) (Hopkins, 1988). However, about 1 Sv is also thought to pass episodically over the Iceland-Faeroe Ridge, about half concentrated through a gap in the western portion of the Ridge and perhaps accompanied by a northward meander of the front.

The figures of Appendix A may be reasonably interpreted to support this scenario. The 200 m depth temperature contours appear to show a filament of cold water wending south southeast roughly parallel to the 400 m isobath (compare the figure in Appendix A with the bathymetry contours in Fig. 1), with a possible detached blob of water at about 63.5° N latitude. The 300 and 400 m depth temperature contours suggest an incomplete southward penetration of cold water along the western flank of the ridge that halts by about 63.25° N. Unfortunately, we have only this one snapshot. We probably did not observe an overflow event that took place before we arrived, since there is no evidence of cold water south of 63.25°. Perhaps the warm and cold penetrations intensified later, or perhaps this was just an example of dynamic back and forth undulations of the interface between the two water masses: additional measurements later on might have provided the answer.

On 6 September 1992 a high resolution track was run north-south along 7° W, extending for 125 nmi (232 km) from 65:13.5° N, 7:00.8° W to 63:08.5° N, 7:00.8° W. Sonobuoy arrays for the acoustics transmission loss experiments were centered at 64° N, 7° W. AXBTs and MK 82 SUS were dropped at nominal 5 and 2.5 nmi spacings, respectively. The vertical temperature and sound speed fields along the track are given in Appendix B. Sound speed was computed from temperature and salinity using Del Grosso's equation (Del Grosso, 1973). Salinity was obtained from temperature and the appropriate T-S relationship from the Naval Oceanographic Office's GIUK region dynamic GDEM climatology for September.

Between 63° N to 63.5° N the front was nearly horizontal and at a depth of 400 - 500 m. It then sloped up to very near the surface between 63.5° N to 64.1° N. The sonobuoy arrays were located in this region, as also were, unfortunately, two of the three AXBT failures.

The data themselves are summarized in Appendices C, D, and E. For each flight a plot of the station locations is given, followed by a listing of all positions and times, an overplot of all profiles for the flights, and finally the profile plots themselves in "waterfall" format.

References

Del Grosso, V.A. (1973). Tables of the speed of sound in open ocean water (with Mediterranean Sea and Red Sea applicability). J. Acous. Soc. Am. 53(5), 1384-1401.

Hopkins, T.S. (1988). The GIN Sea: Review of the physical oceanography and literature from 1972. SACLANTCEN Report SR-124, SACLANT Undersea Research Centre, La Spezia, Italy, 195 pp.

Kerr, G.A. (1991). Ocean acoustic model validation project in the GINSea: Preliminary NORDIC 91 environmental acoustic results. Naval Oceanographic and Atmospheric Research Laboratory, SSC, MS, AEAS Report 92-001, 98 pp.

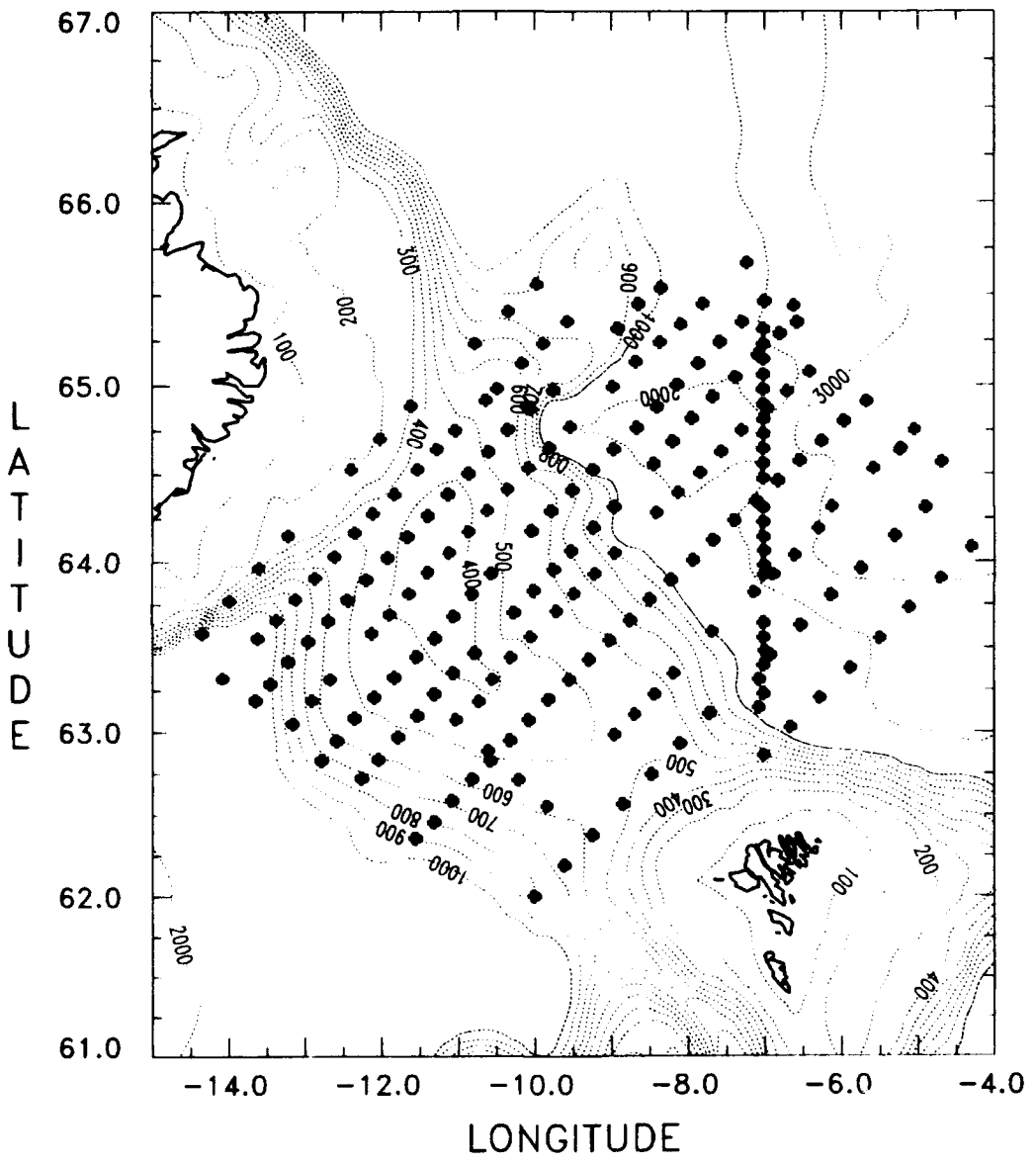


Figure 1. The study area for the September 1991 operations. AXBT drop locations for 3 September are red, those for 4 September are blue, and those for 6 September are green. Bathymetric contours are shown by dashed lines, with depths being in m.

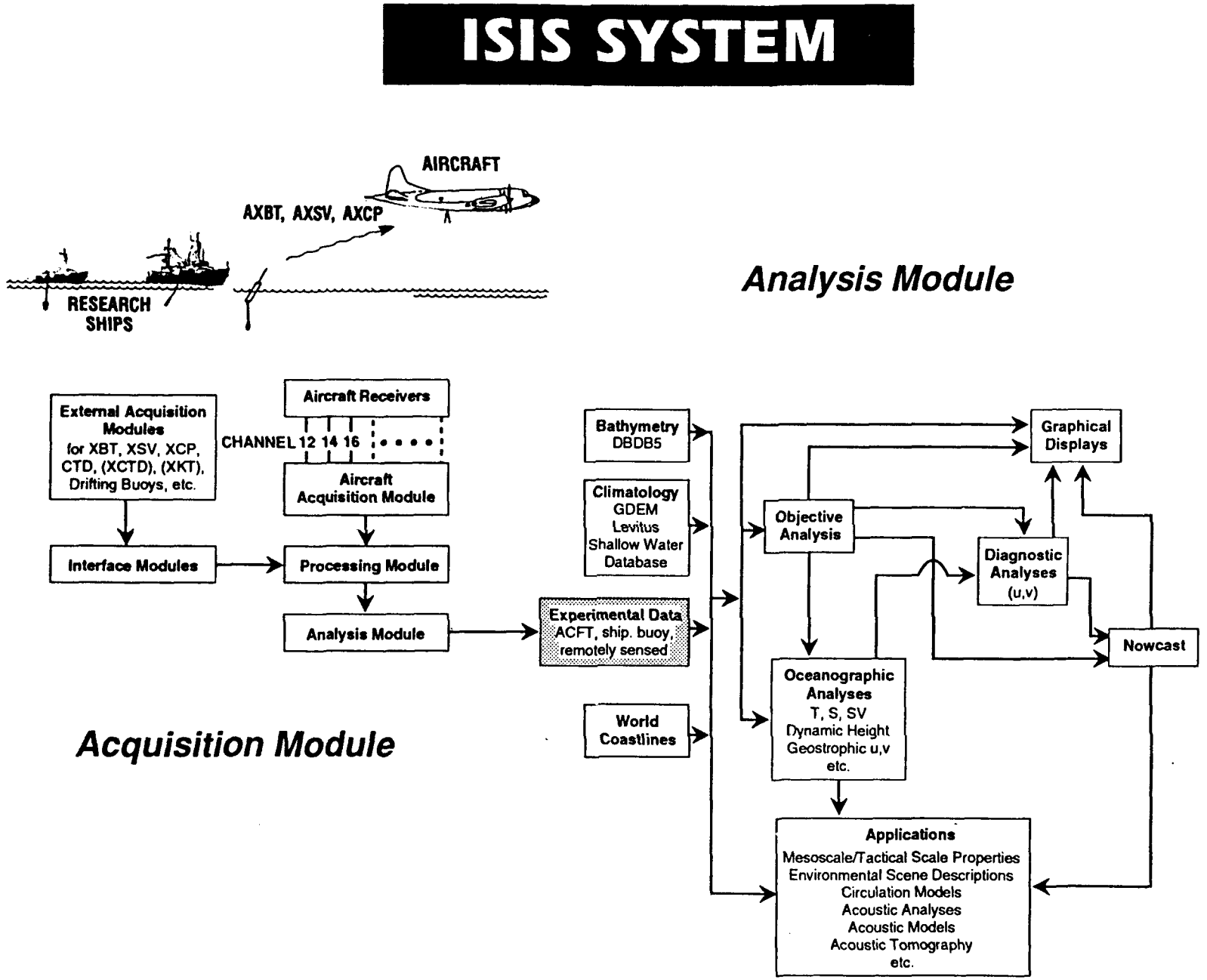
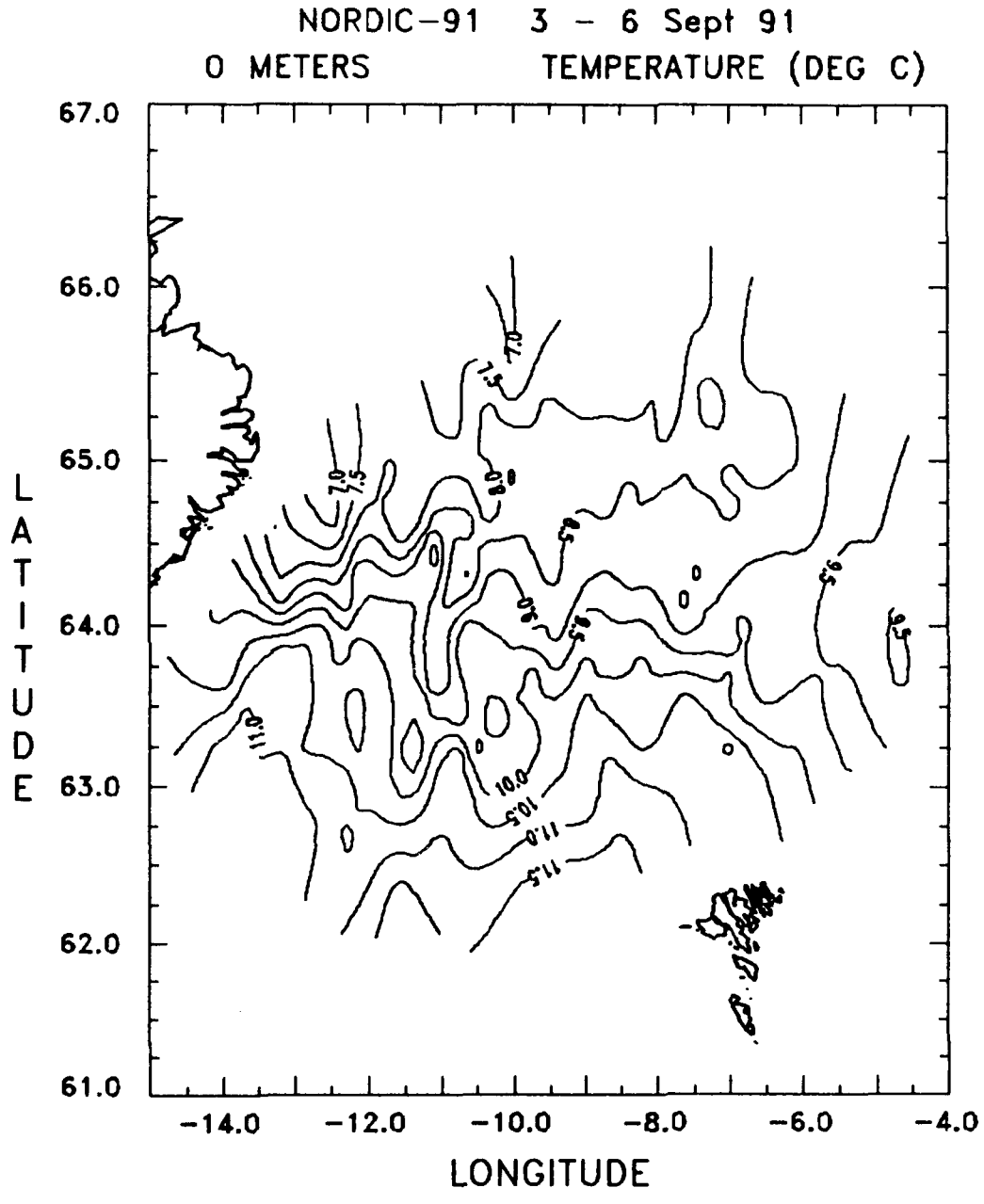


Figure 2. Schematic of the Isis acquisition, processing, and analysis system.

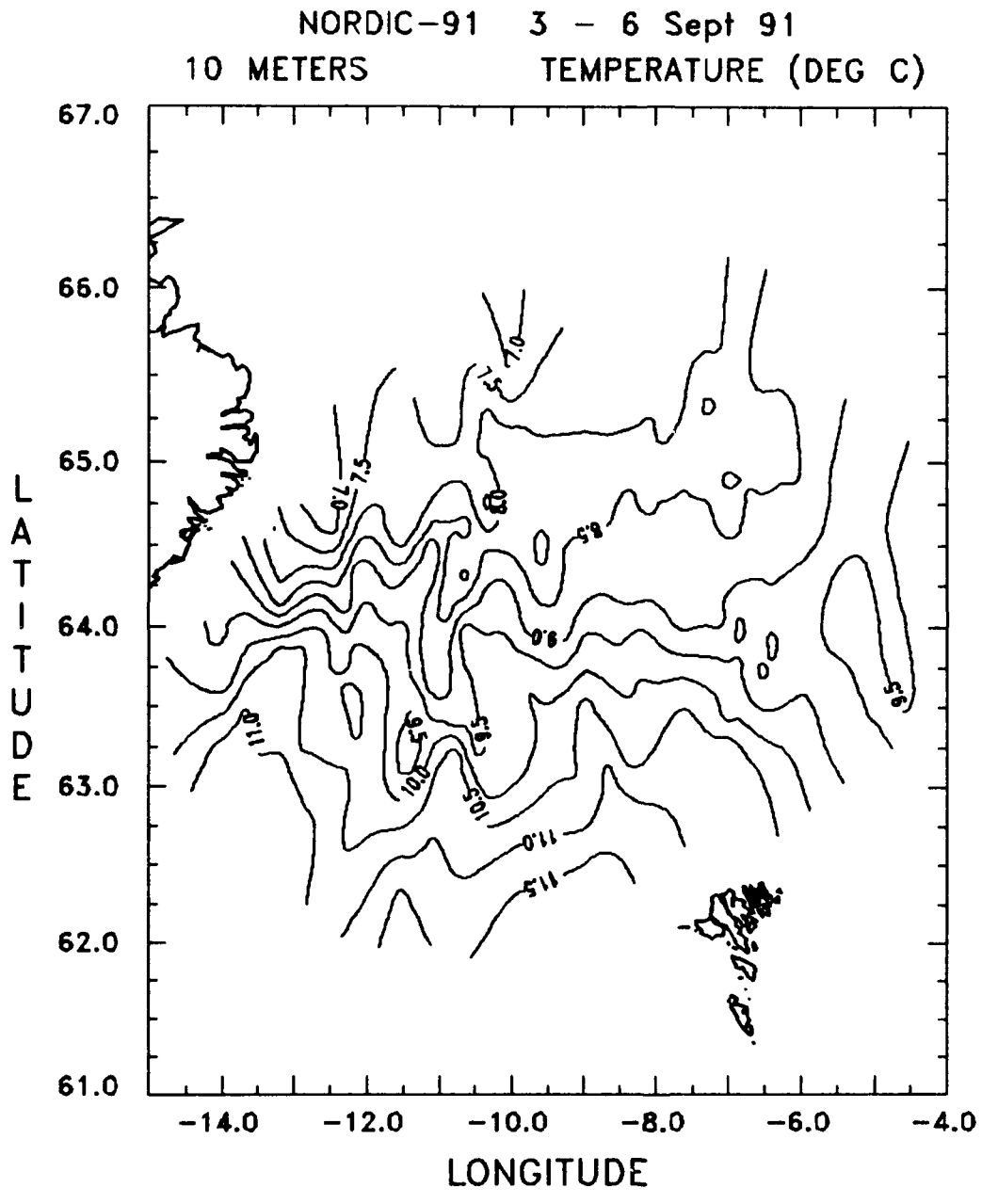
Appendix A

Temperature Contours at Selected Depths,

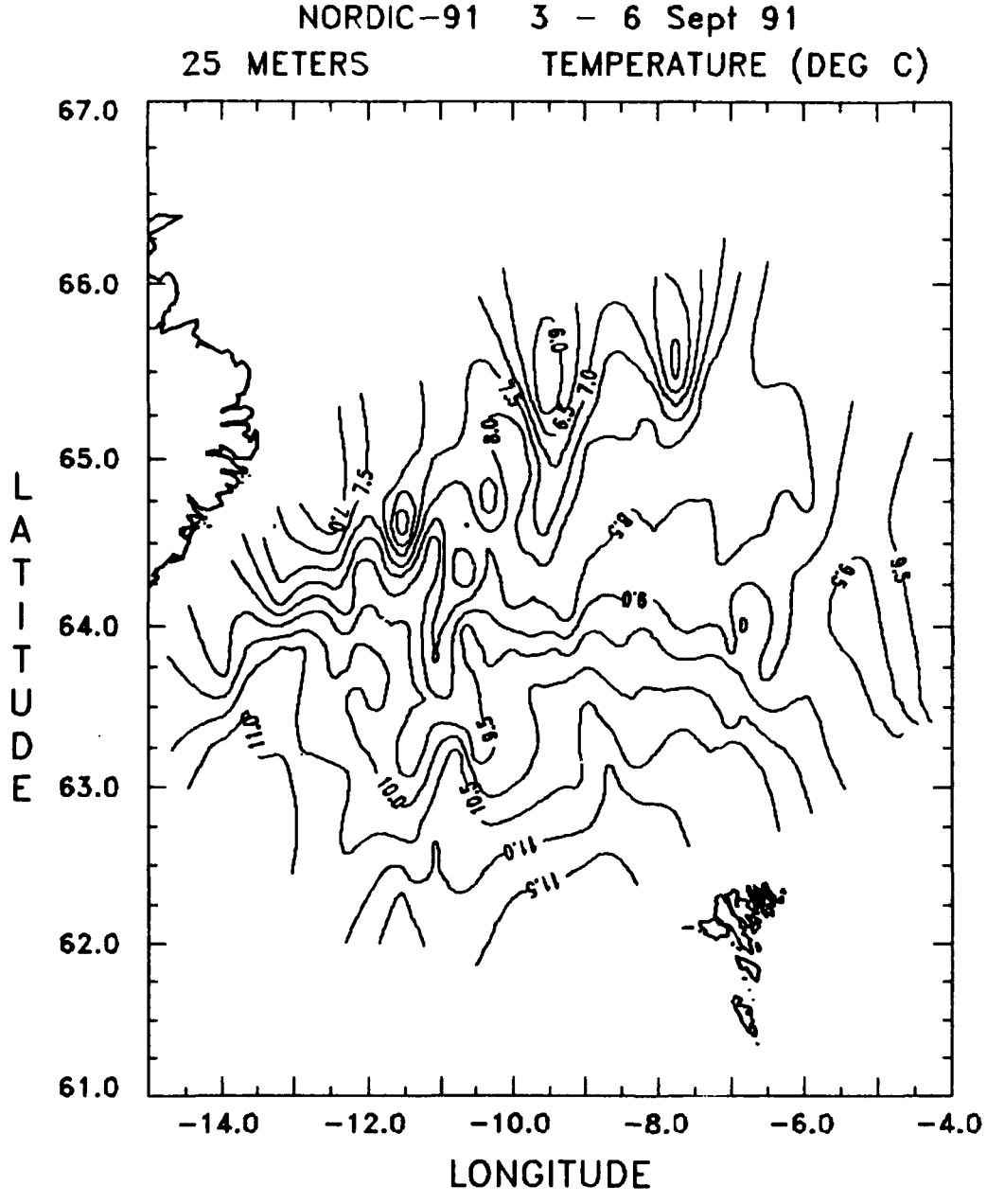
3 - 6 September 1991



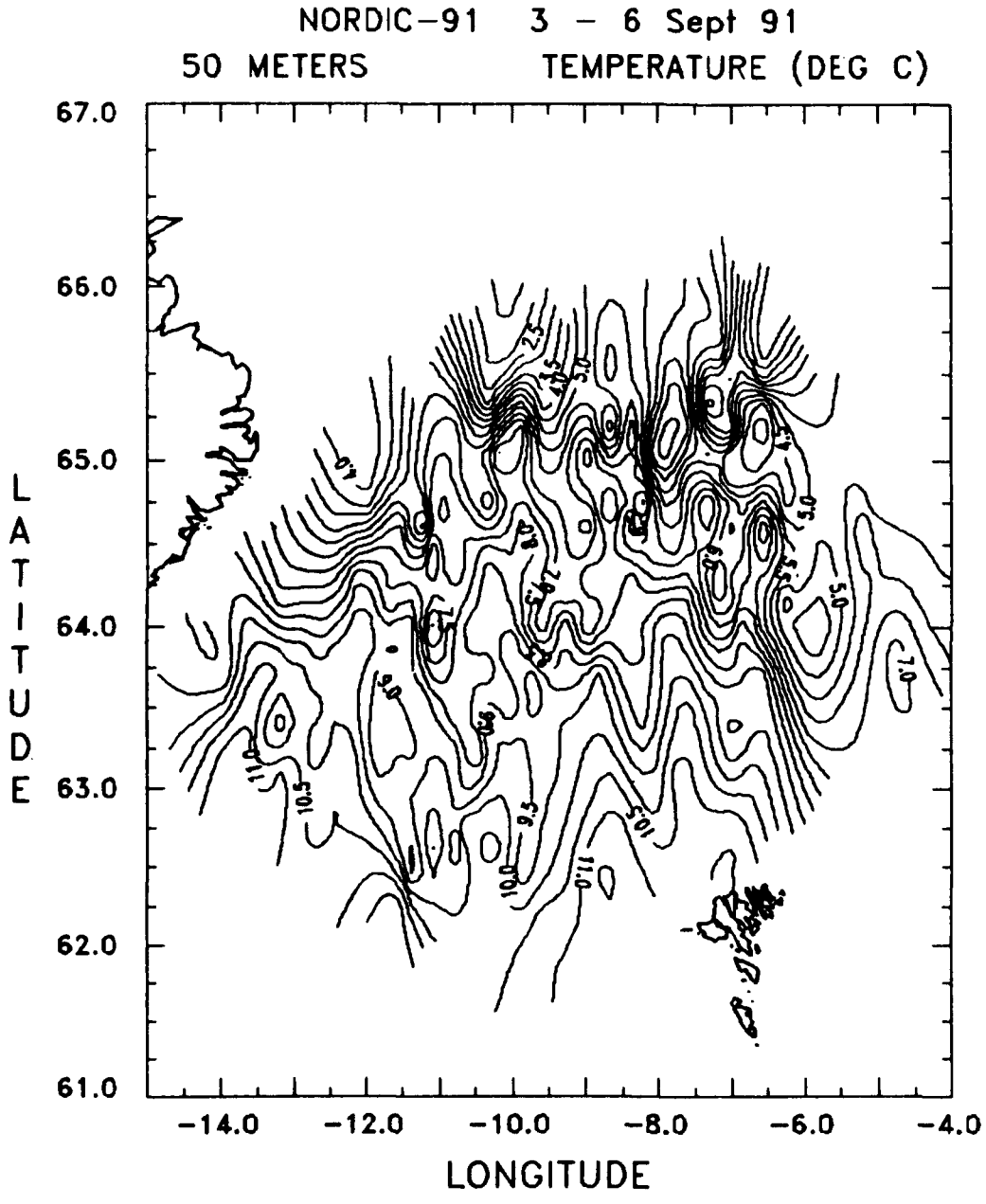
NOARL Code 331



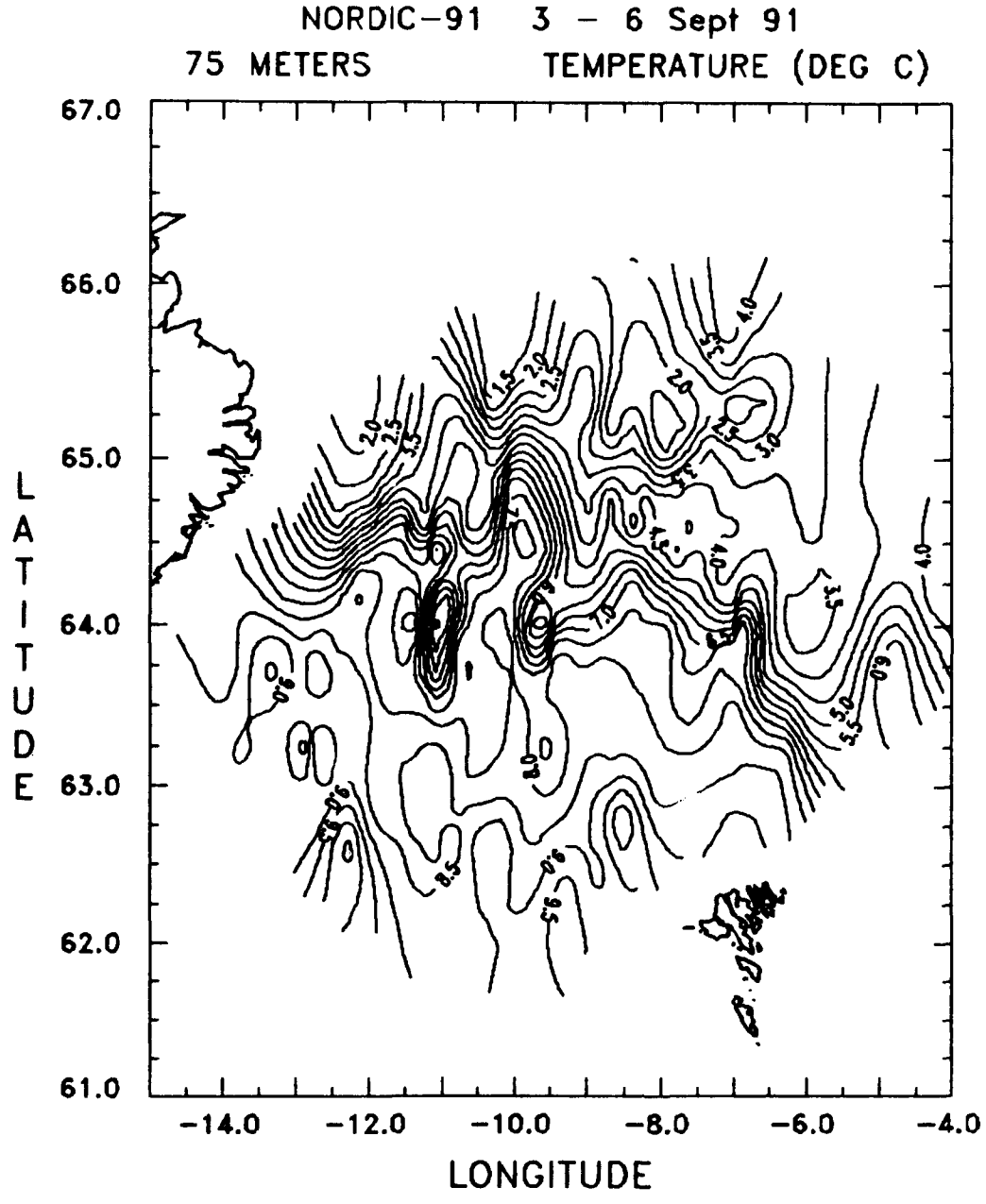
NOARL Code 331



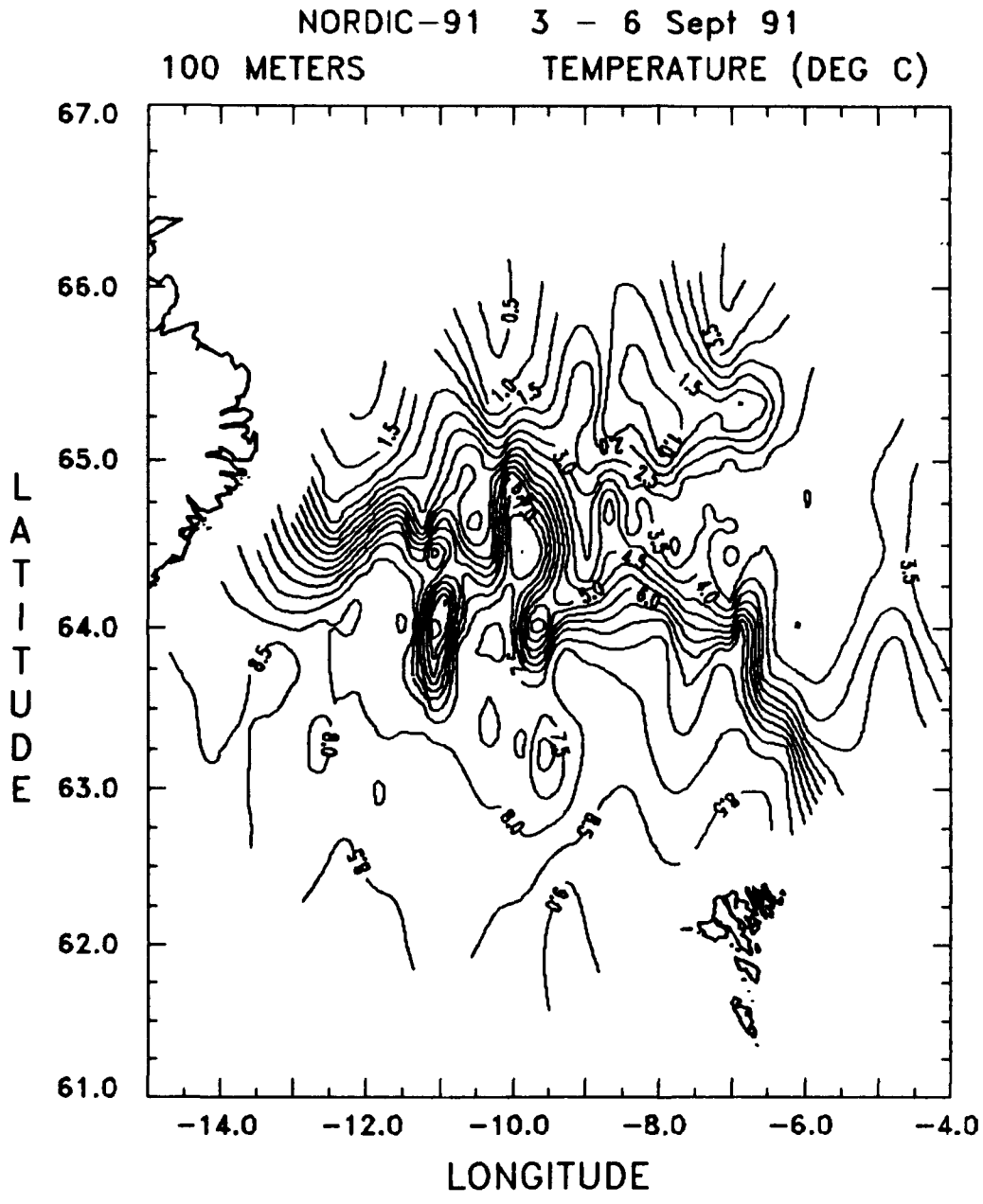
NOARL Code 331



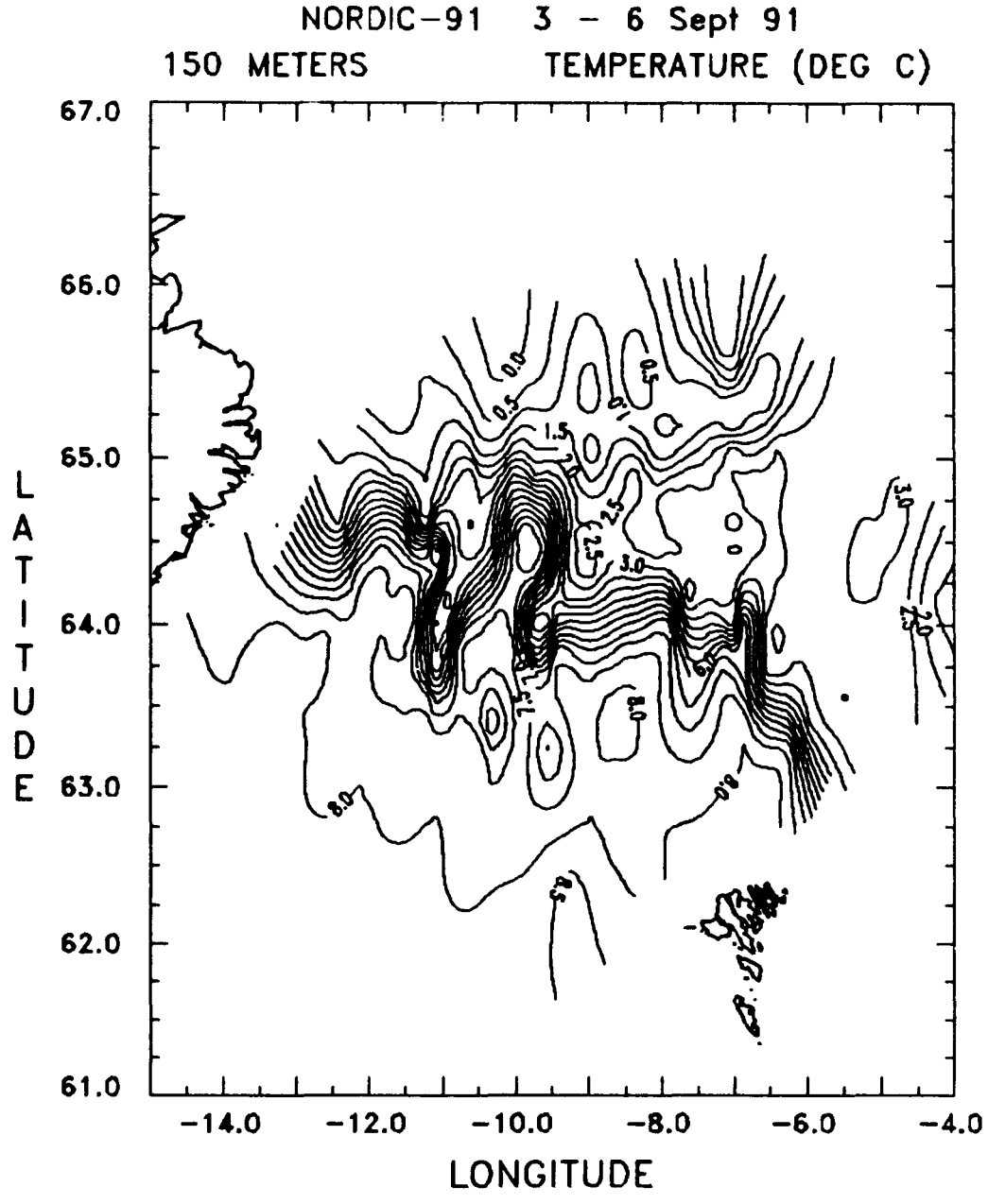
NOARL Code 331



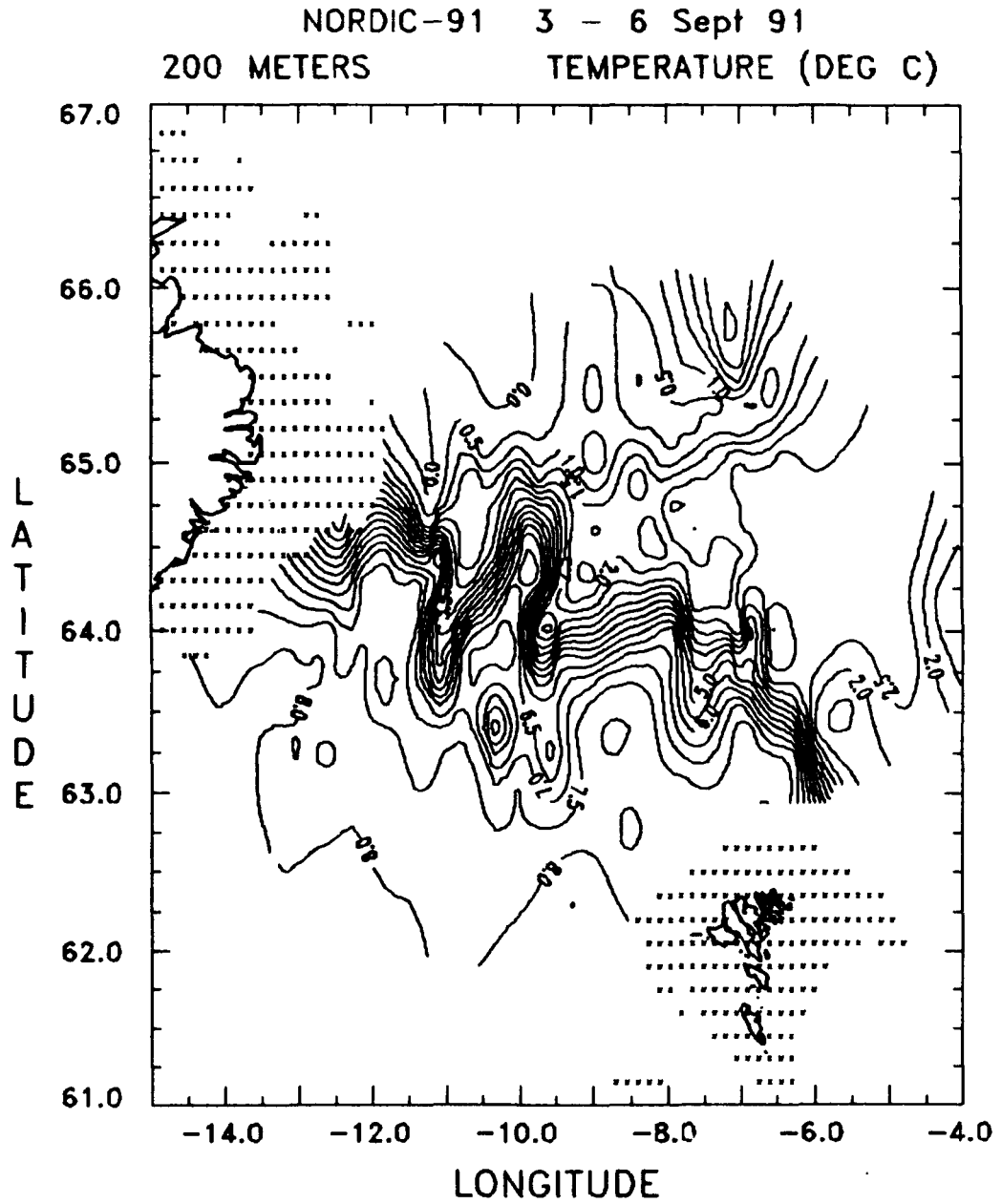
NOARL Code 331

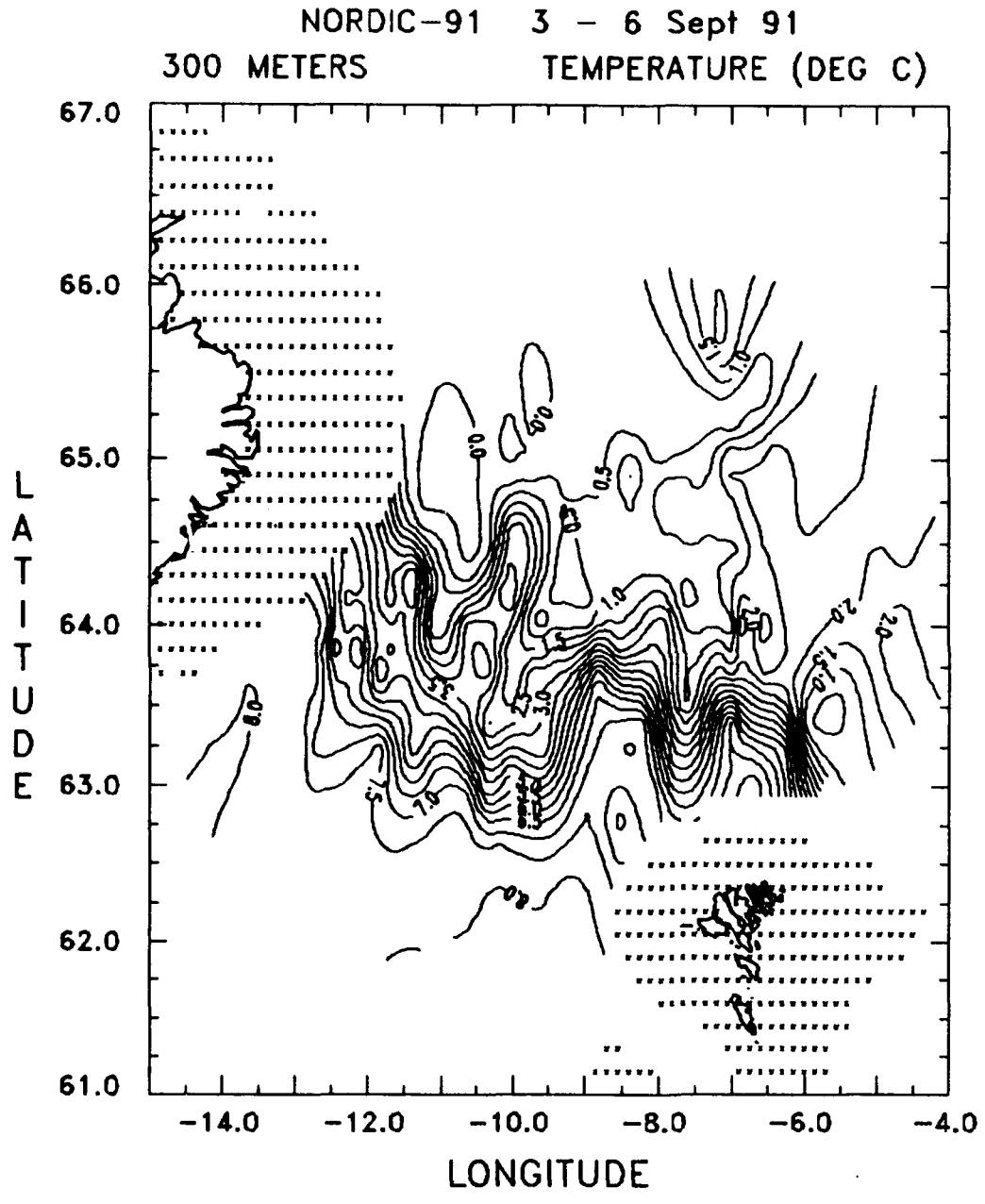


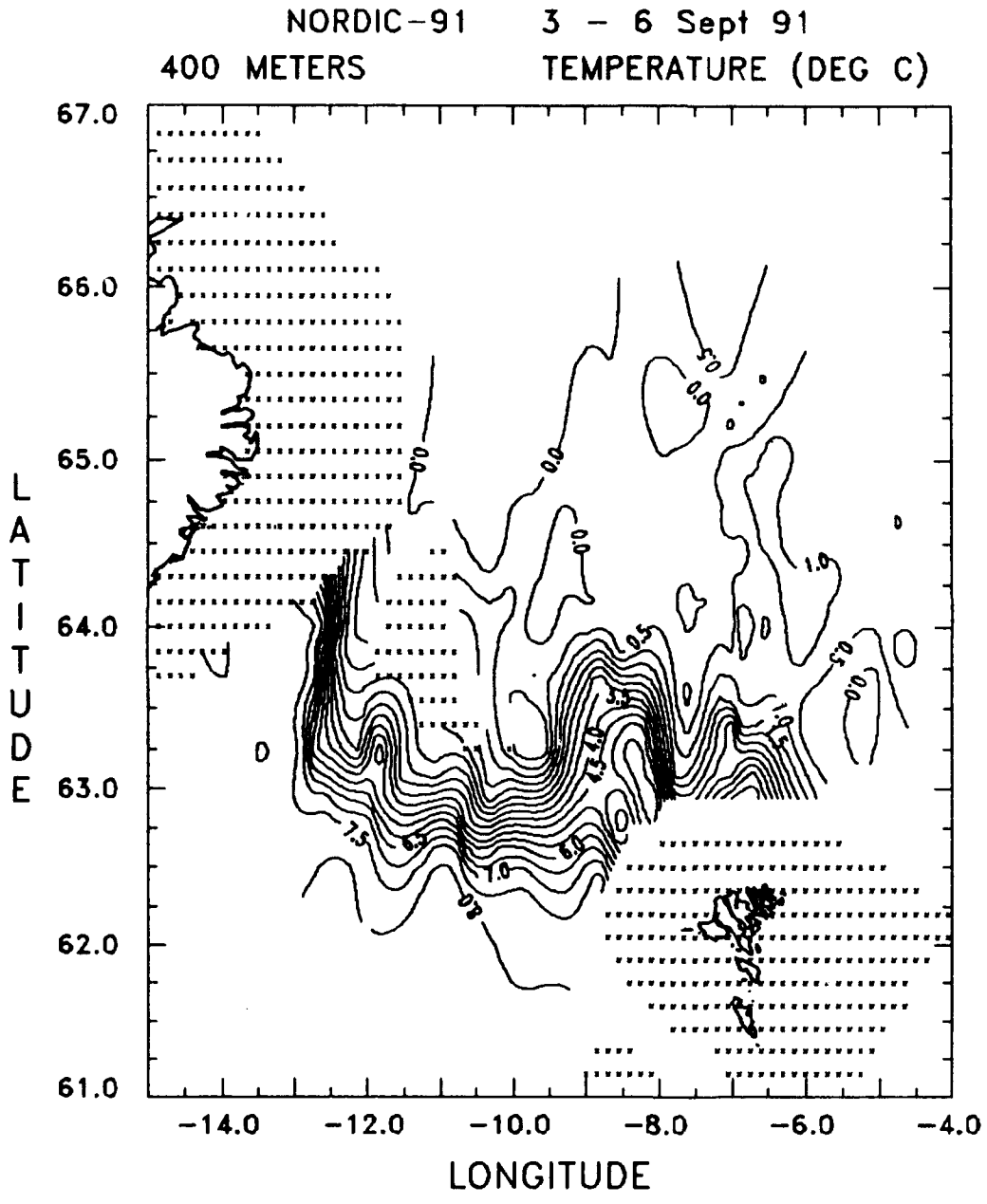
NOARL Code 331



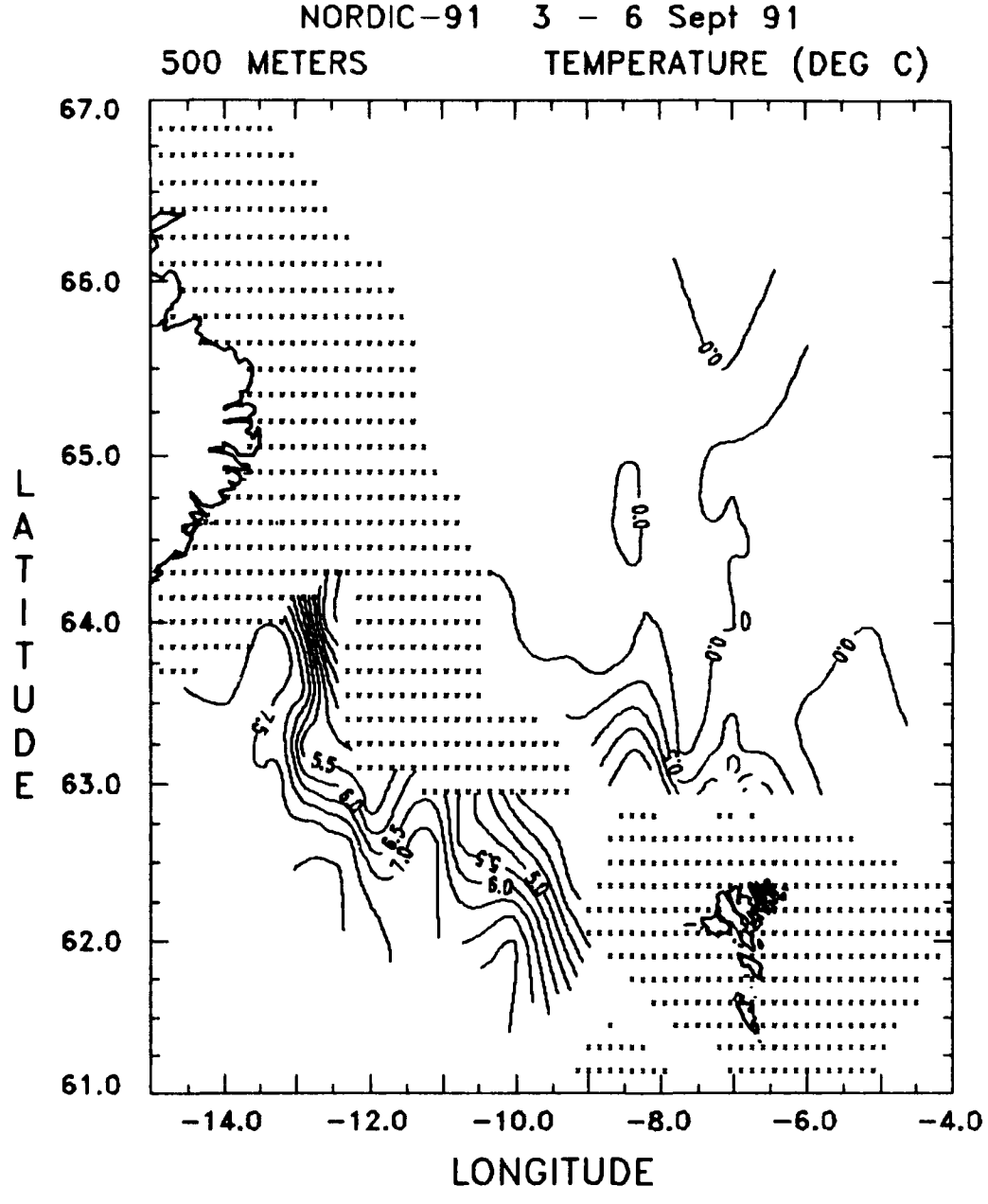
NOARL Code 331


NORDIC-91 3 - 6 Sept 91
200 METERS TEMPERATURE (DEG C)
67.0
66.0
65.0
64.0
63.0
62.0
61.0
LATITUDE
-14.0
-12.0
-10.0
-8.0
-6.0
-4.0
LONGITUDE
NRL Code 331

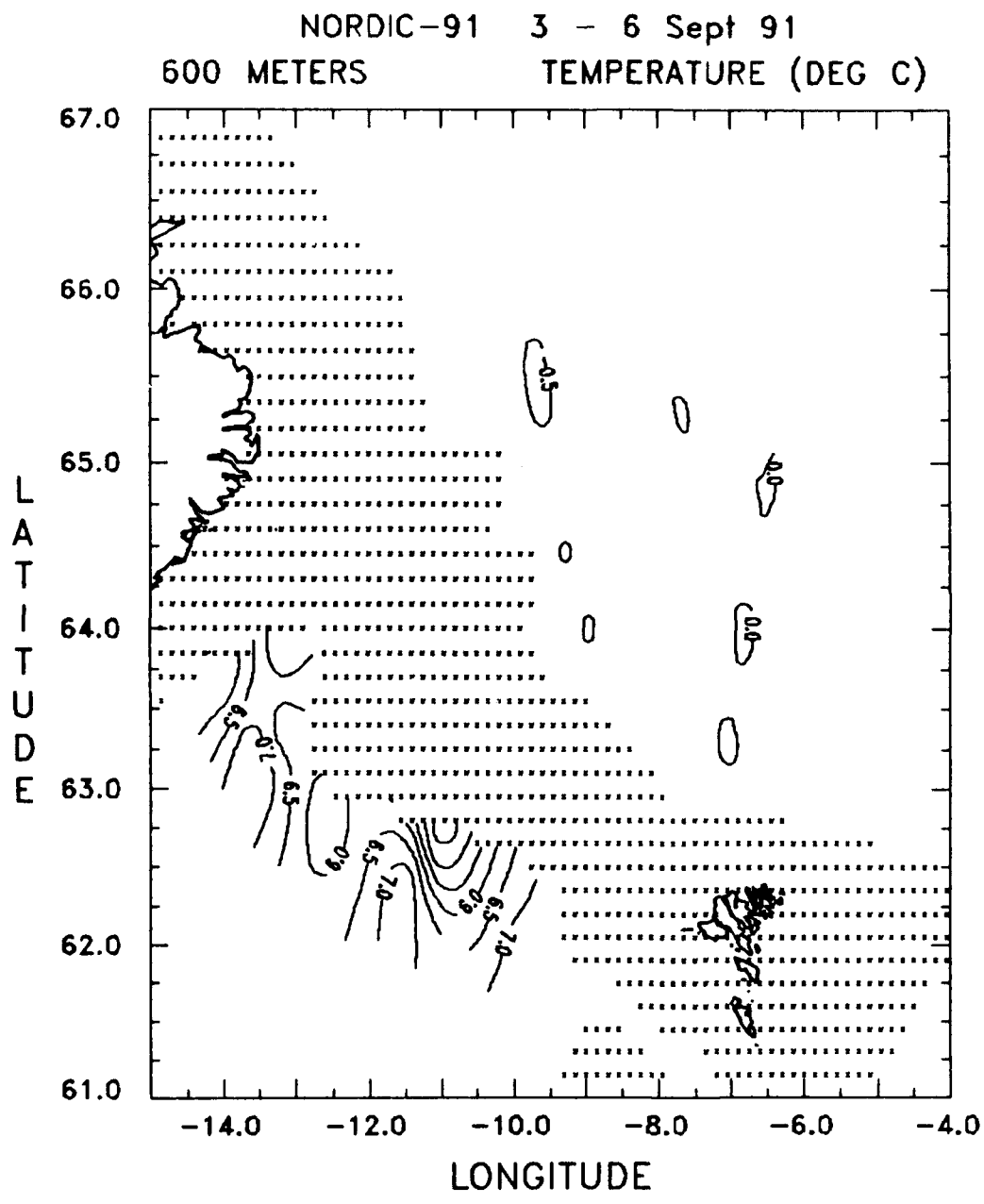

NORDIC-91 3 - 6 Sept 91
300 METERS TEMPERATURE (DEG C)
67.0
66.0
65.0
64.0
63.0
62.0
61.0
LATITUDE
-14.0
-12.0
-10.0
-8.0
-6.0
-4.0
LONGITUDE
NRL Code 331

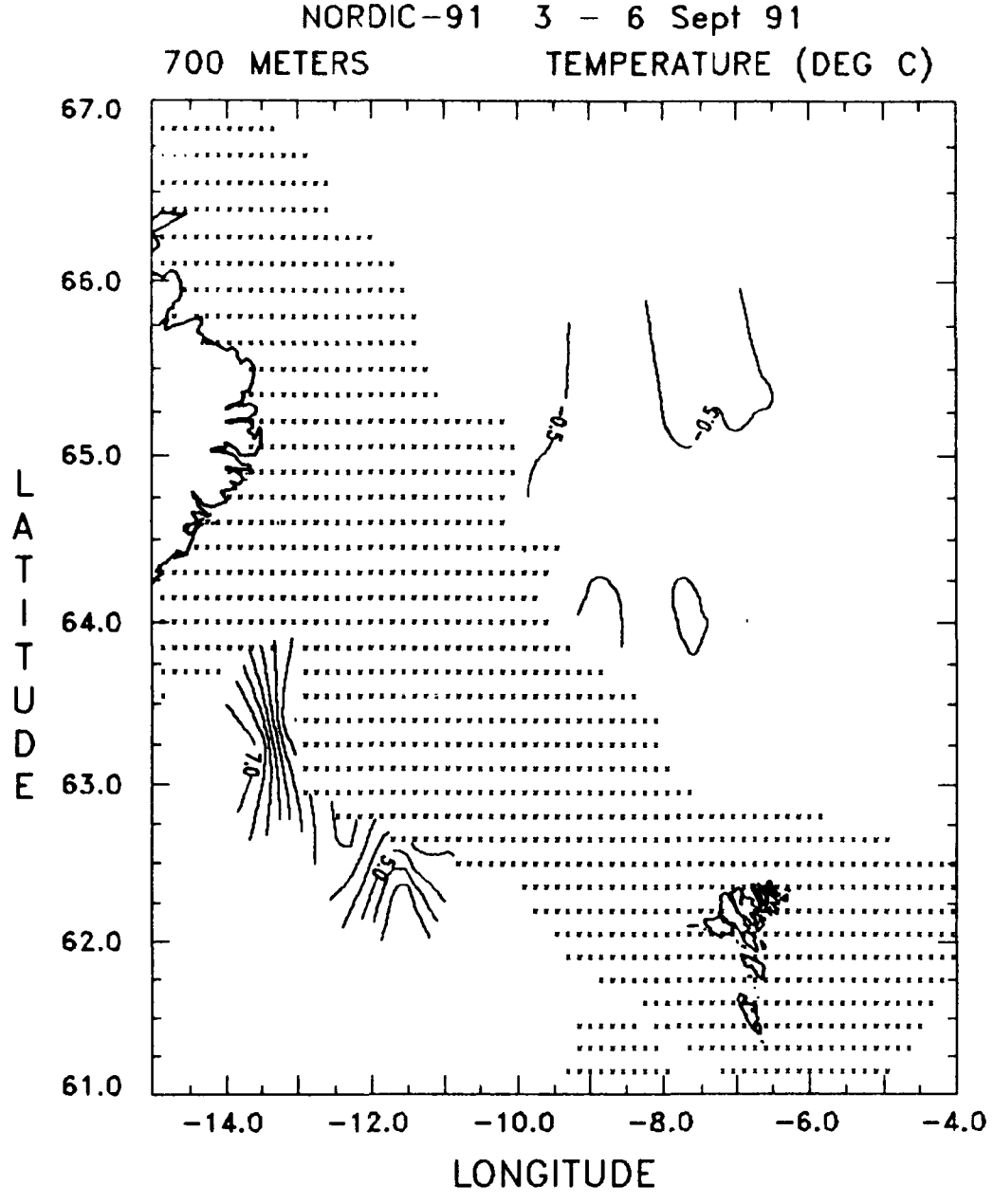

NORDIC-91 3 - 6 Sept 91
400 METERS TEMPERATURE (DEG C)
67.0
66.0
65.0
64.0
63.0
62.0
61.0
LATITUDE
-14.0
-12.0
-10.0
-8.0
-6.0
-4.0
LONGITUDE

NRL Code 331


NORDIC-91 3 - 6 Sept 91
500 METERS TEMPERATURE (DEG C)
67.0
66.0
65.0
64.0
63.0
62.0
61.0
LATITUDE
-14.0
-12.0
-10.0
-8.0
-6.0
-4.0
LONGITUDE
0.0
0
7.5
5.5
6.0
6.5
7.0
5.5
6.0
5.0

NRL Code 331


NORDIC-91 3 - 6 Sept 91
600 METERS TEMPERATURE (DEG C)
67.0
66.0
65.0
64.0
63.0
62.0
61.0
LATITUDE
-14.0
-12.0
-10.0
-8.0
-6.0
-4.0
LONGITUDE
NRL Code 331

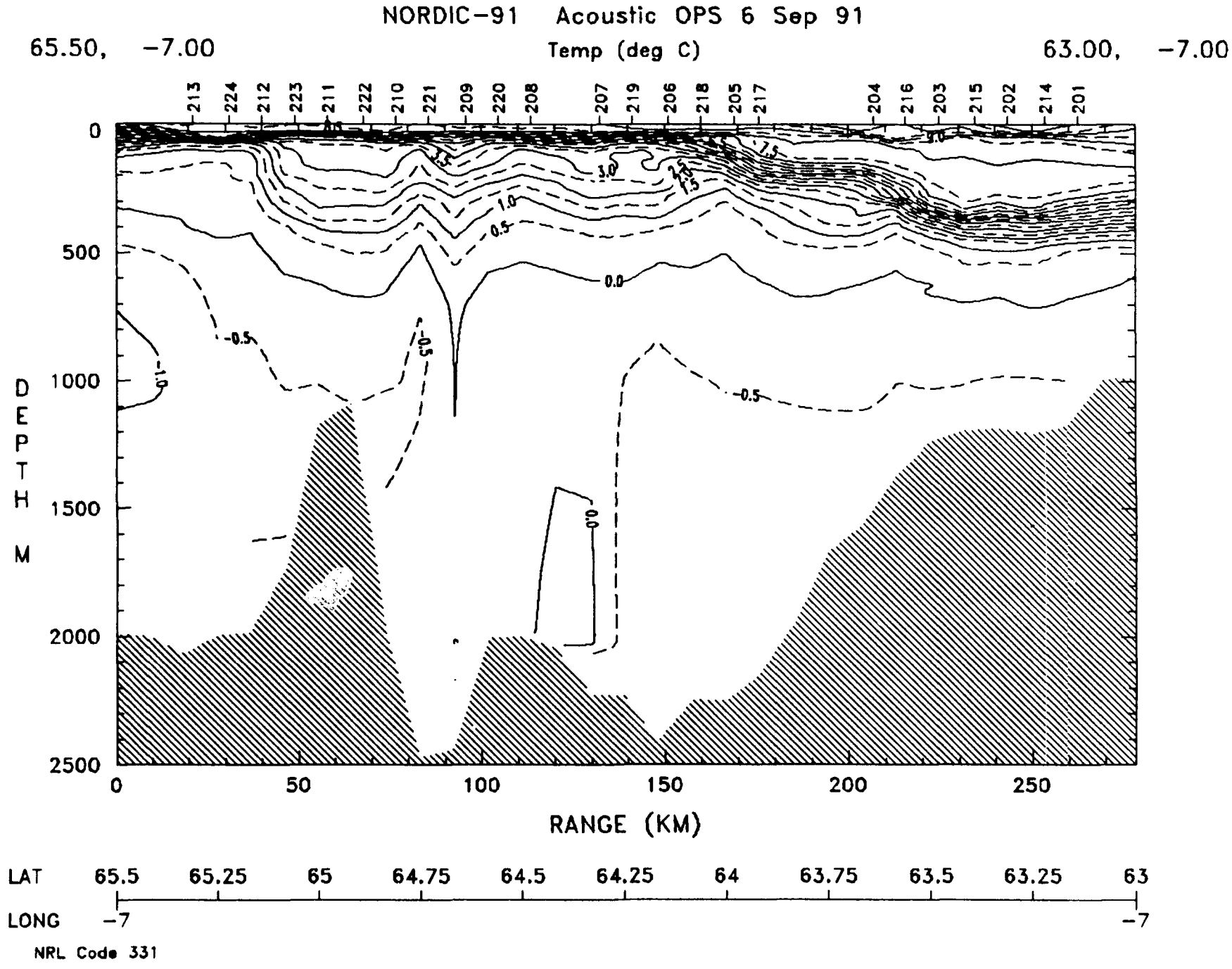

NORDIC-91 3 - 6 Sept 91
700 METERS TEMPERATURE (DEG C)
67.0
66.0
65.0
64.0
63.0
62.0
61.0
LATITUDE
-14.0
-12.0
-10.0
-8.0
-6.0
-4.0
LONGITUDE
-0.5
-0.5
1.0
1.5

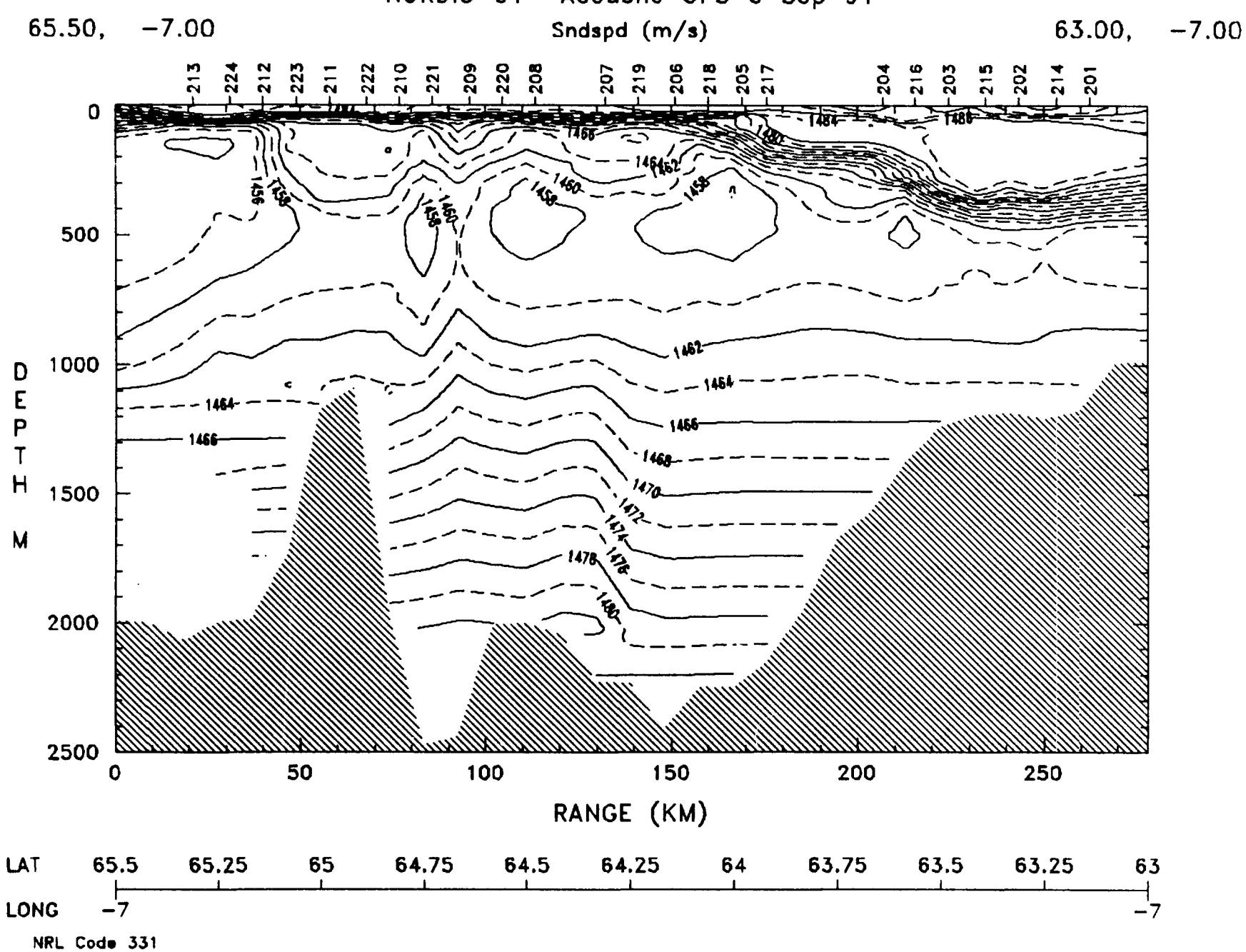
NRL Code 331

Appendix B

Temperature and sound speed along the 7° W track,

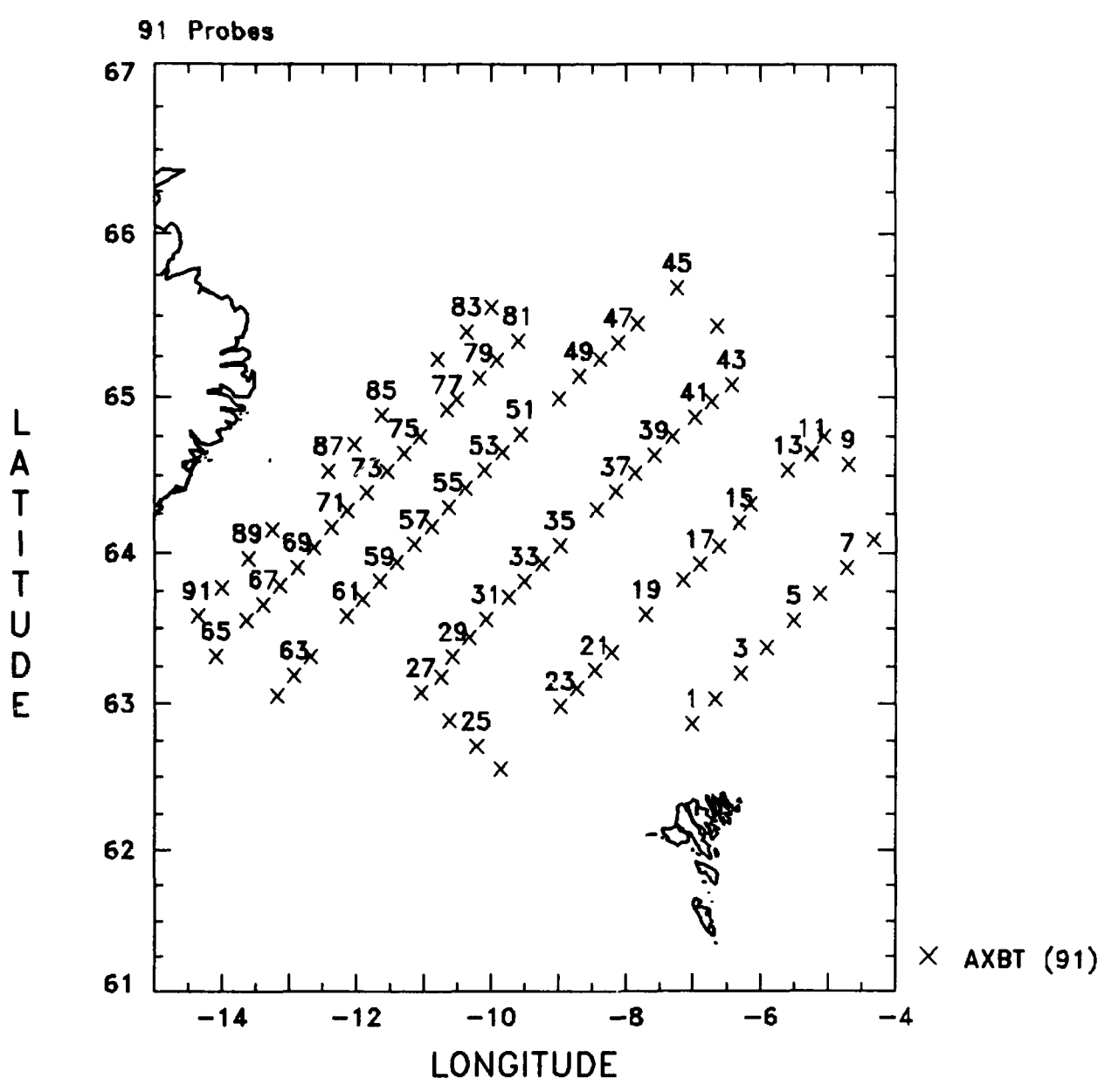
6 September 1991


NORDIC-91 Acoustic OPS 6 Sep 91
65.50, -7.00
Temp (deg C)
63.00, -7.00
213 224 212 223 211 222 210 221 209 220 208 207 219 206 218 205 217 204 216 203 215 202 214 201
0
500
1000
1500
2000
2500
DEPTH M
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
0
50
100
150
200
250
RANGE (KM)
LAT 65.5 65.25 65 64.75 64.5 64.25 64 63.75 63.5 63.25 63
LONG -7 -7
NRL Code 331


NORDIC-91 Acoustic OPS 6 Sep 91
65.50, -7.00
Sndspd (m/s)
63.00, -7.00
213 224 212 223 211 222 210 221 209 220 208 207 219 206 218 205 217 204 216 203 215 202 214 201
0
500
1000
1500
2000
2500
DEPTH M
1456
1458
1460
1462
1464
1466
1468
1470
1472
1474
1476
1478
1480
1482
1484
1486
0
50
100
150
200
250
RANGE (KM)
LAT 65.5 65.25 65 64.75 64.5 64.25 64 63.75 63.5 63.25 63
LONG -7 -7
NRL Code 331

Appendix C

Drop Times, Positions, and Data Traces, 3 September 1991


NORDIC-91 Flt. M1 3 Sept 91
91 Probes
67
66
65
64
63
62
61
LATITUDE
-14
-12
-10
-8
-6
-4
LONGITUDE
× AXBT (91)
NOARL Code 331

Header information for AXBT drops, 3 September 1991. Times are UTC.

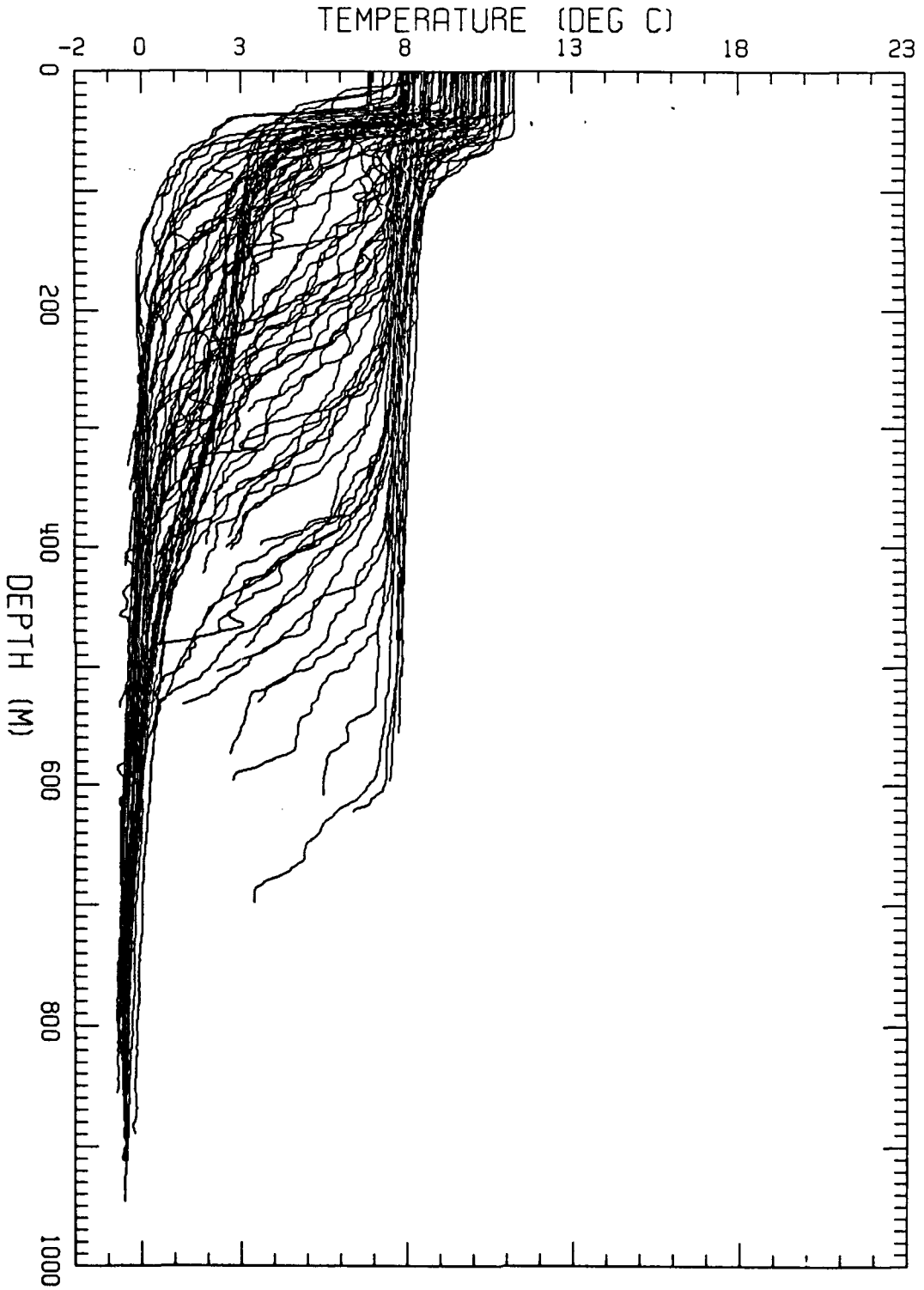
DATE: 9/03/91 PROJECT ID: NORDIC 91

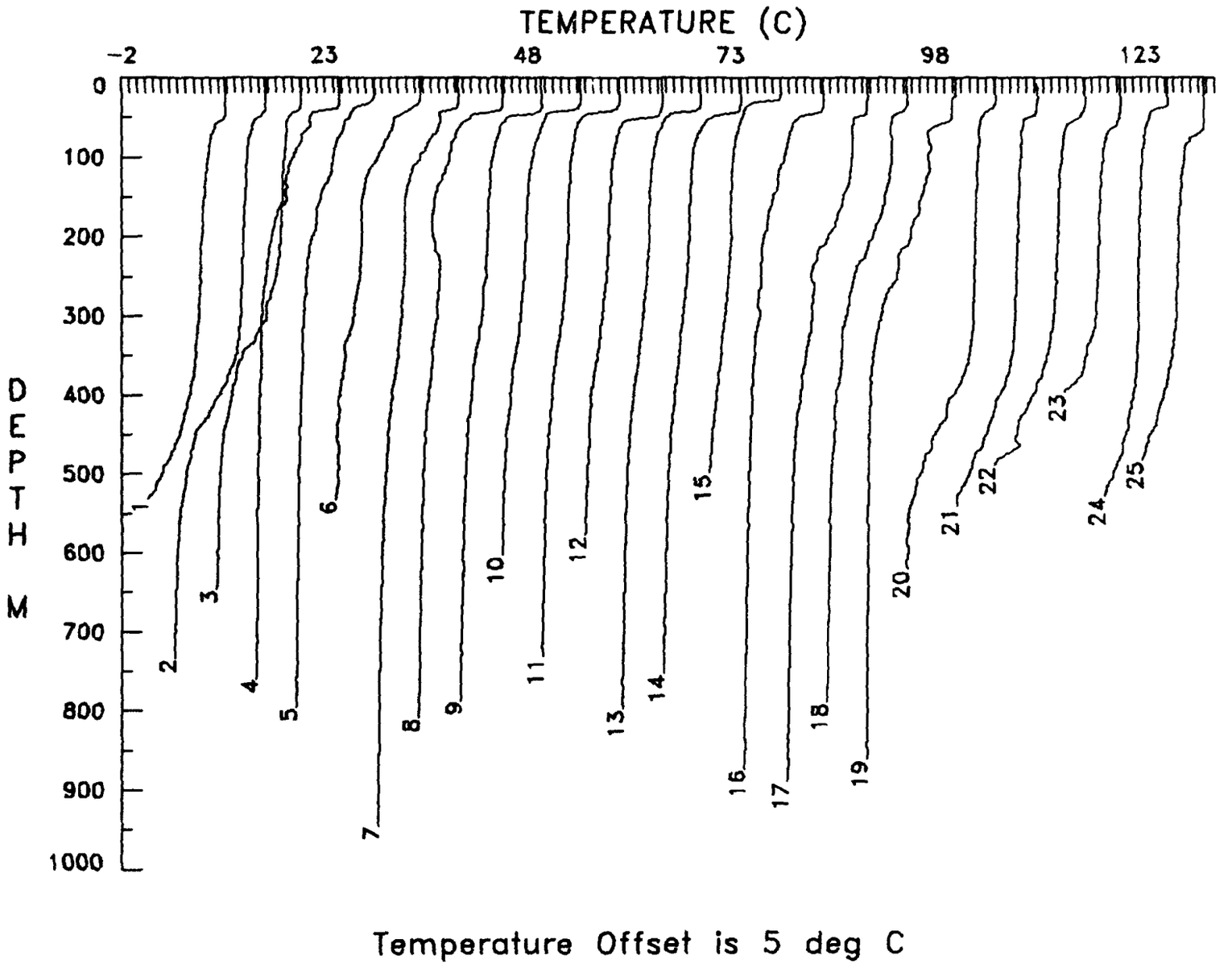
#	TYPE	D/S	LATITUDE	LONGITUDE	TIME	FLT	CH
1	AXBT	D	62: 51.69	-7: -.64	14:02:28	1	12
2	AXBT	D	63: 1.79	-6:-39.68	14:06:22	1	14
3	AXBT	D	63: 12.25	-6:-16.77	14:10:02	1	16
4	AXBT	D	63: 22.74	-5:-53.04	14:13:48	1	12
5	AXBT	D	63: 33.26	-5:-29.91	14:17:32	1	14
6	AXBT	D	63: 44.01	-5: -6.75	14:21:26	1	16
7	AXBT	D	63: 54.26	-4:-42.08	14:25:13	1	12
8	AXBT	D	64: 5.07	-4:-18.09	14:29:00	1	14
9	AXBT	D	64: 34.27	-4:-40.96	14:41:11	1	12
10	AXBT	D	64: 45.11	-5: -2.47	14:45:07	1	14
11	AXBT	D	64: 38.74	-5:-13.14	14:47:58	1	14
12	AXBT	D	64: 38.32	-5:-13.97	14:48:09	1	16
13	AXBT	D	64: 32.02	-5:-34.68	14:50:40	1	12
14	AXBT	D	64: 19.05	-6: -7.07	14:55:26	1	16
15	AXBT	D	64: 11.52	-6:-17.85	14:58:03	1	22
16	AXBT	D	64: 2.32	-6:-36.86	15:01:21	1	12
17	AXBT	D	63: 55.56	-6:-53.36	15:04:01	1	14
18	AXBT	D	63: 49.43	-7: -8.36	15:06:26	1	16
19	AXBT	D	63: 35.65	-7:-41.37	15:11:43	1	12
20	AXBT	D	63: 20.96	-8:-11.42	15:17:03	1	16
21	AXBT	D	63: 13.42	-8:-26.30	15:19:51	1	22
22	AXBT	D	63: 6.29	-8:-42.01	15:22:40	1	12
23	AXBT	D	62: 59.06	-8:-57.57	15:25:29	1	14
24	AXBT	D	62: 33.30	-9:-50.60	15:34:38	1	12
25	AXBT	D	62: 42.79	-10:-12.56	15:39:10	1	14
26	AXBT	D	62: 53.30	-10:-36.78	15:43:06	1	16
27	AXBT	D	63: 4.52	-11: -1.85	15:47:24	1	12
28	AXBT	D	63: 11.00	-10:-43.80	15:50:07	1	14
29	AXBT	D	63: 18.86	-10:-33.11	15:52:36	1	16
30	AXBT	D	63: 26.59	-10:-18.87	15:55:06	1	22
31	AXBT	D	63: 33.82	-10: -3.36	15:57:42	1	12
32	AXBT	D	63: 42.68	-9:-43.09	16:00:59	1	14
33	AXBT	D	63: 48.81	-9:-29.57	16:03:10	1	16
34	AXBT	D	63: 55.76	-9:-13.17	16:05:44	1	22
35	AXBT	D	64: 3.01	-8:-57.27	16:08:24	1	12
36	AXBT	D	64: 16.95	-8:-24.43	16:13:48	1	16
37	AXBT	D	64: 23.81	-8: -7.48	16:16:26	1	22
38	AXBT	D	64: 30.62	-7:-50.07	16:19:04	1	12
39	AXBT	D	64: 37.67	-7:-33.79	16:21:41	1	14
40	AXBT	D	64: 44.90	-7:-17.78	16:24:21	1	16
41	AXBT	D	64: 52.19	-6:-57.69	16:27:21	1	22
42	AXBT	D	64: 57.98	-6:-42.33	16:29:41	1	12
43	AXBT	D	65: 4.53	-6:-24.63	16:32:19	1	14
44	AXBT	D	65: 26.33	-6:-37.10	16:41:31	1	12
45	AXBT	D	65: 40.32	-7:-13.60	16:47:04	1	14
46	AXBT	D	65: 26.98	-7:-48.12	16:52:39	1	12
47	AXBT	D	65: 20.24	-8: -5.57	16:55:13	1	14
48	AXBT	D	65: 14.33	-8:-21.90	16:57:35	1	16
49	AXBT	D	65: 7.80	-8:-40.70	17:00:31	1	22
50	AXBT	D	64: 59.54	-8:-58.86	17:03:15	1	12
51	AXBT	D	64: 45.93	-9:-32.11	17:08:30	1	16
52	AXBT	D	64: 39.00	-9:-48.38	17:11:10	1	22
53	AXBT	D	64: 32.00	-10: -4.75	17:13:52	1	12
54	AXBT	D	64: 24.99	-10:-21.06	17:16:35	1	14
55	AXBT	D	64: 17.74	-10:-36.97	17:19:17	1	16
56	AXBT	D	64: 10.50	-10:-51.84	17:21:59	1	22
57	AXBT	D	64: 3.21	-11: -7.14	17:24:40	1	12
58	AXBT	D	63: 56.41	-11:-23.57	17:27:19	1	14

#	TYPE	D/S	LATITUDE	LONGITUDE	TIME	FLT	CH
59	AXBT	D	63: 48.91	-11:-38.21	17:29:58	1	16
60	AXBT	D	63: 41.67	-11:-53.41	17:32:42	1	22
61	AXBT	D	63: 35.08	-12: -7.50	17:35:26	1	12
62	AXBT	D	63: 18.86	-12:-39.99	17:41:01	1	16
63	AXBT	D	63: 11.26	-12:-54.27	17:43:36	1	22
64	AXBT	D	63: 3.02	-13: -9.61	17:46:29	1	12
65	AXBT	D	63: 19.07	-14: -4.79	17:55:42	1	16
66	AXBT	D	63: 33.24	-13:-37.37	18:00:24	1	14
67	AXBT	D	63: 39.71	-13:-22.48	18:02:40	1	16
68	AXBT	D	63: 46.93	-13: -7.12	18:05:14	1	22
69	AXBT	D	63: 54.37	-12:-51.41	18:07:53	1	12
70	AXBT	D	64: 1.89	-12:-36.55	18:10:26	1	14
71	AXBT	D	64: 10.09	-12:-20.70	18:13:15	1	16
72	AXBT	D	64: 16.66	-12: -6.45	18:15:38	1	22
73	AXBT	D	64: 23.34	-11:-49.32	18:18:12	1	12
74	AXBT	D	64: 31.70	-11:-31.52	18:21:08	1	14
75	AXBT	D	64: 38.60	-11:-16.55	18:23:33	1	16
76	AXBT	D	64: 44.90	-11: -2.14	18:25:49	1	22
77	AXBT	D	64: 55.08	-10:-38.23	18:29:27	1	12
78	AXBT	D	64: 59.01	-10:-29.09	18:30:50	1	14
79	AXBT	D	65: 7.22	-10: -9.90	18:33:46	1	16
80	AXBT	D	65: 13.82	-9:-53.44	18:36:12	1	22
81	AXBT	D	65: 21.08	-9:-34.39	18:39:00	1	12
82	AXBT	D	65: 33.26	-9:-58.22	18:43:46	1	14
83	AXBT	D	65: 24.38	-10:-20.59	18:47:45	1	16
84	AXBT	D	65: 14.01	-10:-46.65	18:51:41	1	12
85	AXBT	D	64: 53.17	-11:-36.80	18:59:29	1	16
86	AXBT	D	64: 42.16	-12: -.81	19:03:29	1	12
87	AXBT	D	64: 31.82	-12:-23.34	19:07:23	1	14
88	AXBT	D	64: 9.07	-13:-13.02	19:15:24	1	12
89	AXBT	D	63: 57.87	-13:-35.96	19:19:18	1	14
90	AXBT	D	63: 46.42	-13:-59.10	19:23:18	1	16
91	AXBT	D	63: 35.03	-14:-20.89	19:27:17	1	12

Total number profiles: 91

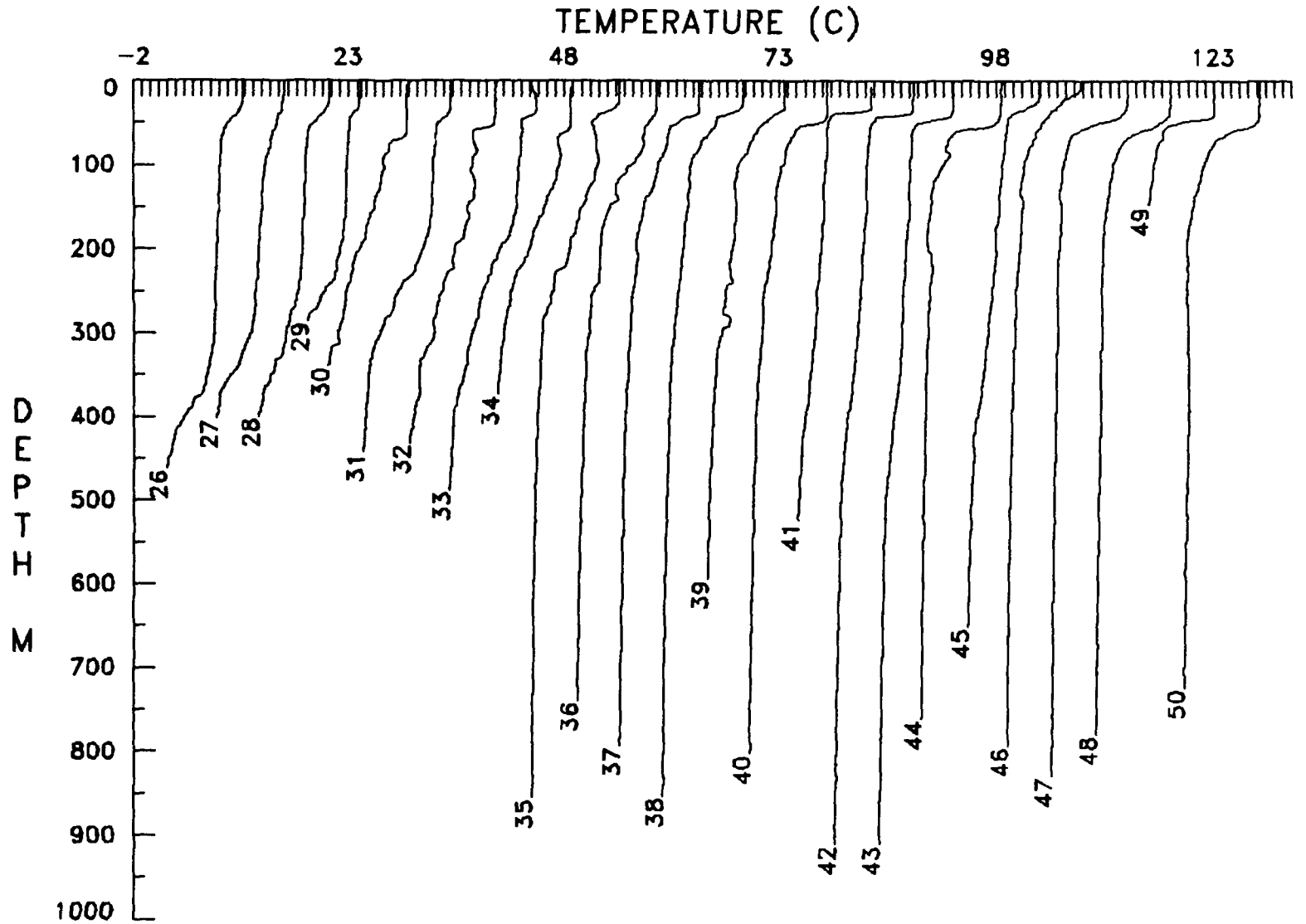
PROJECT: NORDIC '91
DROP NOS: 1 TO 91
M1 NORDIC91 Corrected AXBT Data Overplot





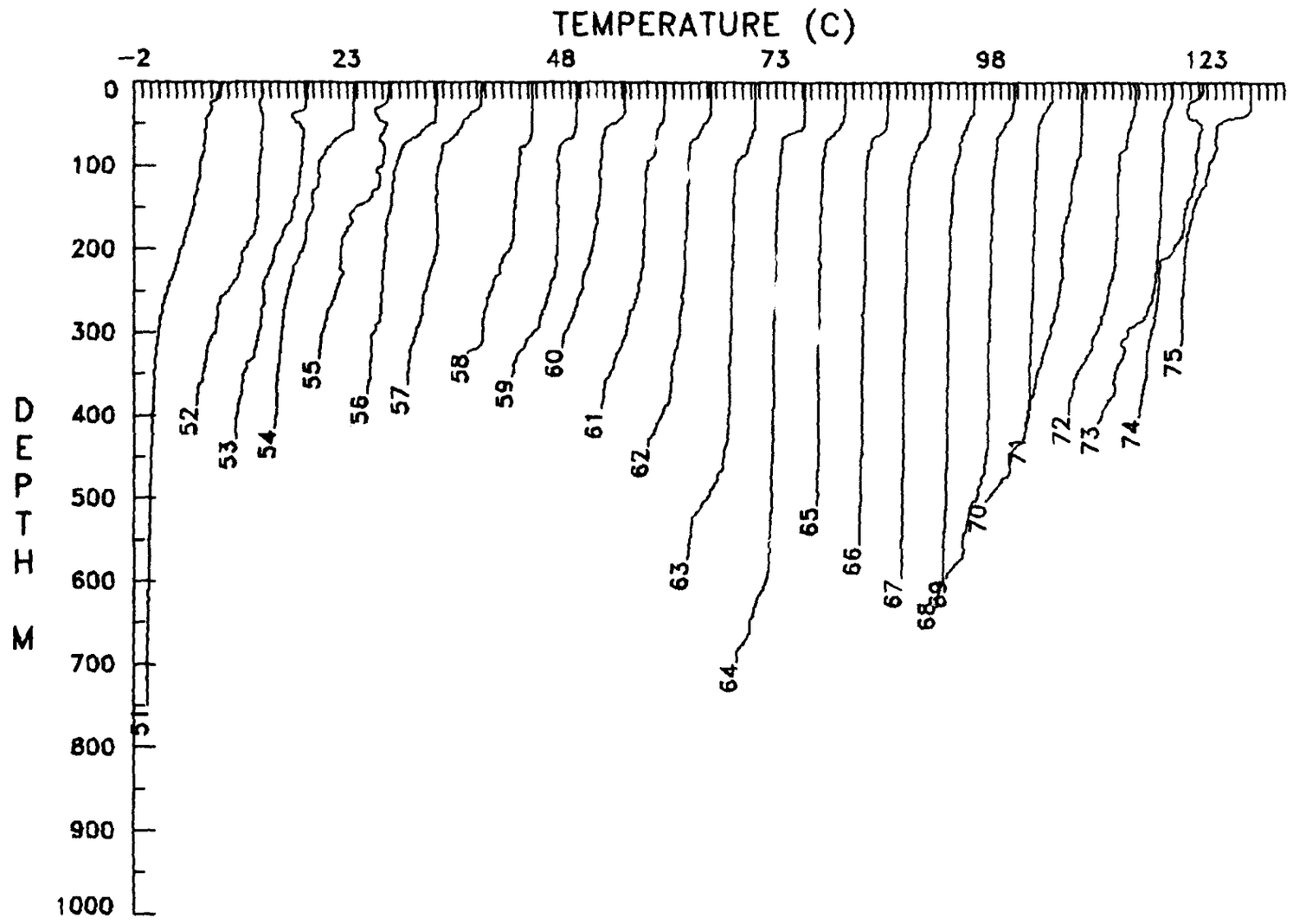
Temperature Offset is 5 deg C

NRL Code 331



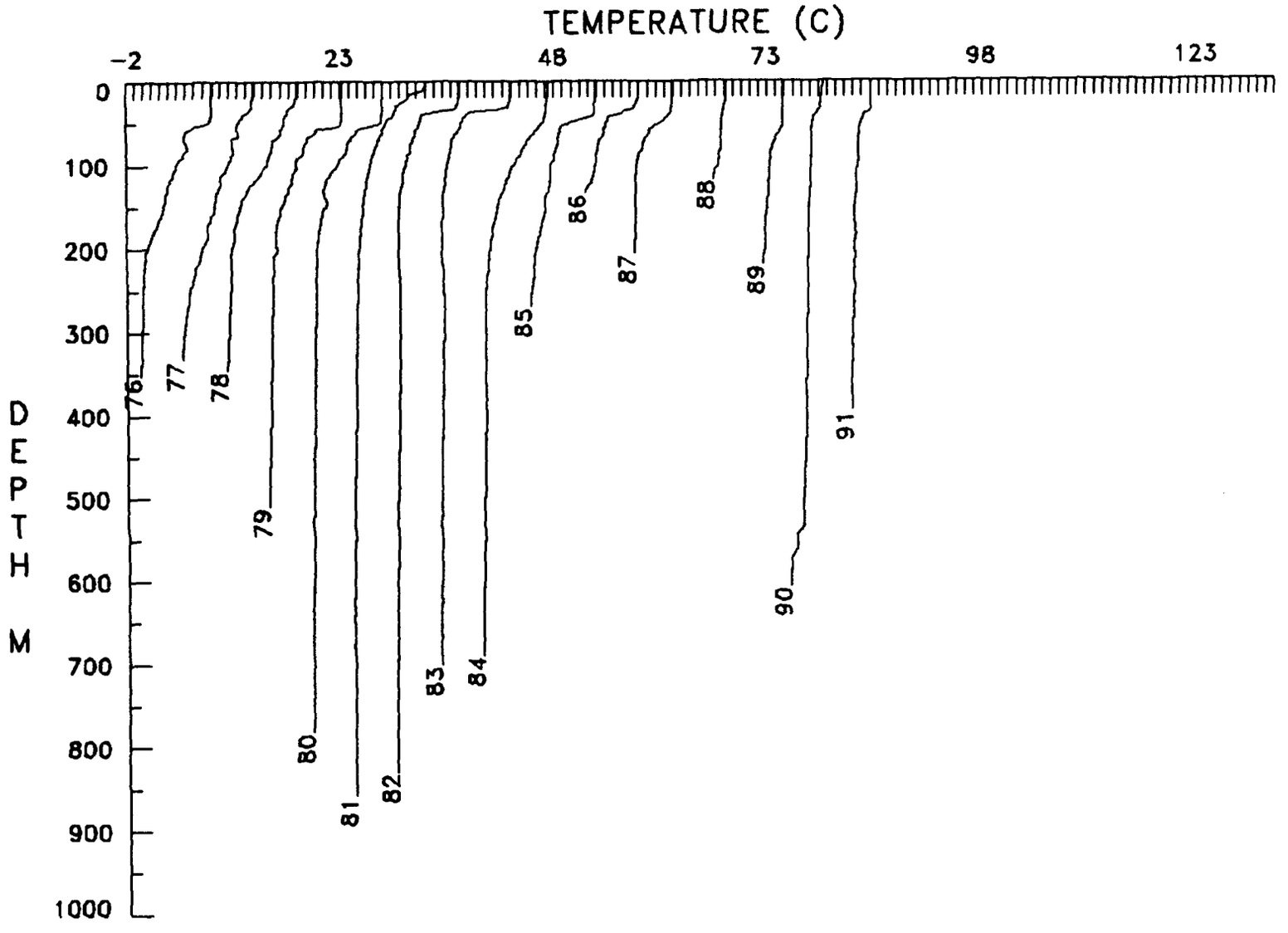
Temperature Offset is 5 deg C

NRL Code 331



Temperature Offset is 5 deg C

NRL Code 331



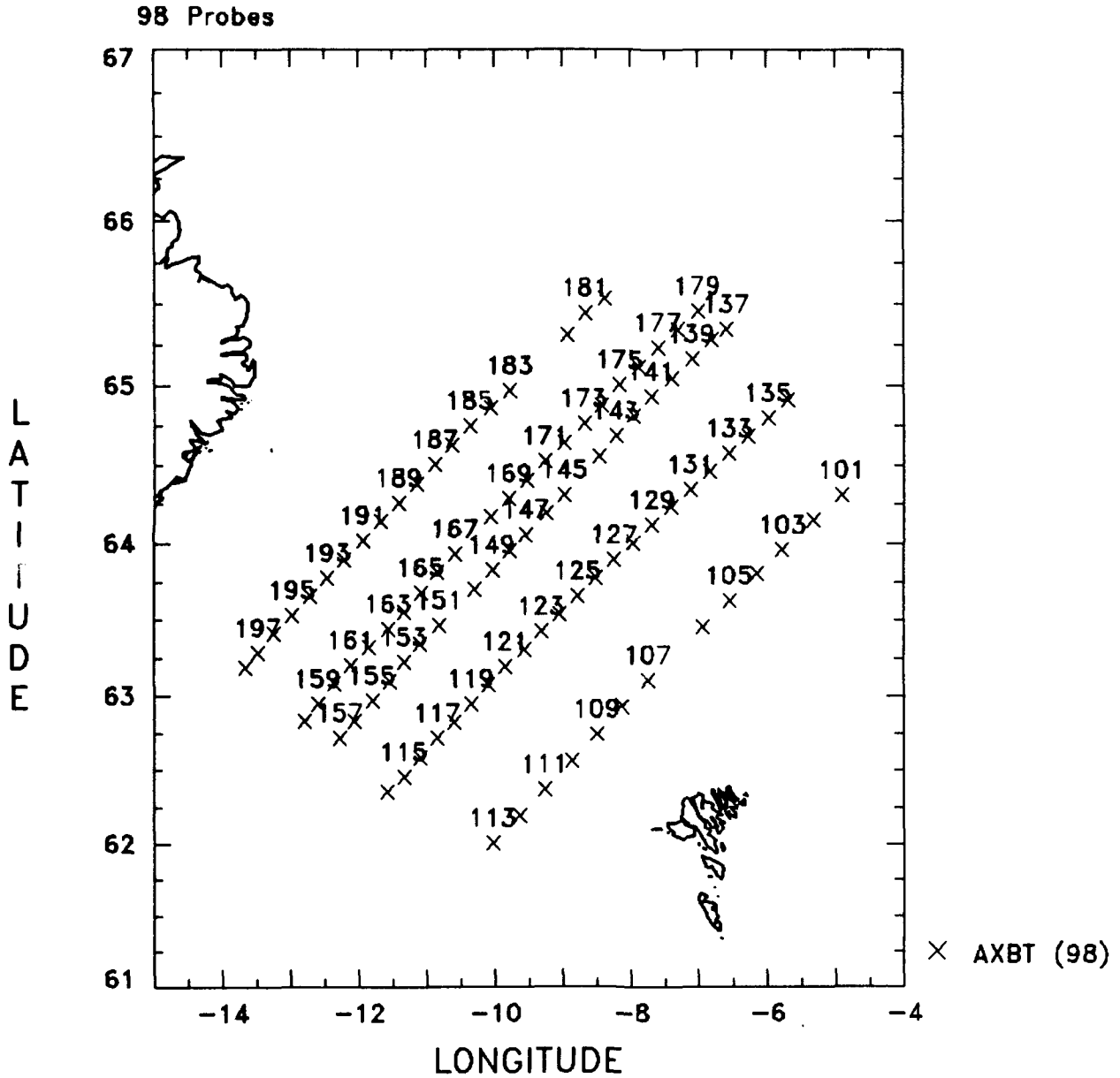
Temperature Offset is 5 deg C

NRL Code 331

Appendix D

Drop Times, Positions, and Data Traces, 4 September 1991

NORDIC-91 Flt. M2 4 Sept 91



NOARL Code 331

Header information for AXBT drops, 4 September 1991. Times are UTC.

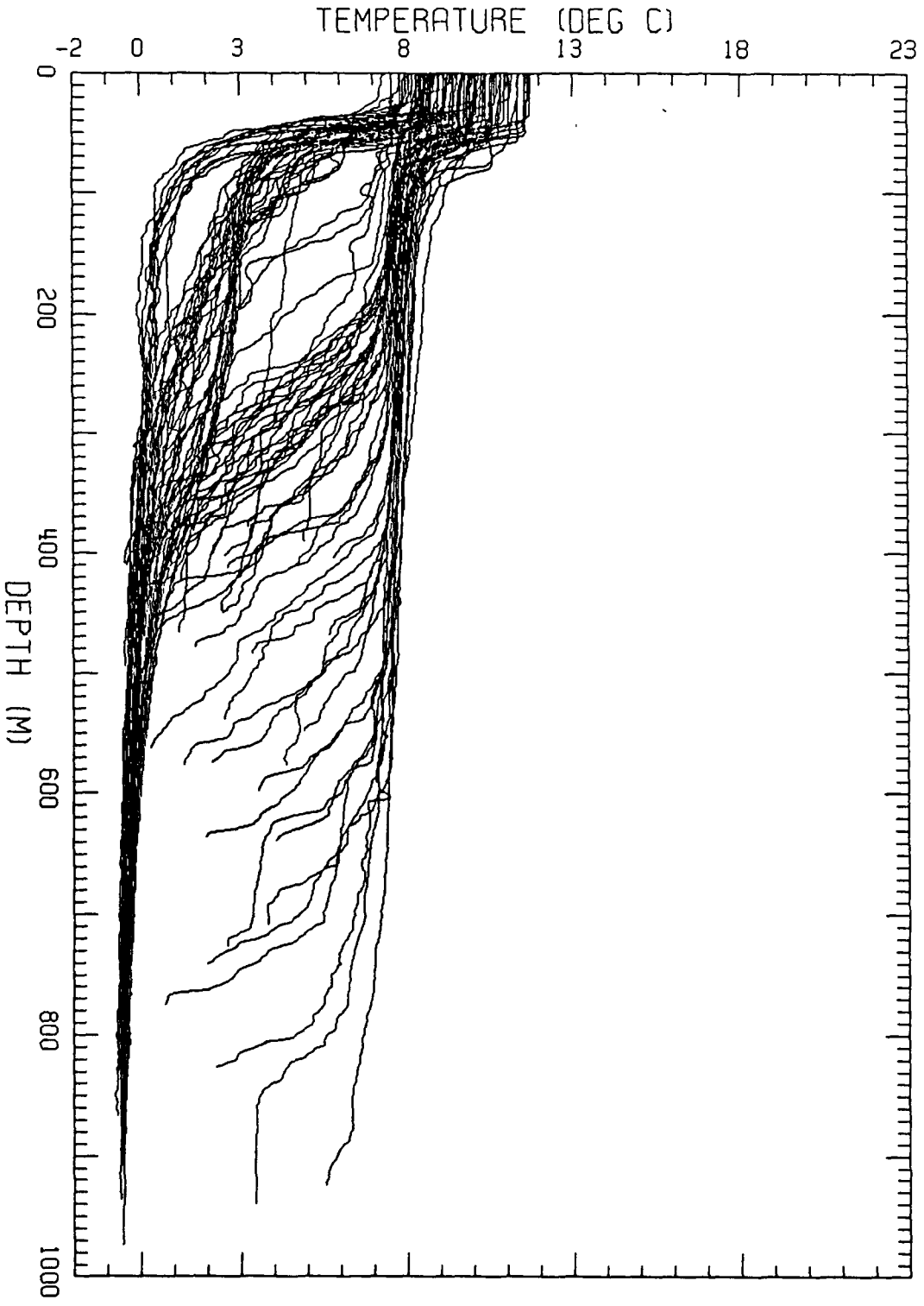
DATE: 9/04/91 PROJECT ID: NORDIC 91

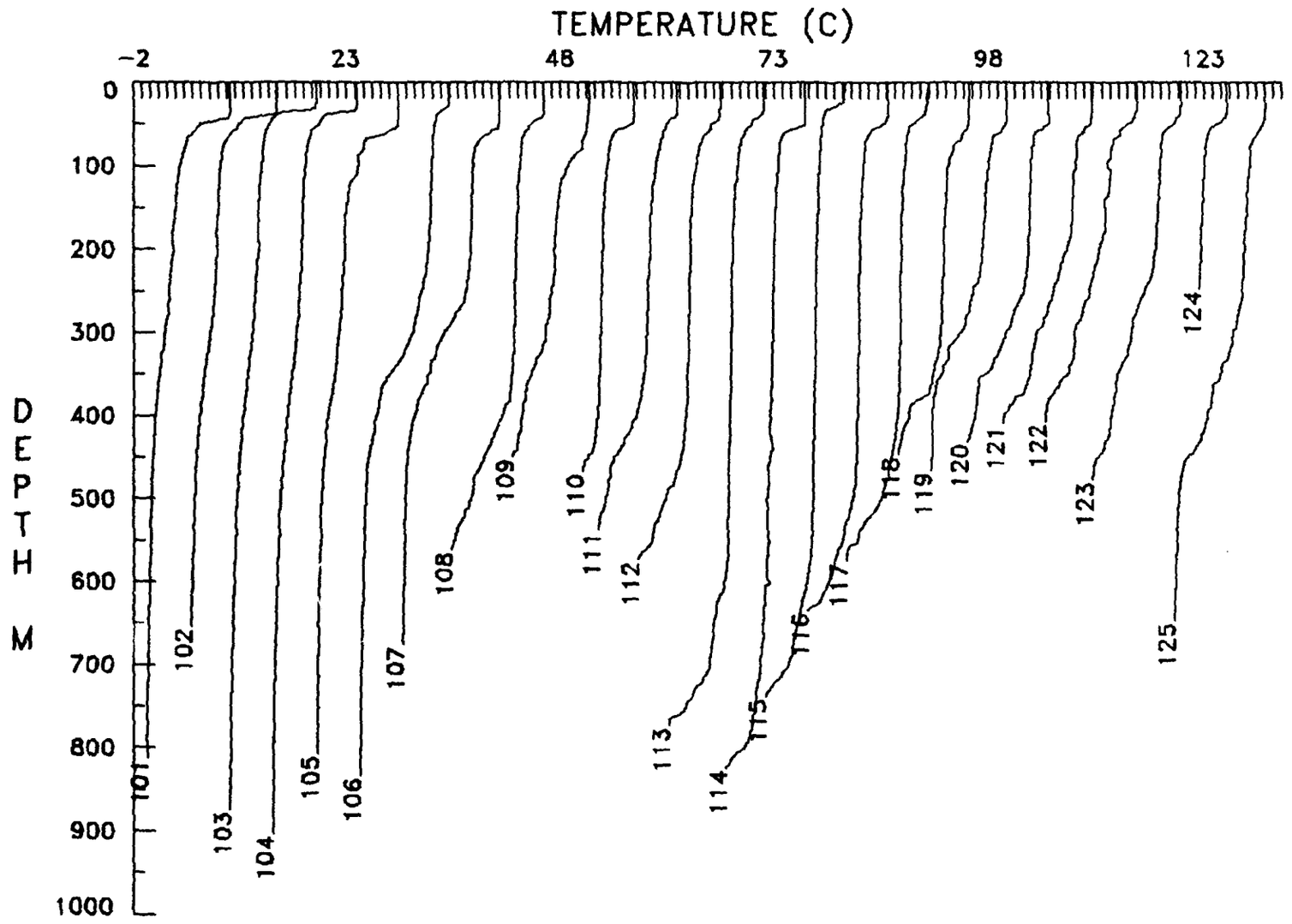
#	TYPE	D/S	LATITUDE	LONGITUDE	TIME	FLT	CH
101	AXBT	D	64: 18.70	-4:-53.60	13:27:25	2	14
102	AXBT	D	64: 8.89	-5:-18.36	13:31:23	2	16
103	AXBT	D	63: 57.61	-5:-45.07	13:35:21	2	12
104	AXBT	D	63: 48.34	-6: -7.99	13:39:02	2	14
105	AXBT	D	63: 37.85	-6:-31.83	13:42:57	2	16
106	AXBT	D	63: 27.34	-6:-55.69	13:46:56	2	12
107	AXBT	D	63: 6.56	-7:-43.22	13:54:41	2	16
108	AXBT	D	62: 55.79	-8: -6.36	13:58:34	2	12
109	AXBT	D	62: 44.68	-8:-28.46	14:02:24	2	14
110	AXBT	D	62: 33.81	-8:-50.83	14:06:23	2	16
111	AXBT	D	62: 22.45	-9:-14.65	14:10:42	2	12
112	AXBT	D	62: 11.54	-9:-36.74	14:14:39	2	14
113	AXBT	D	62: .16	-10: -.38	14:18:50	2	16
114	AXBT	D	62: 21.37	-11:-33.16	14:32:24	2	12
115	AXBT	D	62: 27.40	-11:-18.80	14:35:15	2	14
116	AXBT	D	62: 35.13	-11: -4.94	14:37:40	2	16
117	AXBT	D	62: 42.98	-10:-49.23	14:40:24	2	22
118	AXBT	D	62: 49.65	-10:-34.84	14:42:41	2	12
119	AXBT	D	62: 56.97	-10:-19.34	14:45:17	2	14
120	AXBT	D	63: 4.34	-10: -4.75	14:47:47	2	16
121	AXBT	D	63: 11.66	-9:-49.32	14:50:22	2	22
122	AXBT	D	63: 18.48	-9:-32.92	14:52:57	2	12
123	AXBT	D	63: 25.64	-9:-17.62	14:55:28	2	14
124	AXBT	D	63: 32.51	-9: -1.47	14:57:56	2	16
125	AXBT	D	63: 39.52	-8:-45.37	15:00:29	2	22
126	AXBT	D	63: 46.87	-8:-30.00	15:03:03	2	12
127	AXBT	D	63: 53.65	-8:-13.31	15:05:33	2	14
128	AXBT	D	64: .50	-7:-56.61	15:08:05	2	16
129	AXBT	D	64: 7.39	-7:-40.28	15:10:41	2	22
130	AXBT	D	64: 14.15	-7:-23.51	15:13:14	2	12
131	AXBT	D	64: 20.86	-7: -6.34	15:15:46	2	14
132	AXBT	D	64: 27.70	-6:-49.22	15:18:19	2	16
133	AXBT	D	64: 34.58	-6:-32.21	15:20:51	2	22
134	AXBT	D	64: 41.15	-6:-15.09	15:23:21	2	12
135	AXBT	D	64: 47.91	-5:-57.65	15:25:56	2	14
136	AXBT	D	64: 54.57	-5:-40.13	15:28:33	2	16
137	AXBT	D	65: 20.86	-6:-34.28	15:39:50	2	12
138	AXBT	D	65: 17.06	-6:-47.90	15:41:59	2	14
139	AXBT	D	65: 10.02	-7: -4.99	15:44:41	2	16
140	AXBT	D	65: 2.67	-7:-22.83	15:47:27	2	22
141	AXBT	D	64: 56.11	-7:-40.51	15:50:02	2	12
142	AXBT	D	64: 48.91	-7:-56.84	15:52:36	2	14
143	AXBT	D	64: 41.05	-8:-11.70	15:55:11	2	16
144	AXBT	D	64: 33.47	-8:-26.50	15:57:45	2	22
145	AXBT	D	64: 18.77	-8:-57.48	16:03:00	2	14
146	AXBT	D	64: 11.65	-9:-13.95	16:05:43	2	16
147	AXBT	D	64: 3.58	-9:-31.56	16:08:42	2	22
148	AXBT	D	63: 57.19	-9:-45.33	16:11:02	2	12
149	AXBT	D	63: 49.91	-10: -.90	16:13:41	2	14
150	AXBT	D	63: 42.29	-10:-16.29	16:16:21	2	16
151	AXBT	D	63: 28.09	-10:-47.21	16:21:37	2	12
152	AXBT	D	63: 21.00	-11: -4.10	16:24:11	2	14
153	AXBT	D	63: 13.60	-11:-18.60	16:26:44	2	16
154	AXBT	D	63: 5.79	-11:-31.85	16:29:21	2	22
155	AXBT	D	62: 58.18	-11:-46.74	16:32:00	2	12
156	AXBT	D	62: 50.09	-12: -2.28	16:34:52	2	14
157	AXBT	D	62: 43.28	-12:-15.28	16:37:17	2	16
158	AXBT	D	62: 49.74	-12:-46.94	16:42:09	2	12

#	TYPE	D/S	LATITUDE	LONGITUDE	TIME	FLT	CH
159	AXBT	D	62: 56.86	-12:-34.77	16:44:54	2	14
160	AXBT	D	63: 4.90	-12:-20.90	16:47:32	2	16
161	AXBT	D	63: 12.36	-12: -5.46	16:50:11	2	22
162	AXBT	D	63: 19.45	-11:-49.62	16:52:50	2	12
163	AXBT	D	63: 26.71	-11:-32.56	16:55:35	2	14
164	AXBT	D	63: 33.23	-11:-18.27	16:57:58	2	16
165	AXBT	D	63: 41.00	-11: -3.80	17:00:38	2	22
166	AXBT	D	63: 48.87	-10:-49.45	17:03:23	2	12
167	AXBT	D	63: 55.98	-10:-33.89	17:05:59	2	14
168	AXBT	D	64: 10.46	-10: -2.24	17:11:08	2	22
169	AXBT	D	64: 17.34	-9:-46.60	17:13:38	2	12
170	AXBT	D	64: 24.47	-9:-30.42	17:16:15	2	14
171	AXBT	D	64: 31.48	-9:-14.29	17:18:52	2	16
172	AXBT	D	64: 38.46	-8:-57.86	17:21:26	2	22
173	AXBT	D	64: 45.70	-8:-39.91	17:24:10	2	12
174	AXBT	D	64: 52.75	-8:-24.01	17:26:46	2	14
175	AXBT	D	65: .13	-8: -8.25	17:29:25	2	16
176	AXBT	D	65: 7.25	-7:-51.84	17:32:02	2	22
177	AXBT	D	65: 14.31	-7:-34.89	17:34:42	2	12
178	AXBT	D	65: 20.94	-7:-17.55	17:37:19	2	14
179	AXBT	D	65: 27.72	-6:-59.89	17:40:03	2	16
180	AXBT	D	65: 32.12	-8:-21.02	17:49:43	2	12
181	AXBT	D	65: 26.90	-8:-38.50	17:52:10	2	14
182	AXBT	D	65: 18.76	-8:-54.58	17:54:47	2	16
183	AXBT	D	64: 58.27	-9:-45.18	18:02:53	2	14
184	AXBT	D	64: 51.87	-10: -2.99	18:05:32	2	16
185	AXBT	D	64: 45.12	-10:-20.80	18:08:11	2	22
186	AXBT	D	64: 37.71	-10:-36.01	18:10:45	2	12
187	AXBT	D	64: 30.34	-10:-51.63	18:13:20	2	14
188	AXBT	D	64: 23.16	-11: -7.64	18:15:55	2	16
189	AXBT	D	64: 15.85	-11:-23.50	18:18:32	2	22
190	AXBT	D	64: 8.64	-11:-39.43	18:21:10	2	12
191	AXBT	D	64: 1.36	-11:-54.97	18:23:50	2	14
192	AXBT	D	63: 53.77	-12:-11.27	18:26:38	2	16
193	AXBT	D	63: 46.69	-12:-26.13	18:29:11	2	22
194	AXBT	D	63: 39.38	-12:-41.64	18:31:50	2	12
195	AXBT	D	63: 32.14	-12:-57.23	18:34:28	2	14
196	AXBT	D	63: 25.03	-13:-13.15	18:37:07	2	16
197	AXBT	D	63: 17.19	-13:-27.10	18:39:44	2	22
198	AXBT	D	63: 11.22	-13:-38.87	18:41:49	2	12

Total number profiles: 98

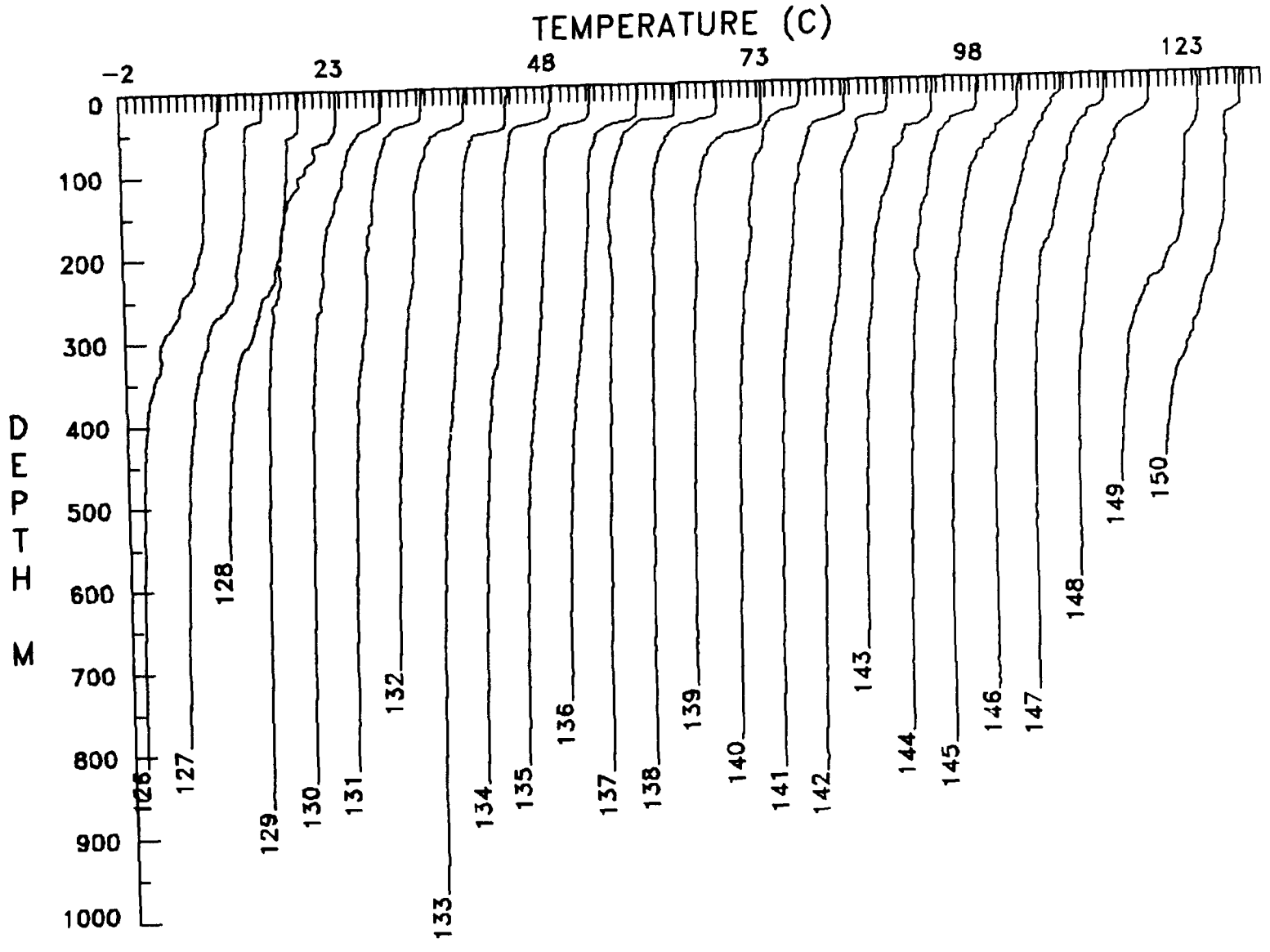
PROJECT: NORDIC '91
DROP NOS: 101 TO 198
M2 Overplot of Corrected AXBT Data





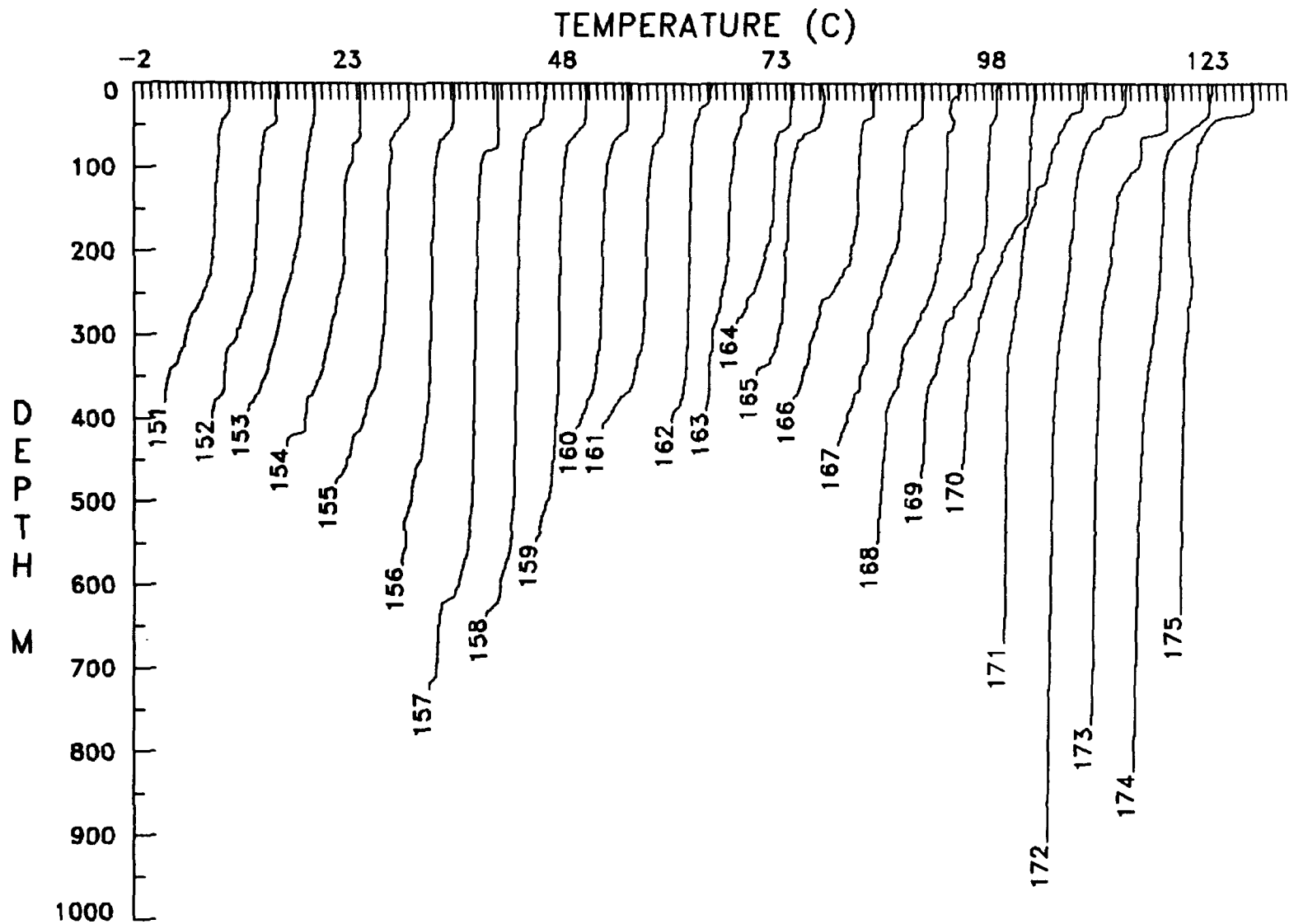
Temperature Offset is 5 deg C

NRL Code 331



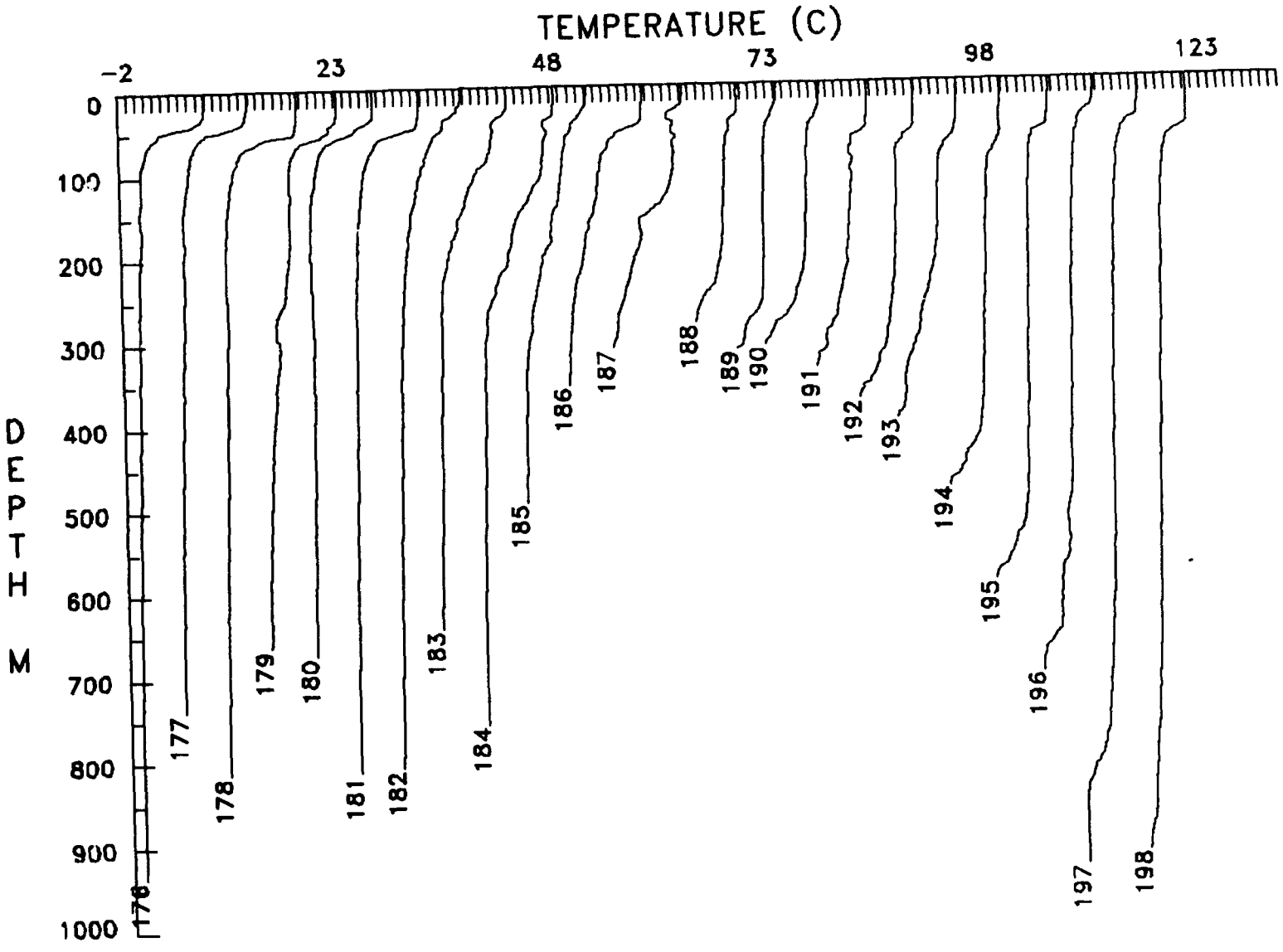
Temperature Offset is 5 deg C

NRL Code 331



Temperature Offset is 5 deg C

NRL Code 331



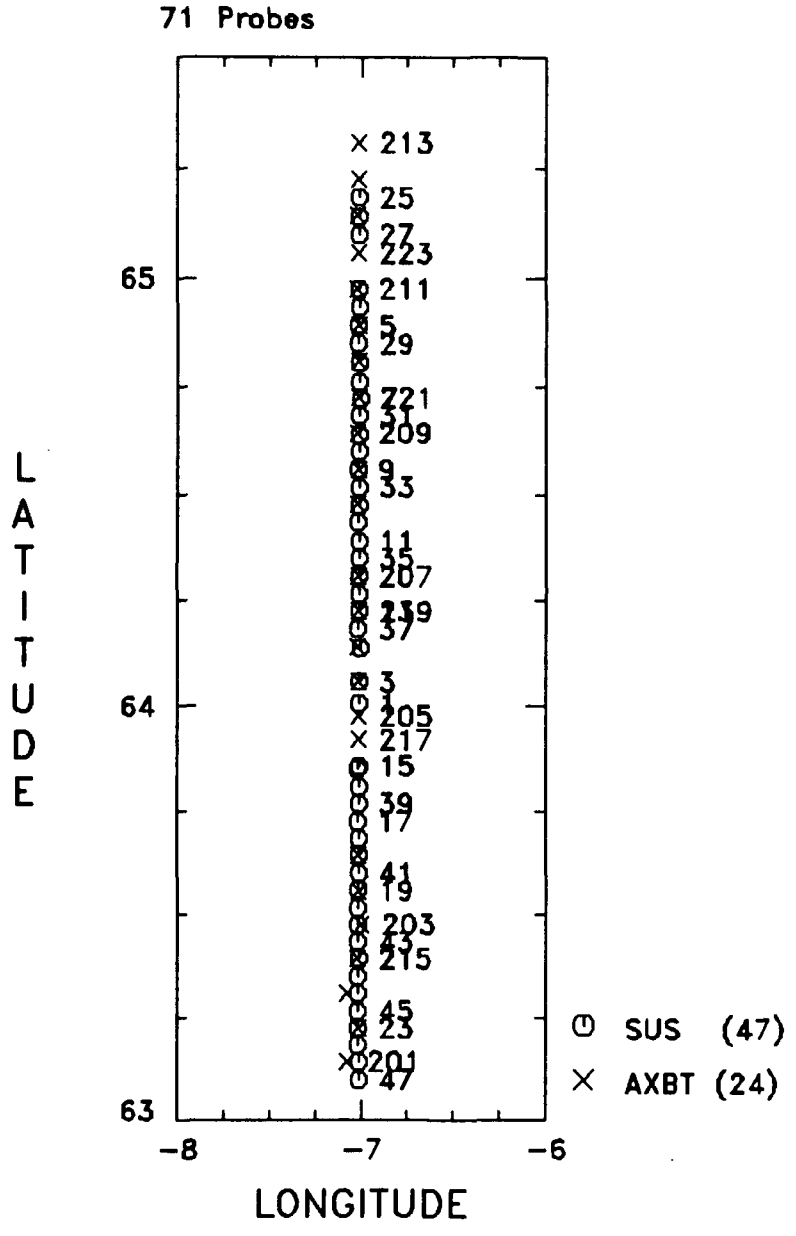
Temperature Offset is 5 deg C

NRL Code 331

Appendix E

Drop Times, Positions, and Data Traces, 6 September 1991

NORDIC-91 Acoustic OPS 6 Sept 91



NOARL Code 331

Header information for AXBT drops, 6 September 1991. Times are UTC.

DATE: 9/06/91 PROJECT ID: NORDIC 91

#	TYPE	D/S	LATITUDE	LONGITUDE	TIME	FLT	CH
201	AXBT	D	63: 8.62	-7: -4.46	14:02:12	3	12
202	AXBT	D	63: 18.59	-7: -4.21	14:04:53	3	14
203	AXBT	D	63: 28.62	-6:-59.74	14:07:34	3	16
204	AXBT	D	63: 38.59	-7: -.67	14:10:13	3	22
205	AXBT	D	63: 58.59	-7: -.60	14:15:38	3	14
206	AXBT	D	64: 8.53	-7: -.92	14:18:41	3	16
207	AXBT	D	64: 18.50	-7: -.72	14:21:51	3	22
208	AXBT	D	64: 28.57	-7: -.91	14:24:49	3	12
209	AXBT	D	64: 38.62	-7: -.90	14:27:33	3	14
210	AXBT	D	64: 48.52	-7: -.69	14:30:17	3	16
211	AXBT	D	64: 58.58	-7: -.88	14:33:03	3	22
212	AXBT	D	65: 8.55	-7: -.94	14:35:47	3	12
213	AXBT	D	65: 18.49	-7: -.60	14:38:31	3	14
214	AXBT	D	63: 13.49	-7: -.79	15:43:42	3	16
215	AXBT	D	63: 23.63	-7: -.89	15:46:37	3	12
216	AXBT	D	63: 33.46	-7: -.71	15:49:21	3	14
217	AXBT	D	63: 55.26	-7: -.76	15:55:10	3	22
218	AXBT	D	64: 3.57	-7: -.75	15:57:22	3	12
219	AXBT	D	64: 13.52	-7: -.63	15:59:59	3	14
220	AXBT	D	64: 33.59	-7: -.59	16:05:14	3	22
221	AXBT	D	64: 43.56	-7: -.61	16:07:55	3	12
222	AXBT	D	64: 53.49	-7: -.69	16:10:38	3	14
223	AXBT	D	65: 3.49	-7: -.66	16:13:22	3	16
224	AXBT	D	65: 13.48	-7: -.64	16:16:06	3	22

Total number profiles: 24

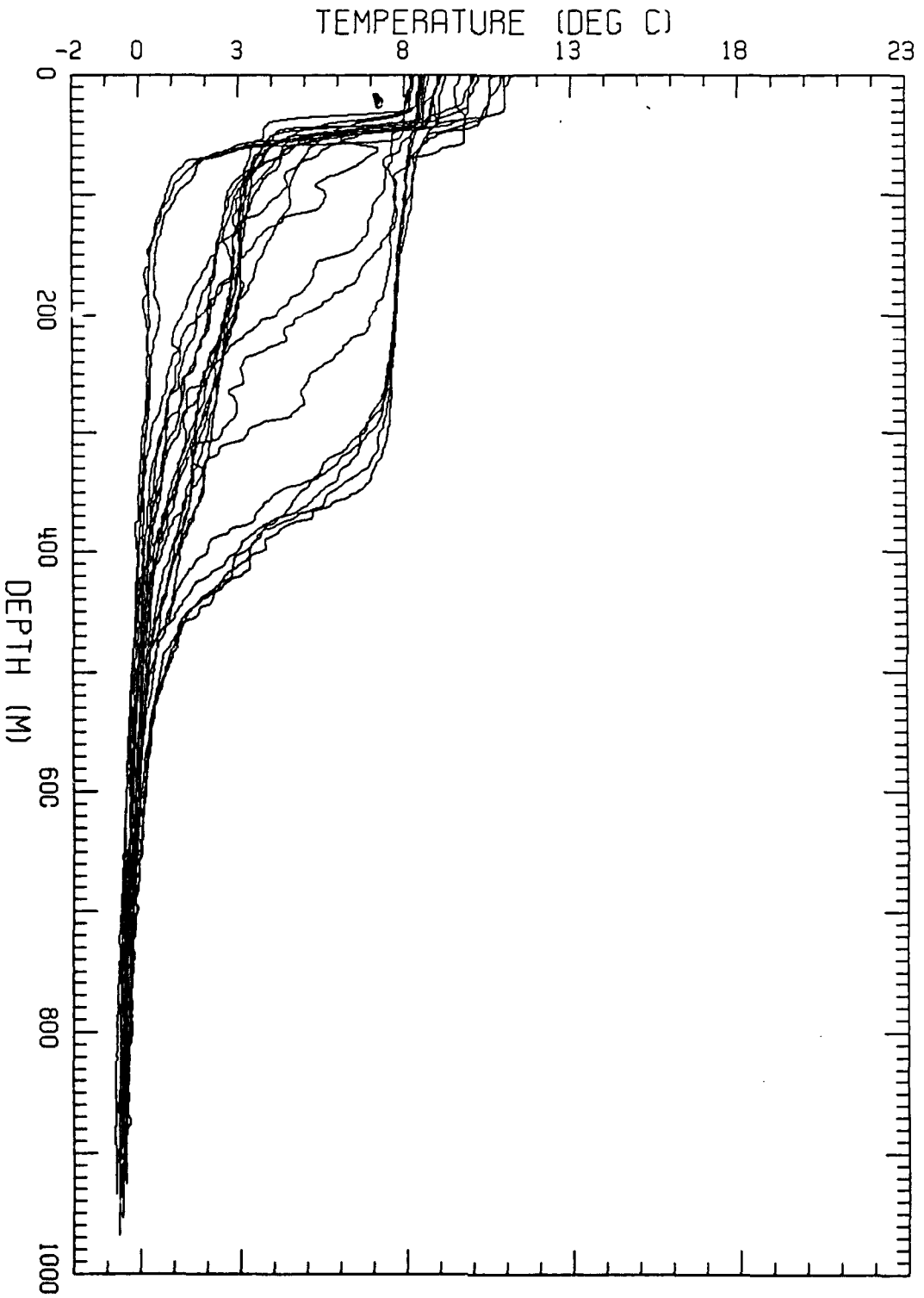
Header information for SUS drops, 6 September 1991. Times are UTC.

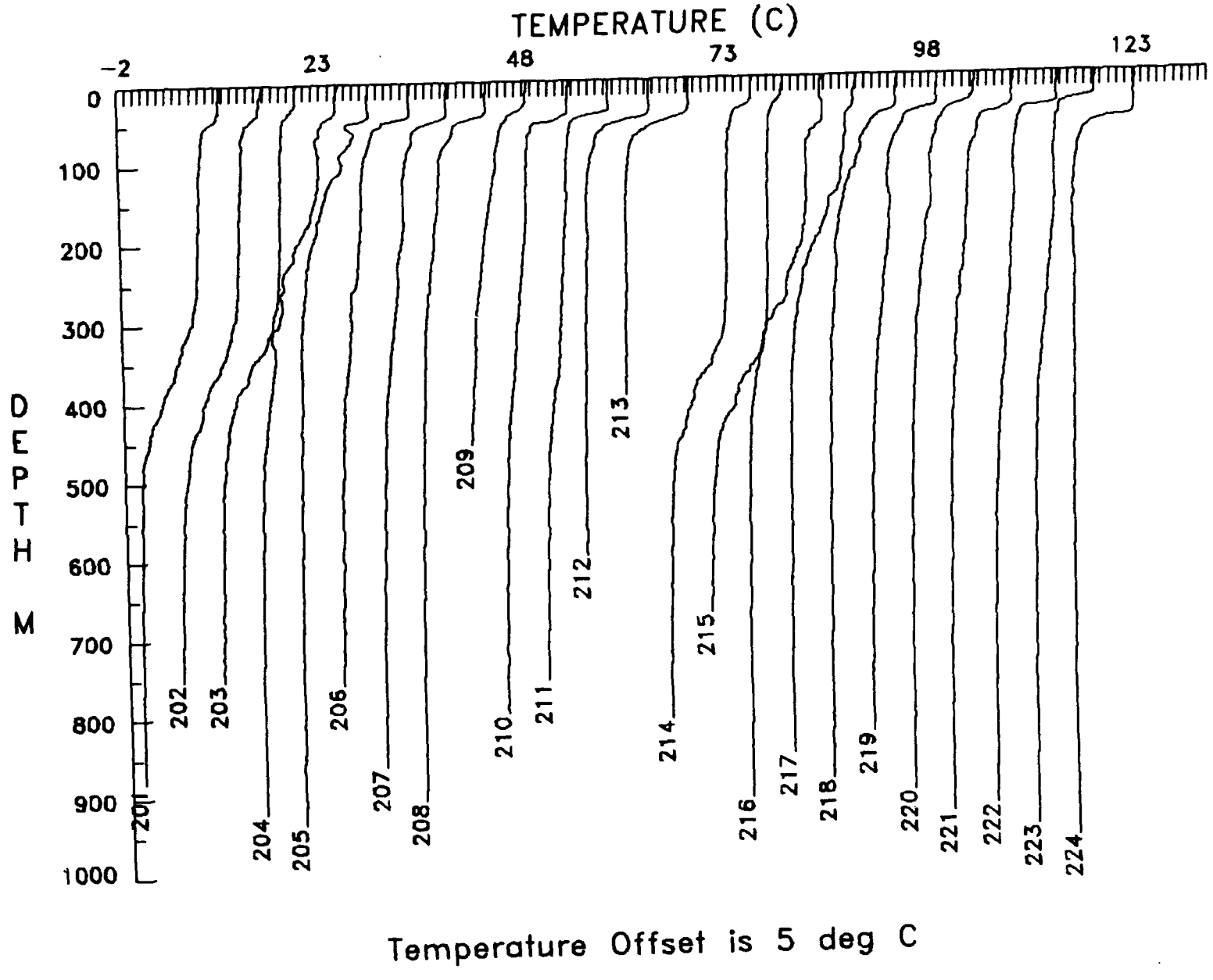
DATE: 9/06/91 PROJECT ID: NORDIC 91

#	TYPE	LATITUDE	LONGITUDE	TIME	FLT
1	SUS	64: 00.4	-7: -.6	13:19:34	3
2	SUS	65: 08.426	-7: -.67	13:20:54	3
3	SUS	64: 03.481	-7: -.747	13:22:14	3
4	SUS	64: 58.494	-7: -.820	13:23:34	3
5	SUS	64: 53.511	-7: -.856	13:24:55	3
6	SUS	64: 48.466	-7: -.832	13:26:17	3
7	SUS	64: 43.471	-7: -.332	13:27:38	3
8	SUS	64: 38.443	-7: -.594	13:29:00	3
9	SUS	64: 33.482	-7: -1.026	13:30:21	3
10	SUS	64: 28.493	-7: -.608	13:31:42	3
11	SUS	64: 23.451	-7: -.822	13:33:04	3
12	SUS	64: 18.463	-7: -.742	13:34:25	3
13	SUS	64: 13.512	-7: -.618	13:35:45	3
14	SUS	64: 8.31	-7: -.4	13:37:09	3
15	SUS	63: 51.47	-7: -.575	13:41:12	3
16	SUS	63: 48.48	-7: -.75	13:42:32	3
17	SUS	63: 43.505	-7: -1.019	13:43:53	3
18	SUS	63: 38.526	-7: -.780	13:45:14	3
19	SUS	63: 33.502	-7: -.875	13:46:36	3
20	SUS	63: 28.525	-7: -.939	13:47:57	3
21	SUS	63: 23.575	-7: -.658	13:49:17	3
22	SUS	63: 18.565	-7: -.929	13:50:38	3
23	SUS	63: 13.490	-7: -.849	13:52:00	3
24	SUS	63: 8.535	-7: -.788	13:53:20	3
25	SUS	65: 11.044	-7: -.736	14:52:22	3
26	SUS	65: 06.043	-7: -.577	14:53:42	3
27	SUS	65: 01:005	-7: -.708	14:55:03	3
28	SUS	64: 56.002	-7: -.781	14:56:24	3
29	SUS	64: 51.009	-7: -.850	14:57:45	3
30	SUS	64: 45.70	-7: -.750	14:59:11	3
31	SUS	64: 41.019	-7: -.819	15:00:27	3
32	SUS	64: 36.090	-7: -.789	15:01:47	3
33	SUS	64: 31.093	-7: -.735	15:03:08	3
34	SUS	64: 26.039	-7: -.866	15:04:30	3
35	SUS	64: 21.042	-7: -.732	15:05:51	3
36	SUS	64: 16.054	-7: -.759	15:07:12	3
37	SUS	64: 11.001	-7: -.877	15:08:34	3
38	SUS	63: 51.057	-7: -.880	15:13:57	3
39	SUS	63: 46.047	-7: -.742	15:15:18	3
40	SUS	63: 40.991	-7: -.826	15:16:40	3
41	SUS	63: 36.007	-7: -.789	15:18:01	3
42	SUS	63: 31.038	-7: -.898	15:19:22	3
43	SUS	63: 26.065	-7: -.860	15:20:43	3
44	SUS	63: 21.079	-7: -.839	15:22:04	3
45	SUS	63: 16.030	-7: -.838	15:23:26	3
46	SUS	63: 11.048	-7: -.899	15:24:47	3
47	SUS	63: 05.953	-7: -.814	15:26:10	3

Total number SUS: 47

PROJECT: NORDIC 91
DROP NOS: 201 TO 224
Flt. 3 Acoustic OPS Corrected Data Overplot




TEMPERATURE (C)
-2
23
48
73
98
123
DEPTH M
0
100
200
300
400
500
600
700
800
900
1000
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
Temperature Offset is 5 deg C

NRL Code 331

Distribution List

Director
Ocean Sciences Directorate, Code 112
Office Of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Alan Brandt
Program Manager
Small Scale Physical Oceanography,
Code 1122SS
Office Of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Thomas Curtin
Program Manager
Arctic Sciences, Code 1125AR
Office Of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. David Evans
Program Manager
Meso/Large Scale Oceanography,
Code 1122ML
Office Of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

Office Of Naval Research
Attn: Library (Code 1231L)
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Eric Hartwig
Code 7000
Naval Research Laboratory
Washington, DC 20375-5000

Dr. Marshall Orr
Program Manager
Ocean Acoustics, Code 1125OA
Office Of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Robert Peloquin
Program Manager
Ocean Modeling and Prediction, Code 1242
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

Fleet Numerical Oceanography Center
Attn: LCDR Peter Tunicliffe, Code 42
Monterey, CA 93943-5005

Chief, URD
SACLANT Undersea Research Center
APO New York, NY 09019

Dr. Henry Perkins
SACLANT Undersea Research Center
APO New York, NY 09019

Juergen Sellschopp (2)
FWG
Klausdorfer Weg 2-24
2300 Kiel 14
Germany

Dr. John Scott (2)
ARE/Southwell
Portland, Dorset DT5-2JS
Great Britain

Dr. Alex Warn-Varnas (3)
SACLANT Undersea Research Center
APO New York, NY 09019

NRL Code 125L (10)
Code 125P
Code 110
Code 200
Code 222 (G. Kerr)
Code 300
Code 323 G. Heburn (3)
Code 330 A.W. Green
Code 331 R. Hollman
Code 331 J. Boyd (20)

Commanding Officer
Naval Oceanographic Office
Attn: Code CS
Code OC
Code OP
Code OPTR (T. Bennett)
Code TD
Library
Stennis Space Center, MS 39522-5001

Commander
Naval Oceanography Command
SSC, MS 39529-5000

Commanding Officer
Fleet Numerical Oceanography Center
Attn: Library
Monterey, CA 93943-5005

Superintendent
Naval Postgraduate School
Attn: Library
Monterey, CA 93943

Document Library
Clark 141
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

University of California
Scripps Institute of Oceanography
Attn: Library
PO Box 6049
San Diego, CA 92106

Johns Hopkins University
Applied Physics Laboratory
Attn: Library
Johns Hopkins Road
Laurel, MD 20707

University of Washington
Applied Physics Laboratory
Attn: Library
1013 NE 40th St.
Seattle, WA 98105

Naval Research Laboratory
Attn: Library
Washington, DC 20375-5000

REPORT DOCUMENTATION PAGE

Form Approved
OBM No. 0704-0188

1. Agency Use Only *(Leave blank).*

2. Report Date. September 1992

3. Report Type and Dates Covered. Final

4. Title and Subtitle.

NORDIC-91: AXBT Measurements in the Iceland-Faeroe Frontal Zone, September 1991

5. Funding Numbers.

Program Element No. 0602435N
Project No. RH35G95
Task No.
Accession No. DN256002
Work Unit No. 13312H

6. Author(s).

J.D. Boyd

7. Performing Organization Name(s) and Address(es).

Naval Oceanographic and Atmospheric Research Laboratory
Ocean Science Directorate
Stennis Space Center, MS 39529-5004

8. Performing Organization Report Number.

NOARL Technical Note 271

9. Sponsoring/Monitoring Agency Name(s) and Address(es).

Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

10. Sponsoring/Monitoring Agency Report Number.

NOARL Technical Note 271

11. Supplementary Notes.

12a. Distribution/Availability Statement.

Approved for pubic release; distribution is unlimited.

12b. Distribution Code.

13. Abstract *(Maximum 200 words).*

In September 1992, 213 deep AXBTs and 47 MK-82 SUSs were dropped in the vicinity of the Iceland-Faeroe Front between Iceland and the Faeroe Islands. This technical note describes the experimental plan and the data acquisition and processing techniques used and presents the resulting data in graphical and tabular form.

14. Subject Terms.

Physical Oceanography, Oceanographic Models, Acoustic Models

15. Number of Pages. 51

16. Price Code.

17. Security Classification of Report.	18. Security Classification of This Page.	19. Security Classification of Abstract.	20. Limitation of Abstract.
Unclassified	Unclassified	Unclassified	SAR