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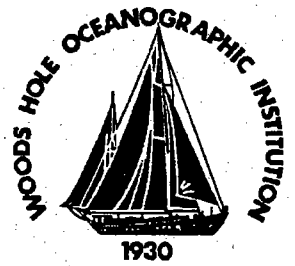

Cruise Summaries
of
Oceanus Cruises 205, leg 8, and 216

by

Terrence M. Joyce, Marvel C. Stalcup, R. Lorraine Barbour,
Jane A. Dunworth and David M. Schubert

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Technical Report

Funding was provided by the National Science Foundation
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Approved for Distribution:

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Department of Physical Oceanography

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by
T.M. Joyce, M.C. Stalcup, R.L. Barbour,
J.A. Dunworth and D.M. Schubert

ABSTRACT

A study of the upper ocean thermal and density structure in the northwestern Atlantic in 1989 compared temperature and density measurements made with Expendable Bathythermograph (XBT) and Conductivity-Temperature-Depth instruments with current data from an acoustic Doppler current profiler and satellite infrared imagery and altimetry. Two cruises were made in the spring and winter of 1989 with the goal of directly measuring the upper ocean currents and variability of the Gulf Stream. The XBT observations were used to extend the measured velocities geostrophically from the near-surface region to depths of 750 meters, thereby allowing transport estimates to be made for the upper ocean. In April the measurements were compared and used with the GEOSAT altimeter which, unfortunately, was not operating during the December cruise.

1. Introduction

Two cruises were conducted in 1989 to study the upper ocean structure and transport of the Gulf Stream by combining *in situ* sampling using Expendable Bathythermographs (XBTs) and an Acoustic Doppler Current profiler (ADCP) with satellite infrared imagery and GEOSAT altimeter data. the area of study was the northwest Atlantic Ocean between Bermuda and the eastern coast of the U.S. and Canada. Both cruises were aboard the R/V Oceanus; the first cruise was conducted in April and the second in December 1989. The GEOSAT altimeter was operating during the first cruise but it failed before the start of the second cruise.

The shipboard part of the program was under the direction of T.M. Joyce with support from NSF while the satellite component of the study was directed by K. Kelly with support from NASA. During the second cruise T. Sanford's group at the Applied Physics Laboratory of the University of Washington, participated with a Towed Transport Meter (TTM). Results of this latter work will be reported elsewhere. In this report we will present cruise summaries of the shipboard program at WHOI. Scientific results have and are being submitted elsewhere for publication. These include papers by Joyce, et al. (1990), Kelly et al. (1991) and an M.S. Thesis by Schubert (1990). A further study in collaboration with Sanford is planned.

The following sections are self-contained summaries of the two cruises, OC205 leg 8 and OC216.

2. Cruise summary Oceanus 205, Leg 8, 4-21 April 1989

R/V Oceanus cruise 205-8 left Bermuda at 2112 GMT on April 4, 1989 and occupied CTD station 1 two hours later at Station 'S' located about 22 km southeast of the island. During this and the following station northwest of Bermuda, a transmissometer was attached to the CTD to measure the light transmittance of the water column. Following these stations XBT section 1 (Figure 1.1 and Table 1.1) was made northwesterly towards Cape Cod during which hourly XBTs (T-7, 760 m probes) were deployed, surface bucket temperatures were measured and salinity samples were collected for later analysis ashore. XBT section 2 was made along the 300 m isobath towards Cape Hatteras using T-10, 200 m probes. A CTD/XBT section was then made from the shelf to Bermuda along section 3. Eleven CTD stations were occupied along this line together with hourly XBTs. Section 4 repeated section 1 with T-7 probes and, in addition, two CTD stations were taken in the Slope Water. Section 5 was made along the edge of the continental shelf towards Nova Scotia using T-10 probes. Section 6 was made southwards along 65°W with 16 CTD stations and hourly T-7 XBTs. Section 7 was a repeat of sections 1 and 4 towards Cape Cod with hourly XBTs together with two CTD stations in the Sargasso Sea and one in Slope Water. The cruise ended at 1230 GMT on April 21, 1989 at the WHOI dock. The locations of the XBT deployments and CTD stations for the cruise are shown in Figure 1.2. Profiles of XBT temperature and density are shown in Figures 1.3a-e.

A Sea-Bird Electronics Inc. Seacat SBE 19 CTD, serial # 147, was used to collect pressure, temperature and conductivity measurements at 0.5-second intervals (about 0.5 m) at each CTD station. Each of the 34 CTD stations occupied in deep water was made to a depth of about 2100 m. A bottom finding pinger was used to position the CTD to within a few meters of the bottom at stations in shallow water. Data from a Sea Tech 0.25 m transmissometer were recorded during stations 1 and 2. The conductivities measured at stations 1 and 2 appear to be about 0.030 milli-Siemens (mS) too high when compared with surface salinities collected at these stations and with the historical θ/S curve for the western North Atlantic. At all subsequent stations the conductivities vary so erratically ($\pm$ 0.250 mS) that they cannot be used to calculate salinity without a station-by-station adjustment. Similar problems with other Seacat CTDs convinced the manufacturer that the fault was due to leaking at the feed-throughs of the conductivity cell into the pressure case. Our Seacat was returned to the manufacturer for repair and calibration.

XBTs (see Table 1.1) were deployed at roughly hourly intervals, or about every 19 km except when the ship's speed

was reduced by heavy weather. A surface temperature was measured and a salinity sample was collected with each XBT. Eighteen probes failed for various reasons, 252 T-7 probes were successfully deployed in deep water and 46 T-10 probes were used in shallow water along the continental slope. A continuously recording surface thermo-salinograph measured temperature and conductivity while underway. The temperature from this instrument was generally about 0.3°C higher than those measured by the XBT and read from the bucket thermometer. Salinity and potential density along each of the sections were estimated from the historical θ/S correlation following Joyce, et al. (1988).

All of the sections made across the Gulf Stream are shown in Figures 1.3a-e. The section between Bermuda and Cape Cod was occupied three times (1.3a, 1.3c and 1.3e) during which the ring found near Bermuda appears to have moved towards the west. The well-defined ring visible in section 1 is much less apparent during the subsequent sections along this line. The position of the Gulf Stream in this section did not vary significantly during the cruise. Both the southern section (Figure 1.3b from Cape Hatteras to Bermuda) and the northern section (Figure 1.3d from Nova Scotia to Bermuda) contain prominent cold core rings that were also visible in the satellite imagery.

A 150 kHz RDI Acoustic Doppler Current Profiler (ADCP) was operated continuously during the cruise. This instrument employs acoustic pulses to measure the Doppler frequency shift of reflectors within the water column to depths of 400 m. These were averaged for two minutes in 8 m vertical bins. The movement of the ship was determined using Loran, two GPS satellite and a Sat-Nav navigation system. Loran signals were poor near Bermuda and GPS was useful for only about 12 hours a day. The ship's velocity was added to the averaged Doppler data to yield vertical profiles of absolute currents. Data were calibrated following Joyce (1988) tracking to estimate the amplitude and rotation parameters: $(\beta,\alpha) = (-.02, -3.5°)$ Results from the ADCP along legs 1, 4 and 7 were used by Joyce, et al. (1990) to study rapid Gulf Stream variability and by Kelly et al. (1991) to estimate the geoid together with GEOSAT altimeter data along the line between Bermuda and Cape Cod. The average current vectors at 100 m are shown in Figure 1.4 where the Gulf Stream and the various rings are clearly represented.

Some 298 water samples were collected during the cruise and analyzed ashore using a Guildline 8400A salinometer. This instrument has an accuracy of ±0.003 PSU and it was anticipated that these data could be used to calibrate the CTD conductivity measurements. In nearly all cases, the differences between Seacat and actual surface salinities were close to what was

needed to bring deep Seacat salinities into agreement with differences from the historical θ/S relationship for the western North Atlantic. However, as noted above, corrections were large and erratic and therefore the CTD data from this cruise is suspect.

3. Cruise summary Oceanus 216, 30 November-13 December 1989

R/V Oceanus cruise 216 left Woods Hole, Massachusetts on 30 November, 1989 at 1612 (GMT). The focus of this cruise was on the triangle: Cape Cod-Bermuda-Cape Hatteras. Because of very stormy weather, the orginal cruise plan could not be accomplished and the Cape Hatteras to Cape Cod section was omitted (see Figure 2.1)

On December 1, 1989 (at the beginning of section 1, Woods Hole to Bermuda), the 150 kHz RDI ADCP was calibrated on the continental shelf in the bottom track mode. This instrument employs acoustic pulses to measure the Doppler frequency shift of reflectors within the water column to depths of 400 m and was used continuously throughout the cruise. These Doppler data were averaged for two minutes in 8 meter vertical bins to calculate the water motion relative to the ship. The movement of the ship was determined using Loran, GPS satellite and Sat-Nav navigation systems. The Loran coverage was better than normal during the cruise and provided good estimates of the ship's velocity. The ship's velocity vectors are added to the bin averaged Doppler vectors to yield vertical profiles of absolute currents.

Later on December 1 (1255 GMT) the Towed Transport Meter (TTM) was launched. This instrument measures the electric field created by the motion of salt water through the Earth's magnetic field. The strength of the electric field is a function of the water velocity. The instrument was towed continuously during the cruise, and hauled only while CTD stations were being made during section 3. Several TTM calibration runs were made on December 2, 9 and 12.

The XBTs (Table 2.1) were deployed at roughly hourly intervals along section 1 except when the ship's speed was reduced by heavy weather. A bucket sample was collected at each XBT to measure the surface temperature and collect a salinity sample. The salinity samples were analyzed ashore as described above. The latitude and longitude of the ship (Table 2.1) was determined using GPS 'T'(1), the Loran 800 (2) or the Loran 7000 (4) receivers (Nav. Source column in Table 2.1).

Section 2 (Bermuda to Cape Hatteras) began on 4 December with a continuation of XBTs, bucket samples, ADCP and TTM

measurements.

During Section 3 (Cape Hatteras to Bermuda) eight CTD (Table 2.2) stations were made using the repaired and recalibrated Seacat SBE 19. Pressure, temperature and conductivity measurements were made at 0.5 second intervals (about 0.5 m) at each station. A bottom pinger was used at the shallow stations to position the CTD to within a few meters of the bottom. The conductivity sensor was broken after CTD station 6 so that the data from Station 7 is not presented. A different Seacat was used during CTD station 8. See Table 2.1 for the CTD log.

Section 4 (Bermuda to Woods Hole) began on 10 December and, as on Section 3, XBTs, bucket samples, ADCP and TTM measurements were made. The cruise ended on 13 December at 0800 (GMT). The location of the XBT and CTD stations is shown in Figure 2.2.

Sections 1 and 4 (Figs. 2.3a and 2.3d, Woods Hole to Bermuda) were made about 9 days apart and indicate that little changes in the thermal structure occurred during this period. The 700 m temperature in the cold core ring in section 4 is a degree colder than during the section 1 and suggests that this section crossed more nearly over the center of this prominent ring. Sections 2 and 3 (Figs. 2.3b and 2.3c, Cape Hatteras to Bermuda) were made only two days apart and show nearly identical thermal structure.

Figure 2.4 shows the averaged 100 m current vectors measured by the ADCP. The location of the Gulf Stream and the two cold core rings on legs 1 and 2 depicted in Figures 2.3a-d are readily apparent. θ/S diagrams for the CTD stations are presented in Figure 2.5.

4. Acknowledgements

The cruise-related work at WHOI was supported by NSF grant OCE88-17698 with satellite (infrared and altimeter) parts of the research (not described in this report) by NASA grant NAGW-1666. Principal investigators for the project were T. Joyce and K. Kelly at WHOI. Cruise participants for both cruises include T. Joyce (Chief Scientist) M. Stalcup, R.L. Barbour, J. Dunworth from WHOI and D. Schubert from the MIT-WHOI Joint Program in Oceanography. D. Weise and M. Caruso from WHOI participated on OC205 and OC216 respectively. J. Dunlap and R. Drever from U. Washington, APL also participated in OC216. We would like to thank the Captain, Officers and crew of the Oceanus for their able assistance during the cruises.

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TABLE 1.1
R/V OCEANUS Cruise 205, leg 8
XBT LOG

XBT #	Julian Day	Time (GMT)	Latitude (N)	Longitude (W)	Max Depth	Surface Temps. Bkt	XBT	SAIL	Salinity (PSS78)
1	095	002200	32 09.8	-64 30.6	760	20.5	20.5	20.7	36.642
2	095	041800	32 32.8	-64 57.9	760	20.2	20.1	20.5	36.629
3	095	070600	32 47.1	-65 05.8	760	20.0	20.0	20.3	36.638
7	095	081300	32 58.4	-65 11.8	760	20.0	20.1	20.3	36.623
8	095	090123	33 06.3	-65 15.9	760	19.9	19.6	20.1	36.603
9	095	100100	33 16.1	-65 21.7	760	20.0	19.8	20.2	36.602
16	095	111343	33 28.1	-65 29.1	760	20.1	20.1	20.4	36.639
17	095	115849	33 36.1	-65 33.5	760	20.1	20.1	20.4	36.617
18	095	130325	33 46.4	-65 39.2	760	20.3	20.3	20.5	36.642
19	095	140129	33 56.6	-65 44.2	760	20.2	20.3	20.5	36.642
20	095	150100	34 06.1	-65 48.2	760	20.3	20.0	20.6	36.637
21	095	160200	34 17.1	-65 52.0	760	20.5	20.6	20.8	36.654
22	095	170500	34 28.6	-65 57.1	760	20.0	20.2	20.3	36.662
23	095	180102	34 38.4	-66 02.5	760	20.2	20.4	20.3	36.610
24	095	190000	34 48.5	-66 09.2	760	20.1	20.5	20.4	36.674
25	095	195721	34 57.9	-66 15.9	760	19.8	19.7	19.9	36.601
26	095	210000	35 08.6	-66 22.1	760	19.6	19.6	19.8	36.597
27	095	215948	35 18.2	-66 27.6	760	19.5	19.5	19.8	36.595
28	095	230000	35 28.5	-66 33.1	760	19.4	19.4	19.7	36.603
29	096	000200	35 38.3	-66 38.4	760	19.4	19.4	19.7	36.619
30	096	005837	35 48.4	-66 46.5	760	19.6	19.5	19.8	36.607
31	096	015500	35 56.7	-66 53.6	760	19.5	19.5	19.9	36.620
32	096	025800	36 06.2	-67 00.2	760	19.6	19.5	19.9	36.614
33	096	035800	36 15.3	-67 06.9	760	19.7	19.6	20.0	36.610
34	096	045800	36 25.3	-67 12.8	760	19.6	19.5	19.8	36.604
35	096	055737	36 35.0	-67 18.6	760	19.7	19.5	19.5	36.594
36	096	070100	36 45.7	-67 24.9	760	19.2	19.2	19.5	36.613
37	096	080200	36 56.0	-67 30.0	760	20.1	20.0	20.3	36.596
39	096	090500	37 06.2	-67 34.6	760	21.8	21.6	21.9	36.600
40	096	100151	37 16.4	-67 40.1	760	22.7	22.6	22.9	36.553
41	096	110154	37 26.6	-67 45.7	760	22.9	22.8	23.2	36.481
42	096	115500	37 36.2	-67 49.5	760	23.0	22.8	23.3	36.562
43	096	130000	37 46.1	-67 55.0	760	22.0	21.9	22.3	36.488
44	096	135800	37 54.1	-68 00.3	340	14.8	-9.9	15.3	35.464
45	096	150100	38 02.1	-68 06.5	760	17.0	17.2	17.1	35.783
46	096	160100	38 10.2	-68 11.3	760	16.7	16.9	17.1	35.720
47	096	170210	38 18.6	-68 16.4	760	13.8	14.9	14.2	35.136
48	096	180410	38 26.9	-68 21.3	760	14.4	14.8	14.6	35.141
49	096	190417	38 34.8	-68 26.2	760	16.0	16.0	16.2	35.338
50	096	195900	38 43.3	-68 31.2	760	17.7	17.9	18.1	35.896
51	096	210026	38 52.0	-68 35.4	760	10.1	10.0	10.5	34.072
52	096	220145	39 00.3	-68 41.0	630	10.0	10.7	10.4	34.404
53	096	230125	39 07.9	-68 47.2	760	10.5	10.6	10.8	34.251
54	097	000017	39 14.4	-68 53.4	760	7.8	9.5	8.1	33.138
55	097	010013	39 22.1	-68 59.1	760	11.4	11.5	11.6	34.606
56	097	020100	39 30.6	-69 04.0	760	11.2	11.5	11.5	34.494
60	097	030800	39 38.8	-69 08.0	760	12.4	11.0	12.5	34.600
61	097	035600	39 44.5	-69 11.1	760	13.1	12.6	13.3	35.112
62	097	050100	39 52.2	-69 16.4	760	8.6	8.6	8.8	33.527
63	097	055600	39 57.8	-69 20.8	160	7.5	7.5	7.8	33.080
64	097	072800	39 56.0	-69 33.4	200	9.2	7.8	9.2	33.826
65	097	085901	39 55.7	-69 47.3	200	9.3	8.7	9.3	33.749
66	097	102400	39 58.6	-70 03.7	195	8.4	8.3	8.8	33.591
68	097	120000	40 00.3	-70 24.6	200	8.0	8.0	8.6	33.443
69	097	132500	40 00.1	-70 44.3	200	7.9	8.4	8.4	33.394
70	097	145600	40 00.0	-71 05.8	200	6.3	6.7	6.6	32.941
71	097	162754	39 57.2	-71 26.0	200	8.8	8.7	8.5	33.368
72	097	175318	39 52.0	-71 43.5	200	7.8	8.1	8.2	33.194

73	097	192841	39	38.8	-71	58.1	200	8.0	8.3	8.4	33.193
74	097	205805	39	25.6	-72	11.4	200	7.9	8.2	8.6	33.183
75	097	222852	39	13.6	-72	28.2	200	8.9	8.5	9.0	33.475
76	098	000106	39	02.3	-72	44.1	200	7.8	7.5	8.1	32.987
77	098	013300	38	47.5	-72	59.5	200	10.1	9.5	10.5	33.844
78	098	025827	38	35.5	-73	12.4	200	7.9	8.5	8.4	33.277
79	098	043400	38	21.8	-73	26.7	200	8.6	8.5	9.0	33.465
80	098	060300	38	09.1	-73	39.5	690	8.9	7.8	9.3	33.650
82	098	073700	37	57.0	-73	52.1	760	8.6	8.4	8.8	33.492
83	098	085944	37	47.4	-74	02.3	760	9.3	9.0	9.6	33.618
84	098	102918	37	37.0	-74	14.0	200	8.6	8.1	9.0	33.415
85	098	120152	37	22.1	-74	23.4	760	10.3	10.1	10.5	33.929
86	098	132819	37	07.5	-74	31.5	200	9.7	9.7	10.1	33.775
87	098	150318	36	51.4	-74	35.1	760	13.2	14.0	13.5	34.496
88	098	162836	36	36.5	-74	38.6	200	14.6	14.5	14.9	34.739
89	098	175931	36	20.9	-74	41.7	200	14.6	16.4	16.9	35.162
90	098	192831	36	05.5	-74	44.9	200	20.5	20.1	20.8	36.349
91	098	205822	35	50.2	-74	49.5	200	19.0	18.7	19.3	36.123
92	098	231150	35	27.6	-74	50.4	135	21.2	20.9	21.4	36.456
95	099	000158	35	27.9	-74	45.5	760	21.6	21.5	21.7	36.485
96	099	021015	35	28.2	-74	38.6	595	22.8	22.5	22.9	36.546
97	099	044600	35	29.0	-74	31.5	635	22.9	22.8	23.1	36.483
98	099	060300	35	28.9	-74	26.9	760	23.7	23.5	23.9	36.447
99	099	070400	35	23.9	-74	15.0	760	24.3	24.2	24.6	36.432
100	099	080236	35	17.9	-74	02.8	760	24.3	23.5	24.6	36.405
101	099	090307	35	12.1	-73	51.5	760	23.0	22.9	23.4	36.489
102	099	113057	35	09.2	-73	40.1	760	23.3	23.0	23.5	36.462
103	099	123547	35	05.1	-73	29.8	760	21.6	21.2	22.0	36.489
104	099	134020	35	02.0	-73	19.2	760	20.0	19.7	20.3	36.592
105	099	143510	34	59.1	-73	08.4	760	20.1	19.9	20.4	36.567
106	099	153137	34	56.2	-72	58.1	760	20.3	20.1	20.6	36.564
108	099	180154	34	51.1	-72	50.0	760	20.3	20.1	20.5	36.549
109	099	190007	34	49.3	-72	42.4	760	20.1	19.5	20.4	36.514
110	099	200049	34	45.7	-72	29.6	760	20.3	19.7	20.5	36.585
111	099	210008	34	42.5	-72	17.9	760	20.3	20.3	20.5	36.577
112	099	220058	34	37.7	-72	03.7	760	20.3	20.1	20.5	36.598
113	099	230152	34	33.9	-71	51.3	760	20.2	20.0	20.5	36.588
114	100	000520	34	31.2	-71	40.0	760	20.3	20.5	20.6	36.708
115	100	023346	34	25.4	-71	28.4	760	19.3	19.0	19.6	36.618
117	100	033848	34	21.4	-71	15.0	760	19.4	18.8	19.6	36.592
118	100	043100	34	18.6	-71	04.2	760	19.4	19.6	19.6	36.518
119	100	053400	34	15.0	-70	52.2	760	19.3	19.2	19.6	36.462
120	100	062900	34	12.6	-70	41.6	760	19.2	19.2	19.5	36.448
121	100	073600	34	09.9	-70	28.0	760	19.3	19.3	19.6	36.448
122	100	100142	34	08.3	-70	16.1	760	19.4	19.2	19.6	36.461
123	100	110100	34	05.1	-70	04.3	760	19.3	19.4	19.7	36.543
124	100	120304	34	01.9	-69	53.0	760	19.6	19.5	19.8	36.608
125	100	130155	33	58.8	-69	41.6	760	19.7	19.7	20.0	36.643
126	100	140527	33	54.4	-69	29.7	760	19.8	19.8	20.0	36.625
127	100	150226	33	50.0	-69	17.6	760	20.6	20.7	20.8	36.664
128	100	173114	33	45.7	-69	07.6	760	20.7	20.7	20.9	36.691
129	100	183257	33	42.9	-68	55.7	760	20.9	20.9	21.1	36.661
130	100	193332	33	39.4	-68	42.1	760	20.8	20.9	21.1	36.666
131	100	203018	33	35.8	-68	28.3	760	20.8	21.0	21.1	36.656
132	100	213043	33	30.6	-68	15.5	760	20.7	20.7	21.0	36.683
134	100	223709	33	27.3	-68	02.3	760	20.9	20.7	21.2	36.661
135	101	005947	33	22.0	-67	47.2	760	20.8	20.8	21.1	36.714
136	101	020058	33	17.0	-67	33.3	760	20.8	20.5	21.0	36.827
137	101	030300	33	13.6	-67	20.8	760	20.9	20.5	21.2	36.676
138	101	040500	33	09.4	-67	07.5	760	21.1	21.0	21.4	36.670
139	101	050200	33	05.3	-66	55.4	760	21.1	21.1	21.4	36.668
140	101	060400	33	01.0	-66	42.4	760	20.8	20.8	21.1	36.617
141	101	070459	32	57.7	-66	29.6	760	20.7	20.6	20.9	36.652
142	101	092936	32	51.9	-66	16.8	760	20.7	-9.9	21.0	36.576
143	101	103233	32	48.3	-66	03.8	760	20.6	-9.9	20.9	36.461
144	101	112918	32	45.6	-65	51.9	760	20.7	-9.9	21.0	36.629

145	101	123326	32	43.8	-65	40.0	760	20.7	-9.9	20.9	36.658
146	101	132935	32	41.3	-65	27.8	760	20.7	-9.9	21.0	36.626
147	101	142904	32	38.4	-65	16.5	760	20.8	-9.9	21.0	36.622
148	101	155755	32	32.8	-64	58.1	760	21.1	-9.9	21.3	36.661
149	101	165955	32	42.5	-65	02.8	760	21.0	-9.9	21.3	36.639
151	101	181639	32	56.5	-65	09.8	760	20.9	-9.9	21.1	36.621
152	101	190046	33	03.6	-65	13.4	760	20.7	-9.9	20.9	36.630
153	101	200134	33	16.0	-65	19.3	760	20.6	-9.9	21.0	36.604
154	101	210215	33	25.4	-65	25.3	760	20.6	-9.9	20.8	36.606
155	101	220037	33	35.1	-65	32.5	760	20.6	-9.9	20.8	36.597
156	101	230121	33	46.2	-65	39.6	760	20.6	-9.9	20.9	36.613
157	102	000152	33	55.7	-65	45.3	760	20.6	-9.9	20.9	36.605
158	102	010300	34	05.4	-65	51.0	760	20.6	-9.9	20.9	36.723
159	102	020132	34	15.0	-65	56.3	760	20.4	-9.9	20.7	36.640
160	102	030108	34	25.2	-66	01.8	760	20.3	-9.9	20.6	36.556
161	102	040343	34	36.4	-66	07.1	760	20.2	-9.9	20.4	36.559
162	102	050401	34	46.7	-66	12.3	760	19.6	-9.9	19.9	36.491
163	102	060220	34	56.3	-66	17.6	760	19.0	-9.9	20.0	36.577
164	102	070228	35	06.2	-66	23.0	760	19.5	-9.9	19.8	36.592
165	102	080120	35	16.7	-66	29.0	760	20.6	-9.9	20.8	36.558
166	102	085921	35	25.4	-66	35.3	760	21.3	-9.9	21.5	36.562
167	102	095955	35	34.6	-66	40.1	760	21.3	-9.9	21.5	36.554
168	102	110008	35	42.8	-66	44.7	760	21.2	-9.9	21.5	36.580
169	102	120200	35	49.7	-66	45.4	760	21.1	-9.9	21.3	36.615
170	102	130518	35	56.8	-66	48.9	760	21.0	-9.9	21.2	36.641
171	102	140214	36	04.4	-66	52.2	760	20.9	-9.9	21.1	36.636
172	102	145700	36	12.1	-66	55.0	760	20.7	-9.9	21.1	36.606
173	102	160027	36	19.8	-66	59.8	760	20.5	-9.9	20.6	36.593
174	102	170239	36	28.0	-67	06.3	760	21.2	-9.9	21.4	36.570
175	102	180404	36	36.4	-67	12.7	760	20.6	-9.9	20.8	36.590
176	102	190230	36	45.5	-67	19.3	760	20.3	-9.9	20.6	36.602
177	102	200128	36	55.8	-67	28.1	760	21.1	-9.9	21.3	36.571
178	102	210100	37	06.6	-67	35.0	760	21.2	-9.9	21.3	36.590
179	102	220131	37	16.6	-67	40.3	760	22.6	-9.9	22.7	36.587
180	102	230004	37	26.9	-67	45.9	760	22.7	-9.9	22.9	36.520
181	103	000129	37	35.3	-67	50.2	760	22.6	-9.9	22.8	36.591
182	103	010300	37	44.3	-67	53.8	760	22.0	-9.9	22.3	36.672
183	103	020126	37	51.4	-68	00.8	760	14.7	-9.9	16.5	
184	103	030500	38	00.8	-68	05.8	760	13.2	-9.9	13.5	35.033
185	103	053000	38	07.0	-68	10.0	760	10.6	-9.9	10.8	34.270
186	103	063200	38	16.3	-68	16.9	760	9.9	-9.9	10.2	34.144
187	103	073200	38	25.9	-68	23.5	760	9.9	-9.9	10.2	33.888
188	103	083032	38	35.7	-68	28.9	760	13.5	-9.9	13.6	35.004
189	103	093200	38	46.9	-68	35.0	760	8.9	-9.9	9.2	33.726
191	103	103500	38	57.5	-68	42.0	760	14.4	-9.9	10.4	33.973
192	103	113000	39	07.1	-68	48.2	760	9.9	-9.9	10.2	33.934
193	103	122900	39	17.2	-68	54.6	760	7.9	-9.9	8.6	33.361
194	103	133200	39	27.6	-69	01.2	760	10.4	-9.9	10.7	34.460
195	103	143257	39	37.3	-69	07.4	760	8.2	-9.9	8.8	33.553
196	103	152932	39	46.6	-69	13.0	760	7.9	-9.9	7.5	33.539
197	103	162456	39	49.6	-69	14.8	760	8.5	-9.9	8.9	
198	103	174931	39	58.0	-69	21.0	145	9.6	-9.9	10.0	34.222
199	103	185828	40	01.8	-69	06.7	200	9.4	-9.9	9.8	34.059
203	103	200050	40	05.2	-68	52.0	200	10.8	-9.9	11.4	34.674
204	103	210007	40	08.3	-68	38.0	180	8.1	-9.9	8.7	33.607
205	103	215807	40	11.1	-68	24.3	187	6.2	-9.9	6.6	32.798
206	103	225946	40	16.3	-68	10.8	200	6.8	-9.9	7.2	33.060
207	103	235731	40	18.8	-67	56.9	190	5.9	-9.9	6.3	32.565
208	104	005753	40	21.5	-67	43.3	200	5.8	-9.9	6.2	32.602
209	104	020100	40	24.3	-67	29.3	200	5.7	-9.9	6.3	32.479
210	104	030000	40	28.5	-67	17.6	200	6.1	-9.9	6.4	32.816
211	104	040300	40	33.0	-67	05.8	200	5.6	-9.9	5.9	32.839
212	104	050300	40	42.2	-66	53.1	195	6.2	-9.9	5.8	32.796
213	104	070000	40	51.7	-66	37.7	200	5.5	-9.9	5.9	32.906
214	104	083000	41	01.3	-66	26.3	200	5.3	-9.9	5.8	32.929
215	104	100043	41	12.2	-66	14.4	200	5.3	-9.9	5.8	32.848

216	104	112900	41	23.2	-66	02.9	200	5.4	-9.9	5.8	32.891
217	104	130000	41	35.2	-65	52.0	200	4.5	-9.9	4.8	32.496
218	104	142900	41	47.4	-65	45.2	163	4.3	-9.9	4.7	32.546
219	104	160039	42	00.7	-65	37.5	200	4.4	-9.9	4.5	32.294
220	104	172900	42	10.9	-65	25.5	170	5.3	-9.9	5.6	32.786
221	104	185800	42	17.8	-65	08.4	200	3.4	-9.9	3.8	32.265
222	104	194428	42	20.8	-65	00.2	200	3.8	3.7	4.1	32.350
223	104	204241	42	16.5	-65	00.3	760	3.5	3.5	4.0	32.312
224	104	232126	41	58.3	-65	00.4	760	3.9	3.9	4.4	32.288
225	105	013300	41	49.0	-65	00.3	760	3.8	-9.9	4.4	32.291
227	105	023400	41	37.7	-65	00.6	760	3.7	-9.9	4.2	32.171
228	105	033100	41	26.5	-64	59.8	760	3.7	-9.9	4.6	32.385
229	105	043000	41	15.0	-65	00.4	760	5.3	-9.9	5.9	32.846
230	105	060038	41	03.0	-65	00.8	760	5.4	5.2	5.9	32.883
231	105	080101	40	55.2	-65	00.8	760	5.7	-9.9	6.1	33.020
232	105	090158	40	43.8	-65	00.4	760	5.7	-9.9	6.2	33.007
233	105	100202	40	33.2	-64	59.8	760	6.4	6.3	6.9	33.207
234	105	122900	40	22.6	-64	59.9	760	13.7	-9.9	14.0	35.604
235	105	133200	40	11.1	-65	00.0	760	13.3	-9.9	13.6	35.579
236	105	143200	40	00.0	-64	59.9	760	13.3	13.1	13.8	35.478
237	105	170200	39	49.0	-64	59.8	760	13.9	-9.9	14.2	35.186
238	105	180400	39	37.8	-64	59.8	760	12.8	-9.9	13.2	34.947
239	105	192553	39	27.3	-65	00.2	760	13.1	13.0	13.3	35.394
240	105	212957	39	15.2	-65	01.4	760	13.3	-9.9	13.7	35.483
241	105	222949	39	03.9	-65	01.2	760	17.0	-9.9	17.3	35.757
243	105	233336	38	52.8	-65	01.0	760	21.6	21.1	21.3	36.568
244	106	015800	38	42.0	-64	57.5	760	21.8	-9.9	22.0	36.614
245	106	030000	38	31.2	-64	59.9	760	19.4	-9.9	19.6	36.603
246	106	042635	38	19.9	-64	59.1	760	19.1	19.0	19.3	36.592
247	106	063300	38	11.8	-64	56.6	760	19.2	-9.9	19.5	36.603
249	106	075500	38	02.1	-64	58.2	760	19.1	-9.9	19.5	36.612
250	106	100110	37	49.5	-65	00.0	760	19.2	19.1	19.5	36.594
251	106	140000	37	38.5	-64	58.4	760	19.7	-9.9	19.7	36.611
252	106	161510	37	28.9	-64	58.9	760	19.6	-9.9	19.8	36.458
253	106	191845	37	19.0	-64	58.9	760	19.6	19.6	19.9	36.589
254	106	223100	37	06.5	-65	01.1	760	19.6	-9.9	20.0	36.457
255	107	000000	36	55.7	-65	01.1	760	19.1	-9.9	19.4	36.195
256	107	014000	36	42.9	-64	59.4	760	19.2	-9.9	19.4	36.210
257	107	031521	36	30.3	-64	56.7	760	21.8	21.5	22.2	36.718
258	107	062506	36	20.0	-64	55.0	760	22.0	21.8	22.3	36.572
259	107	091222	36	10.2	-64	59.3	760	22.1	-9.9	22.3	36.588
260	107	101000	36	00.2	-65	00.7	760	21.9	-9.9	22.2	36.553
261	107	111000	35	50.3	-65	01.7	760	21.3	-9.9	21.7	36.580
262	107	120900	35	40.2	-65	00.3	760	19.3	-9.9	19.5	36.622
263	107	131304	35	30.2	-64	58.6	760	19.3	19.2	19.5	36.671
264	107	154200	35	21.0	-64	59.7	760	19.3	-9.9	19.5	36.604
265	107	164600	35	10.2	-64	59.3	720	19.5	-9.9	19.7	36.602
266	107	174511	34	59.3	-64	59.4	760	19.5	-9.9	19.7	36.591
267	107	183532	34	50.4	-64	59.4	760	19.9	-9.9	20.2	36.596
268	107	192936	34	40.0	-65	00.0	760	19.9	-9.9	20.2	36.592
269	107	202104	34	30.2	-65	00.2	760	19.9	19.8	20.2	36.584
270	107	224800	34	19.0	-65	00.6	760	19.8	-9.9	20.1	36.592
271	107	233656	34	10.2	-65	00.4	760	20.1	-9.9	20.3	36.576
272	108	002004	34	01.5	-65	00.4	760	20.2	-9.9	20.3	36.702
273	108	012400	33	49.5	-65	00.0	760	20.3	-9.9	20.4	36.597
274	108	021547	33	40.0	-65	00.0	760	20.1	-9.9	20.4	36.637
275	108	030954	33	31.5	-65	00.2	760	20.0	20.0	20.3	36.612
276	108	053300	33	20.0	-65	00.2	760	20.1	-9.9	20.4	36.584
277	108	063100	33	09.1	-64	59.9	760	20.1	-9.9	20.4	36.581
278	108	072000	33	00.1	-64	59.8	760	20.4	-9.9	20.7	36.612
279	108	082800	32	47.8	-64	58.9	760	20.7	-9.9	21.0	36.603
281	108	100000	32	32.9	-64	58.4	760	20.7	20.7	20.9	36.613
282	108	120300	32	40.0	-65	03.4	760	20.8	-9.9	21.1	36.623
283	108	130019	32	48.9	-65	07.4	760	20.7	-9.9	21.0	36.618
284	108	140305	32	59.3	-65	13.6	760	20.4	-9.9	20.6	36.608
285	108	150000	33	09.2	-65	19.2	760	20.3	-9.9	20.1	36.608

286	108	160000	33	20.1	-65	25.5	760	20.4	-9.9	20.6	36.594
287	108	170200	33	30.3	-65	31.3	760	20.3	-9.9	20.6	36.600
288	108	180252	33	40.5	-65	36.7	760	20.2	-9.9	20.8	36.610
289	108	190100	33	50.8	-65	41.5	760	20.6	-9.9	20.9	36.622
290	108	200100	34	01.2	-65	46.3	760	20.4	-9.9	20.9	36.618
291	108	210406	34	12.4	-65	51.7	760	20.5	-9.9	20.9	36.618
292	108	215859	34	21.5	-65	55.9	760	20.3	-9.9	20.5	36.610
293	108	230016	34	32.2	-66	02.0	760	20.1	-9.9	20.4	36.608
294	109	002041	34	45.9	-66	10.8	760	20.2	-9.9	20.5	36.623
296	109	015413	34	59.4	-66	18.1	760	19.6	19.5	19.8	36.802
298	109	040800	35	10.6	-66	23.2	760	19.8	-9.9	20.0	36.618
299	109	050800	35	21.0	-66	28.9	760	19.9	-9.9	20.1	36.622
300	109	060408	35	29.6	-66	34.1	760	20.4	-9.9	20.7	36.609
301	109	070427	35	39.3	-66	40.3	760	20.9	-9.9	21.2	36.593
302	109	080200	35	49.9	-66	46.8	760	20.8	-9.9	21.2	36.586
303	109	090145	36	00.3	-66	51.4	760	19.7	-9.9	20.0	36.606
304	109	100121	36	09.0	-66	57.6	760	19.5	-9.9	19.7	36.606
305	109	111200	36	20.1	-67	04.6	760	19.4	-9.9	19.8	36.622
306	109	121912	36	29.7	-67	11.3	760	19.6	19.8	19.7	36.760
307	109	143000	36	36.9	-67	15.7	760	19.6	-9.9	19.8	36.635
309	109	153300	36	45.4	-67	22.2	760	21.9	-9.9	22.4	36.594
310	109	163038	36	52.6	-67	27.7	760	22.4	-9.9	22.7	36.523
311	109	173700	37	02.2	-67	33.2	760	22.0	-9.9	22.4	36.534
312	109	184200	37	11.1	-67	38.1	760	22.9	-9.9	23.1	36.486
313	109	194454	37	19.6	-67	41.3	760	23.5	-9.9	23.7	36.516
314	109	212400	37	29.7	-67	45.8	760	23.3	-9.9	23.5	36.459
316	109	233007	37	40.9	-67	54.0	760	16.6	-9.9	16.9	35.647
317	110	005100	37	49.9	-68	00.1	760	10.3	-9.9	10.8	33.644
318	110	022219	37	59.4	-68	07.2	760	12.3	-9.9	12.5	34.409
319	110	034900	38	10.4	-68	13.6	760	16.1	-9.9	15.8	35.458
320	110	050400	38	20.4	-68	19.0	760	9.4	-9.9	9.7	33.654
321	110	061800	38	30.5	-68	24.4	760	8.9	-9.9	9.2	33.592
322	110	073200	38	40.6	-68	30.2	760	7.6	-9.9	8.1	33.111
323	110	084100	38	49.9	-68	36.6	760	6.4	6.5	6.9	32.796
324	110	110149	38	59.1	-68	42.4	760	7.1	-9.9	7.3	32.933
325	110	120245	39	07.9	-68	47.4	760	7.2	-9.9	6.8	32.965
326	110	132503	39	18.0	-68	53.4	760	7.9	-9.9	7.5	33.124
327	110	143445	39	27.0	-68	58.6	760	10.3	-9.9	10.5	34.238
328	110	155600	39	36.1	-69	05.4	760	9.6	-9.9	9.8	33.862
329	110	171200	39	44.9	-69	12.8	760	10.3	-9.9	10.6	34.357
330	110	181500	39	52.8	-69	17.6	760	9.6	-9.9	9.9	33.990
331	110	185500	39	57.9	-69	20.7	140	7.7	-9.9	8.2	33.077

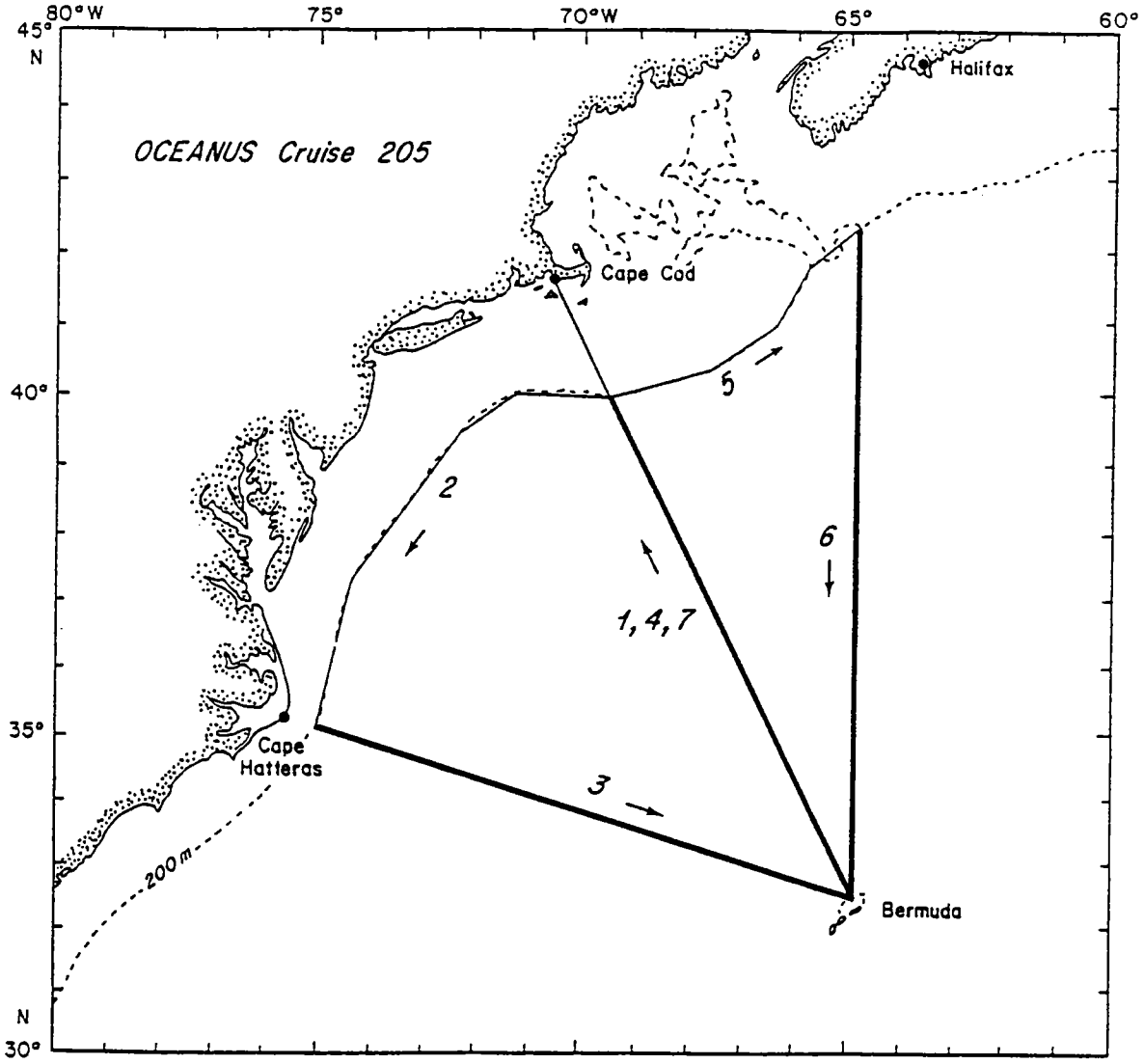

Figure 1.1 The location of the XBT and CTD sections made during R/V Oceanus cruise 205, leg 8. The direction in which each section was made is shown by the arrows.

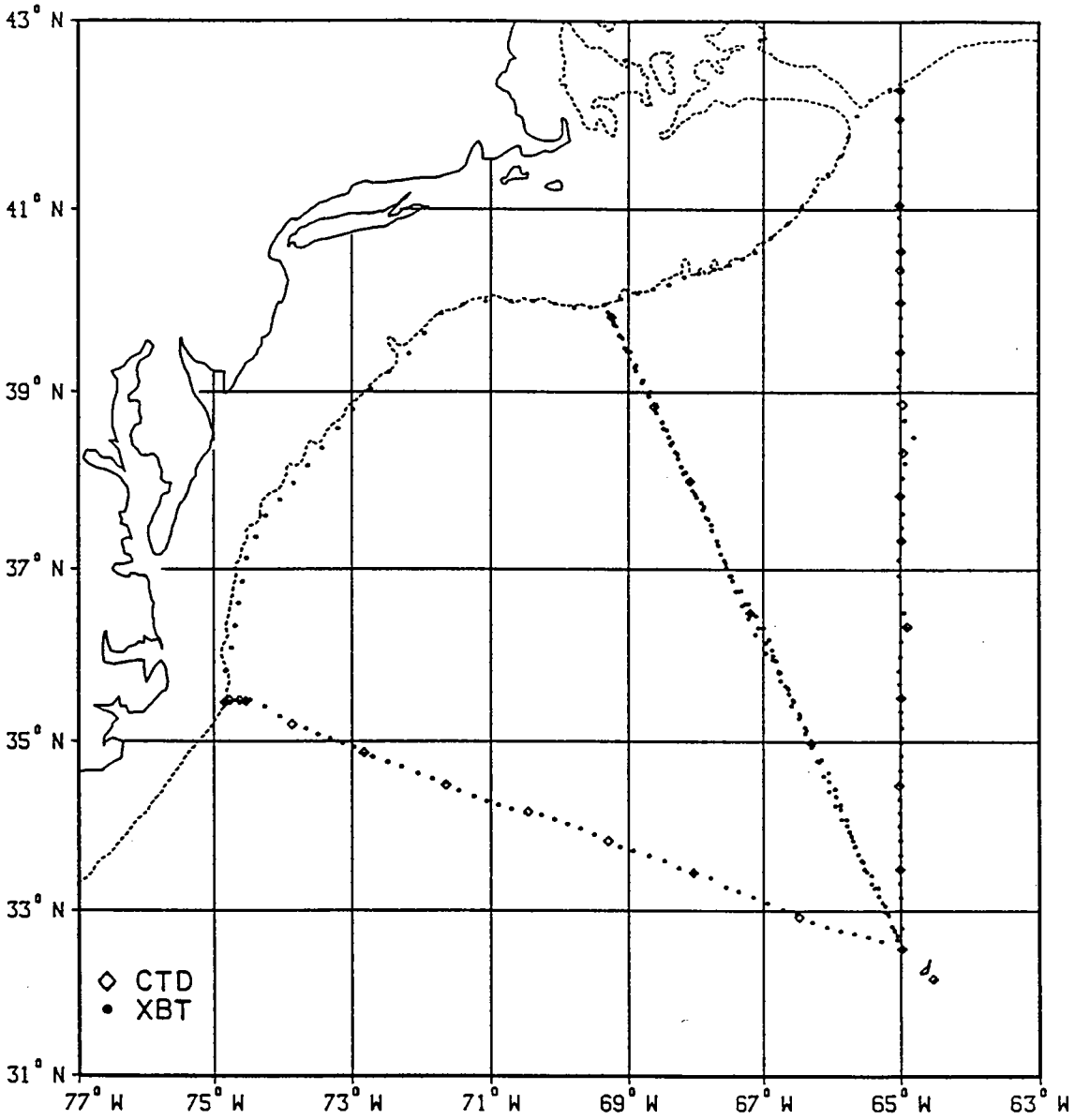

Figure 1.2 The position of each of the XBT (dots) and CTD (diamonds) stations made during R/V Oceanus cruise 205, leg 8. The XBTs along the 200 m isobath were T-10, 200 m probes, all of the other XBTs were T-7, 750 m probes.

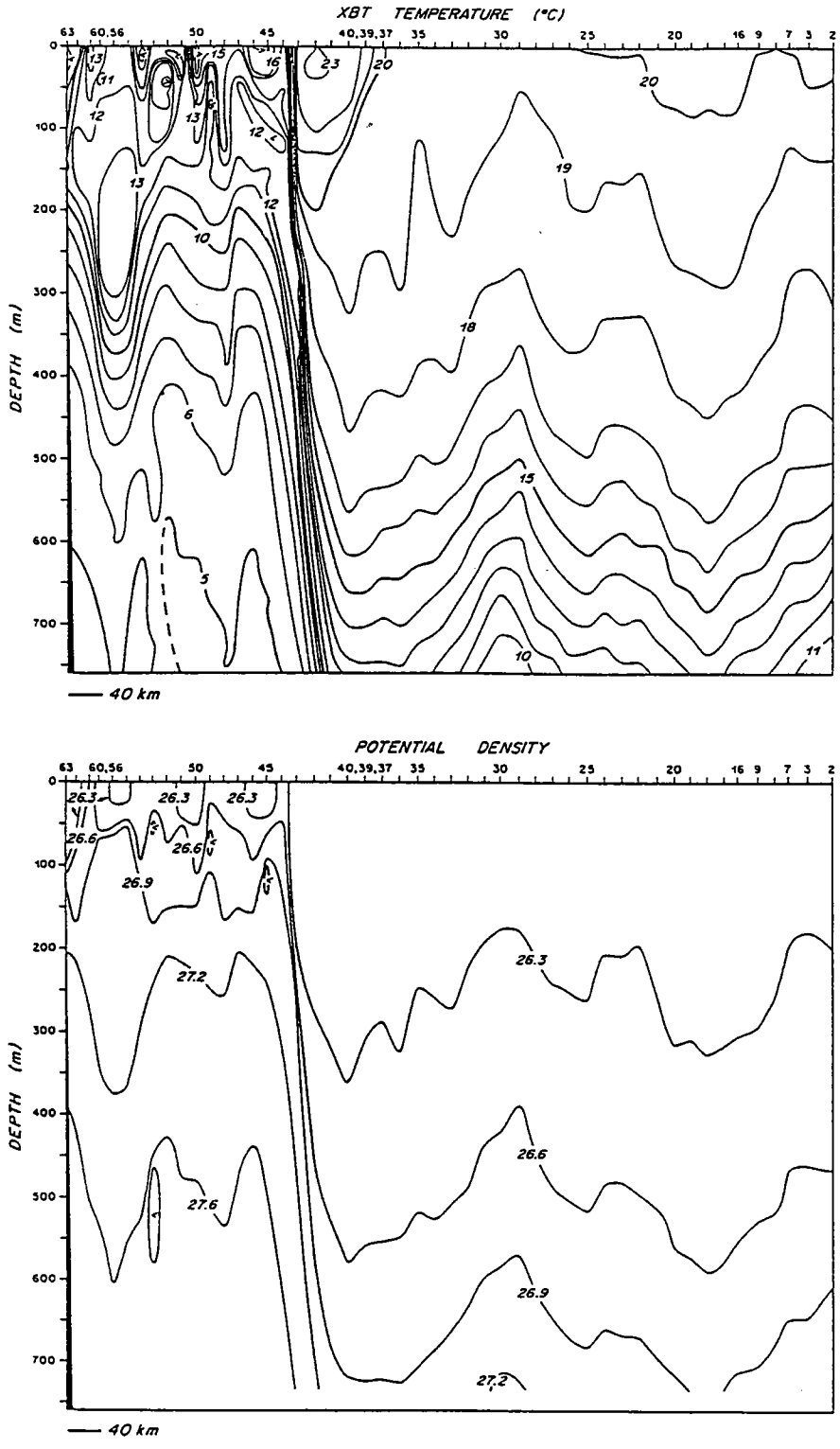

Figure 1.3a-e. The XBT temperature (upper) and potential density calculated as described by Joyce et al., 1988 for measurements made during R/V Oceanus cruise 205, leg 8, section 1.

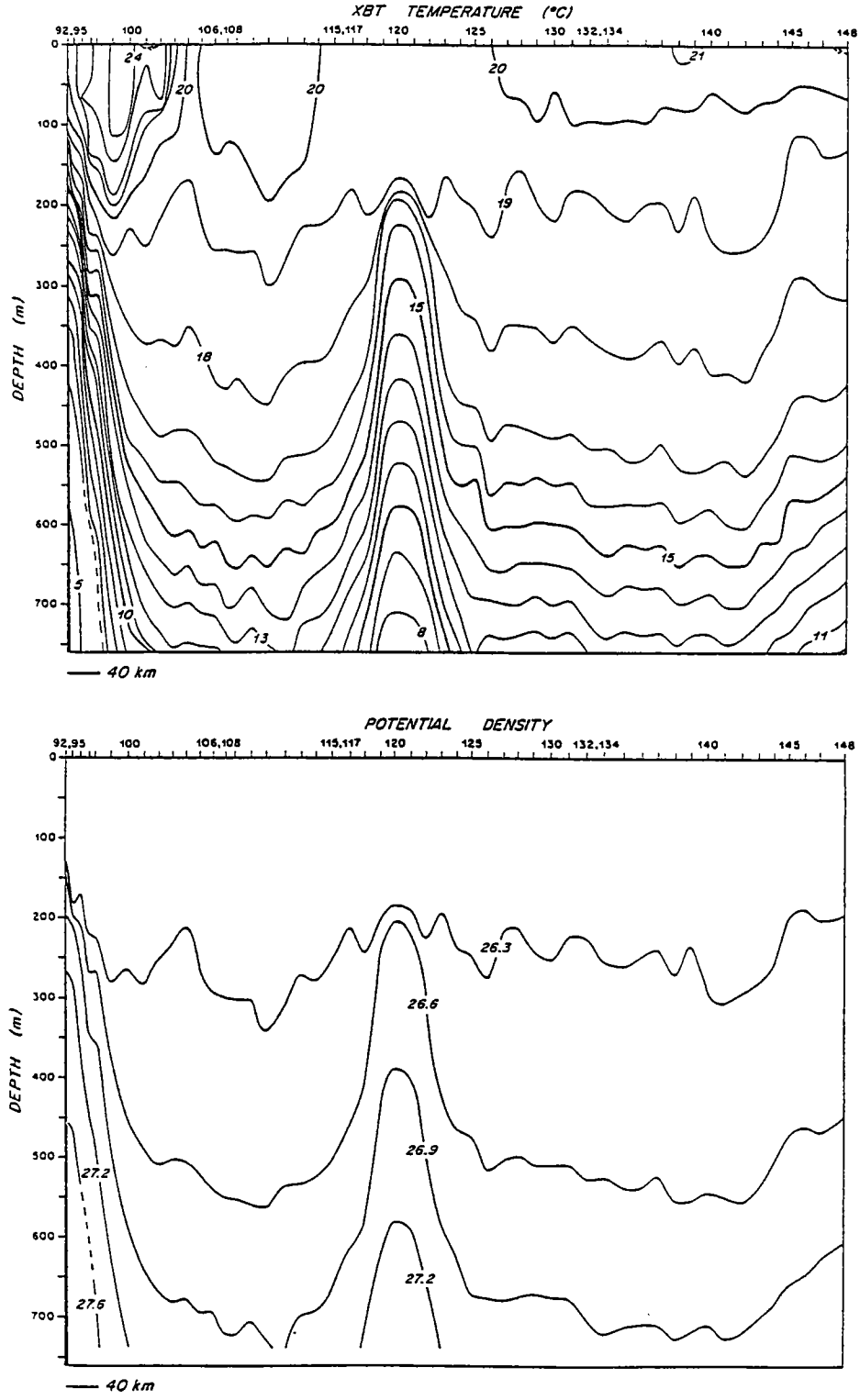

Figure 1.3b. Section 3.

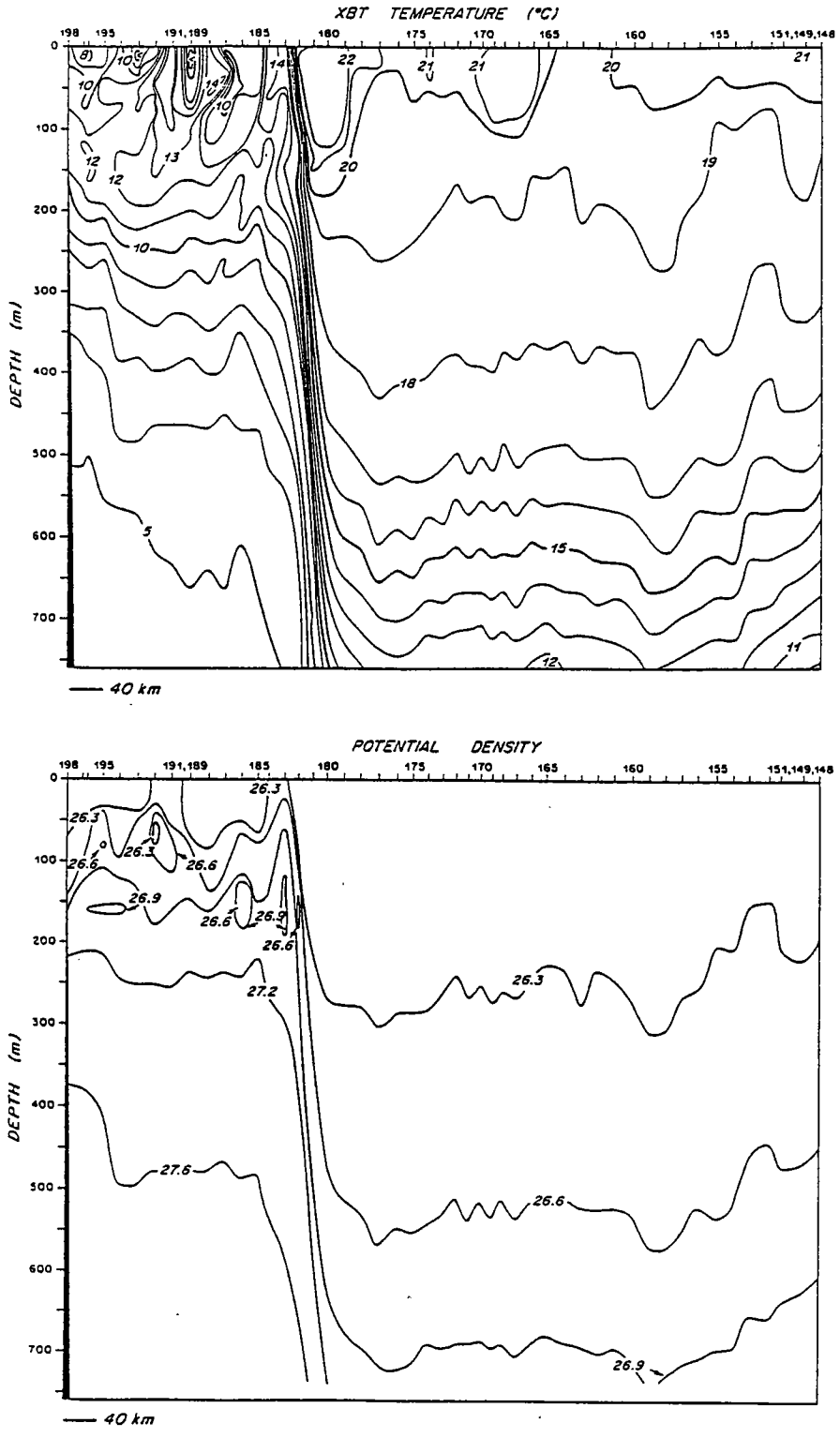

Figure 1.3c. Section 4.

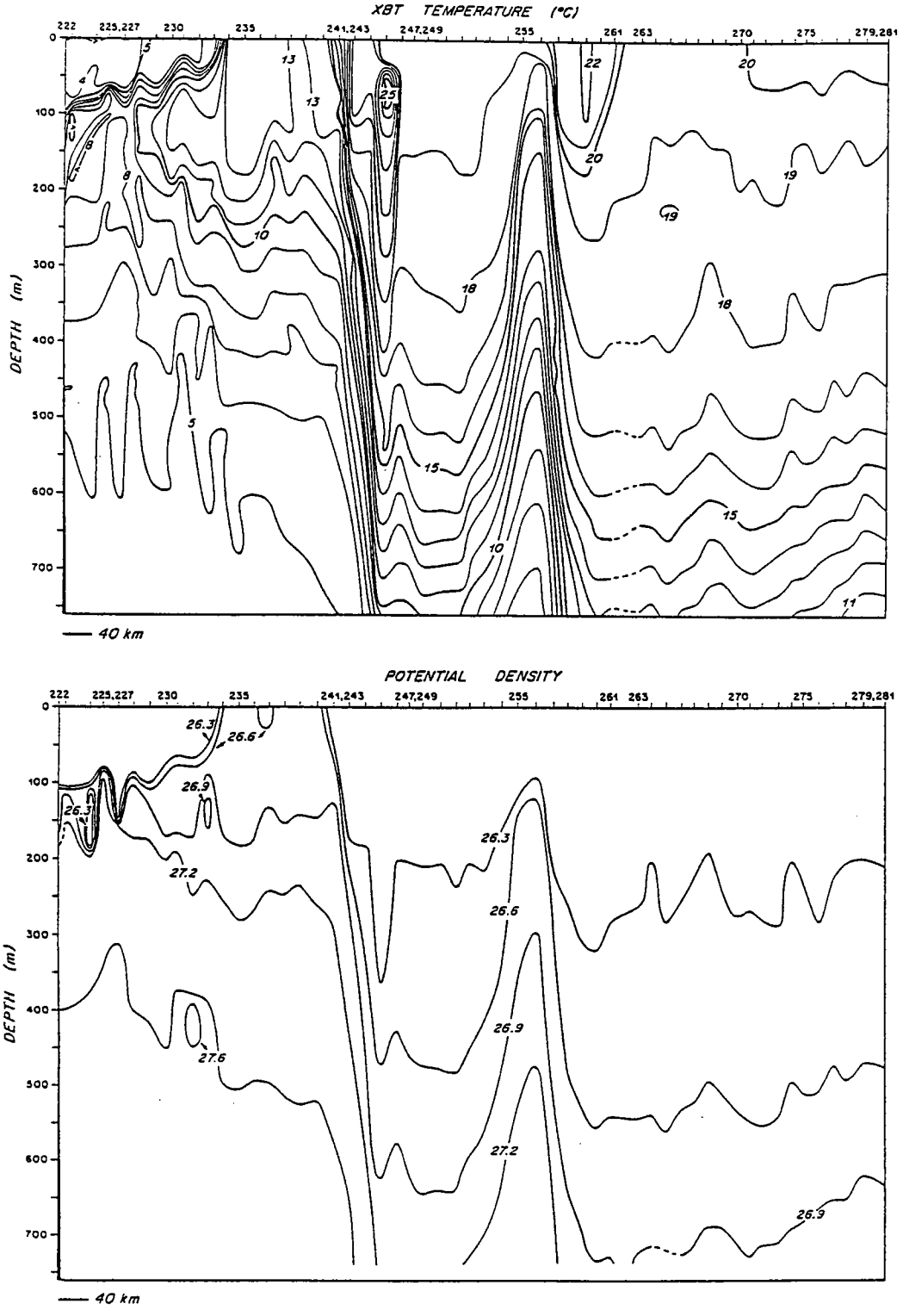

Figure 1.3d. Section 6.

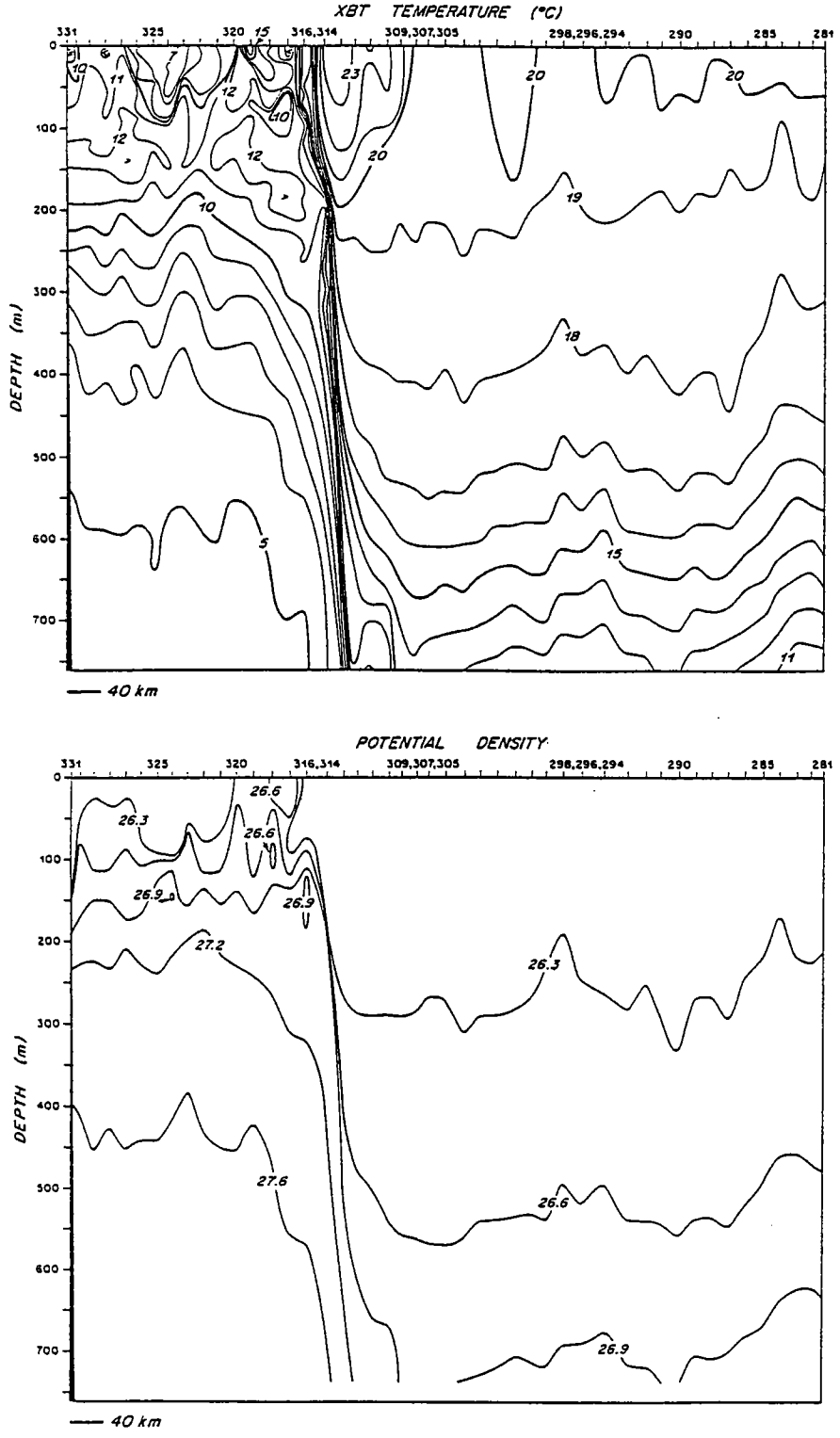

Figure 1.3e. Section 7.

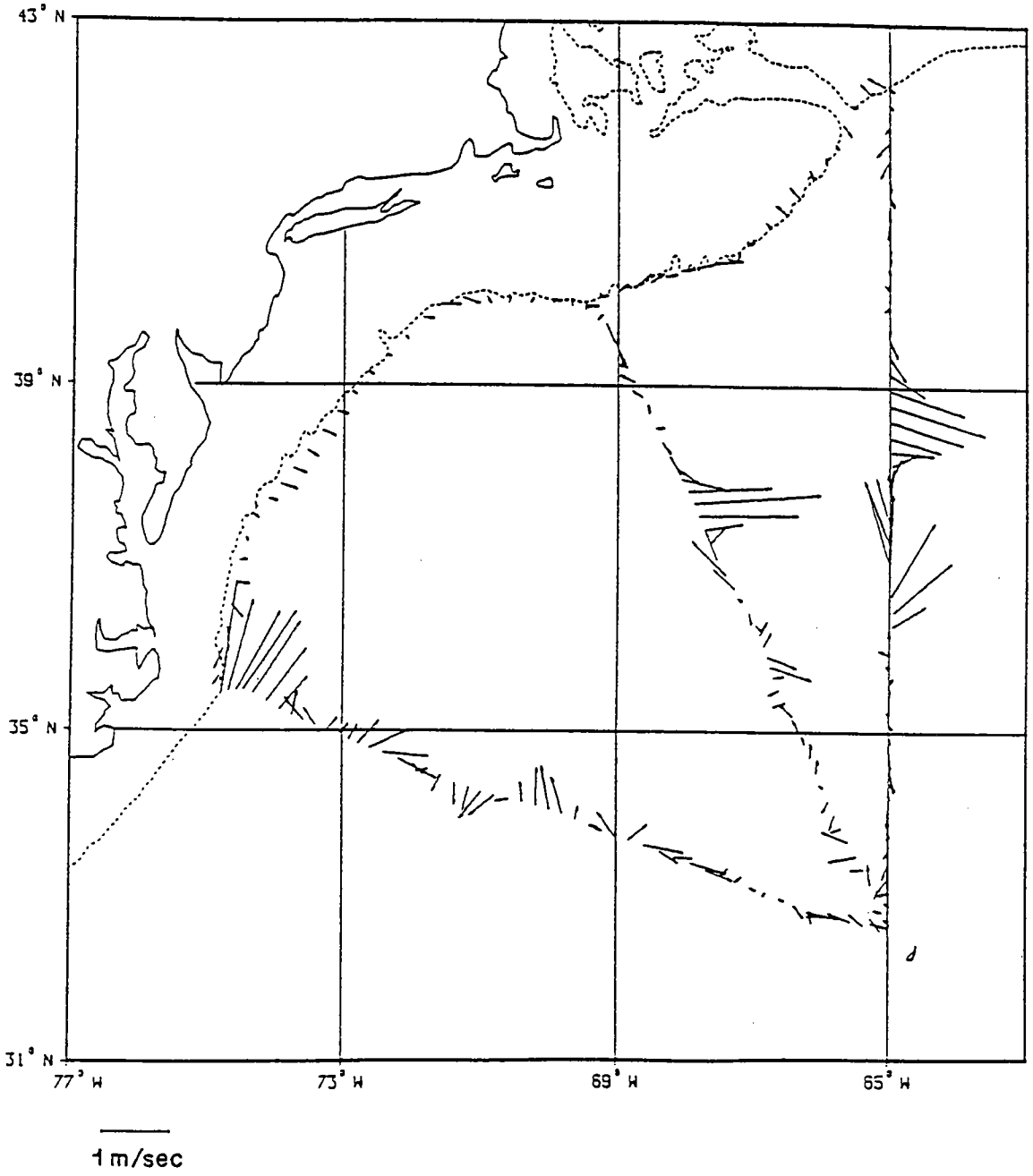

Figure 1.4. Averaged 100 m ADCP current vectors along sections 2-6 during R/V Oceanus cruise 205, leg 8.