Physics and Physical Oceanography Data Report 2004-2

Analysis of Physical Oceanographic Data from Funk Island Bank, August 2004

Nicholas Record, Brad de Young, and Jack Foley

Department of Physics and Physical Oceanography
Memorial University of Newfoundland
St. John's, NL A1B-3X7

Abstract

For the bio-physical coupling component of the NSERC Strategic Project *Importance of capelin (Mallotus villosus) biology in sustaining trophic interactions in the Northwest Atlantic*, two moorings were deployed in the vicinity of Funk Island from the *Wilfred Templeman* (trip WT553) in August 2004. The moorings included ADCP's and thermistors to record current velocity, backscatter intensity, and temperature from 7 August to 21 August. In addition, upon mooring recovery from the *Lady Easton II*, a DTX system was towed in a cross pattern over the mooring locations. We present descriptions of the moorings, plots of the raw data, and some preliminary data analysis, with particular interest in the diel migration of zooplankton as detected by the ADCP. Some of the *W. Templeman* survey data is included as well.

Acknowledgements

We thank the crews and captains of the *Wilfred Templeman* and the *Lady Easton II* for their help in this oceanographic study, and Dan Porter for his help with the DTX system. Funding for this project was provided from an NSERC Strategic Grant to WA Montevecchi, G Davoren, B de Young, JT Anderson, M Koen-Alonso.

Table of Contents

List of Figures

List of Tables

Introduction

One important component of the Northeast Newfoundland Shelf ecosystem is the diel vertical migration of the zooplankton prey of capelin. To study this phenomenon, as well as to collect data on the physical characteristics of the environment, two ADCP moorings were deployed—one near shore in shallow water and one off shore in deeper water—to observe currents and vertical migration of zooplankton in the water column. The moorings also included thermistors spaced from the surface to the bottom to monitor the temperature of the water column.

Mooring 1 (M1) was deployed at 49º15.85 N, 53º18.95 W on 7 August 2004, 17:54 GMT, and was recovered on 23 August 2004, 10:15 GMT, for a total residence time of about 16 days. M1 had an upward looking ADCP at a frequency of 307.2 kHz, at a depth of 70 m, in 75 m of water, collecting ensemble averages at 10 minute intervals. VEMCO thermistors were attached at depths of 15, 20, 30, 40, 50, and 60m, recording temperature at 10 minute intervals.

Mooring 2 (M2) was deployed at 49º27.85 N, 52º51.30 W on 7 August 2004, 14:00 GMT, and was recovered on 21 Aug 2004, 10:15 GMT, for a total residence time of about 14 days. M2 had an upward looking ADCP at a frequency of 307.2 kHz, at a depth of 110 m and a downward looking ADCP at 217 m, in 327 m of water, collecting ensemble averages at 10 minute intervals. *Unfortunately, the downward looking ADCP malfunctioned and did not collect any data.* Thermistors were attached at depths of 15, 20, 30, 40, 50, 60, 70, 80, 150, 250, 300, and 319 m, recording temperature at 10 minute intervals. This location was chosen because of the presence of the Cold Intermediate

Layer (CIL), extending from a depth of approximately 50 m to 200 m, of water at temperature below 0 ºC.

A BioSonics DTX system, with GPS, was towed in a 4 km cross pattern over each of the moorings, once just before morning twilight and once just after morning twilight, on the days of mooring recovery. The system was set with a 90 dB threshold (a 120 dB threshold was intended), 1 ping per second, 2 channels (120 kHz and 39 kHz), and full water depth range. The intention was to observe the dawn vertical migration of zooplankton, and the patchiness of any biology in the water column both before and after migrating away from the surface. However, this may not be apparent at the 90 dB threshold.

Temperature and salinity data, as well as acoustic data, were also collected using a CTD and EK 500 during the same time period in the surrounding areas as part of the *W. Templeman* survey. The survey route and contours of temperature data are included here.

Data Processing

Temperature contours are shown as raw thermistor data, interpolated using the kriging method. Regions below 0 ºC are shaded to highlight the CIL when present. The mean and standard deviation at each depth are shown in an averaged profile and summarized in Table 2. Cloud cover opacity data was provided by Environment Canada (Morin, 2004), and is taken from the station at Bonavista. It is given in tenths, with a value of 10 indicating overcast skies.

The ADCP data from M1 are separated into 1 metre depth bins; for M2, the data are separated into 4 metre depth bins. Data within a few metres of the surface were distorted by side lobe interference, and were thus omitted. Velocity data, including the mean and standard deviation for each direction, are summarized in Tables 3-6. To omit occasional sporadic values within the water column that clearly showed corrupted data, every value over a reasonable threshold was replaced with NaN ("Not a Number" in MATLAB). Mean horizontal current direction is calculated as degrees clockwise of due north.

Velocity plots present daily raw data, decomposed into *u* (east), *v* (north), and *w* (upward) components, with the *w* component clearly showing vertical migration of zooplankton. Backscatter was corrected following standard techniques (Deines, 1999) utilising factory-set instrument characteristics as well as environmental factors (e.g. sound absorption coefficient, speed of sound at each depth cell). These parameters, along with the slant range to each depth cell, were then used in the sonar equation to estimate the backscatter coefficient (*cf.* Tittensor *et al*., 2002).

DTX data were converted to HAC format and echo integrated into 4 metre bins, for correspondence to ADCP data. The echo integration replaced missing values with NaN values and calculated the mean volume backscattering coefficient Sv (MVBS, m^2 per m^3, linear units, see Mac Lennan and Fernandez 2000). Only the path over M2, at 120 kHz, is included in this report because it is the vertical migration of zooplankton that is of interest. Vertical migration was not apparent from the ADCP backscatter data collected at M1.

Some data from the *W. Templeman* survey is included as well. The transect paths and bottom depths were taken from EK500 GPS and depth sounding data. The temperature contours for each line use Seabird 25 CTD data, averaged over each metre and interpolated using the kriging method.

References

Deines, K. L., 1999. Backscatter estimation using broadband acoustic Doppler current profilers. *Proceeding of the IEEE 6th working conference on current measurement, San Diego, CA*.

Mac Lennan, D. N., and P. Fernandez. 2000. Appendix D - Definitions, units and symbols in fisheries acoustics. pp. 31-34, In ICES CM 2000/B: 04. Report of the working group on fisheries acoustics science and technology, Ijmuiden/Haarlem, Netherlands 10-14 April 2000.

Morin, Gérard, 2004. Personal reference. Climate Technician/Technicien Climatologique. Meteorological Service of Canada - Atlantic Region. Service Météorologique du Canada - Région Atlantique. Environment Canada/ Environnement Canada. (Note: from Canadian Hydroacoustic data analysis tool 2, CH2 version 2.2.7.0 files.)

Tittensor, D.P., B de Young, J. Foley, 2002. Analysis of physical oceanographic data from Trinity Bay, May – August 2002. *Physics and Physical Oceanography data report 2002-2*. Department of Physics & Physical Oceanography, Memorial University of Newfoundland.

	Mooring 1 (M1)	**Mooring 2 (M2)**
Location	latitude 49º15.85 N longitude 53º18.95 W	latitude 49º27.85 N longitude 52º51.30 W
Water depth	75 m	327 m
ADCP depth	70 m (upward-facing)	110 m (upward-facing) 217 m (downward-facing: m*alfunctioned, no data*)
ADCP frequency	307.2 kHz	307.2 kHz
Bin size	1 m	4 m
Thermistor depths	15, 20, 30, 40, 50, and 60 m	15, 20, 30, 40, 50, 60, 70, 80, 150, 250, 300, and 319 m
Deployed	7 Aug 2004 17:54 GMT	7 Aug 2004 14:00 GMT
Recovered	23 Aug 2004 10:30 GMT	21 Aug 2004 10:15 GMT

Table 1: Location and description of moorings for the 2004 Funk Island Bank cruise.

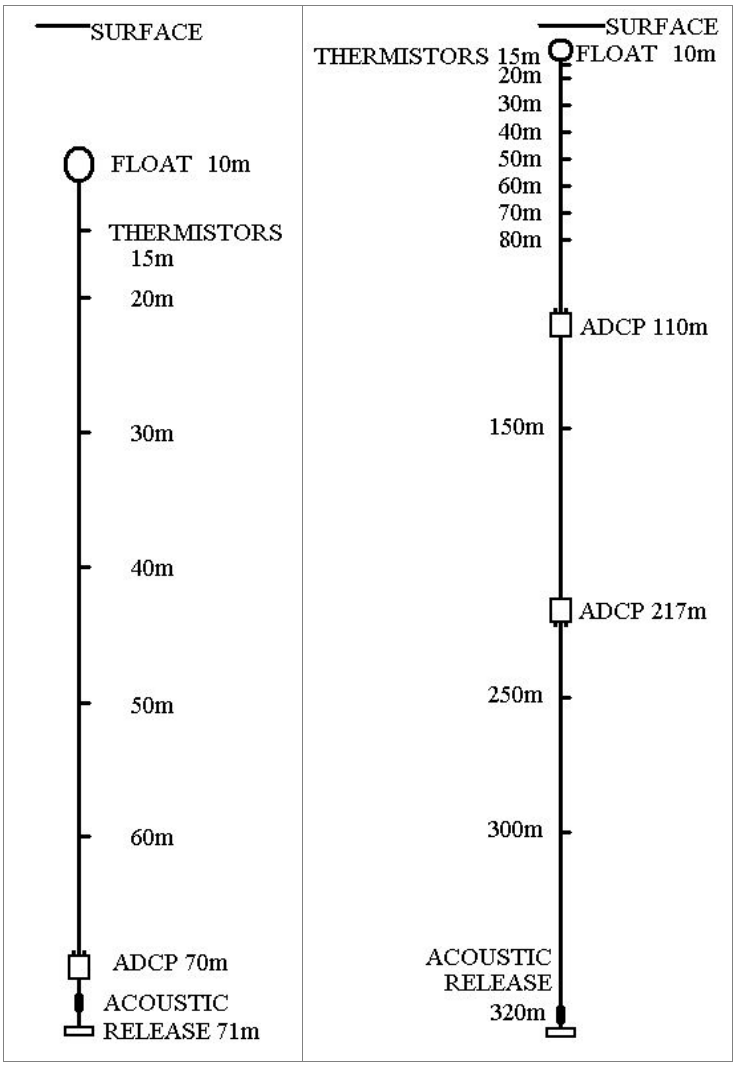

Figure 1: Mooring diagrams for M1 (left) and M2 (right) showing ADCP and thermistor locations. (*Note: the downward-looking ADCP on M2 malfunctioned and did not collect any data.*)

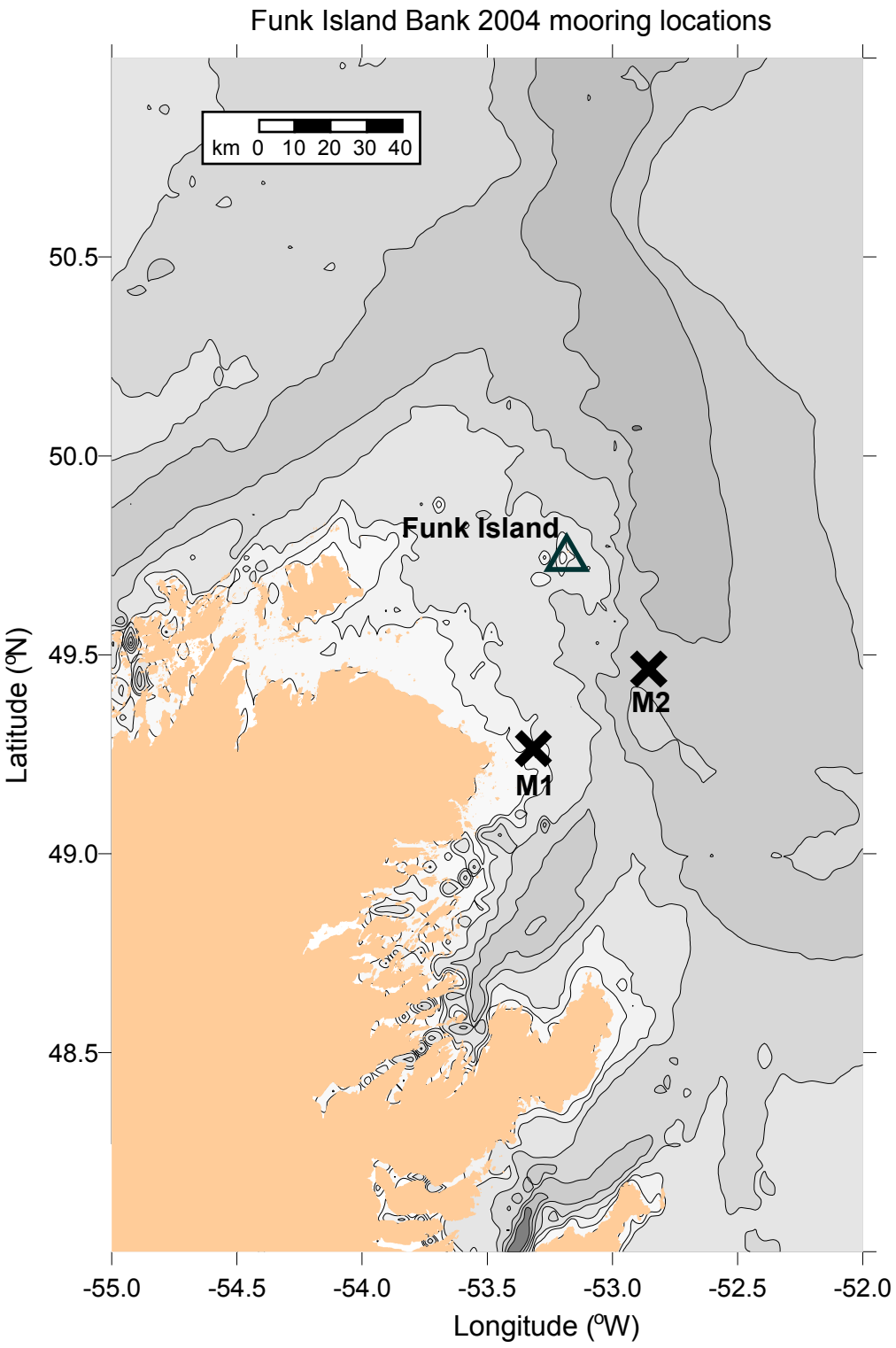

Figure 2: Mooring locations for the 2004 Funk Island Bank cruise.

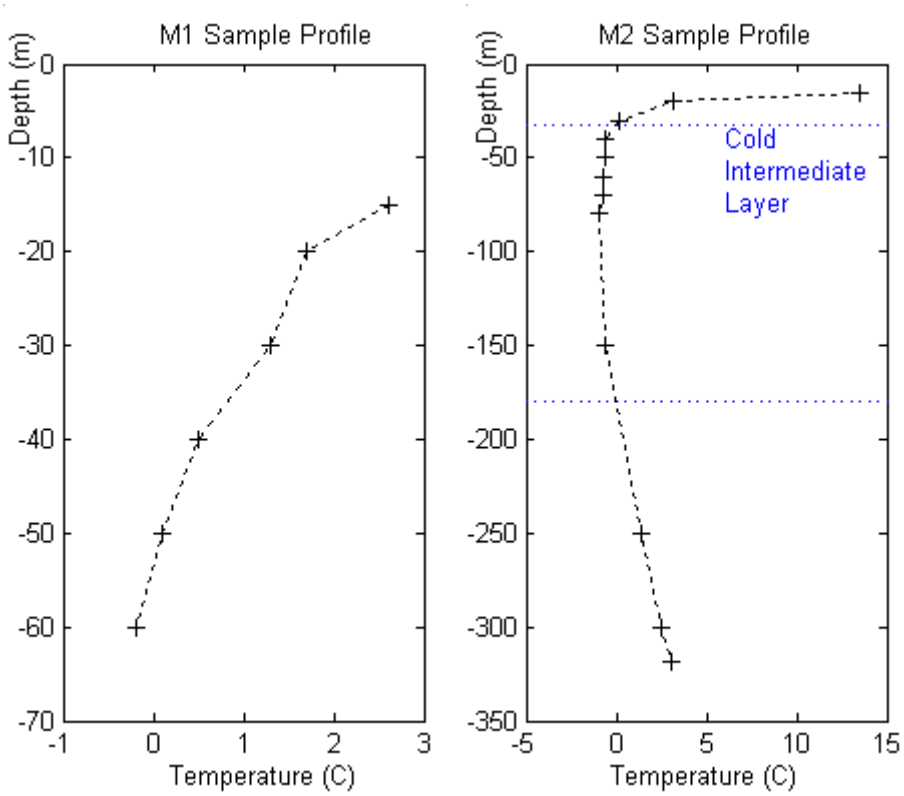

Figure 3: Sample temperature profiles from thermistor data (serial day 38207) at M1 (left), showing no CIL, and M2 (right), showing a 150 m CIL.

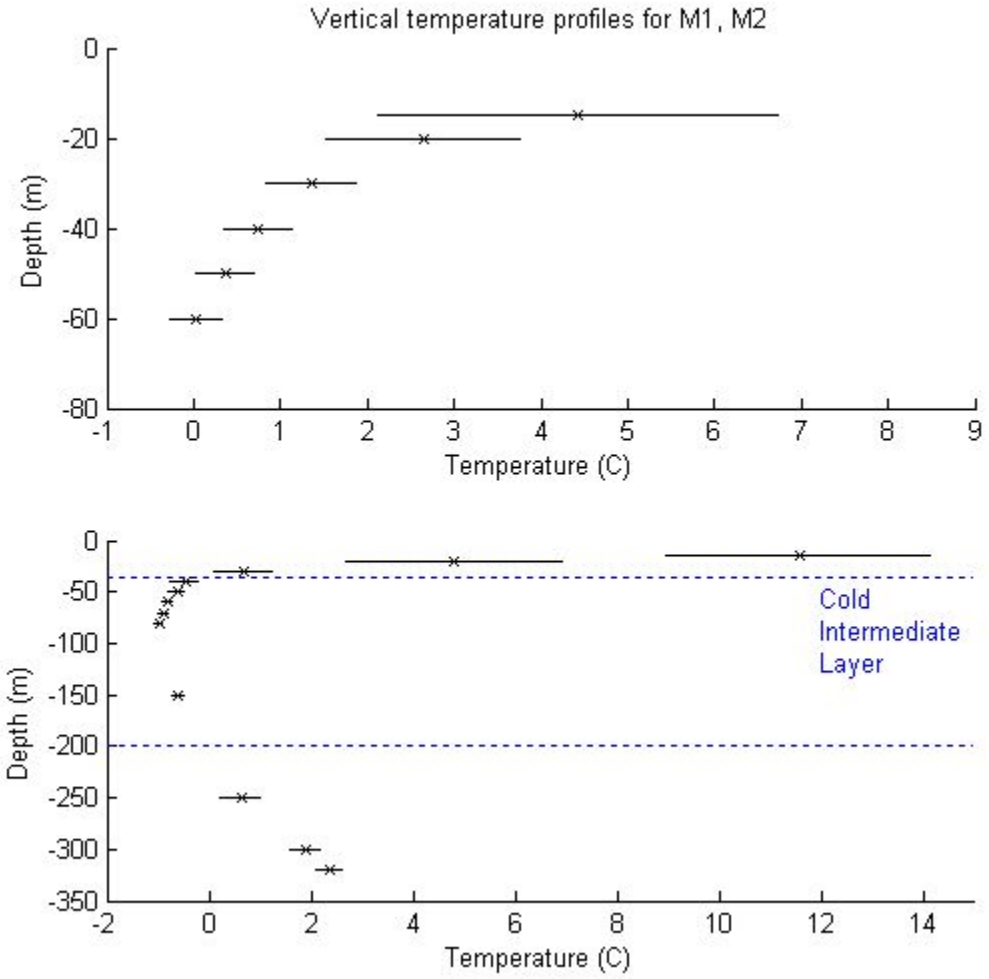

Figure 4: Mean temperature profiles for M1 (top) and M2 (bottom). M1 profile is averaged from year day 220 to 235. M2 profile is averaged from year day 220 to 233. Bars show standard deviation. Presence of CIL shown for M2 data.

Mooring	*Depth (m)*	*Mean temperature (°C)*	*Maximum temperature (°C)*	*Minimum temperature (°C)*	*Standard deviation (°C)*
M1	15	4.43	13.9	1.4	2.31
	20	2.64	10.6	1	1.13
	30	1.35	2.9	0.4	0.53
	40	0.75	1.9	0	0.4
	50	0.37	1.5	-0.3	0.35
	60	0.03	1.3	-0.6	0.32
M2	15	11.56	15.1	2.3	2.61
	20	4.81	12.7	0.7	2.13
	30	0.68	3.7	-0.6	0.59
	40	-0.47	1.1	-1.2	0.29
	50	-0.62	0	-1.2	0.18
	60	-0.79	-0.3	-1.2	0.12
	70	-0.88	-0.4	-1.2	0.1
	80	-0.97	-0.4	-1.2	0.1
	150	-0.6	-0.1	-0.9	0.15
	250	0.63	1.6	-0.3	0.42
	300	1.91	2.9	1.1	0.31
	319	2.37	3.1	1.7	0.28

Table 2: Summary of thermistor data for moorings M1 and M2. The time period for M1 is from year day 220 to 235 and for M2 is from year day 220 to 233.

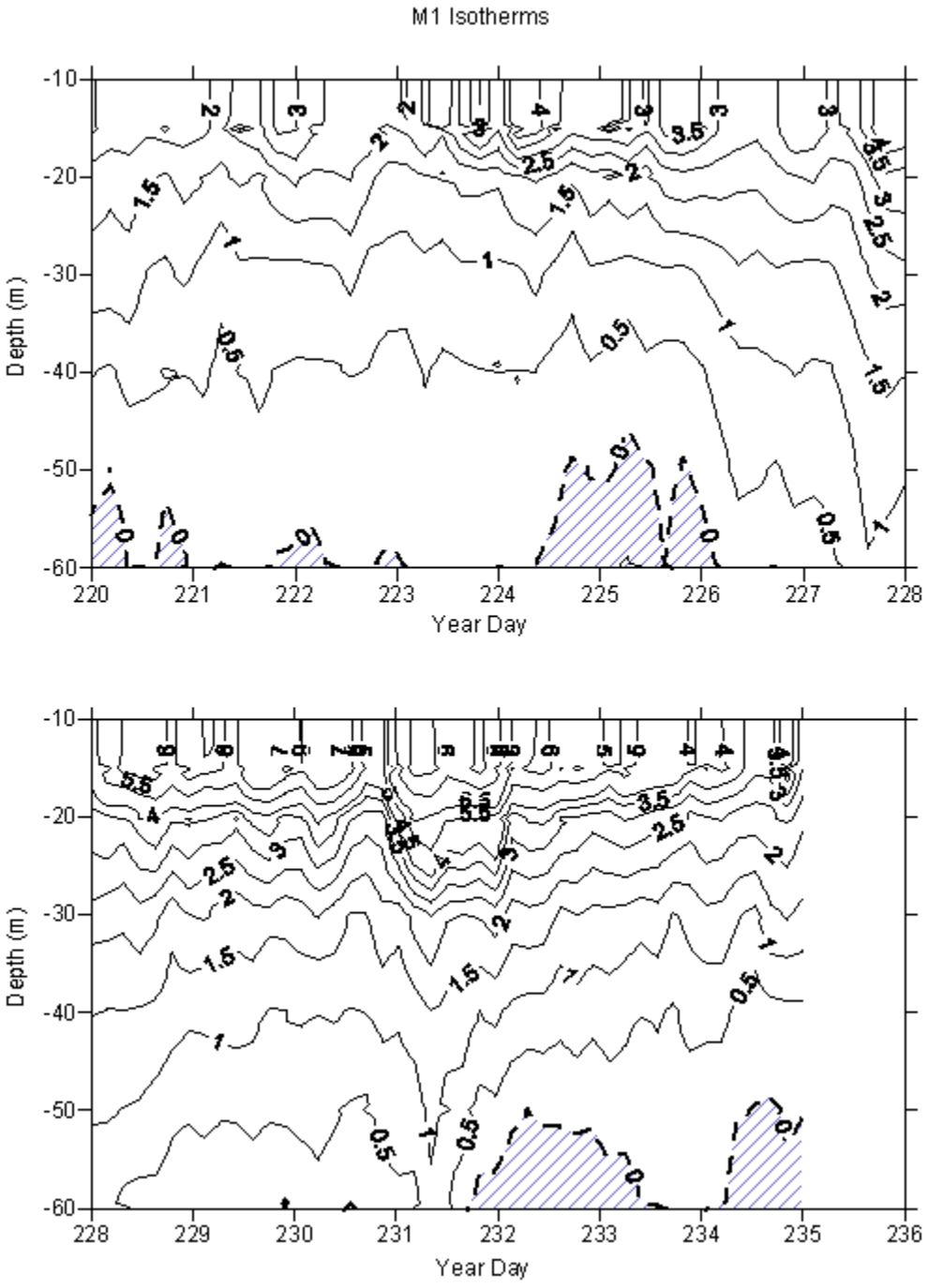

Figure 5: Isotherms at M1 for entire deployment period. From kriging-interpolated temperature data. Total depth is 71 m.

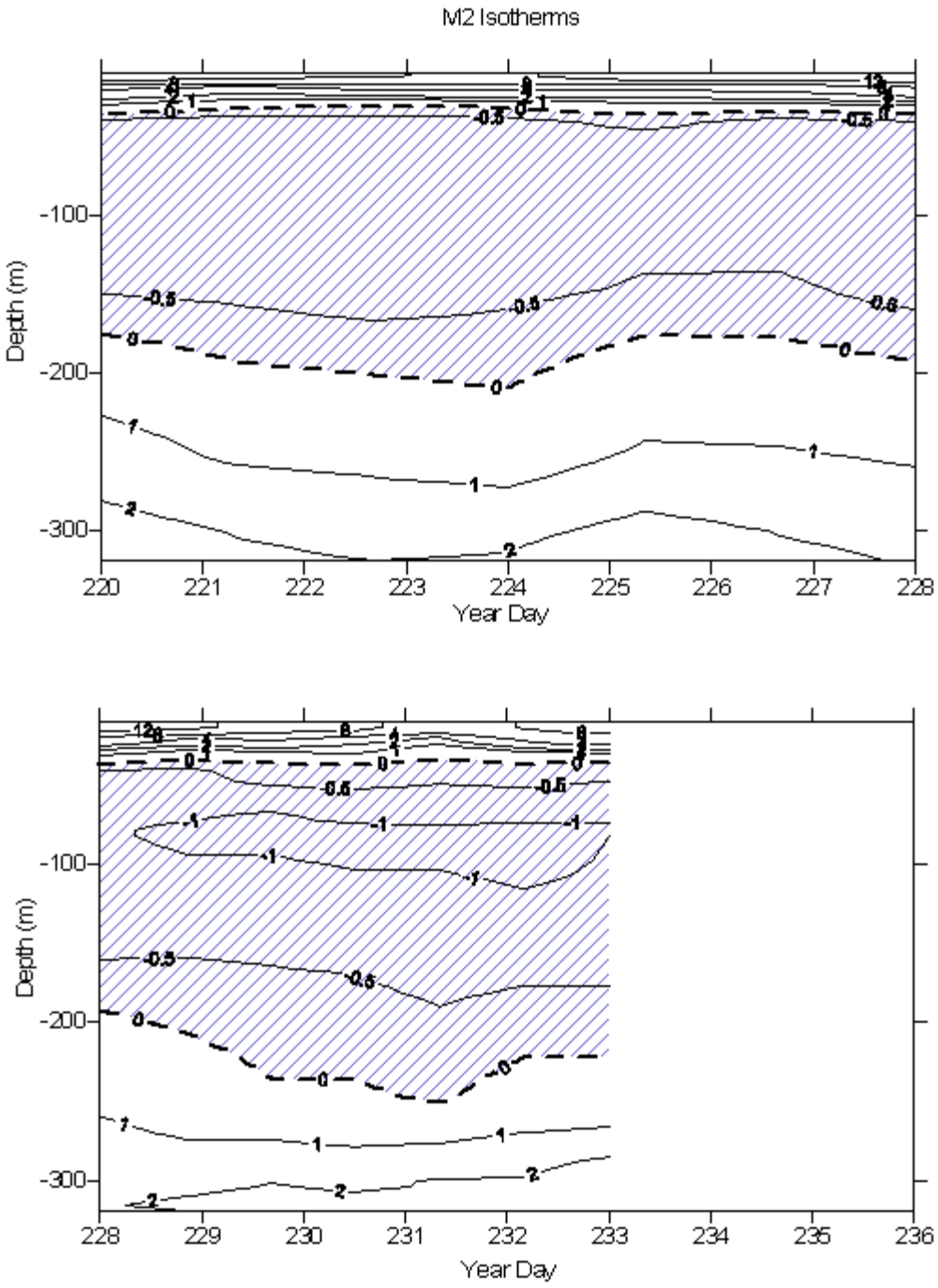

Figure 6: Isotherms at M2 for entire deployment period. From kriging-interpolated thermistor data. Total depth is 327 m. Shaded region shows the CIL.

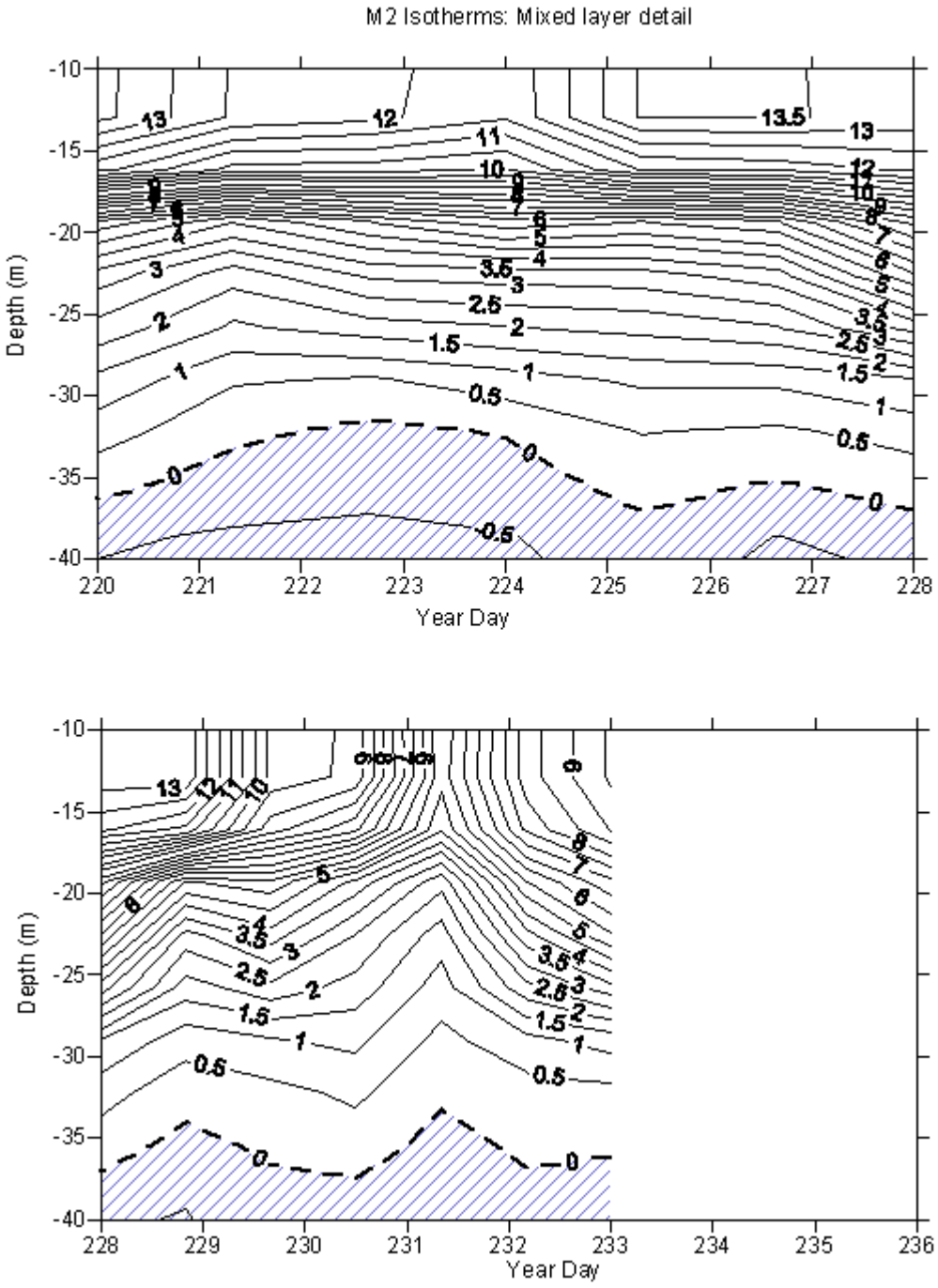

Figure 7: Isotherms at M2: mixed layer detail for entire deployment period. From kriging-interpolated thermistor data. Shaded region shows the CIL.

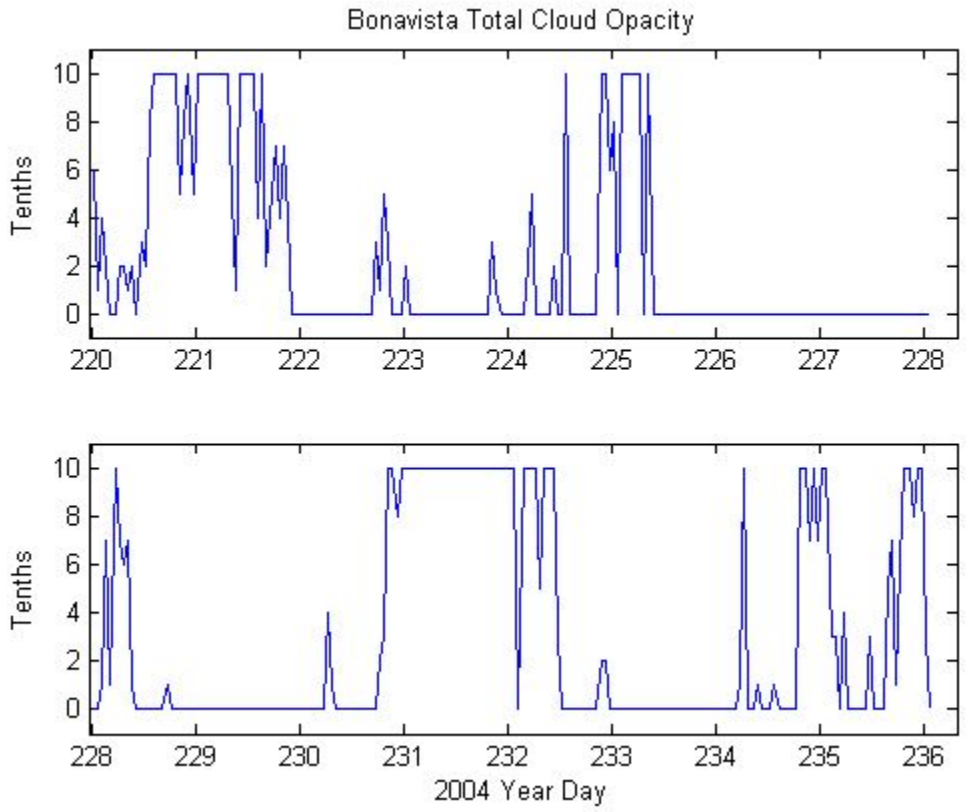

Figure 8: Total cloud opacity at Bonavista station in tenths for entire deployment period, with 10 indicating overcast skies.

Depth (m)	Mean Velocity *U* (mm/sec)	Standard Deviation *U* (mm/sec)	Mean Velocity *V* (mm/sec)	Standard Deviation *V* (mm/sec)	Mean Horizontal Direction
5	123.4	230.99	154.51	385.83	38.61
6	65.11	93.27	12.09	170.97	79.48
7	59.69	129.08	-186.05	144.09	162.21
8	91.94	112.04	-190.97	146.73	154.29
9	83.14	104.55	-183.27	138.39	155.6
10	75.16	99.3	-173.78	131.51	156.61
11	69.6	94.17	-164.02	126.01	157.01
12	62.74	92.4	-153.98	120.22	157.83
13	58.09	89.98	-144.96	113.92	158.16
14	56.12	85.86	-136.75	106.16	157.69
15	57	81.57	-129.4	97.09	156.23
16	57.47	77.17	-122.09	89.1	154.79
17	57.92	73.03	-117.59	85.58	153.78
18	58.79	70.98	-112.12	82.2	152.33
19	59.24	68.92	-106.55	77.72	150.93
20	59.13	67.26	-101.3	72.96	149.73
21	59.62	65.62	-97.05	68.56	148.44
22	59.7	63.44	-94.64	66.23	147.76
23	58.42	62.24	-91.78	64.56	147.52
24	56.21	59.57	-87.07	62.13	147.15
25	56.37	59.04	-85.34	61.24	146.55
26	56.51	58.64	-82.97	59.47	145.74
27	56.11	57.96	-80.71	57.78	145.19
28	55.1	57.5	-78.56	56.98	144.96
29	54.52	56.89	-76.87	55.85	144.65
30	53.41	56.48	-74.98	54.96	144.54
31	51.51	57.19	-74.02	55.56	145.17
32	49.6	57.24	-72.33	55.49	145.56
33	47.86	57.21	-71.05	56.29	146.04
34	46.23	57.07	-70.28	56.98	146.66
35	45.16	57.49	-68.16	57.27	146.47
36	43.98	57.53	-66.88	57.85	146.67
37	43.73	56.75	-65.14	58.2	146.13

Table 3: Summary of horizontal current velocities from ADCP instrument on mooring M1 for each bin depth. Averages are taken over the entire deployment period. Mean horizontal direction is in degrees clockwise from North. *Continued on next page.*

Depth (m)	Mean Velocity *U* (mm/sec)	Standard Deviation *U* (mm/sec)	Mean Velocity *V* (mm/sec)	Standard Deviation *V* (mm/sec)	Mean Horizontal Direction
38	44.2	56.2	-63.35	58.35	145.1
39	44.52	55.32	-61.07	58.85	143.91
40	44.32	54.36	-58.76	58.55	142.97
41	44	52.95	-56.69	58.6	142.18
42	42.99	52	-54.92	57.9	141.95
43	42.43	51.21	-53.33	56.21	141.49
44	42.11	50.65	-51.63	54.59	140.8
45	41.59	50	-49.86	52.84	140.17
46	40.92	49.2	-48.45	51.77	139.82
47	39.77	47.21	-46.35	50.92	139.37
48	38.29	46.85	-44.47	49.94	139.27
49	37.83	46.17	-42.34	48.78	138.22
50	37.09	45.84	-40.09	48.12	137.23
51	35.93	45.63	-37.59	48.09	136.29
52	34.7	44.81	-35.77	47.76	135.87
53	32.58	44.64	-33.37	47.72	135.69
54	31.19	44.71	-31.54	47.65	135.32
55	29.78	44.33	-29.17	48.26	134.41
56	28.42	43.78	-27.59	48.27	134.15
57	27.12	43.29	-26.59	48.27	134.43
58	25.87	42.94	-24.89	48.59	133.89
59	24.46	42.33	-23.44	48.61	133.78
60	23.17	42.03	-21.42	49.13	132.75
61	21.96	41.66	-19.63	49.54	131.79
62	20.33	41.7	-18.25	50.44	131.91
63	19.6	41.18	-17.03	49.94	130.99
64	18.32	40.76	-15.1	49.48	129.5
65	17.13	40.73	-13.64	48.94	128.53
66	16.65	40.55	-11.76	48.36	125.23
67	15.91	41.28	-9.33	48.02	120.39
68	15.37	40.76	-6.98	46.43	114.42
69	14.48	41.75	-4.8	45.53	108.34
70	13.44	40.78	-1.66	42.59	97.04

Table 3 (continued): Summary of horizontal current velocities from ADCP instrument on mooring M1 for each bin depth. Averages are taken over the entire deployment period. Mean horizontal direction is in degrees clockwise from North.

Depth (m)	Mean Velocity *W* (mm/sec)	Standard Deviation *W* (mm/sec)	Depth (m)	Mean Velocity *W* (mm/sec)	Standard Deviation *W* (mm/sec)
5	3.51	15.42	38	-0.8	4.06
6	4.69	17.68	39	-0.87	4.07
7	0.06	12.26	40	-0.81	3.95
8	-0.51	6.71	41	-0.78	4
9	-0.65	5.99	42	-0.72	4.11
10	-0.25	5.8	43	-0.83	3.94
11	0.02	5.8	44	-0.8	3.98
12	0.14	5.53	45	-0.81	3.93
13	-0.19	5.36	46	-0.75	3.87
14	-0.63	5.38	47	-0.71	3.93
15	-0.87	5.18	48	-0.72	3.99
16	-0.81	5.28	49	-0.82	3.92
17	-0.88	4.7	50	-0.76	3.97
18	-0.9	4.96	51	-0.8	4
19	-0.79	4.96	52	-0.83	3.96
20	-0.58	4.22	53	-0.91	4.07
21	-0.64	4.59	54	-0.96	4.1
22	-0.38	4.49	55	-0.94	4.24
23	-0.53	4.27	56	-1.1	4.28
24	-0.54	3.71	57	-1.01	4.27
25	-0.43	4.29	58	-0.93	4.29
26	-0.51	4.26	59	-0.97	4.3
27	-0.62	3.78	60	-1.04	4.36
28	-0.62	3.81	61	-1.05	4.24
29	-0.5	3.82	62	-1.08	4.29
30	-0.62	3.83	63	-1.08	4.41
31	-0.59	4.35	64	-0.9	4.46
32	-0.56	3.8	65	-0.91	4.45
33	-0.51	3.77	66	-0.93	4.6
34	-0.61	3.88	67	-0.96	4.84
35	-0.76	3.94	68	-1.3	5.25
36	-0.75	3.94	69	-1.59	5.61
37	-0.7	4	70	-2.15	5.28

Table 4: Summary of vertical current velocities from ADCP instrument on mooring M1 for each bin depth. Averages are taken over the entire deployment period.

Depth (m)	Mean Velocity *U* (mm/sec)	Standard Deviation *U* (mm/sec)	Mean Velocity *V* (mm/sec)	Standard Deviation *V* (mm/sec)	Mean Horizontal Direction
22	-42.78	135.3	-79.64	135.18	208.24
26	-56.83	113.47	-101.77	105.8	209.18
30	-55.82	90.36	-111.83	82.33	206.53
34	-57.37	86.95	-112.34	83.63	207.05
38	-61.01	86.11	-111.23	86.48	208.74
42	-61.16	87.32	-110.43	90.61	208.98
46	-59.89	88.78	-106.03	94.35	209.46
50	-59.56	88.72	-100.35	94.78	210.69
54	-60.25	86.81	-96.33	96.04	212.02
58	-61.09	86.37	-94.34	97.32	212.93
62	-62.2	87.07	-93.06	98.1	213.76
66	-61.92	87.2	-92.22	98.83	213.88
70	-61.17	86.36	-92.51	99.82	213.47
74	-61.02	84.99	-93.39	101.79	213.16
78	-61.03	84.74	-94.2	102.53	212.94
82	-59.23	85.57	-94.58	102.8	212.06
86	-56.62	88.37	-95.8	104.25	210.58
90	-54.01	92.58	-97.36	106.24	209.02
94	-50.09	93.28	-98.32	109.61	207
98	-46.42	92.32	-98.48	111.01	205.24
102	-42.04	90.73	-95.92	109.51	203.67
106	-37.73	87.78	-93.68	109.66	201.94
110	-37.05	87.76	-93.32	113.55	201.65

Table 5: Summary of horizontal current velocities from ADCP instrument on mooring M2 for each bin depth. Averages are taken over the entire deployment period. Mean horizontal direction is in degrees clockwise from North.

Depth (m)	Mean Velocity *W* (mm/sec)	Standard Deviation *W* (mm/sec)
22	1.87	13.95
26	0.75	7.37
30	0.49	5.81
34	0.52	5.35
38	0.39	5.19
42	-0.05	5.25
46	-0.29	5.73
50	-0.96	5.42
54	-1.25	6.11
58	-1.23	6.35
62	-1.14	6.53
66	-0.91	6.62
70	-0.64	6.74
74	-0.47	6.89
78	-0.23	6.89
82	0.08	6.92
86	0.48	6.88
90	0.91	6.82
94	1.4	6.94
98	2.47	7.73
102	4.12	10.01
106	4.21	10.79
110	1.98	7.23

Table 6: Summary of vertical current velocities from ADCP instrument on mooring M2 for each bin depth. Averages are taken over the entire deployment period.

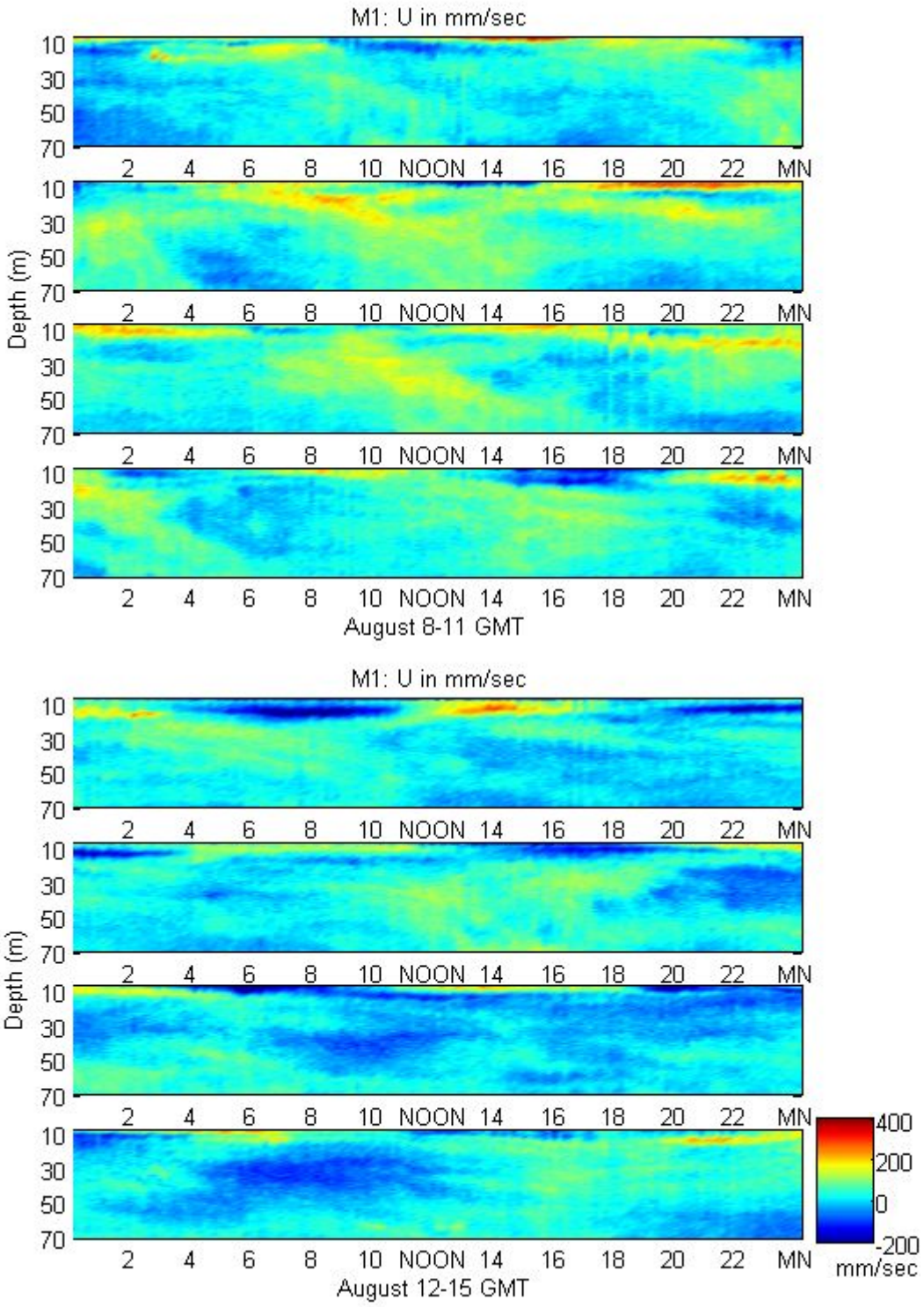

Figure 9: Daily raw ADCP data from mooring M1: *u* (mm/sec), positive to the east. August 8-15. Water depth is 71 m.

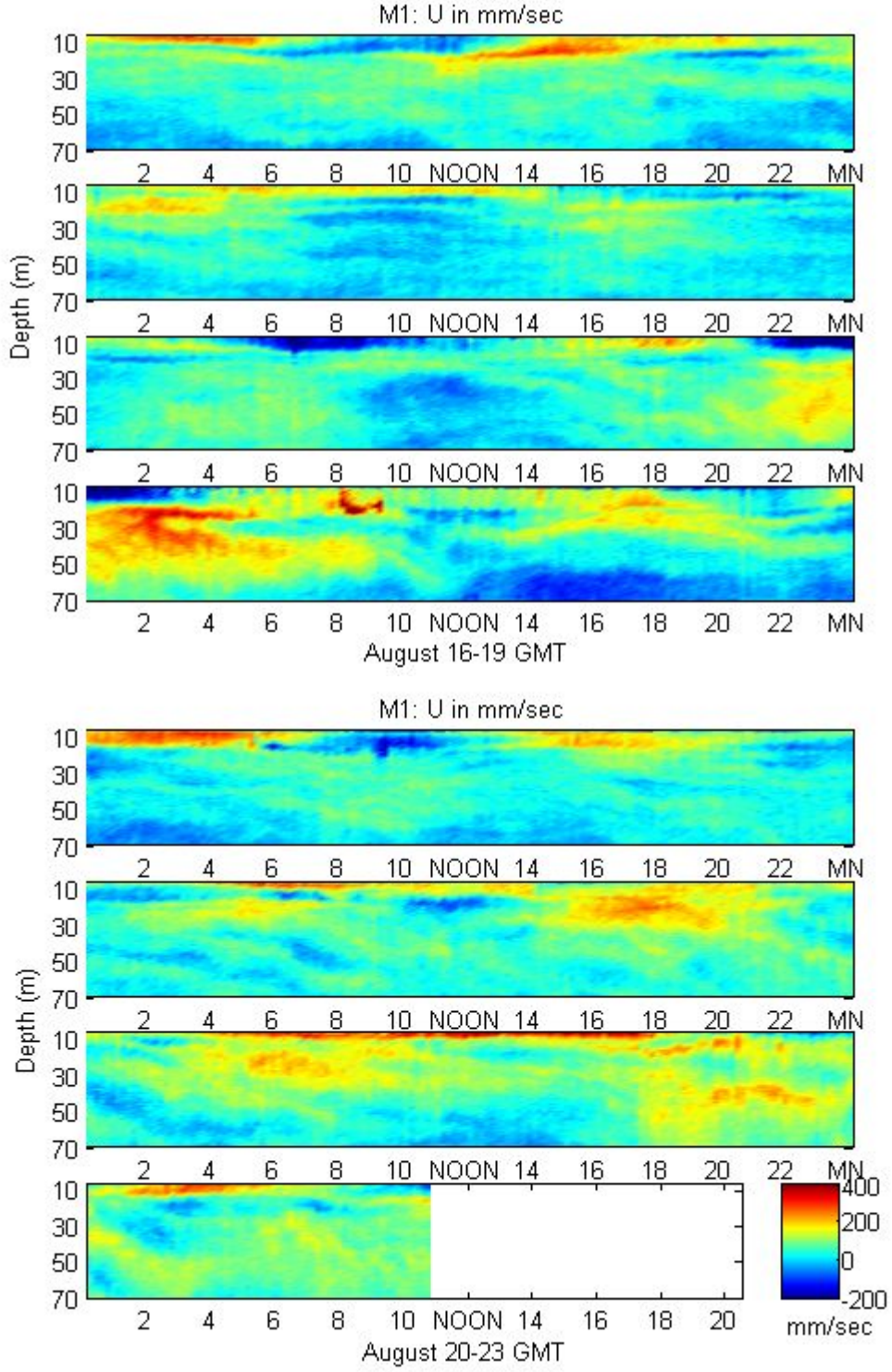

Figure 10: Daily raw ADCP data from mooring M1: *u* (mm/sec), positive to the east. August 16-23. Water depth is 71 m.

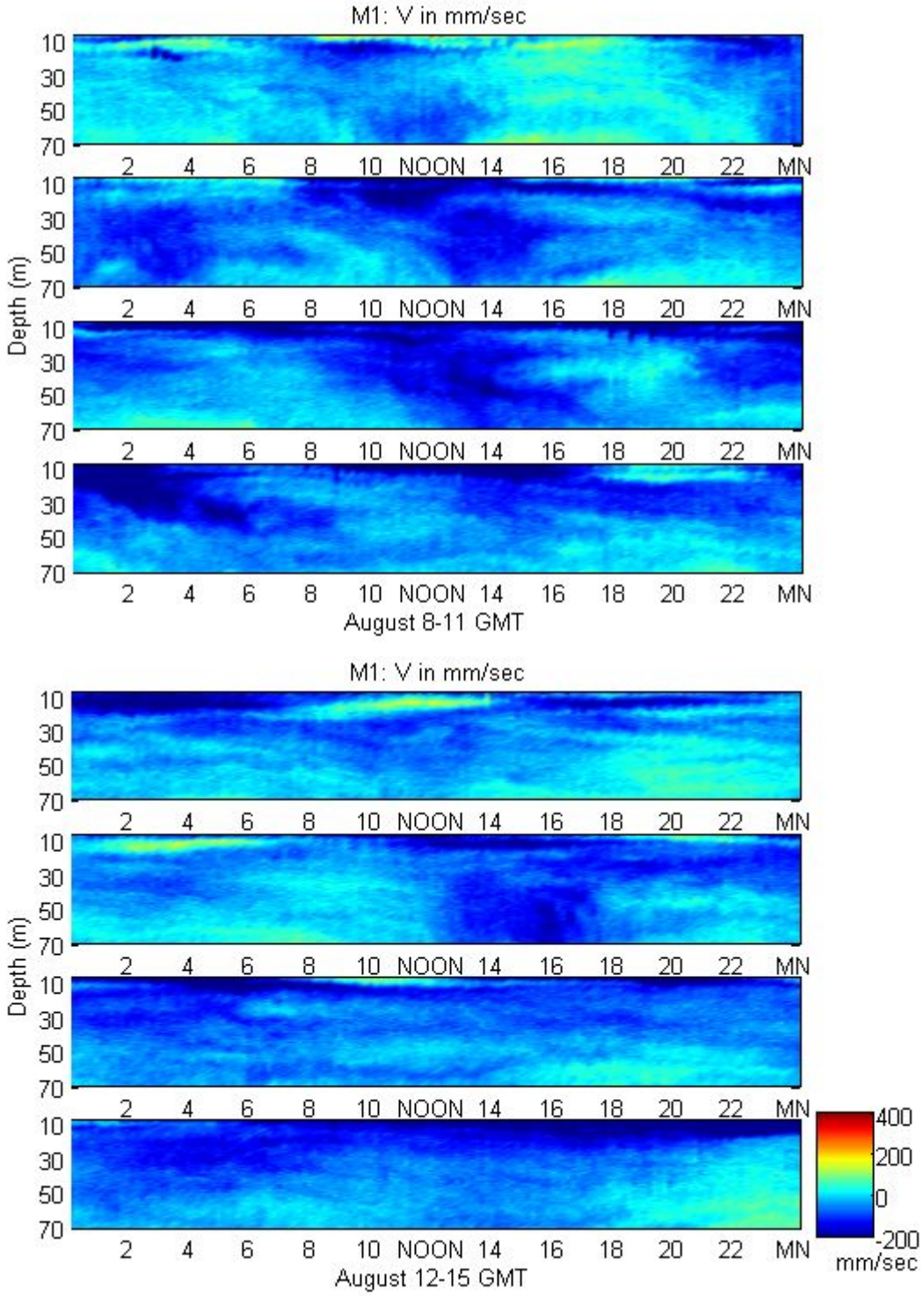

Figure 11: Daily raw ADCP data from mooring M1: *v* (mm/sec), positive to the north. August 8-15. Water depth is 71 m.

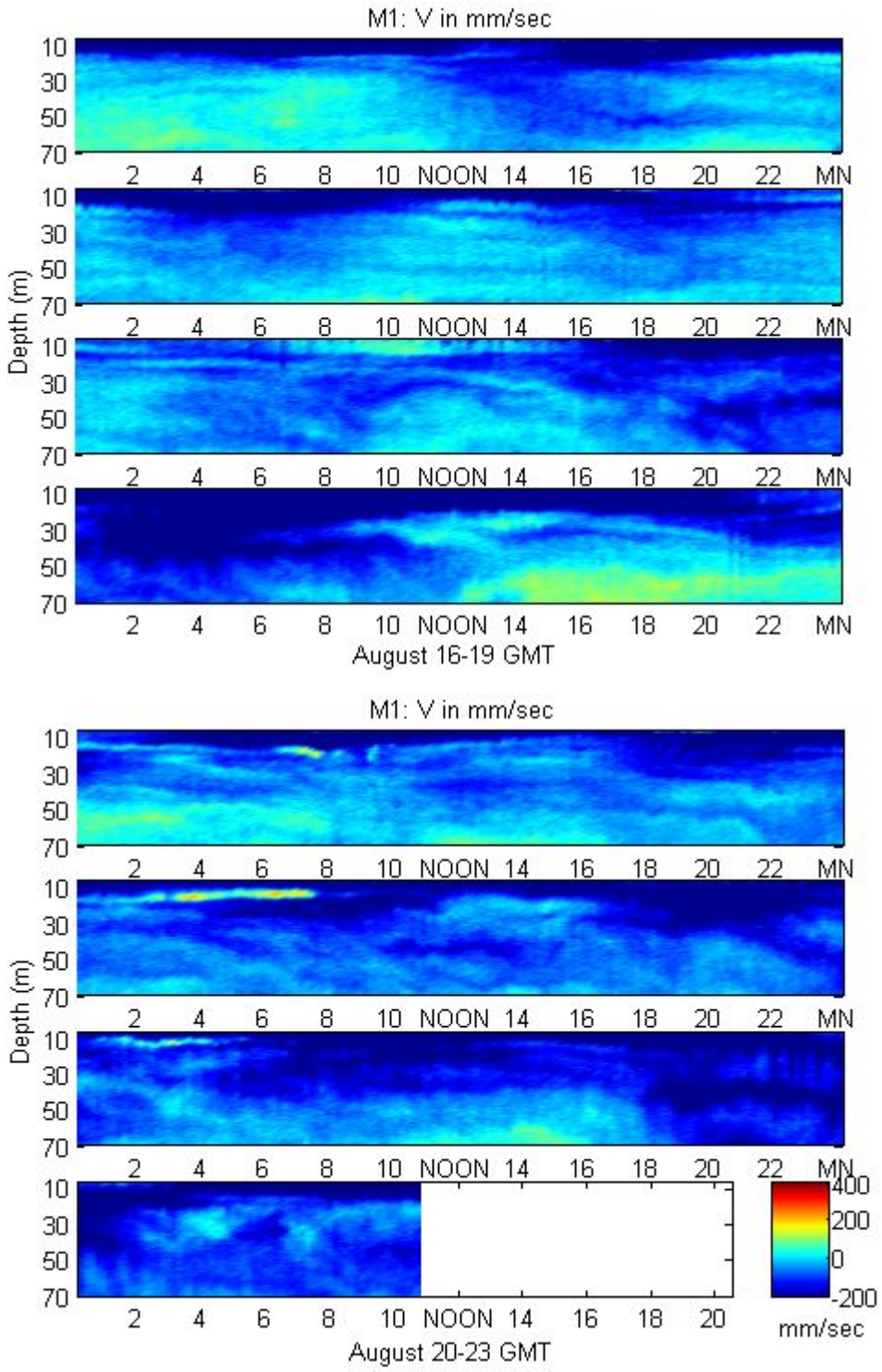

Figure 12: Daily raw ADCP data from mooring M1: *v* (mm/sec), positive to the north. August 16-23. Water depth is 71 m.

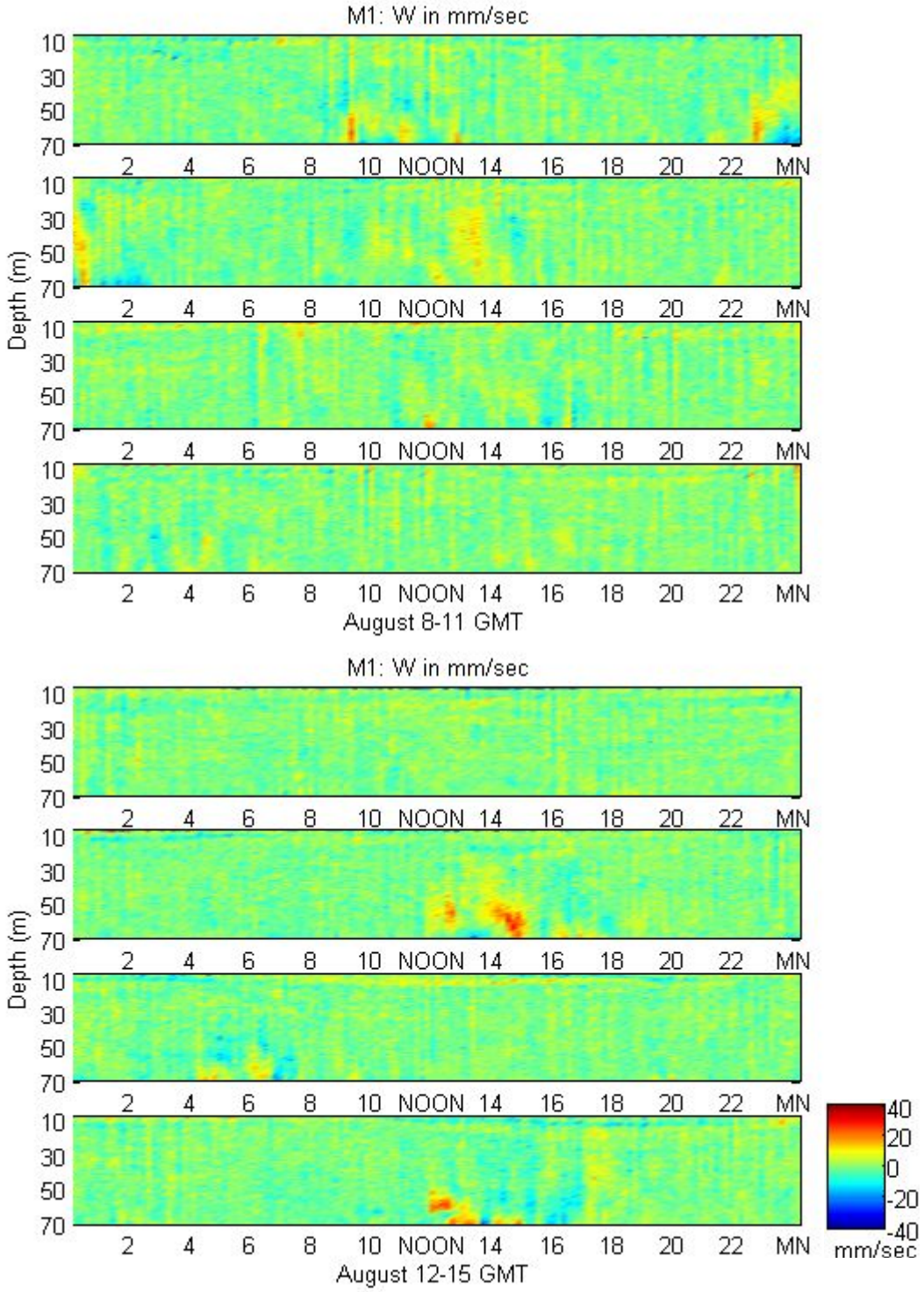

Figure 13: Daily raw ADCP data from mooring M1: *w* (mm/sec), positive upwards. August 8-15. Water depth is 71 m.

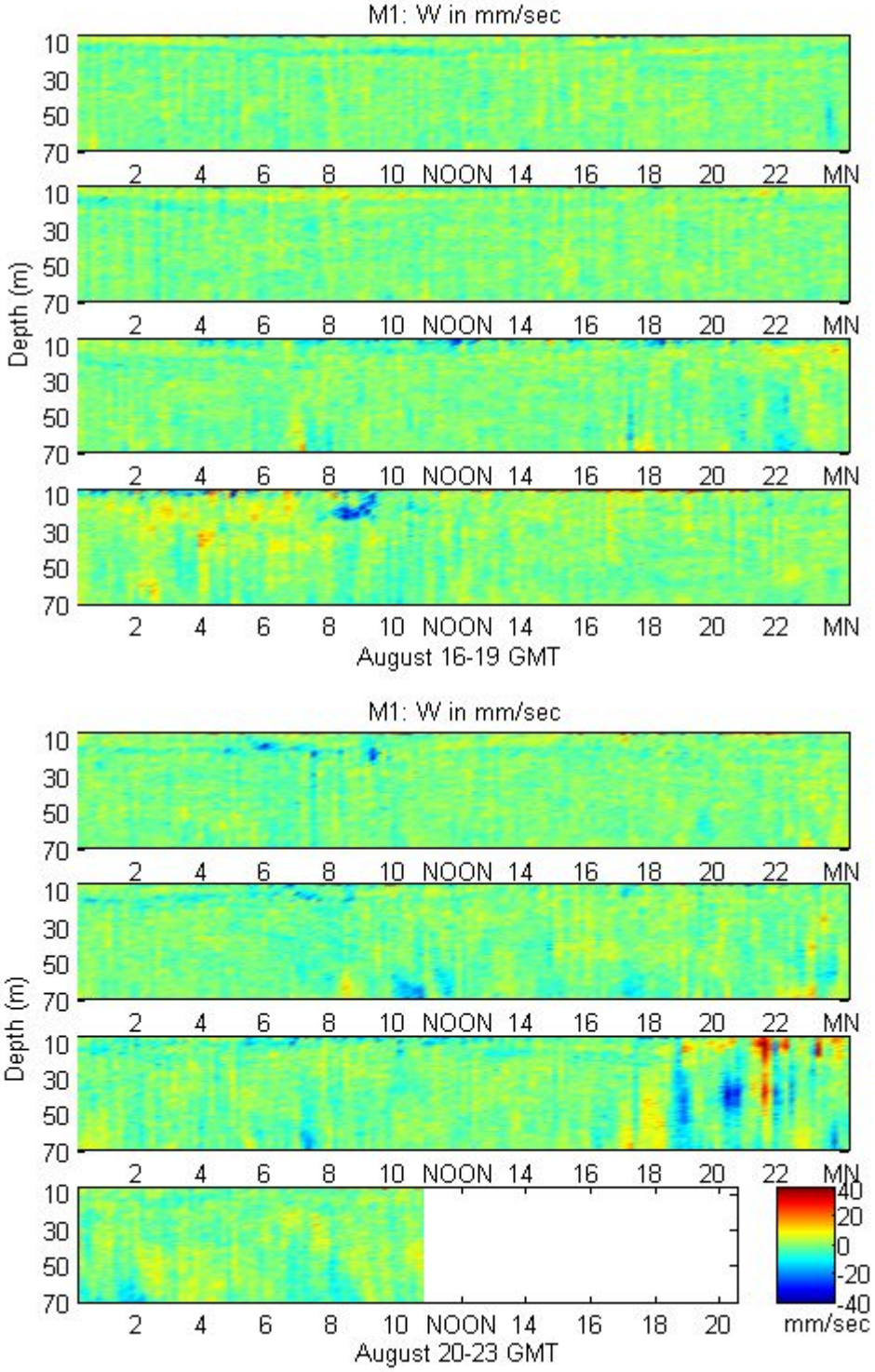

Figure 14: Daily raw ADCP data from mooring M1: *w* (mm/sec), positive upwards. August 16-23. Water depth is 71 m.

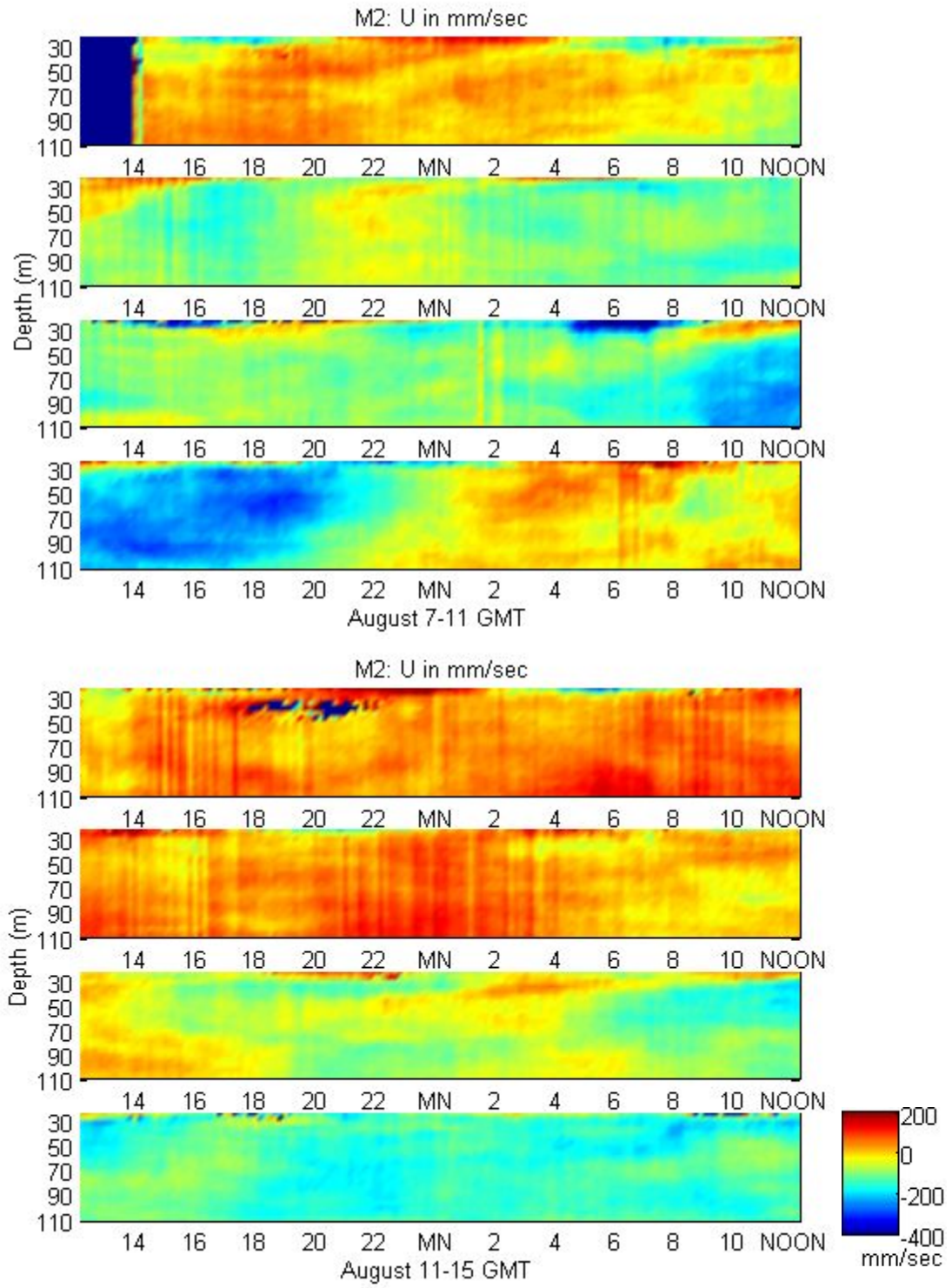

Figure 15: Daily raw ADCP data from mooring M2: *u* (mm/sec), positive to the east. August 7-15. Water depth is 327 m.

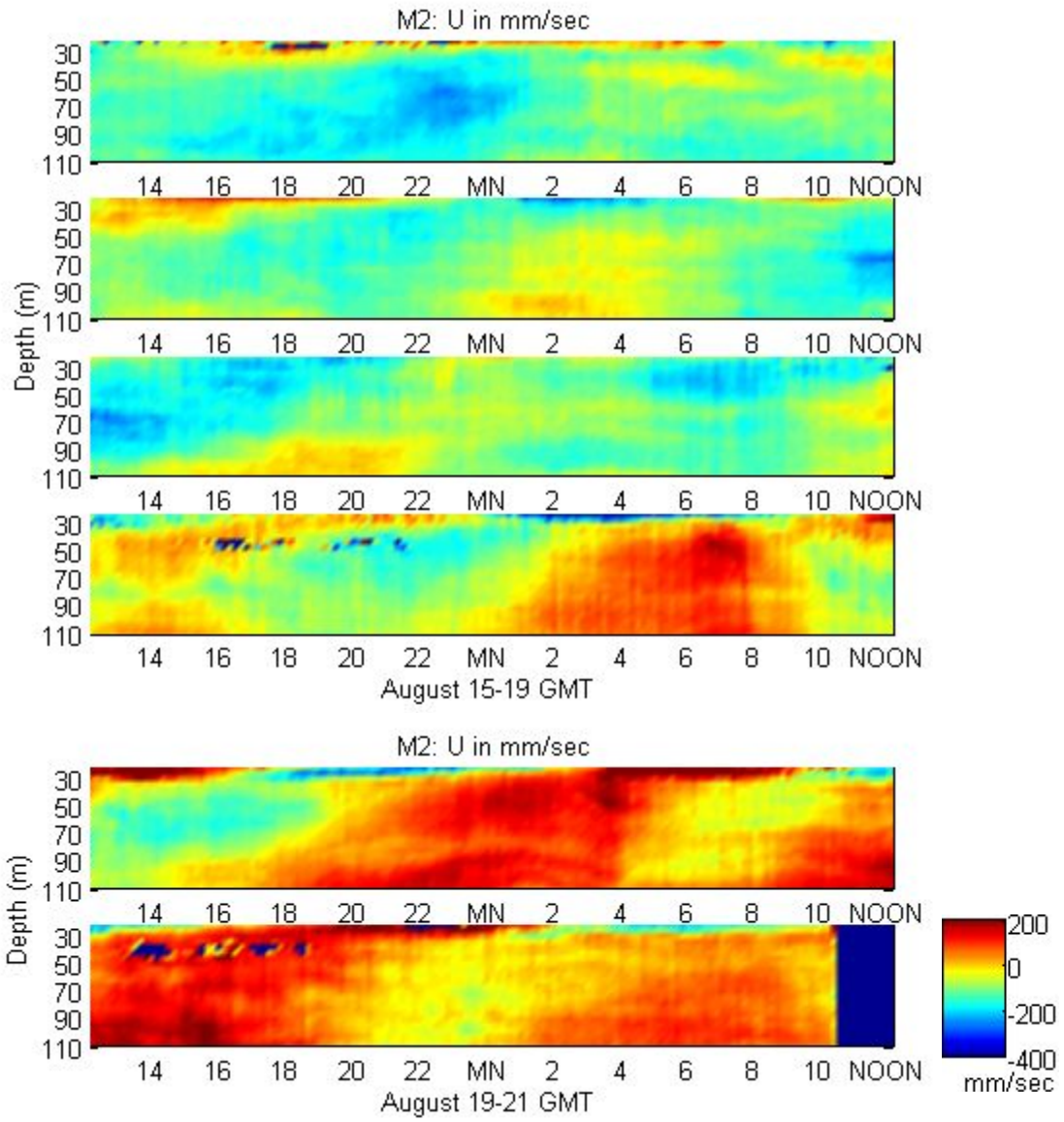

Figure 16: Daily raw ADCP data from mooring M2: *u* (mm/sec), positive to the east. August 15-21. Water depth is 327 m.

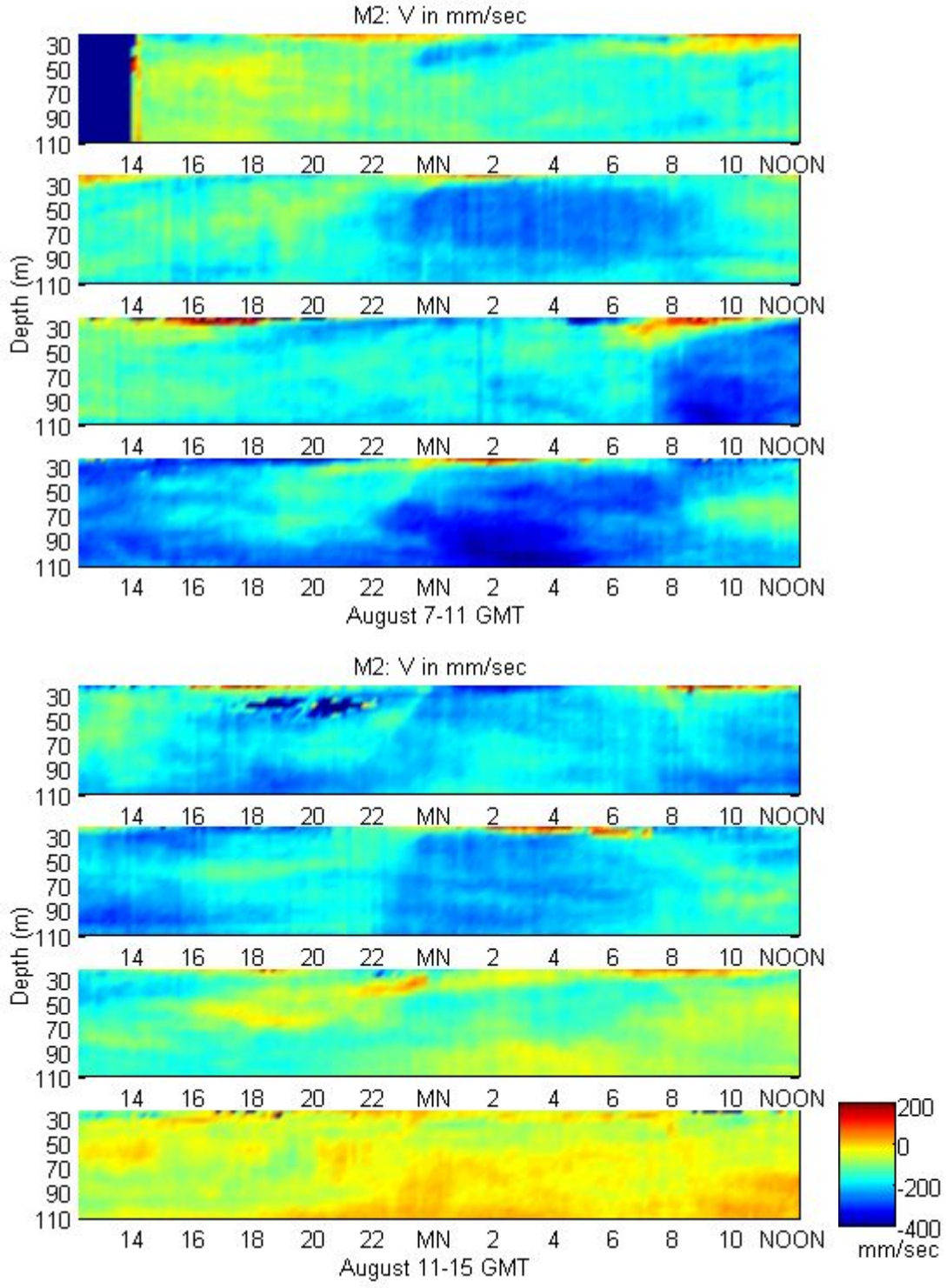

Figure 17: Daily raw ADCP data from mooring M2: *v* (mm/sec), positive to the north. August 7-15. Water depth is 327 m.

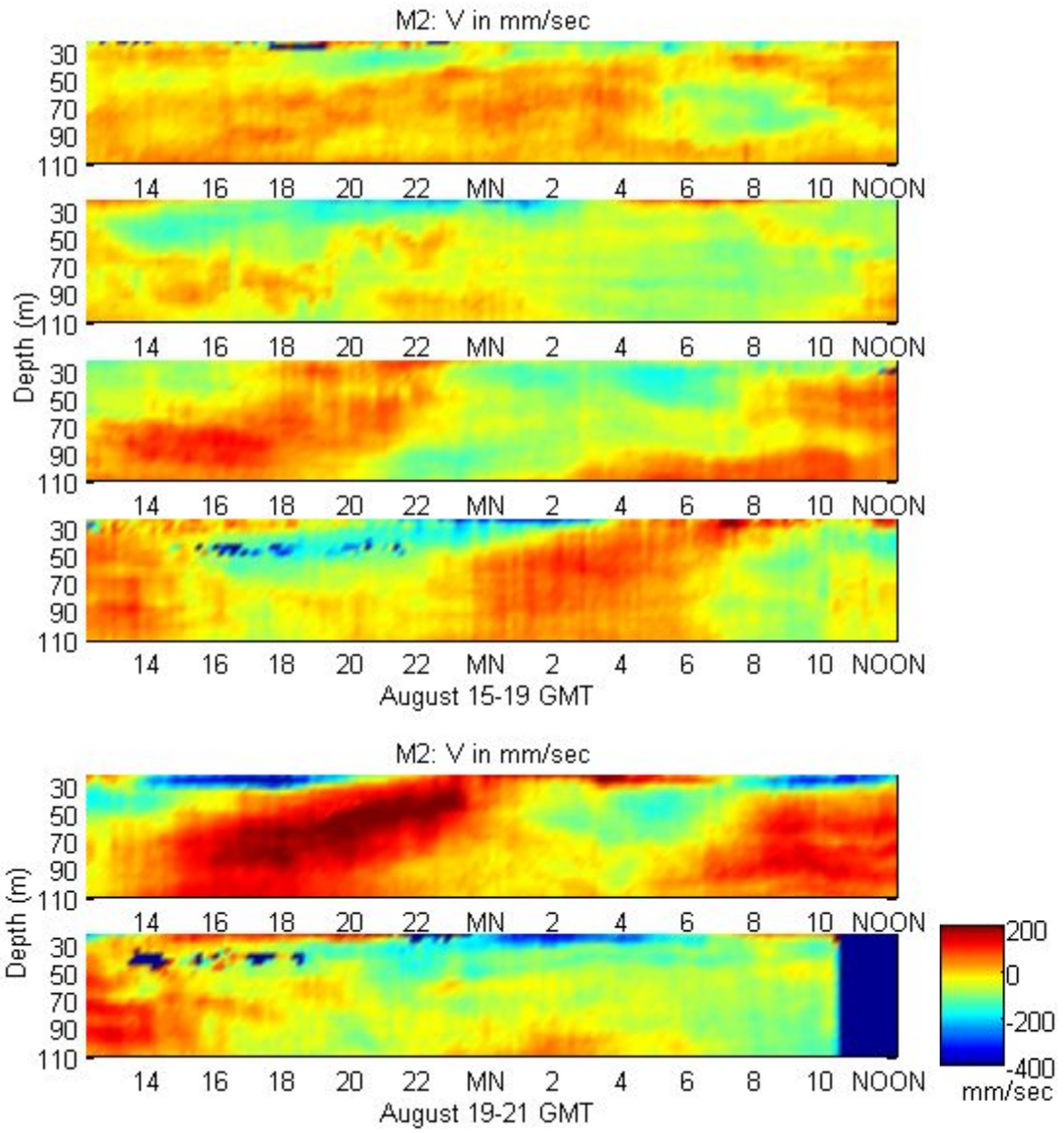

Figure 18: Daily raw ADCP data from mooring M2: *v* (mm/sec), positive to the north. August 15-21. Water depth is 327 m.

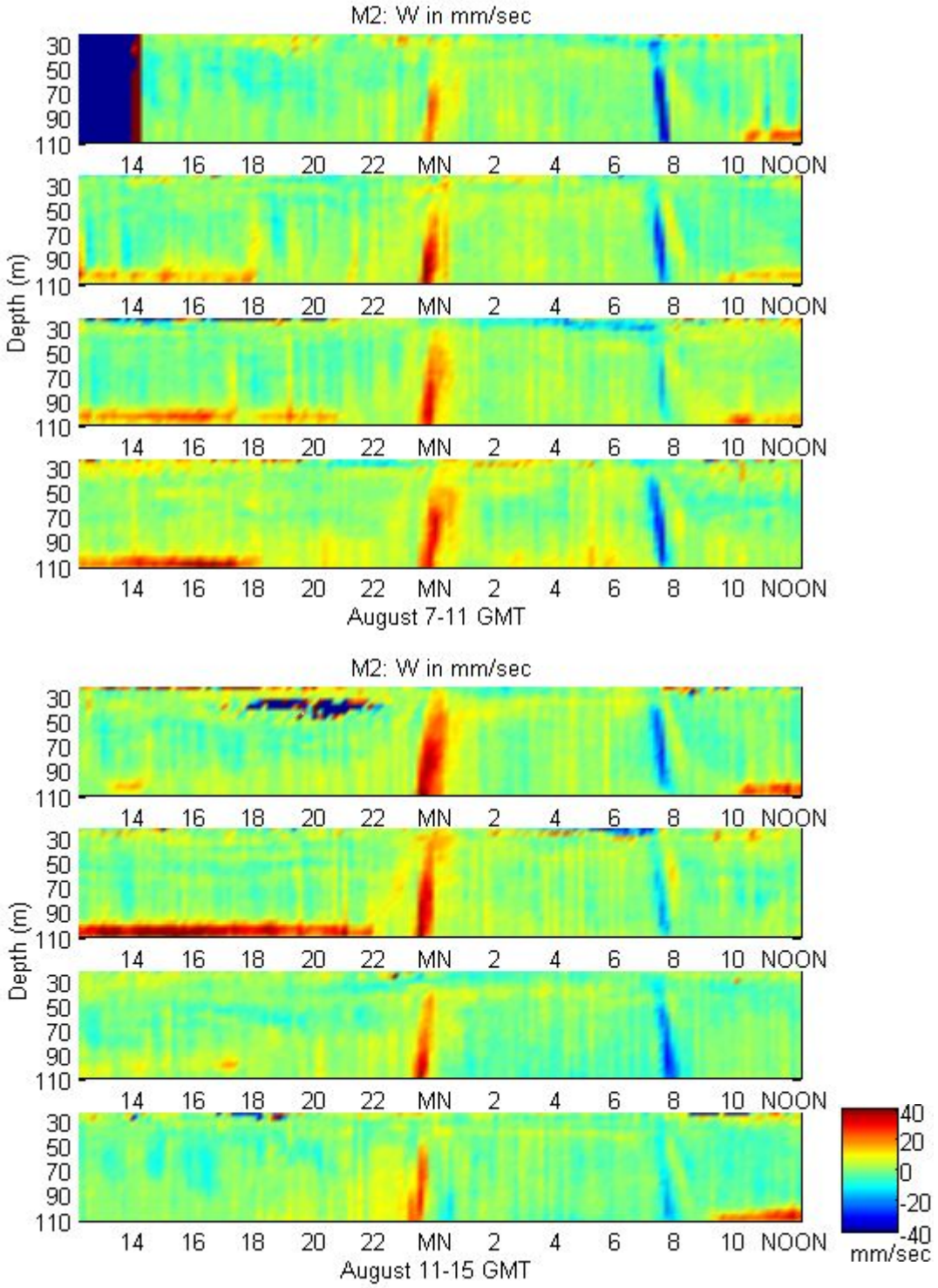

Figure 19: Daily raw ADCP data from mooring M2: *w* (mm/sec), positive upwards. August 7-15. Water depth is 327 m.

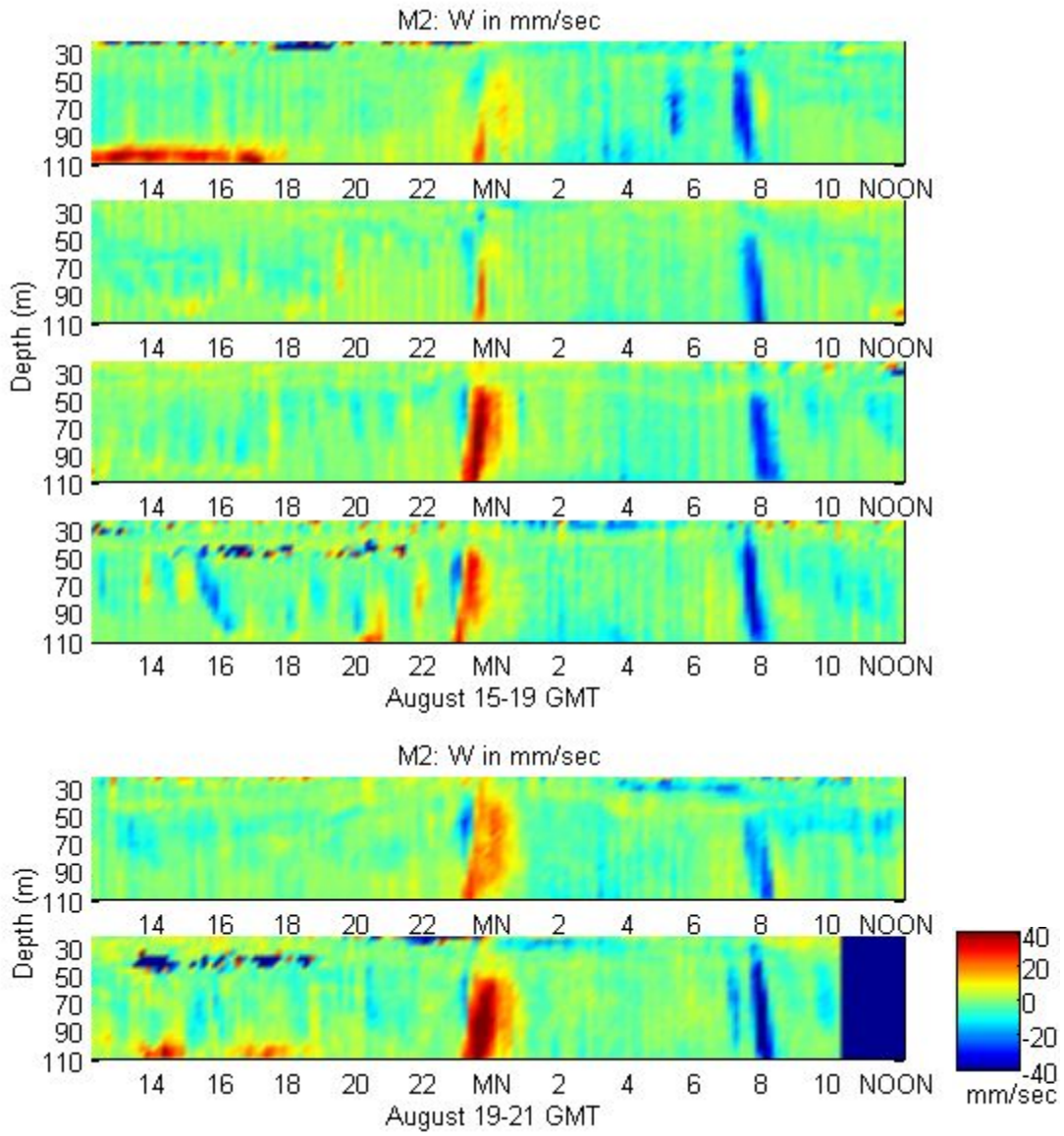

Figure 20: Daily raw ADCP data from mooring M2: *w* (mm/sec), positive upwards. August 15-21. Water depth is 327 m.

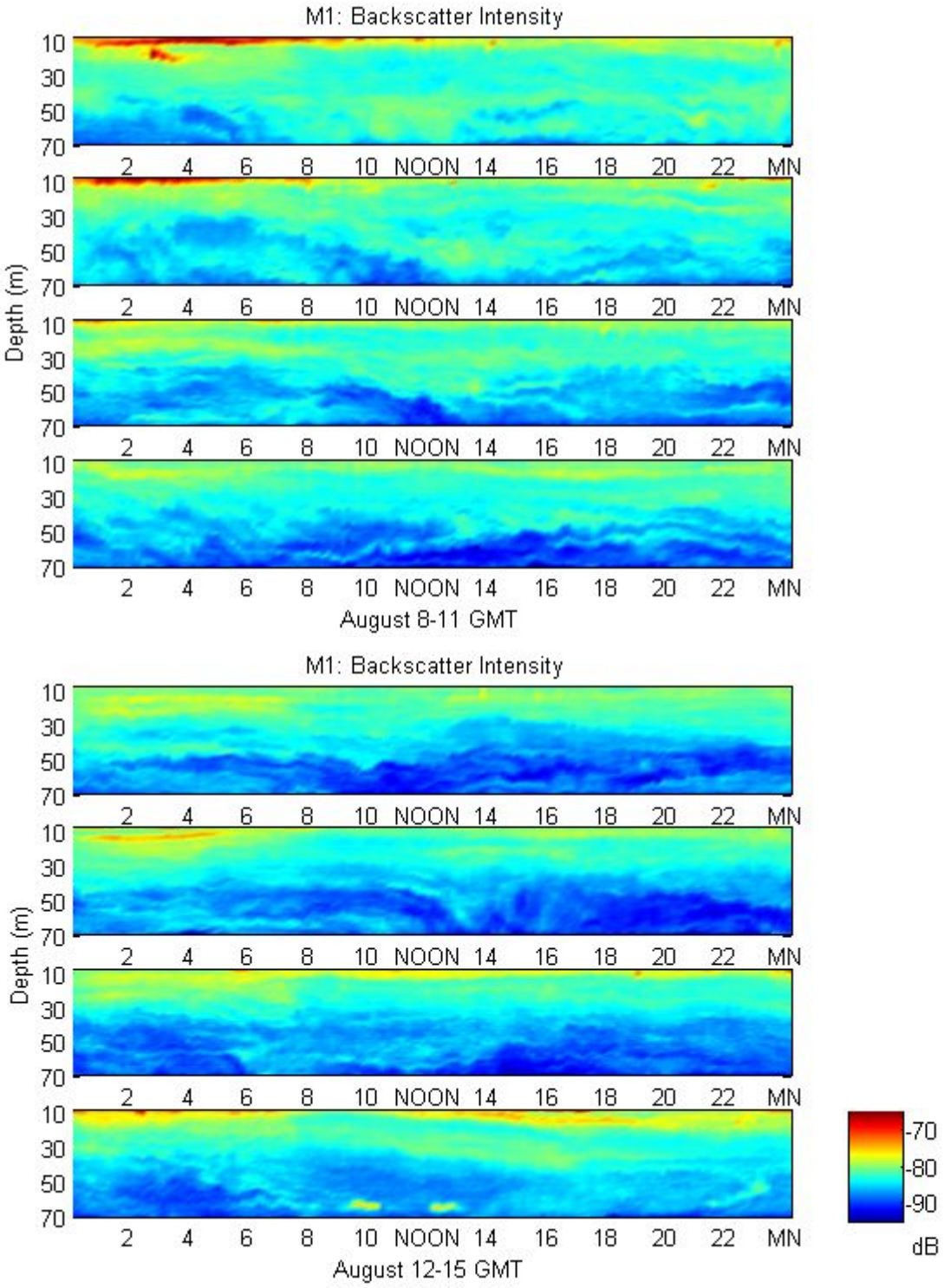

Figure 21: Daily ADCP data from mooring M1: corrected backscatter, re $(4\pi m)^{-1}$. August 8-15. Water depth is 71 m.

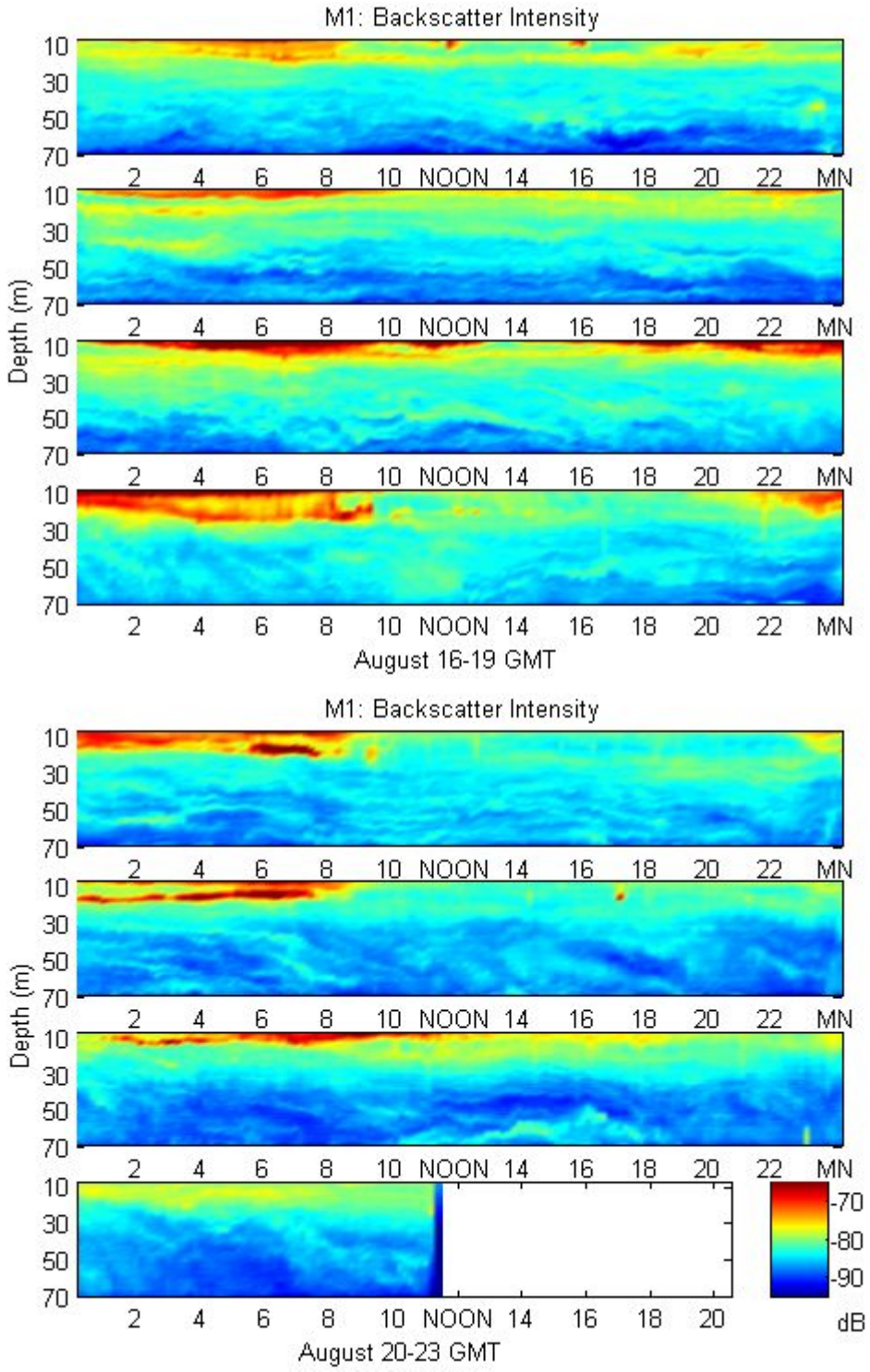

Figure 22: Daily ADCP data from mooring M1: corrected backscatter, re $(4\pi m)^{-1}$. August 16-23. Water depth is 71 m.

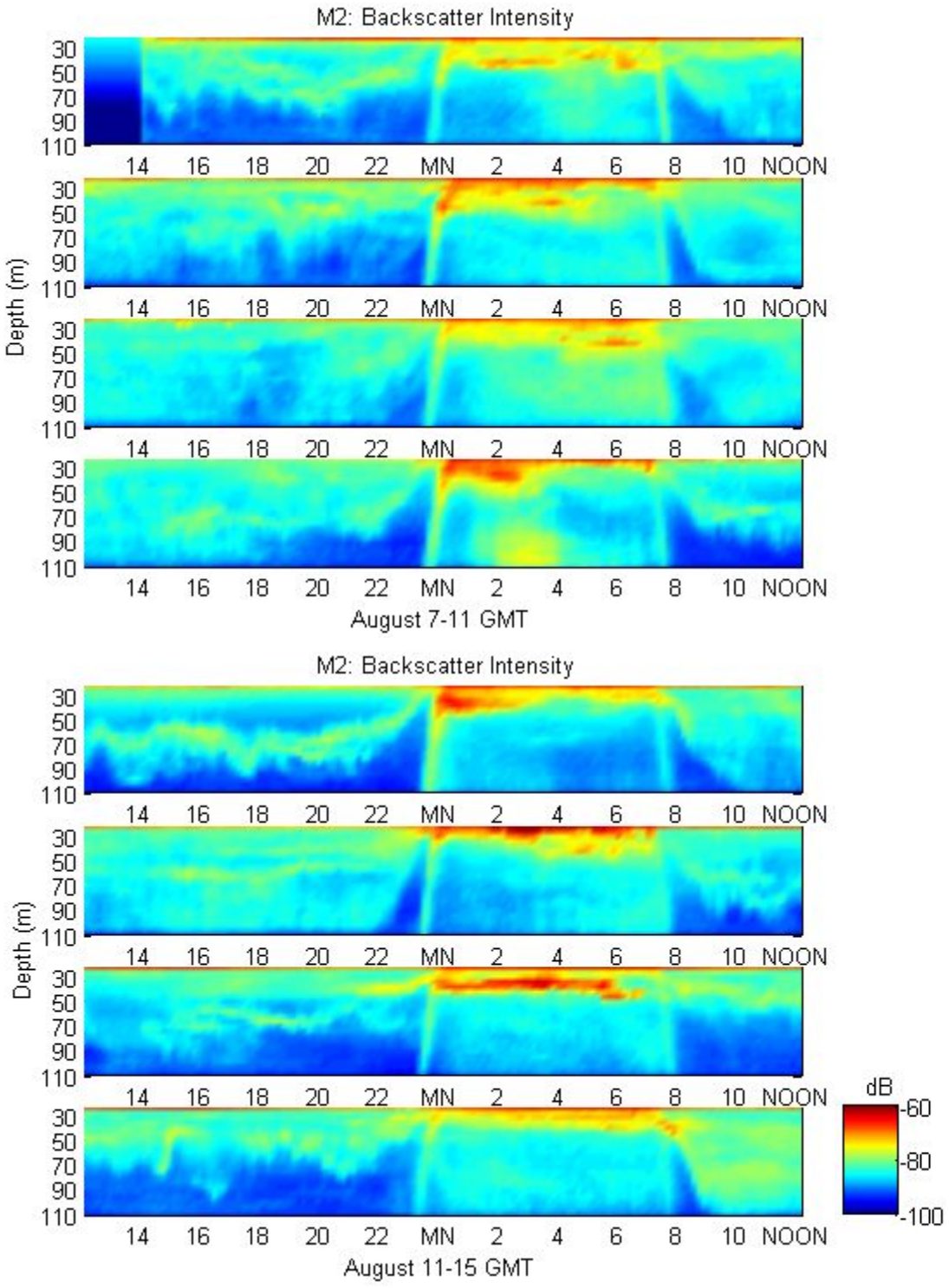

Figure 23: Daily ADCP data from mooring M2: corrected backscatter, re $(4\pi m)^{-1}$. August 7-15. Water depth is 327 m.

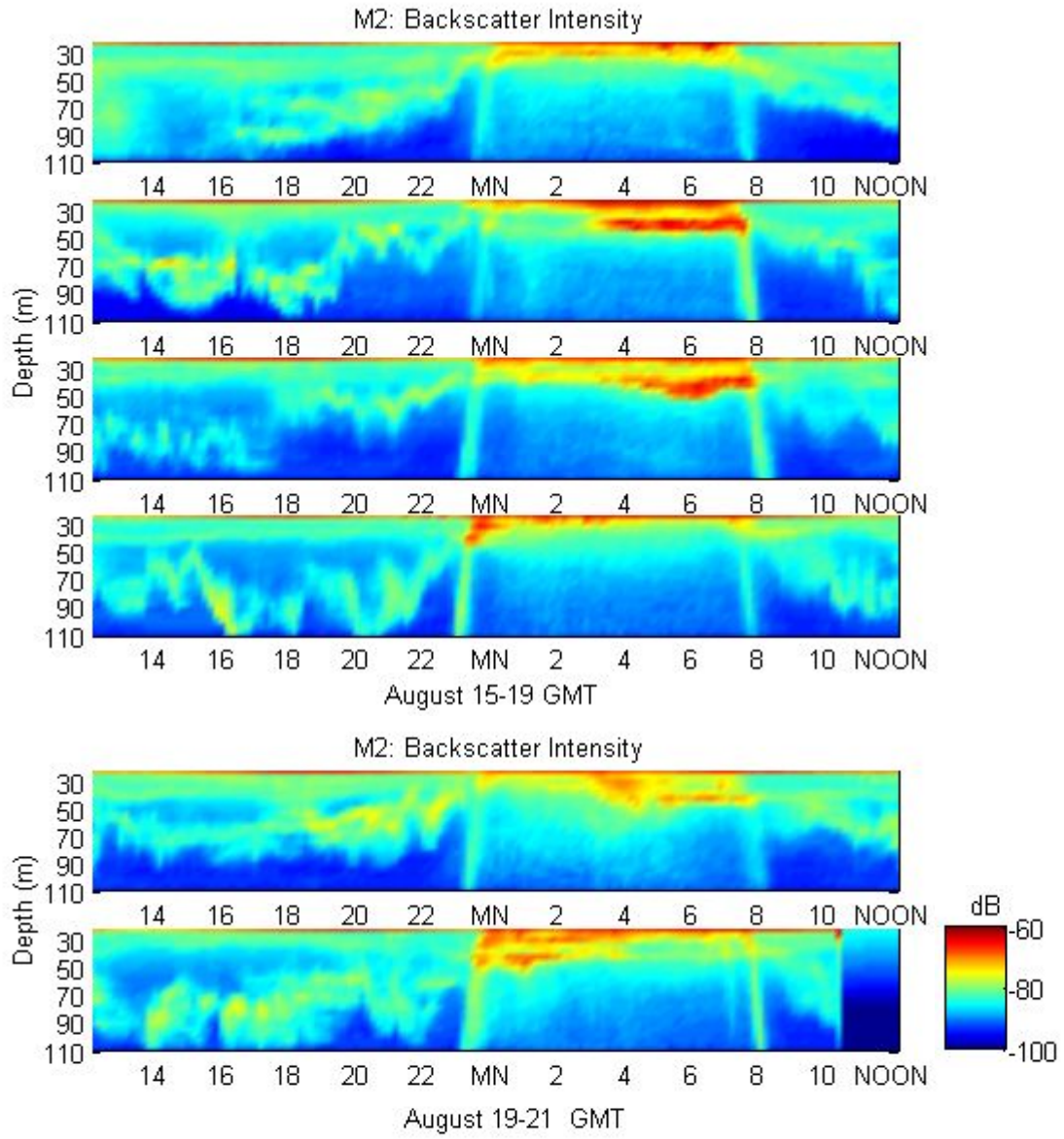

Figure 24: Daily ADCP data from mooring M2: corrected backscatter, re $(4\pi m)^{-1}$. August 15-21. Water depth is 327 m.

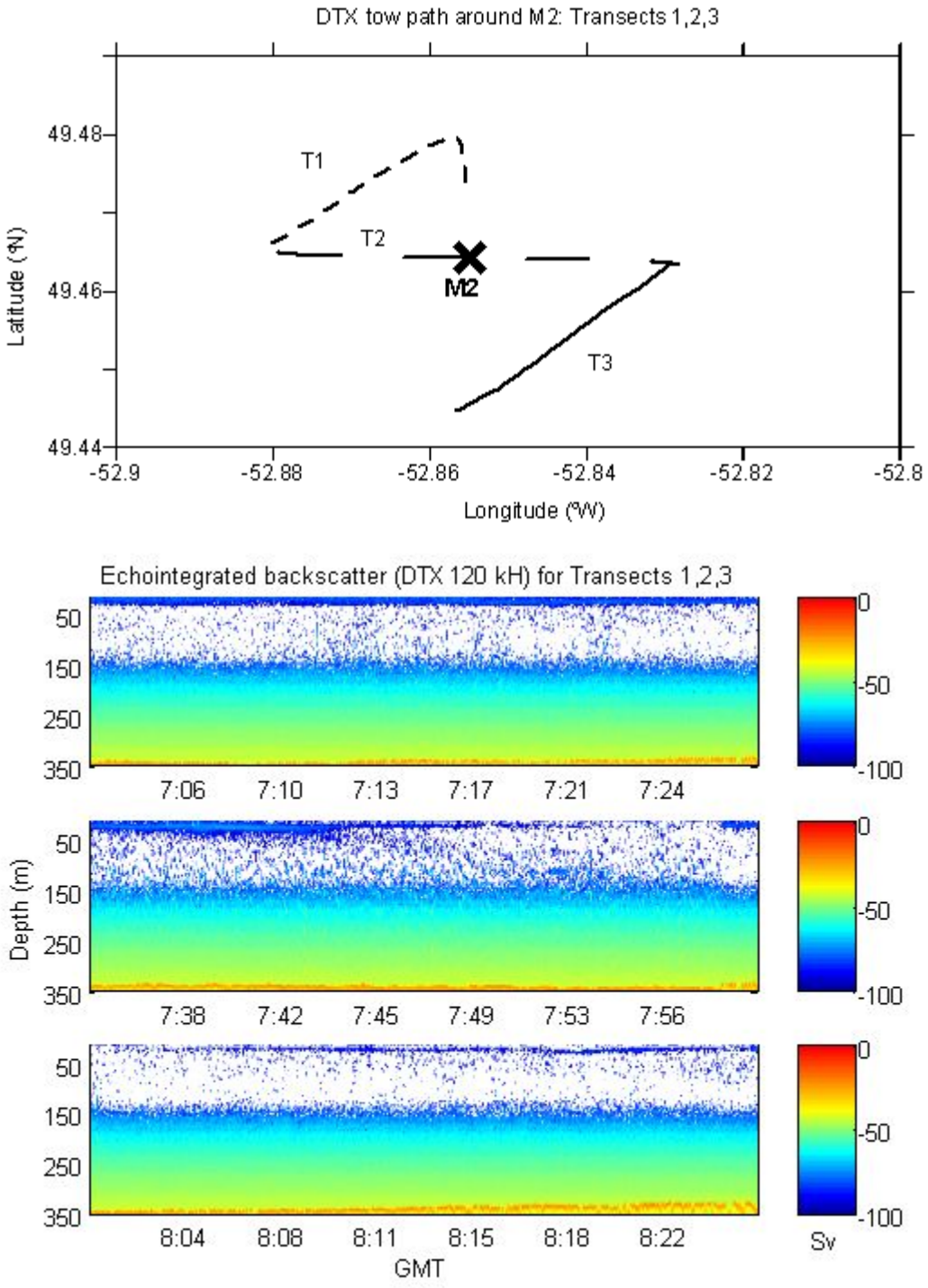

Figure 25: DTX tow path (top) around mooring M2 for transects 1-3, from DTX latitude and longitude data. Echointegrated backscatter (bottom) of the 120 kHz channel for transects 1-3, into 4 m bins, as mean volume backscattering coefficient Sv (MVBS, m^2 per m^3, linear units).

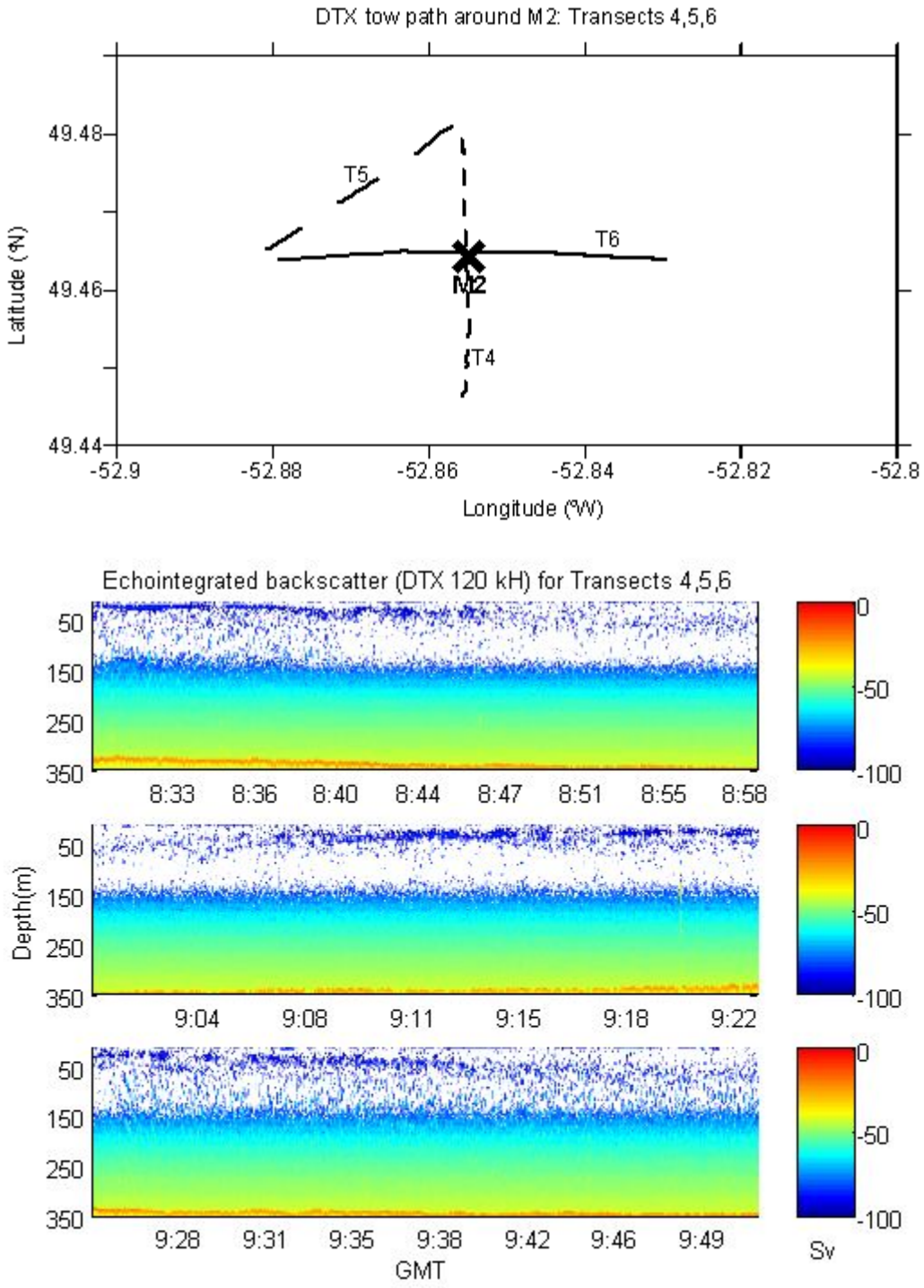

Figure 26: DTX tow path (top) around mooring M2 for transects 4-6, from DTX latitude and longitude data. Echointegrated backscatter (bottom) of the 120 kHz channel for transects 4-6, into 4 m bins, as mean volume backscattering coefficient Sv (MVBS, m^2 per m^3, linear units).

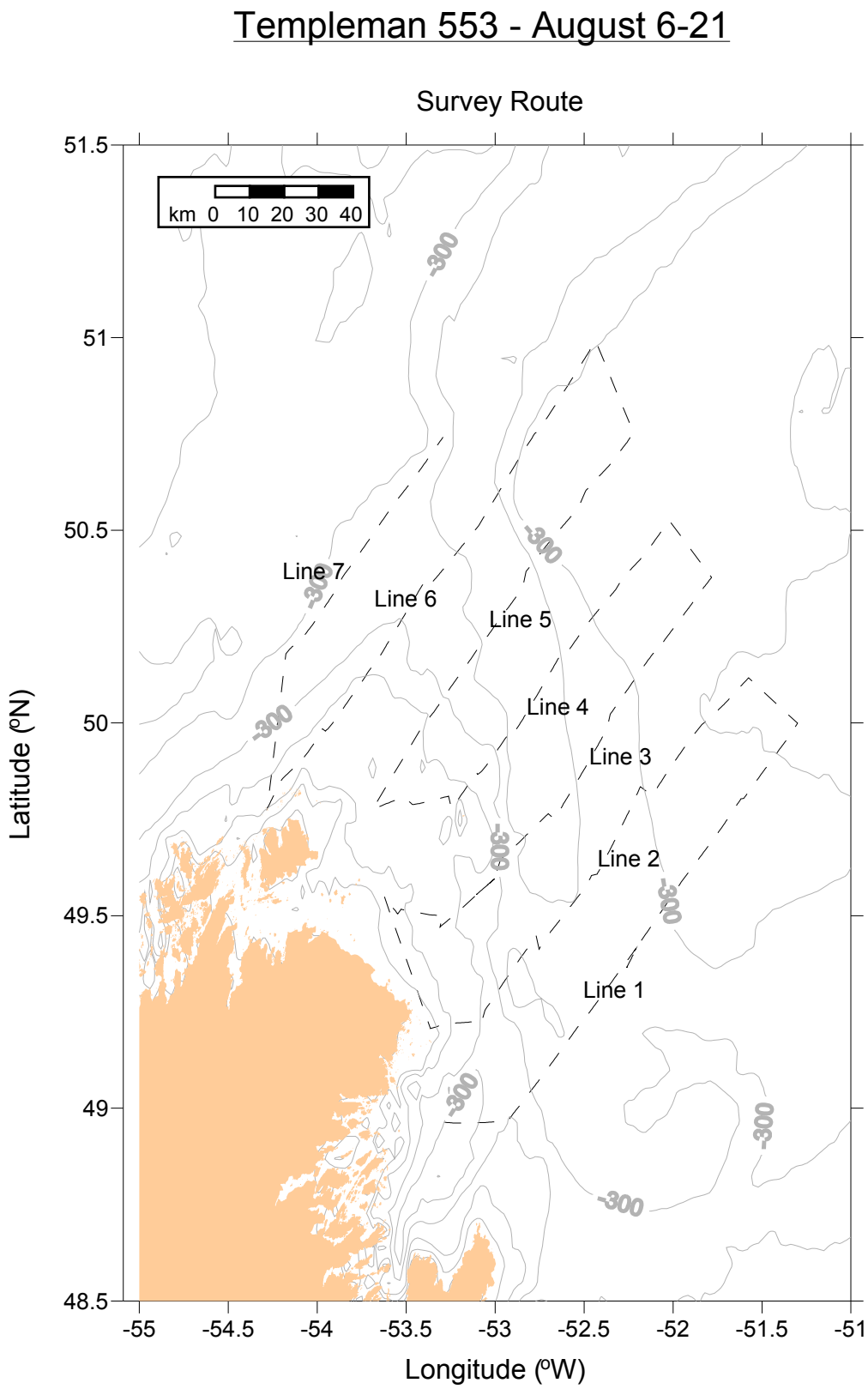

Figure 27: *W. Templeman* cruise data, August 2004: survey route, showing Lines 1-7, taken from EK500 GPS data.

Templeman 553 - August 6-21

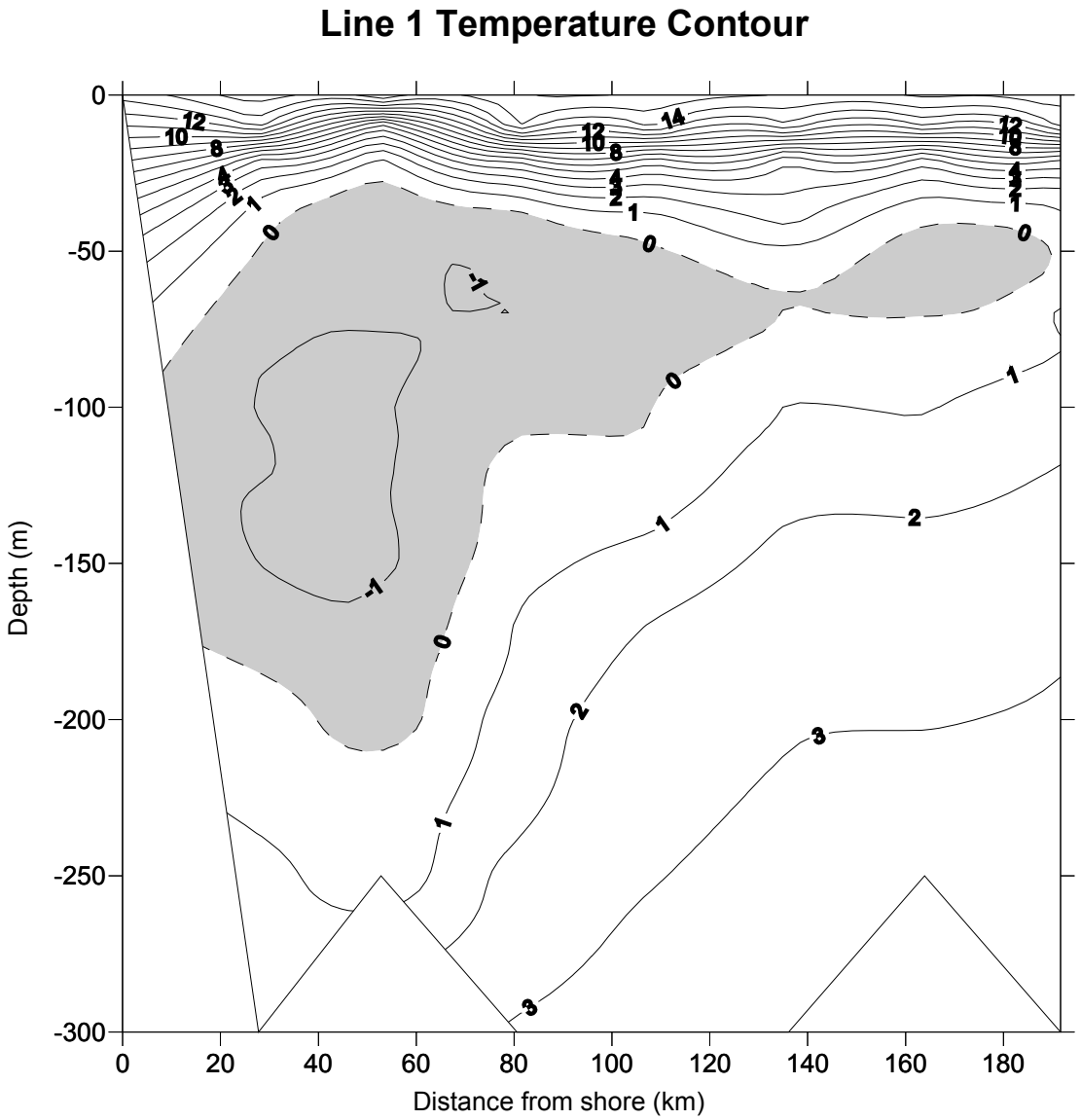

Figure 28: *W. Templeman* cruise data, August 2004: isotherms and bottom depths along line 1, from 7 CTD stations, August 8-10. Interpolated using kriging method. Isotherm lines at 1 °C intervals. Shaded region shows the CIL.

Templeman 553 - August 6-21

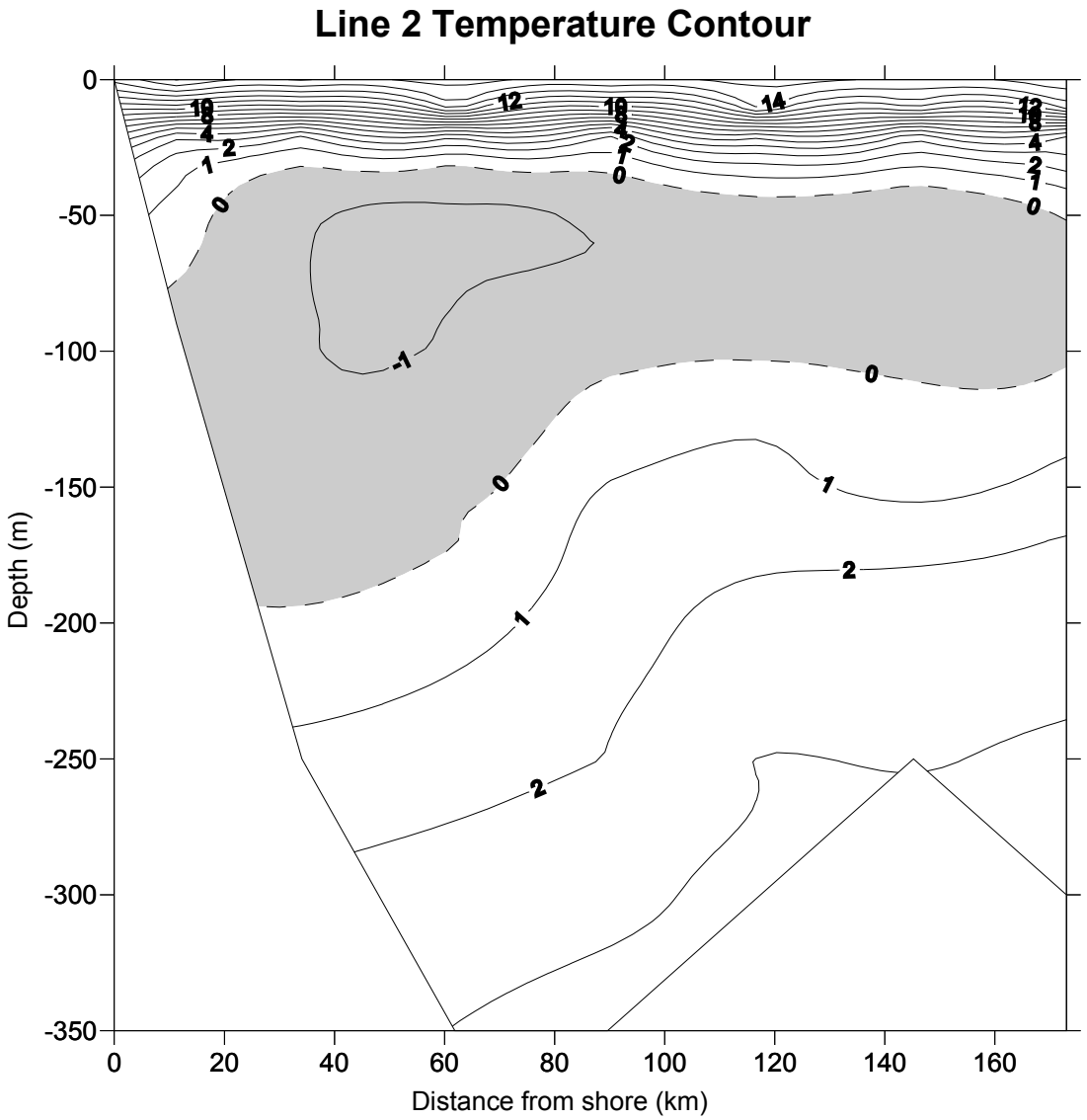

Figure 29: *W. Templeman* cruise data, August 2004: isotherms and bottom depths along line 2 from 7 CTD stations, August 10-11. Interpolated using kriging method. Isotherm lines at 1 °C intervals. Shaded region shows the CIL.

Templeman 553 - August 6-21

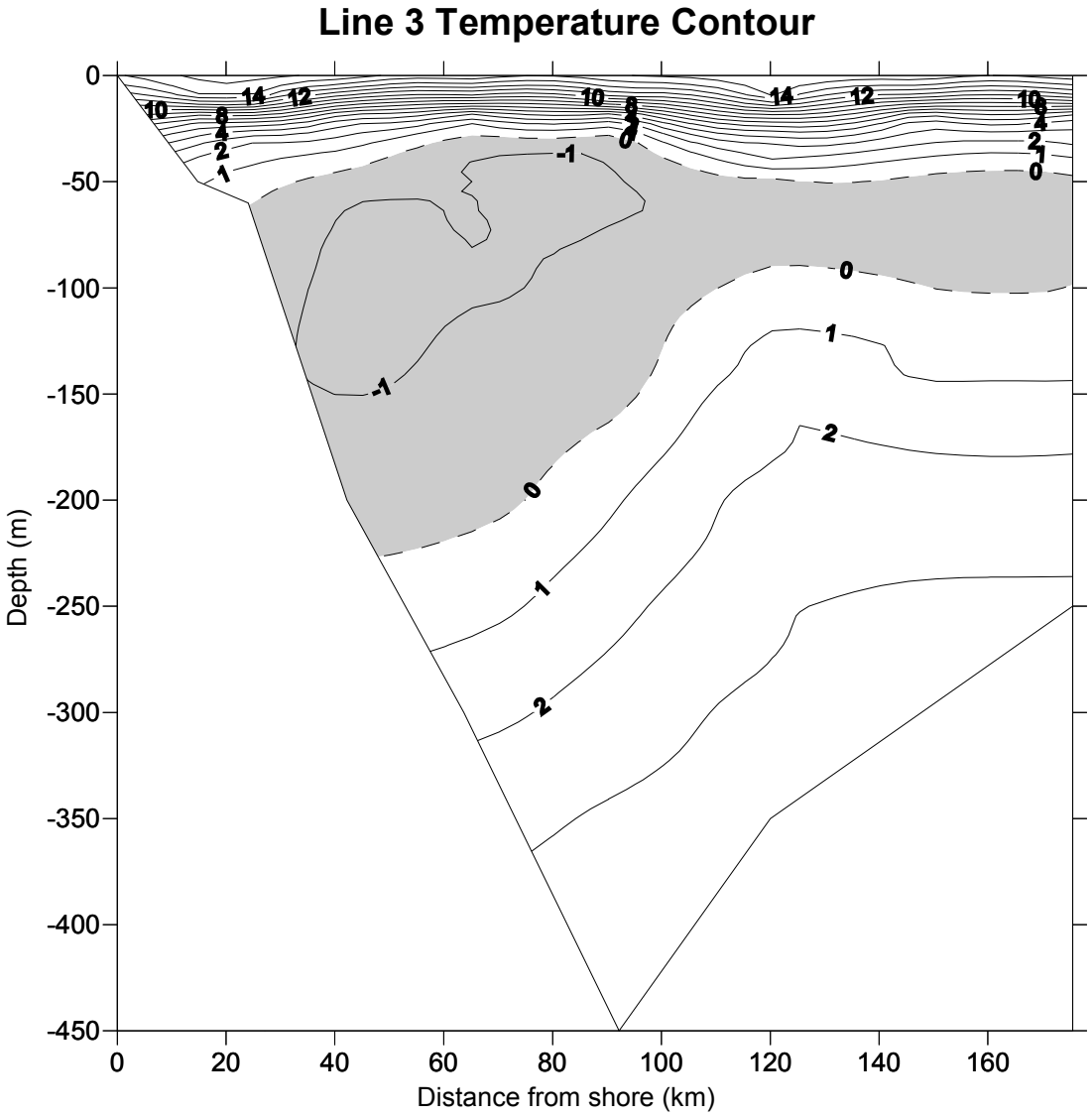

Figure 30: *W. Templeman* cruise data, August 2004: isotherms and bottom depths along line 3 from 8 CTD stations, August 12-13. Interpolated using kriging method. Isotherm lines at 1 °C intervals. Shaded region shows the CIL.

Templeman 553 - August 6-21

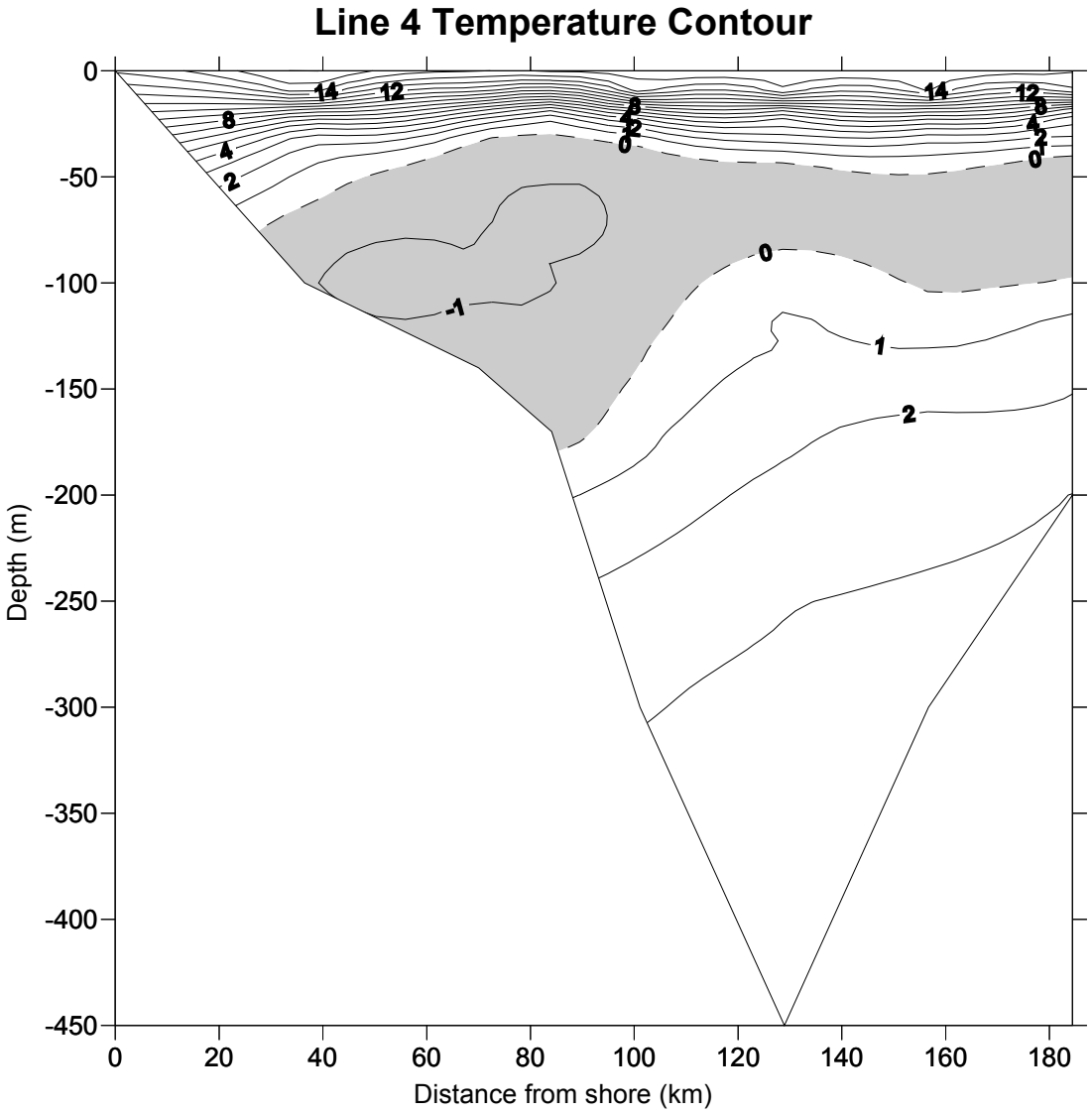

Figure 31: *W. Templeman* cruise data, August 2004: isotherms and bottom depths along line 4 from 7 CTD stations, August 13-14. Interpolated using kriging method. Isotherm lines at 1 °C intervals. Shaded region shows the CIL.

Templeman 553 - August 6-21

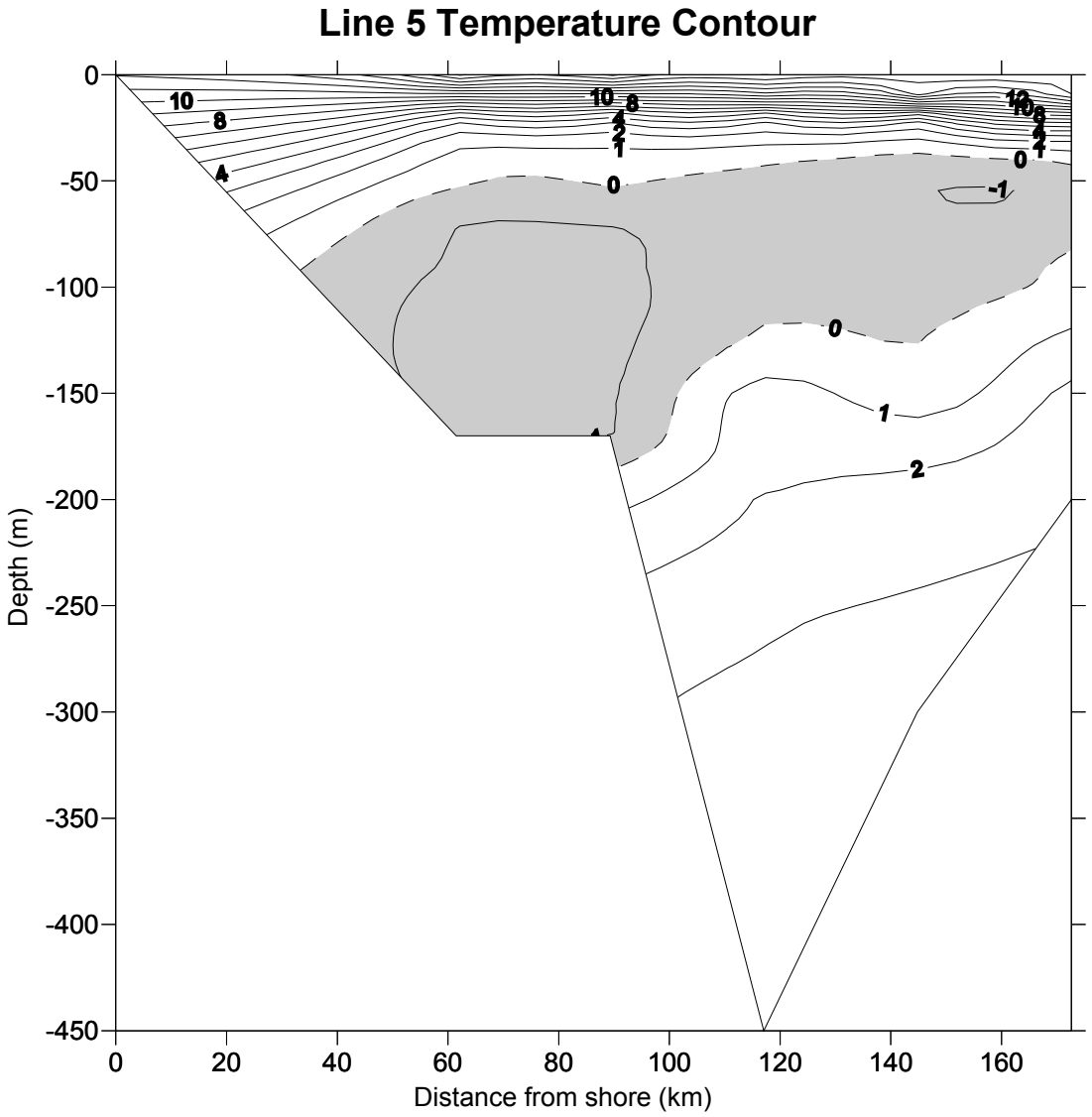

Figure 32: *W. Templeman* cruise data, August 2004: isotherms and bottom depths along line 5 from 6 CTD stations, August 14-15. Interpolated using kriging method. Isotherm lines at 1 °C intervals. Shaded region shows the CIL.

Templeman 553 - August 6-21

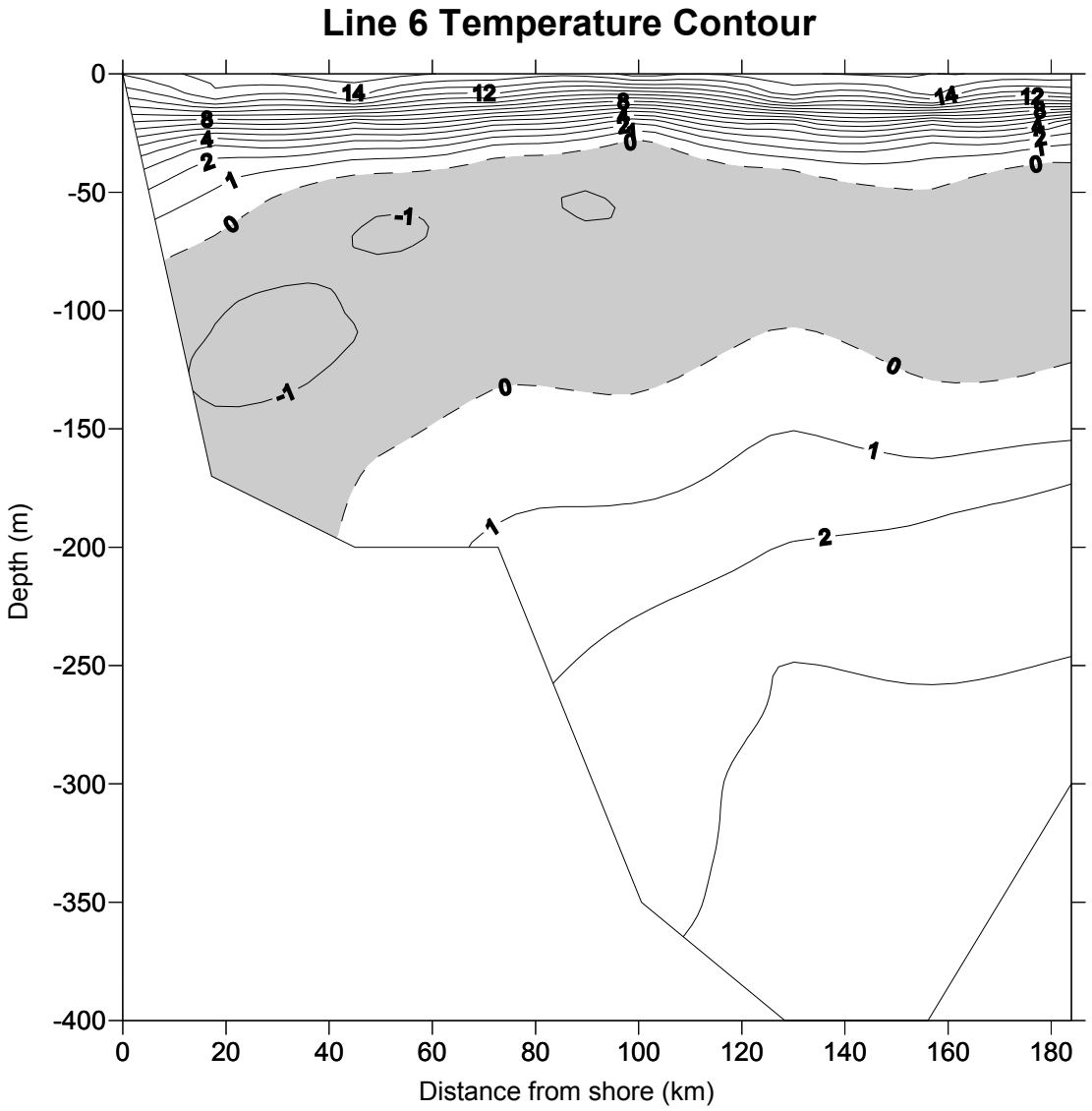

Figure 33: *W. Templeman* cruise data, August 2004: isotherms and bottom depths along line 6 from 7 CTD stations, August 15-16. Interpolated using kriging method. Isotherm lines at 1 °C intervals. Shaded region shows the CIL.

Templeman 553 - August 6-21

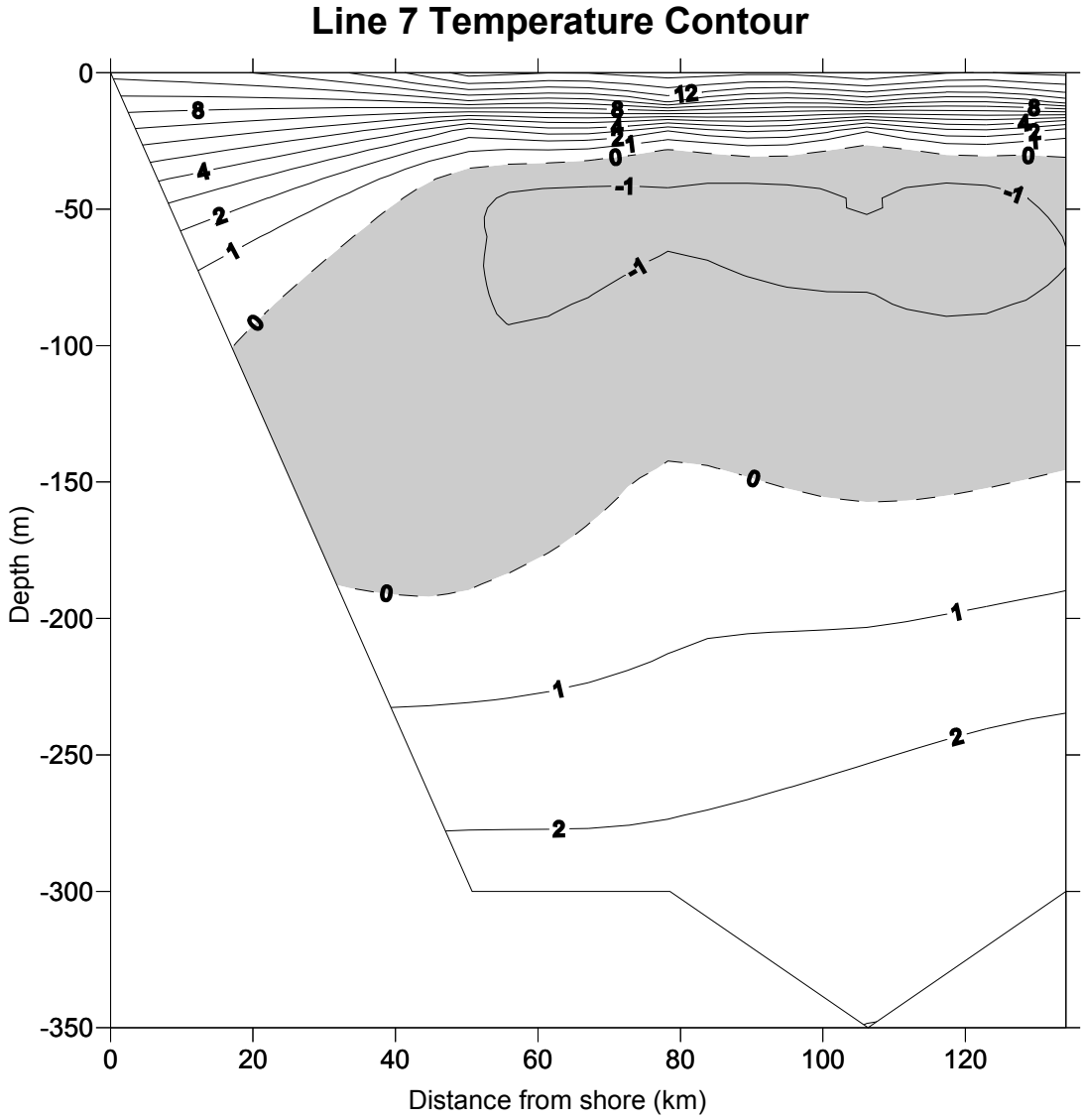

Figure 34: *W. Templeman* cruise data, August 2004: isotherms and bottom depths along line 7 from 5 CTD stations, August 17. Interpolated using kriging method. Isotherm lines at 1 °C intervals. Shaded region shows the CIL.