NOAA Technical Memorandum ERL PMEL-23

OBSERVATIONS IN THE ALASKAN STREAM DURING 1980

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February 1981

UNITED STATES DEPARTMENT OF COMMERCE
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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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DISCLAIMER

CONTENTS

Abstract

From February 4 through March 9, 1980, the NOAA Ship DISCOVERER was used to make CTD casts in the Alaskan Stream and to deploy current meters at two locations off Kodiak Island.

Horizontal and vertical sections of temperature, salinity, geostrophic flow, and volume transport are presented. All the the temperature sections show a subsurface maximum between 100 and 350 m. Geostrophic coastal flow is southwestward with some recirculation occuring west of 170°W. Calculated volume transport values do not balance, implying intense baroclinic readjustment in some areas.

Only one current meter produced a complete record. Flow at 980 m was to the southwest with a reversal to the northeast during a 30-day period in April and May. Net flow was to the southwest at 5.8 cm/sec. The largest concentration of energy is found in the very low-frequency bands followed by the diurnal and semidiurnal tidal bands.

Introduction

From February 4 through March 9, 1980, under the sponsorship of the Outer Continental Shelf Environmental Assessment Program (OCSEAP), the Pacific Marine Environmental Laboratory carried out a project designed to provide environmental data of value in interpreting coastal and oceanic circulation in the Gulf of Alaska. In order to gain understanding of the flow of the Alaskan Stream and to investigate interactions between this offshore boundary current and circulation over the continental shelf, a conductivity and temperature versus depth (CTD) grid, supplemented by expendable bathythermograph (XBT) casts and surface samples, was established along the path of the Alaskan Stream from the head of the Gulf of Alaska to the western Aleutian Islands. Current meter moorings were deployed off Kodiak Island to provide information on deep flow in the stream (near previously used geostrophic reference levels), to assess the possible existence of wind-induced barotropic flow and its variations, and to estimate transfer of energy from the stream onto the continental shelf.

Background

The project area extends from the head of the Gulf of Alaska to the western Aleutian Islands (Figure 1) and is characterized by the offshore westward-flowing Alaskan Stream, the northern segment of the Subarctic gyre. The typically high velocities of the Alaskan Stream do not extend onto the shelf (Schumacher et al., 1978, 1979). Inshore of the stream, counterflows or zones of negligible baroclinicity are present (Reed et al., 1980). From about 145°W to Shelikof Strait, a distinct, narrow, westward coastal flow (Kenai Current) exists throughout the year and increases in speed and transport in the fall because of freshwater runoff (Schumacher and Reed, 1980).

Data

A total of 104 CTD casts (Table 1, Figure 1) were made from the NOAA Ship DISCOVERER using a 1500-m CTD sensor lowered at a rate of 30 m/min above 200 m and about 45 m/min below that depth. During the down-cast, simultaneous values of conductivity, temperature, and depth were collected twice per second using a Plessey model 9040 CTD system and a model 8400 digital data logger. Calibration samples were taken with each cast at alternately shallow, intermediate, and deep levels. Temperature and salinity data were averaged over one-meter intervals to provide values from which density and other parameters were computed.

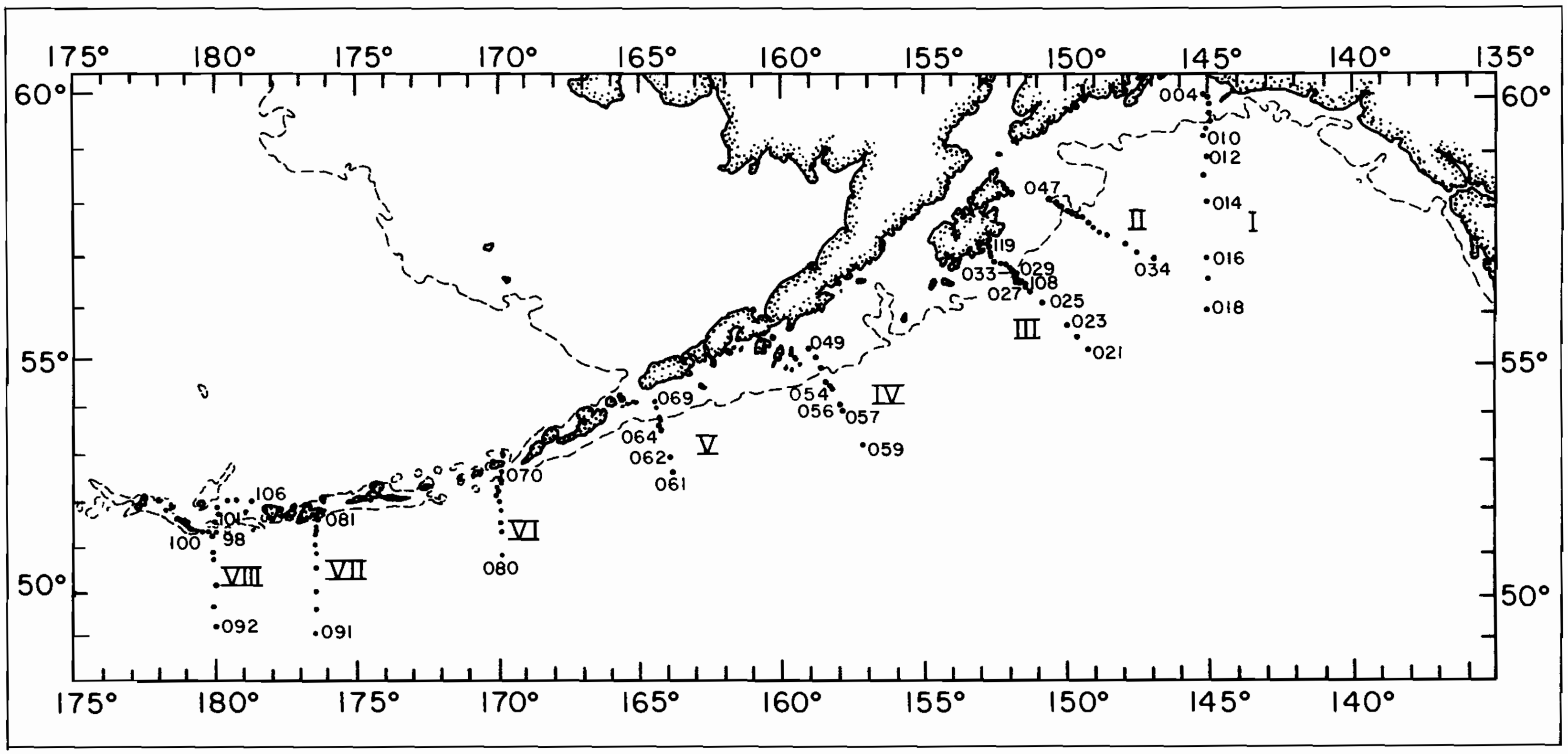

Figure 1. Stations occupied in project area during 10 February-9 March 1980. Roman numerals indicate casts used in vertical sections. Dashed line is 100-fathom contour.

Table 1

CTD Casts

Cast No.	Date	Latitude	Longitude	Water Depth (m)
004	10 Feb 80	60°05.2'N	145°00.8'W	90
005	10 Feb 80	60°00.1'N	145°00.1'W	118
006	10 Feb 80	59°52.5'N	144°59.4'W	203
007	10 Feb 80	59°42.0'N	144°59.4'W	132
008	10 Feb 80	59°32.5'N	144°59.3'W	202
009	11 Feb 80	59°25.6'N	144°59.6'W	1216
010	11 Feb 80	59°20.1'N	145°00.6'W	2633
012	11 Feb 80	58°57.5'N	144°59.4'W	3931
013	11 Feb 80	58°33.7'N	145°00.1'W	3886
014	11 Feb 80	58°03.6'N	144°59.3'W	3804
016	12 Feb 80	57°03.1'N	145°00.0'W	3660
017	12 Feb 80	56°32.3'N	144°59.7'W	3746
018	12 Feb 80	56°02.3'N	145°00.6'W	3767
021	13 Feb 80	55°15.4'N	149°11.2'W	3731
022	13 Feb 80	55°28.1'N	149°32.3'W	4361
023	14 Feb 80	55°42.1'N	149°58.9'W	4513
025	14 Feb 80	56°10.5'N	150°49.8'W	5288
026	14 Feb 80	56°23.3'N	151°15.7'W	4599
027	14 Feb 80	56°32.8'N	151°34.8'W	1873
029	15 Feb 80	56°32.6'N	151°33.5'W	2057
030	15 Feb 80	56°33.9'N	151°38.0'W	1372
031	15 Feb 80	56°38.4'N	151°45.0'W	1150
032	15 Feb 80	56°41.9'N	151°48.7'W	222
033	15 Feb 80	56°48.6'N	152°00.7'W	78

No.	Date	Latitude	Longitude	Water Cast Depth (m)
034	16 Feb 80	57°00.4'N	146°52.6'W	4050
035	16 Feb 80	57°08.9'N	147°24.2'W	4389
036	16 Feb 80	57°17.3'N	147°57.8'W	4778
037	16 Feb 80	57°26.4'N	148°32.2'W	3310
038	16 Feb 80	57°31.3'N	148°45.7'W	3218
039	16 Feb 80	57°36.7'N	149°00.4'W	2496
040	16 Feb 80	57°41.0'N	149°12.3'W	2140
041	17 Feb 80	57°45.2'N	149°23.8'W	1061
042	17 Feb 80	57°48.5'N	149°37.9'W	312
043	17 Feb 80	57°52.8'N	149°49.6'W	250
044	17 Feb 80	57°56.1'N	149°59.4'W	240
045	17 Feb 80	57°59.1'N	150°11.6'W	190
046	17 Feb 80	58°02.1'N	150°21.5'W	177
047	17 Feb 80	58°08.2'N	150°39.7'W	115
049	22 Feb 80	55°16.5'N	159°01.2'W	194
050	22 Feb 80	55°05.6'N	158°50.9'W	122
051	22 Feb 80	54°51.1'N	158°36.3'W	135
052	22 Feb 80	54°37.6'N	158°24.4'W	435
053	22 Feb 80	54°31.4'N	158°19.7'W	590
054	22 Feb 80	54°28.4'N	158°16.4'W	2067
056	23 Feb 80	54°08.2'N	157°59.2'W	4604
057	23 Feb 80	53°59.9'N	157°49.6'W	6050
059	23 Feb 80	53°17.2'N	157°12.9'W	4576
061	24 Feb 80	52°39.0'N	163°49.4'W	5780
062	24 Feb 80	53°02.4'N	163°57.7'W	5002
064	25 Feb 80	53°34.3'N	164°12.1'W	2200
065	25 Feb 80	53°39.3'N	164°17.3'W	1200
066	25 Feb 80	53°43.1'N	164°17.1'W	610
067	25 Feb 80	53°50.6'N	164°19.7'W	85
068	25 Feb 80	54°00.3'N	164°23.6'W	103
069	25 Feb 80	54°07.1'N	164°27.7'W	76

Cast No.	Date	Latitude	Longitude	Water Depth (m)
070	26 Feb 80	52°41.8'N	169°58.8'W	322
071	26 Feb 80	52°33.1'N	170°00.8'W	251
072	26 Feb 80	52°25.3'N	169°59.8'W	266
073	26 Feb 80	52°20.3'N	170°03.2'W	1150
074	26 Feb 80	52°16.5'N	170°01.0'W	1719
075	26 Feb 80	52°12.8'N	170°02.5'W	2734
076	27 Feb 80	52°06.9'N	170°01.8'W	3124
077	27 Feb 80	51°54.0'N	170°00.6'W	3328
078	27 Feb 80	51°37.7'N	169°59.4'W	3840
079	27 Feb 80	51°21.7'N	169°59.3'W	6000
080	27 Feb 80	50°51.7'N	169°58.3'W	5534
081	28 Feb 80	51°41.0'N	176°25.6'W	119
082	28 Feb 80	51°36.8'N	176°25.3'W	195
083	28 Feb 80	51°30.9'N	176°25.0'W	675
084	28 Feb 80	51°26.8'N	176°25.3'W	1465
085	28 Feb 80	51°20.9'N	176°25.6'W	3264
086	29 Feb 80	51°09.6'N	176°25.1'W	4142
087	29 Feb 80	50°56.6'N	176°25.5'W	3778
088	29 Feb 80	50°36.0'N	176°26.0'W	5852
089	29 Feb 80	50°06.8'N	176°25.8'W	5486
090	29 Feb 80	49°38.0'N	176°24.4'W	4755
091	29 Feb 80	49°07.3'N	176°25.8'W	5033
092	1 Mar 80	49°13.9'N	179°59.1'W	4389
093	1 Mar 80	49°41.0'N	179°58.6'E	4535
094	1 Mar 80	50°13.4'N	179°59.5'W	6346
095	2 Mar 80	50°44.4'N	179°57.9'E	5090
096	2 Mar 80	50°58.6'N	179°57.8'E	3950
097	2 Mar 80	51°12.4'N	179°59.8'E	3530
098	2 Mar 80	51°21.5'N	179°58.7'W	1390
099	2 Mar 80	51°21.7'N	179°49.4'E	1160
100	2 Mar 80	51°21.2'N	179°35.3'E	915
101	2 Mar 80	51°33.5'N	179°59.8'E	1350
102	3 Mar 80	51°44.5'N	179°59.1'W	1267
103	3 Mar 80	51°53.5'N	179°59.0'W	1536

No.	Date	Latitude	Longitude	Water Cast Depth (m)
104	3 Mar 80	52°04.2'N	179°35.6'W	2100
105	3 Mar 80	52°03.2'N	179°11.1'W	2350
106	3 Mar 80	52°02.7'N	178°40.1'W	2478
108	8 Mar 80	56°28.2'N	151°27.6'W	2850
109	8 Mar 80	56°31.4'N	151°34.0'W	2100
110	8 Mar 80	56°34.6'N	151°41.5'W	1754
111	9 Mar 80	56°39.1'N	151°45.1'W	1197
112	9 Mar 80	56°42.0'N	151°48.5'W	249
113	9 Mar 80	56°49.5'N	152°00.4'W	84
114	9 Mar 80	56°52.1'N	152°10.5'W	91
115	9 Mar 80	56°55.6'N	152°20.2'W	77
116	9 Mar 80	56°59.0'N	152°29.6'W	140
117	9 Mar 80	57°02.4'N	152°38.5'W	124
118	9 Mar 80	57°05.6'N	152°42.6'W	155
119	9 Mar 80	57°07.7'N	152°48.4'W	133

A Plessey model 9041 CTD system (6000-m depth range) was used on 12 casts. Its conductivity cell was unstable, however, and was later found to be cracked. These data were not processed, and this is the reason for most of the missing casts in Table 1 and Figure 1.

On several tracks between lines of CTD stations, hourly bucket samples for surface temperature and salinity were taken and XBT casts were made. Although there were 151 XBT drops, many of the probes were faulty, and the data could not be used without careful scrutiny.

Two current meter moorings were deployed with Aanderaa current meters and AMF acoustic releases. The sampling interval for pressure, conductivity, and temperature was 30 minutes. The inshore mooring was lost. Of the three meters on the other mooring, only the middle meter provided a complete record: the bottom meter flooded, and the top meter had no speed record. A summary of mooring positions and meter placement appears in Table 2.

Two time series were produced from the edited current data using a Lanczos filter (Charnell and Krancus, 1976). The first series was filtered so that over 99% of the amplitude was passed at periods greater than 5.0 hr, 50% at 2.9 hr, and less than 0.5% at 2.0 hr. This time series was used to calculate sequences of 29-day tidal harmonic analysis. The second series was filtered to remove most of the tidal energy; the filter passed 99% of the amplitude at periods over 55 hr; 50% at 35 hr; and less than 0.5% at periods less than 25 hr. This series was resampled at six-hour intervals for use in examining subtidal circulation.

Current meter and CTD data have been submitted to NODC. They are also stored in the PMEL Coastal Physics Group's retrieval and display system, R2D2 (Rapid Retrieval Data Display), which operates on NOAA's Environmental Research Laboratories' central computer system in Boulder, Colorado. R2D2

Table 2

Current-Meter Moorings

Mooring	Position Water Depth (m)	Meter Depth (m)	Observation Period
AS-1	56°33.6'N 151°36.1'W 1670 m	480	no speeds
		980	15 February- 14 August 1980
		1480	meter flooded
AS-2	56°41.7'N 151°47.9'W 316 m	106 306	mooring lost

allows information in the data base to be retrieved, sorted, and manipulated in a variety of ways (Pearson _et_ _al_., 1978).

Observations

Surface temperature and salinity contours based on CTD casts, XBT casts, and surface samples are shown in Figures 2 and 3. A tongue of relatively warm surface water flowed along the shelf break to about 170°W and was bounded both shoreward and seaward by colder water. Salinity consistently increased seaward.

Depth of the subsurface temperature maximum is plotted in Figure 4, and temperature and sigma-t at the subsurface temperature maximum are plotted in Figures 5 and 6. Temperature and salinity at a common density surface (σ_t = 26.70) are shown in Figures 7 and 8.

Plots of surface geopotential anomaly referred to 1500 db (Figure 9) and of the 600-db surface referred to 1500 db (Figure 10) reveal similar characteristics. Both indicate a basic southwestward geostrophic flow along the continental slope and recirculation in the western part of the region. Both figures also show a clockwise eddy on CTD line I along 145°W.

Transports were computed relative to 1500 db--or the deepest common reference level in depths less than 1500 m--and then adjusted by corrections computed by the Jacobsen and Jensen method (Fomin, 1964). Stations in water depths less than 300 m were not used.

Volume transports calculated for westward flow (Figure 11) show fairly constant values on the order of 12-13 x 10^6 m^3/sec until line V, which shows a large increase. The transport then decreases to its previous value on line VI. The next line (off Adak Island) shows a marked decrease, while the last section (at 180°) has a greater than average transport. A large eastward transport (10.9 x 10^6 m^3/sec) is also present north of the Aleutians. The

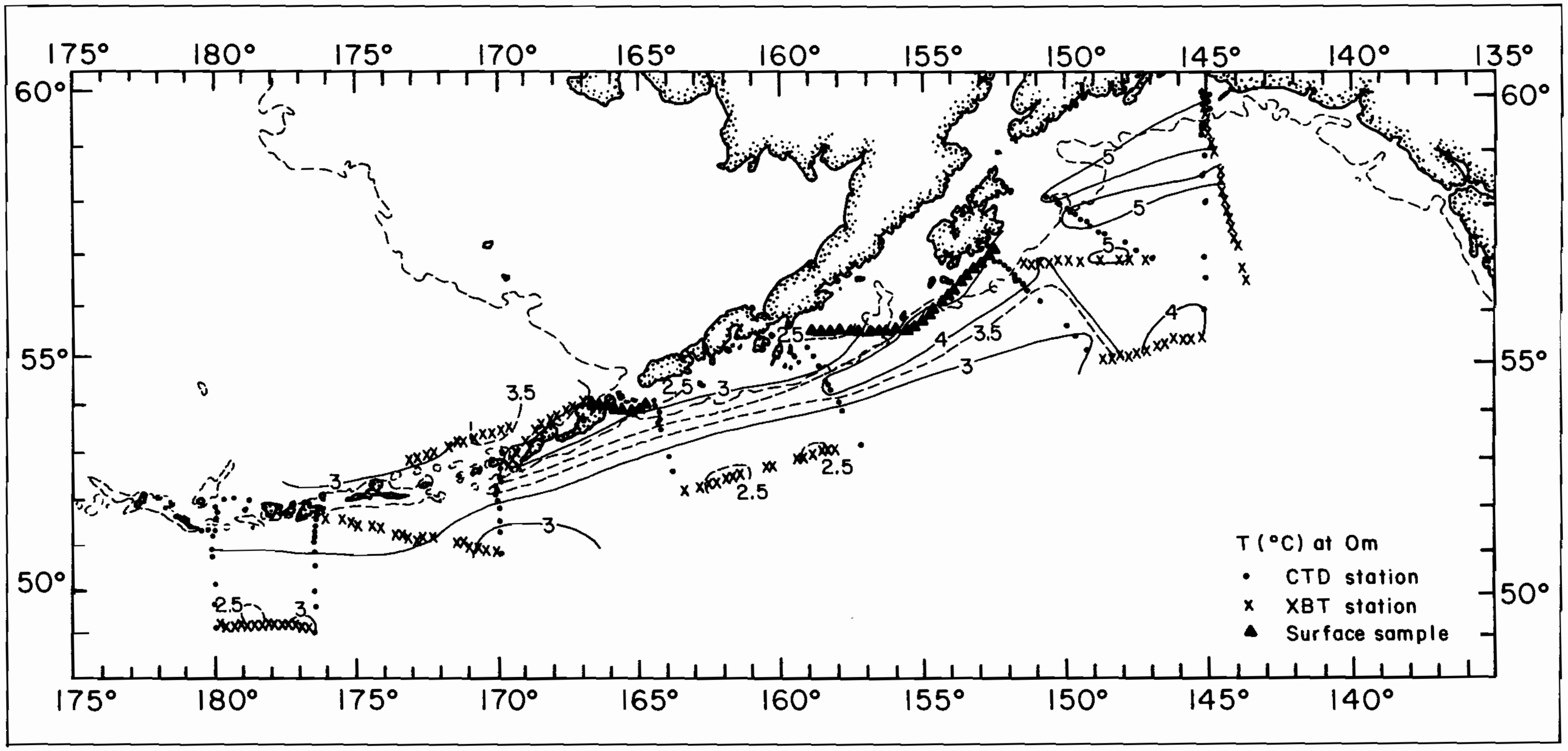

Figure 2. Surface temperature based on CTD casts, XBT casts, and bucket samples, 10 February-9 March 1980.

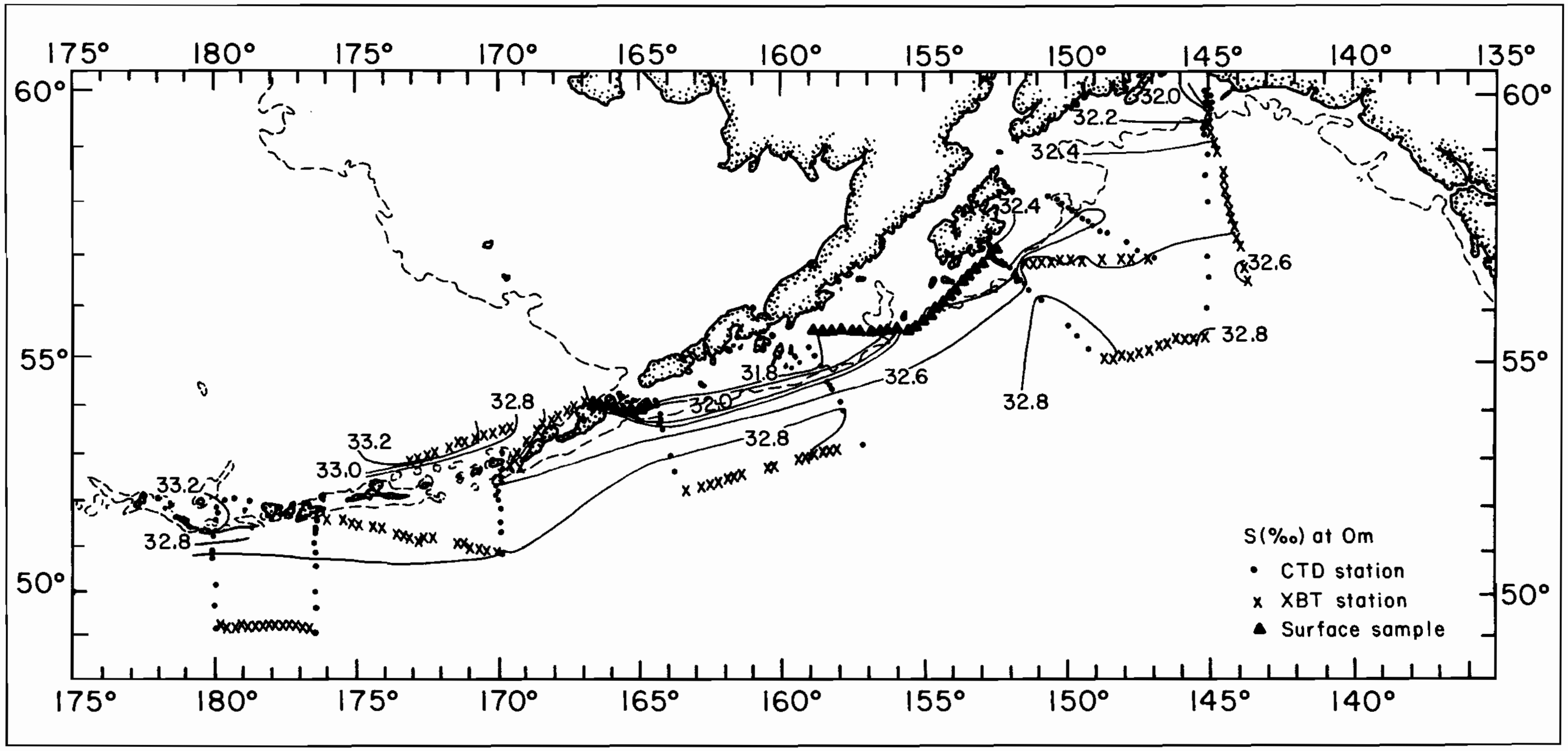

Figure 3. Surface salinity based on CTD casts, XBT casts, and bucket samples, 10 February-9 March 1980.

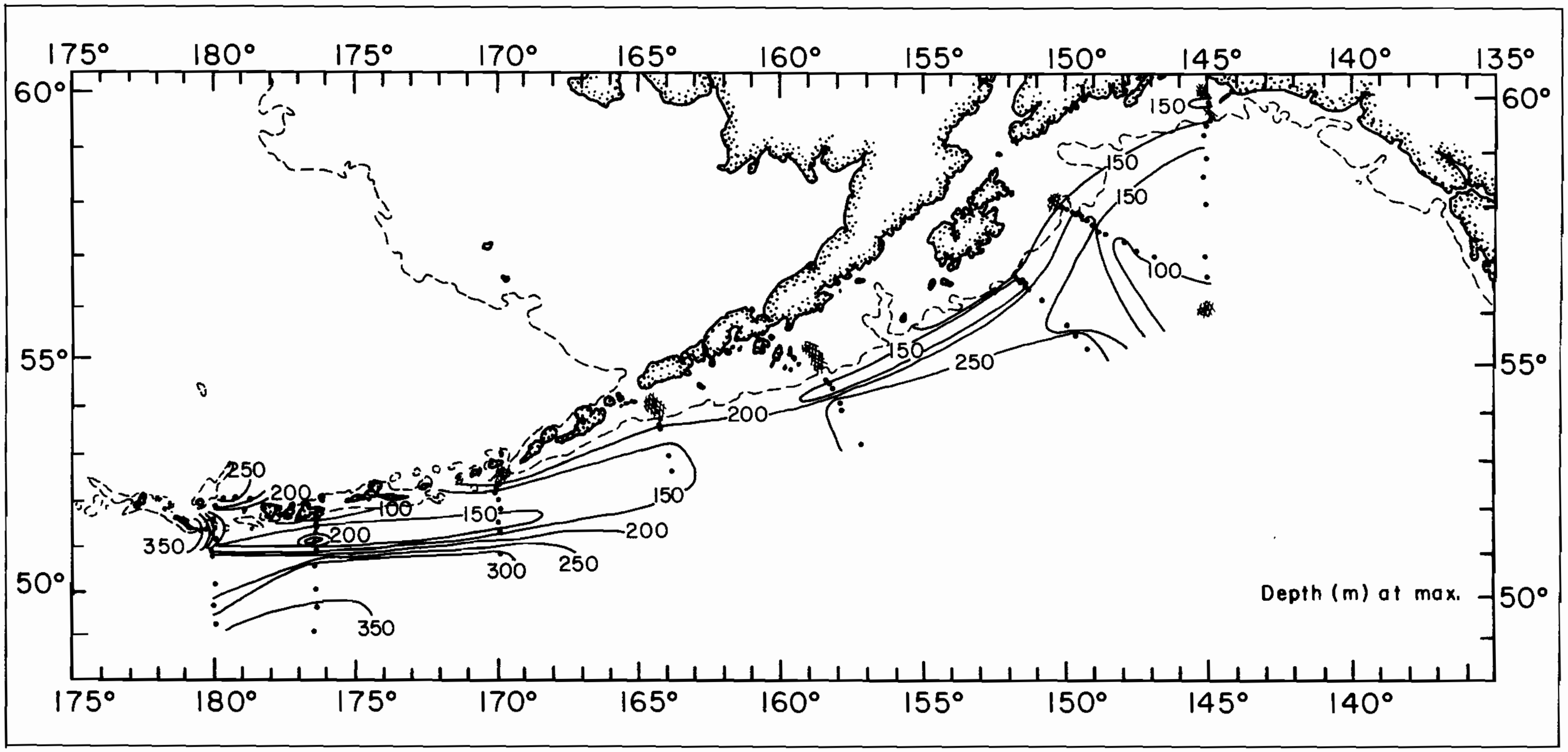

Figure 4. Depth of subsurface temperature mixinum, 10 February-3 March 1980. Hachures indicate stations without subsurface maximums.

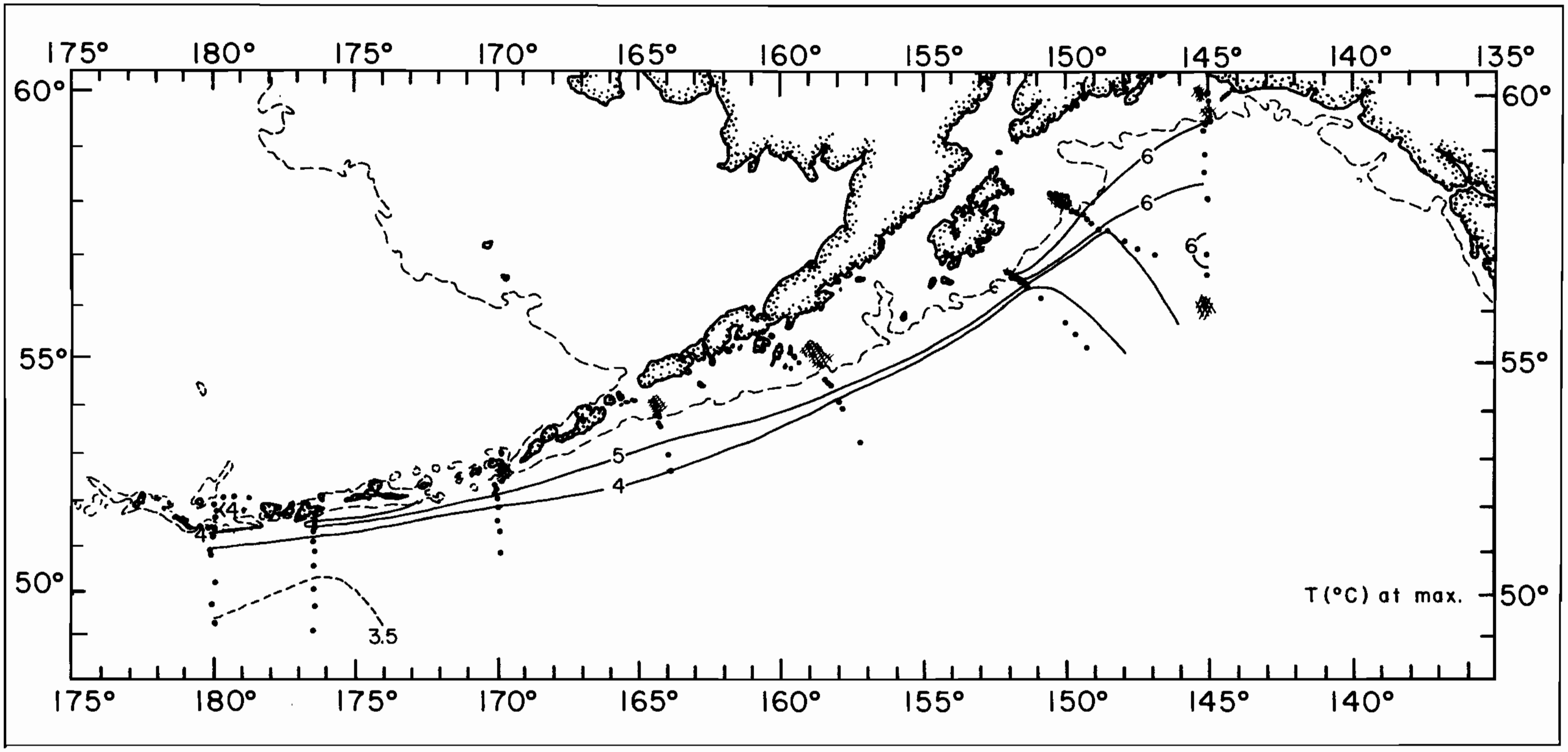

Figure 5. Value of subsurface temperature maximum, 10 February-3 March 1980. Hachures indicate no subsurface maximum.

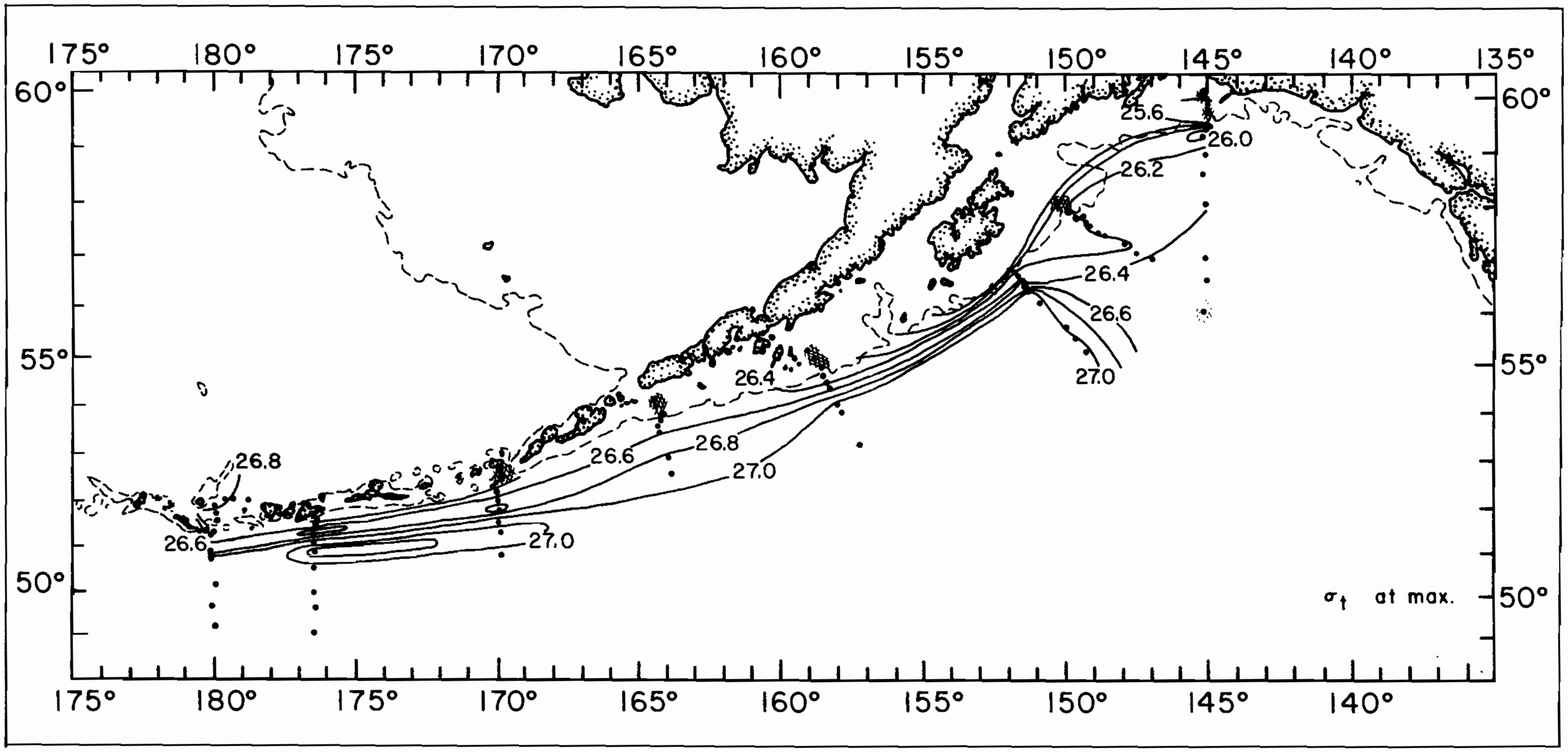

Figure 6. Sigma-t at subsurface temperature maximum, 10 February-3 March 1980. Stations without subsurface maximums are hachured.

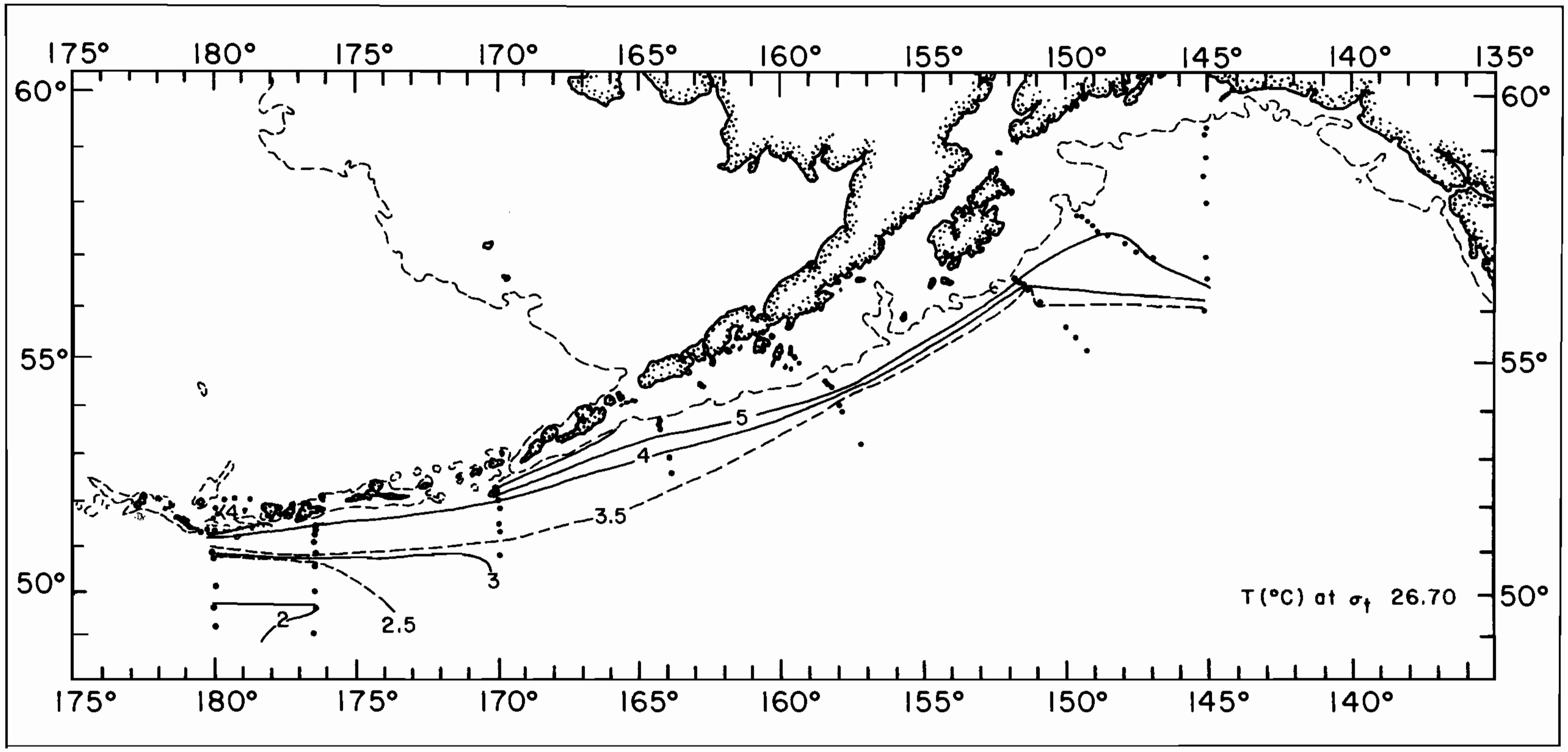

Figure 7. Temperature at σ_t = 26.70, 10 February-3 March 1980. Shallow stations where σ_t did not reach 26.70 were deleted.

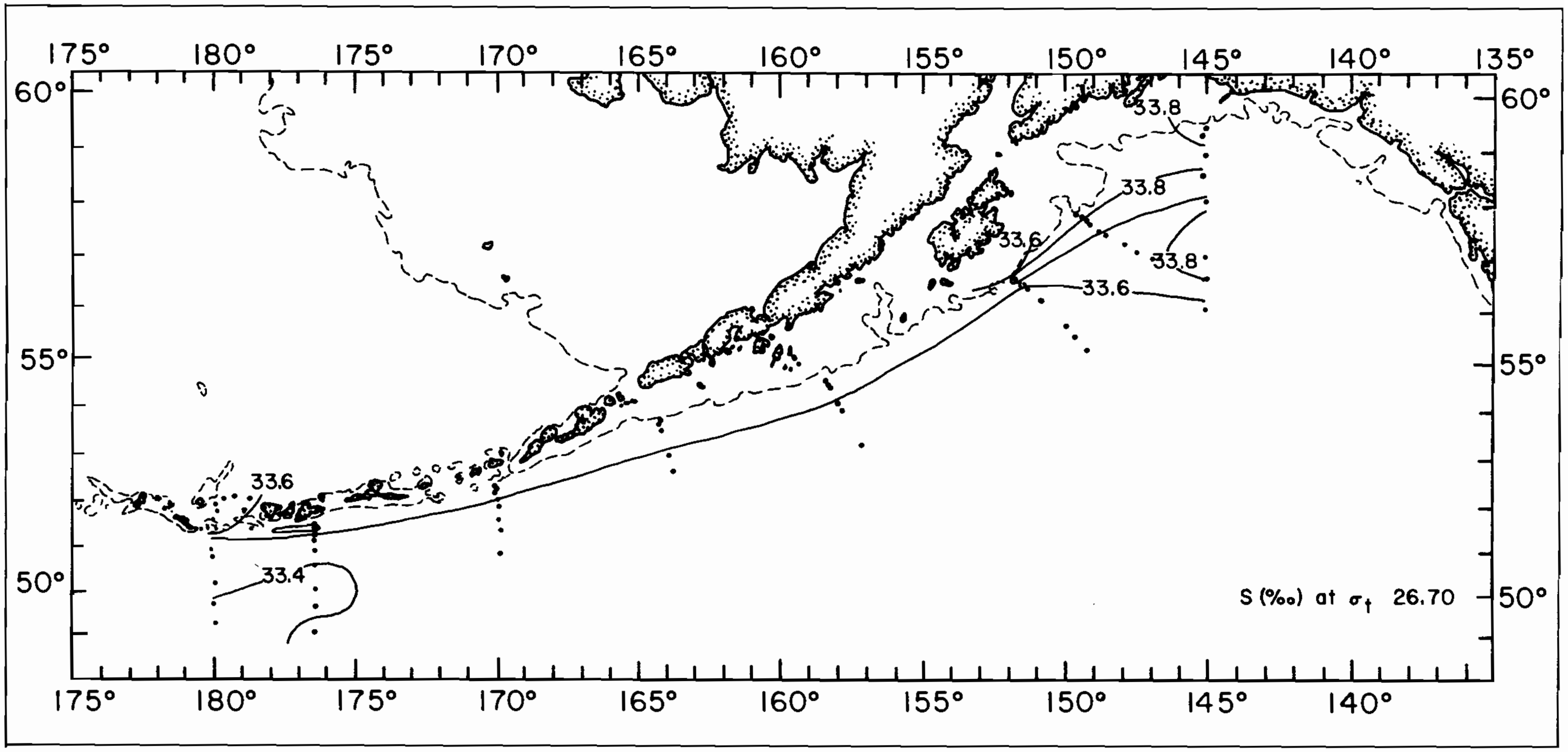

Figure 8. Salinity at σ_t = 26.70, 10 February-3 March 1980. Shallow stations where σ_t did not reach 26.70 were deleted.

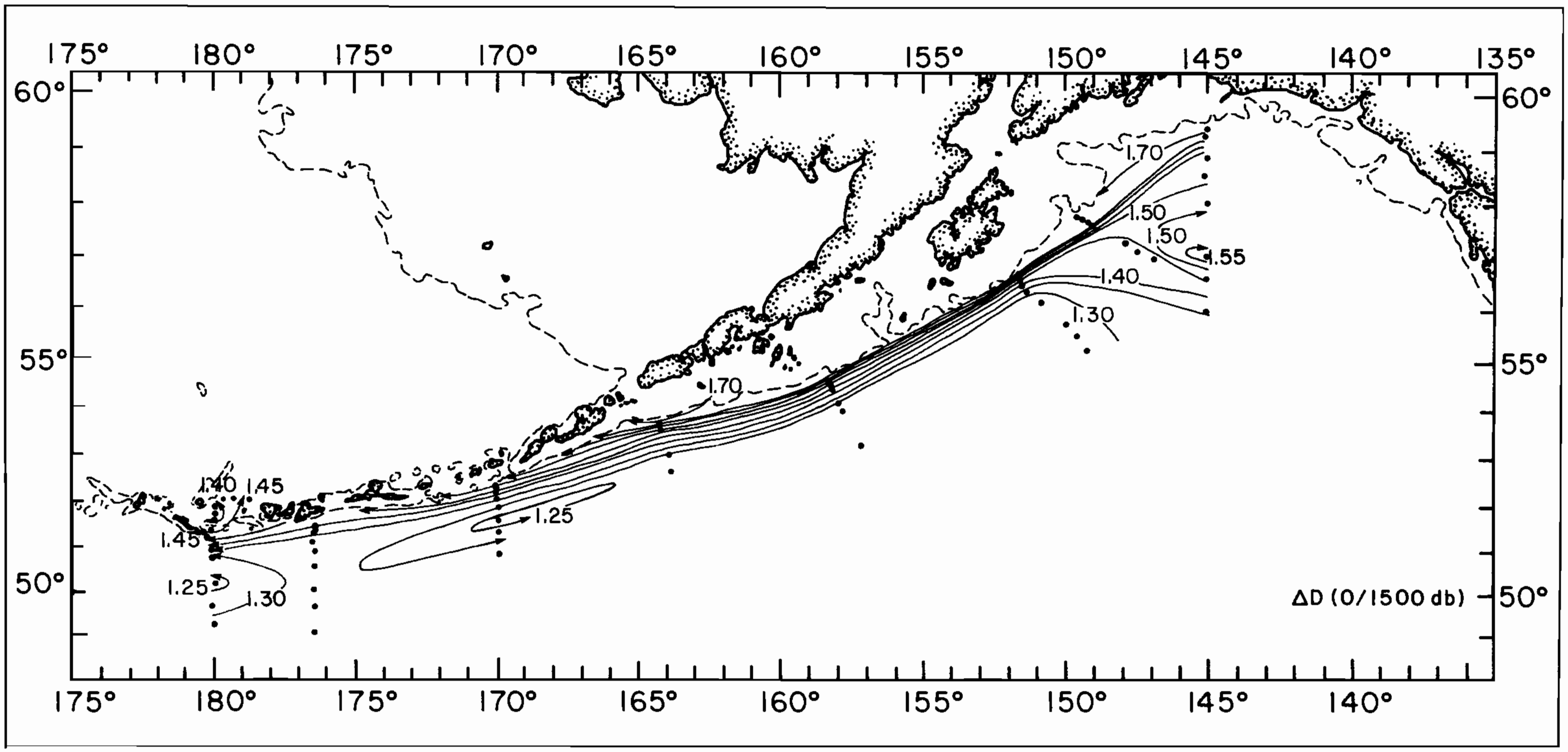

Figure 9. Surface geopotential anomaly (dyn m) referred to 1500 db, 10 February-3 March 1980. Stations shallower than 300 m were not plotted.

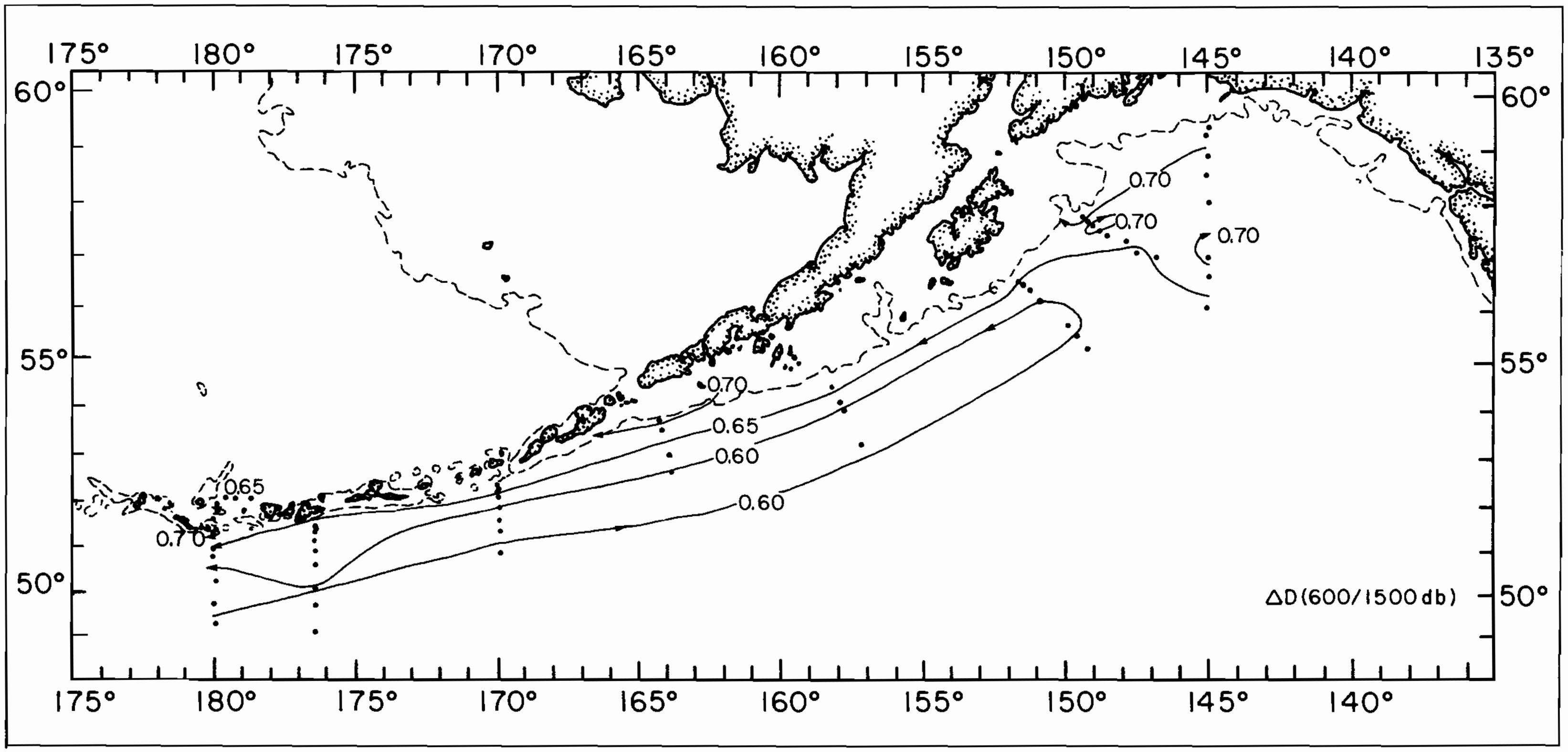

Figure 10. Geopotential anomaly of 600 db surface refered to 1500 db, 10 February-3 March 1980. Stations shallower than 300 m were not plotted.

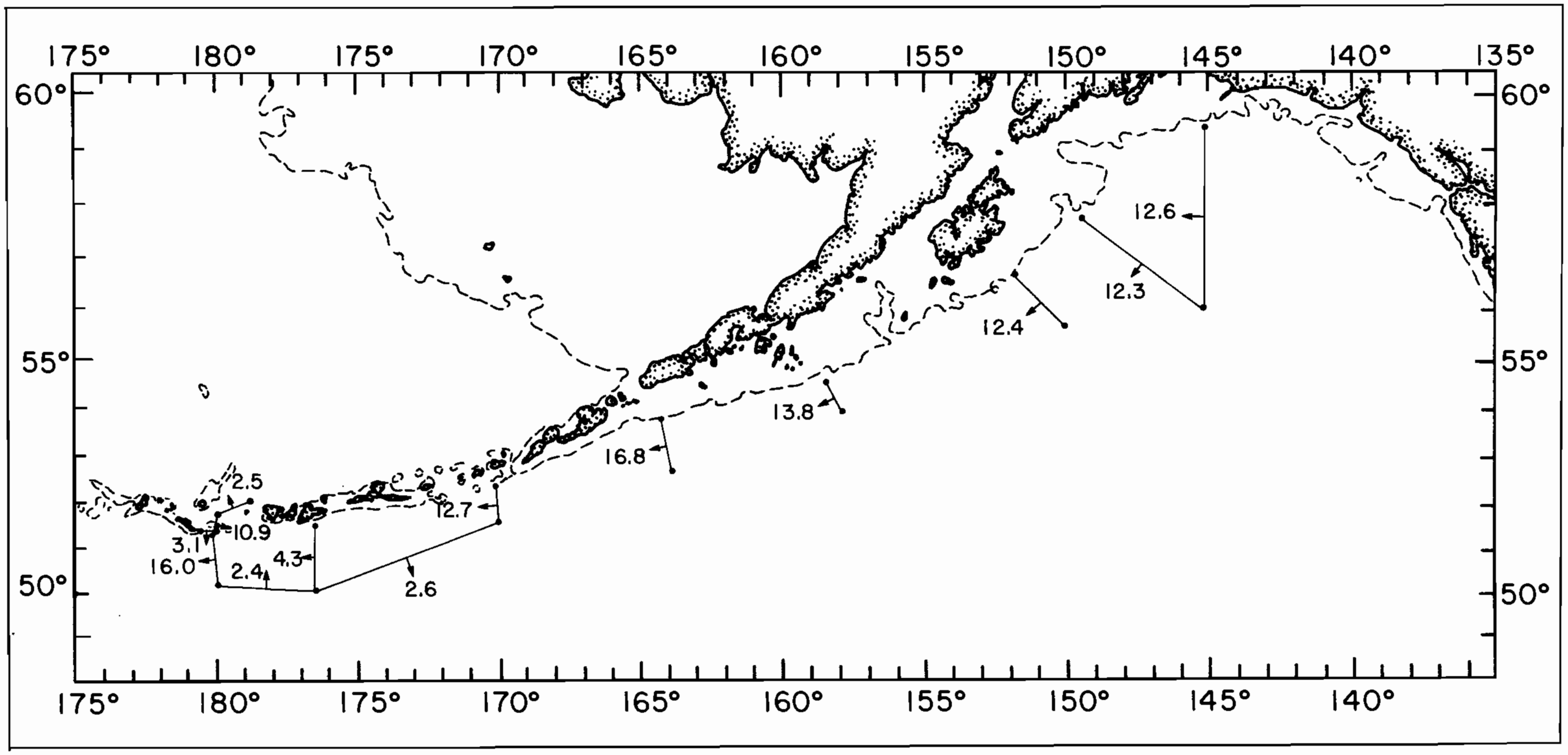

Figure 11. Computed transports (10^6 m^3/sec) relative to 1500 db, 10 February-3 March 1980. Stations shallower than 300 m were not used.

transport values do not balance, and it appears that intense baroclinic readjustments have occurred in some areas.

Vertical sections of temperature, salinity, σ_t, and geostrophic velocity for CTD lines I through VIII are shown in Figures 12 through 19. Common to all of the temperature sections is a subsurface maximum between 100 and 350 m. Vertical temperature range is about 1°C for seaward stations, but is 3°C or more for those stations nearer shore. Strong downward slopes in near-shore property distributions are characteristic of all of the sections. The salinity and σ_t gradients of each section are similar, and the largest gradients are coincident with or just above the subsurface temperature maximum in each section.

Vertical sections of geostrophic velocities indicate highest speeds are in the direction of the Alaskan Stream with only weak counterflows, generally less than 10 cm/sec (shaded areas represent eastward flow). Calculated southwest speeds in the upper 100 m ranged from about 10 to 100 cm/sec with the highest speeds inshore.

The current record (Figure 20) indicates that flow at 980 m was to the southwest during 70% of the period from February 16 to August 14, 1980, with variable speeds reaching a maximum of about 35 cm/sec. Flow reversed to the northeast for a 30-day period during April and May; maximum speed in this direction was about 15 cm/sec. Net flow, shown in the progressive vector diagram (Figure 21), was to the southwest (235°T) at 5.8 cm/sec. The u- and v-component variances were 83 and 55 cm^2/sec^2 respectively.

A U-V spectral plot (Figure 22) shows most of the kinetic energy is in the very low-frequency range with additional concentrations in the tidal range. About 68% lies in periods greater than 10 days, with only about 17% in the semidiurnal range and about 2% in the diurnal range.

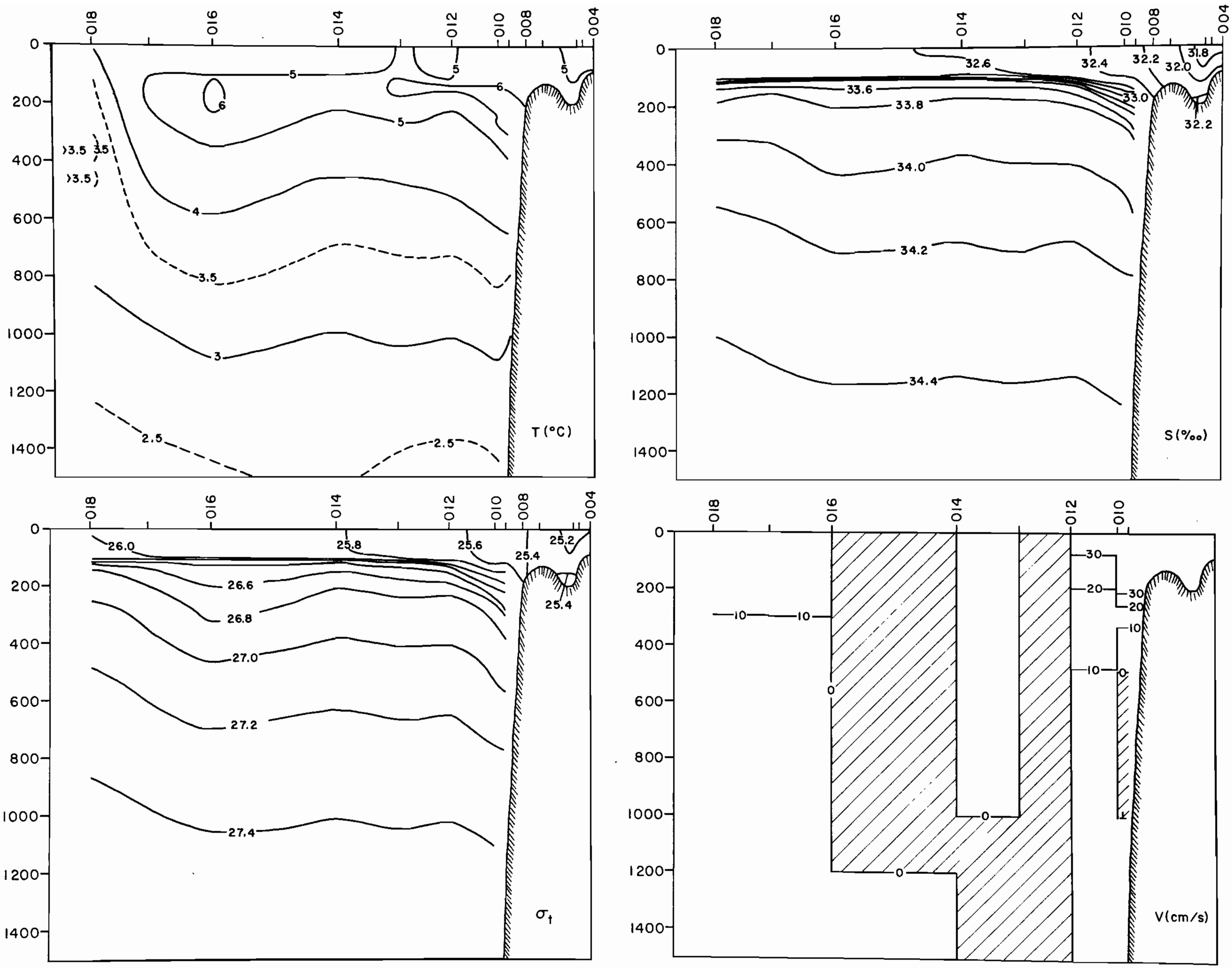

Figure 12. Vertical sections for CTD line I, casts 004-018 (10-12 February 1980).

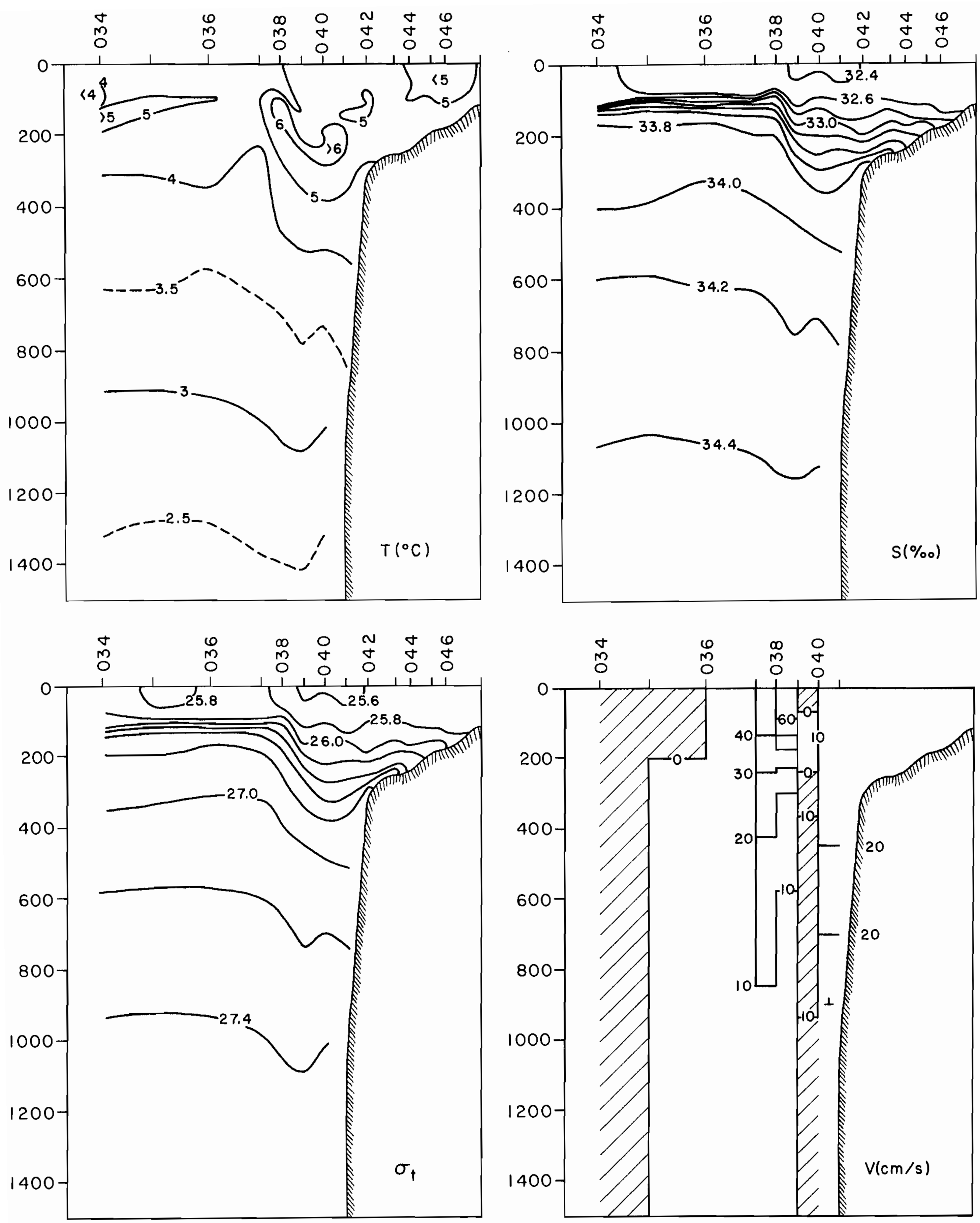

Figure 13. Vertical sections for CTD line II, casts 034-047 (16-17 February 1980)

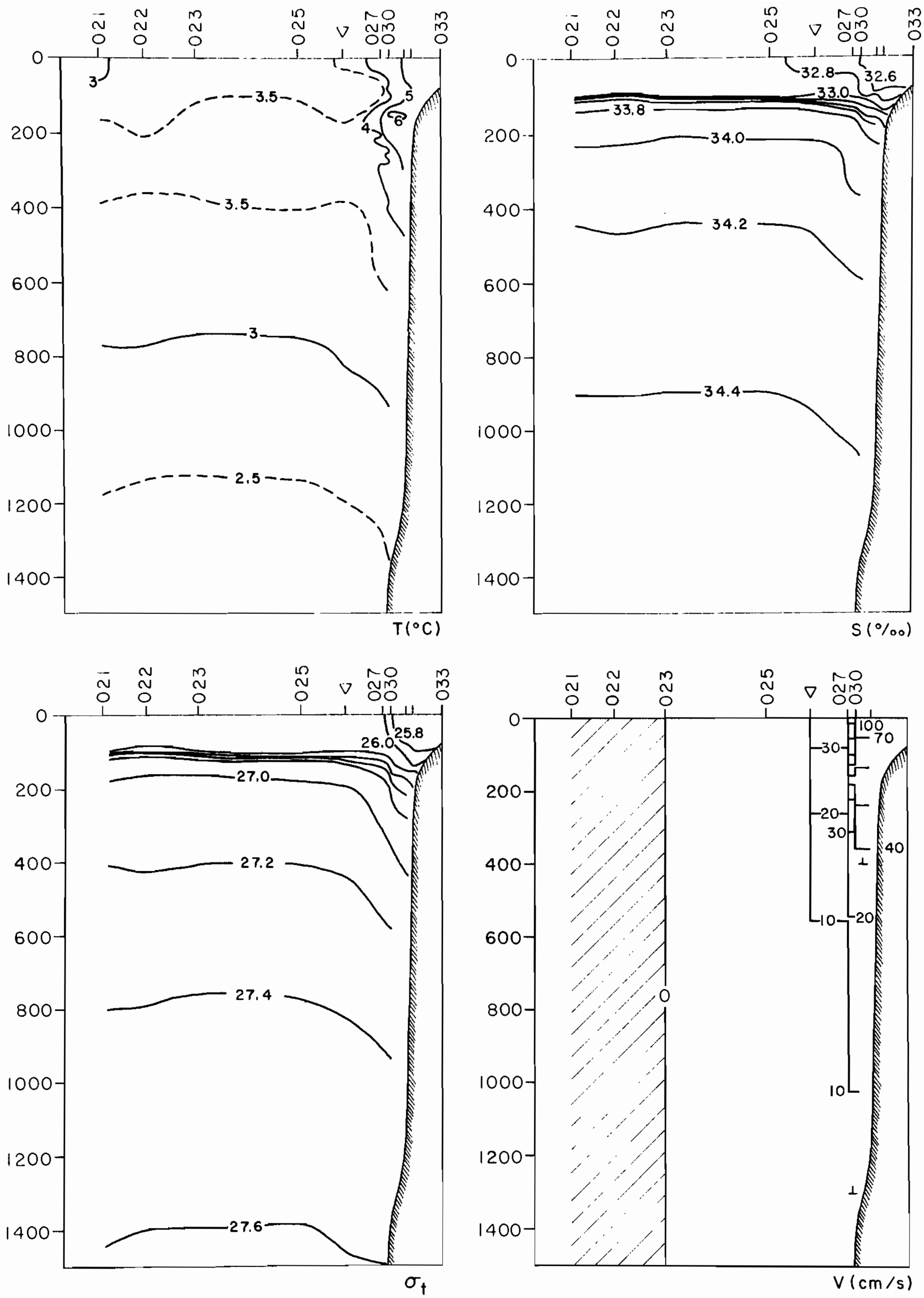

Figure 14. Vertical sections for CTD line III, casts 021-033 (13-15 February 1980).

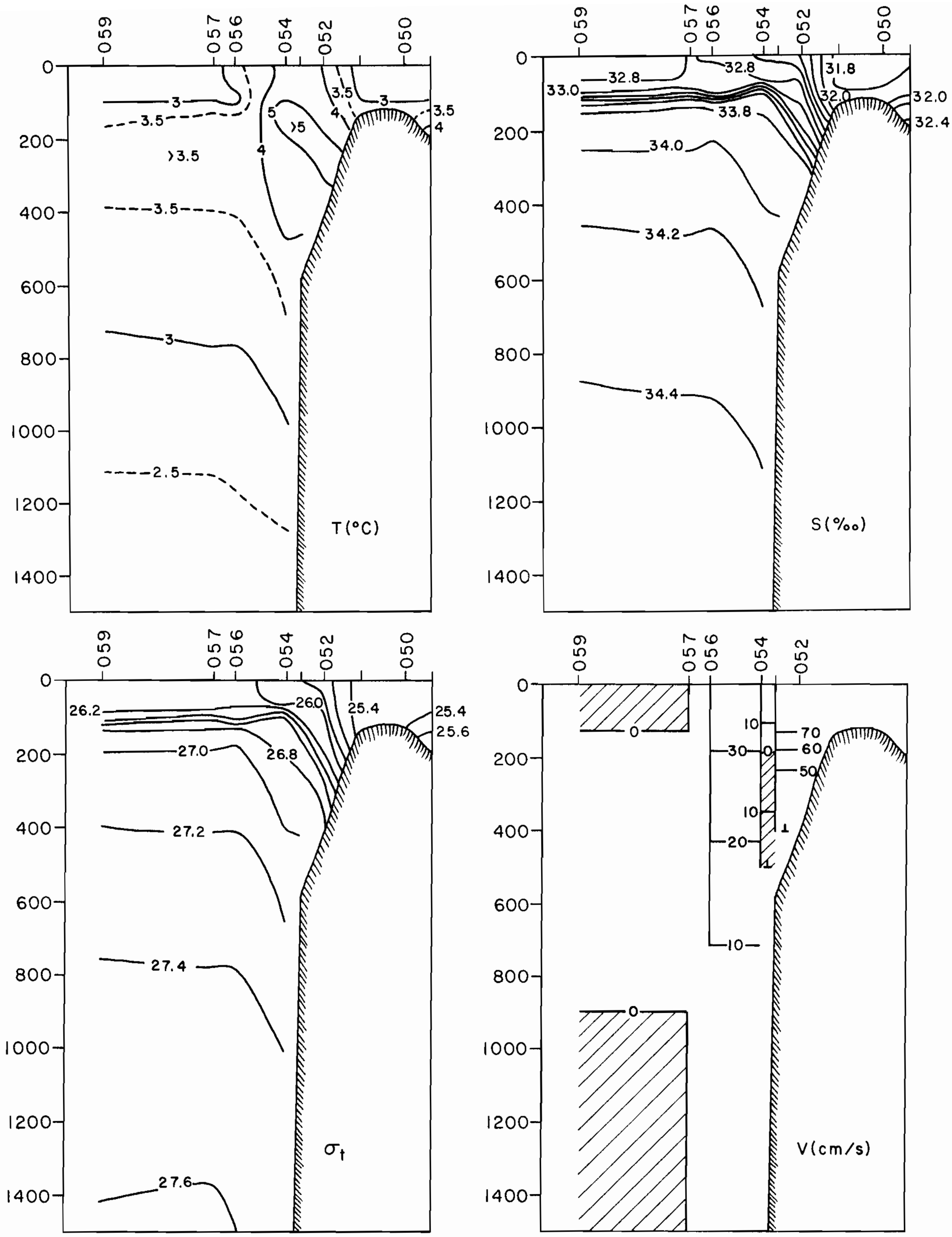

Figure 15. Vertical sections for CTD line IV, casts 049-059 (22-23 February 1980).

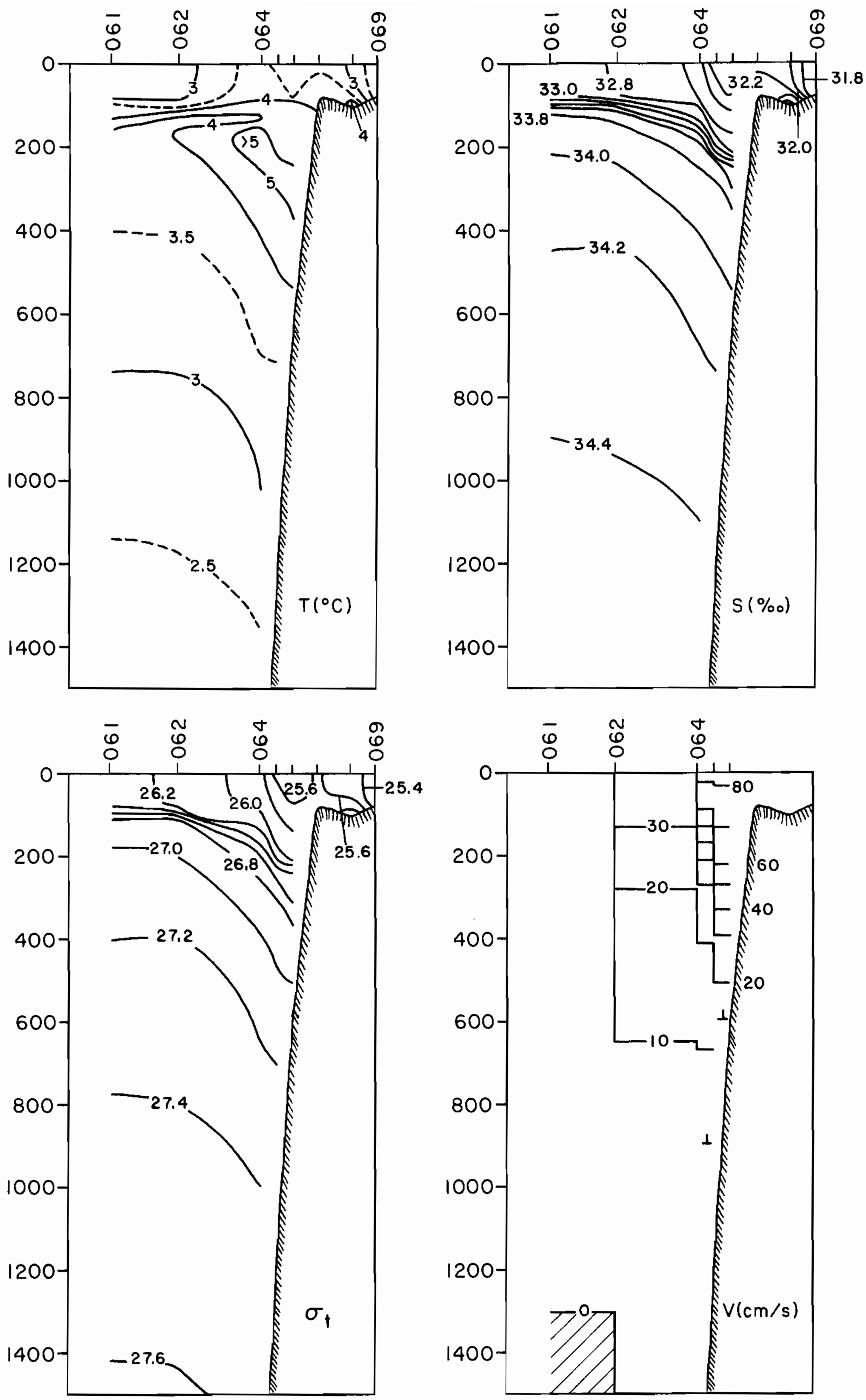

Figure 16. Vertical sections for CTD line V, casts 061-069 (24-25 February 1980).

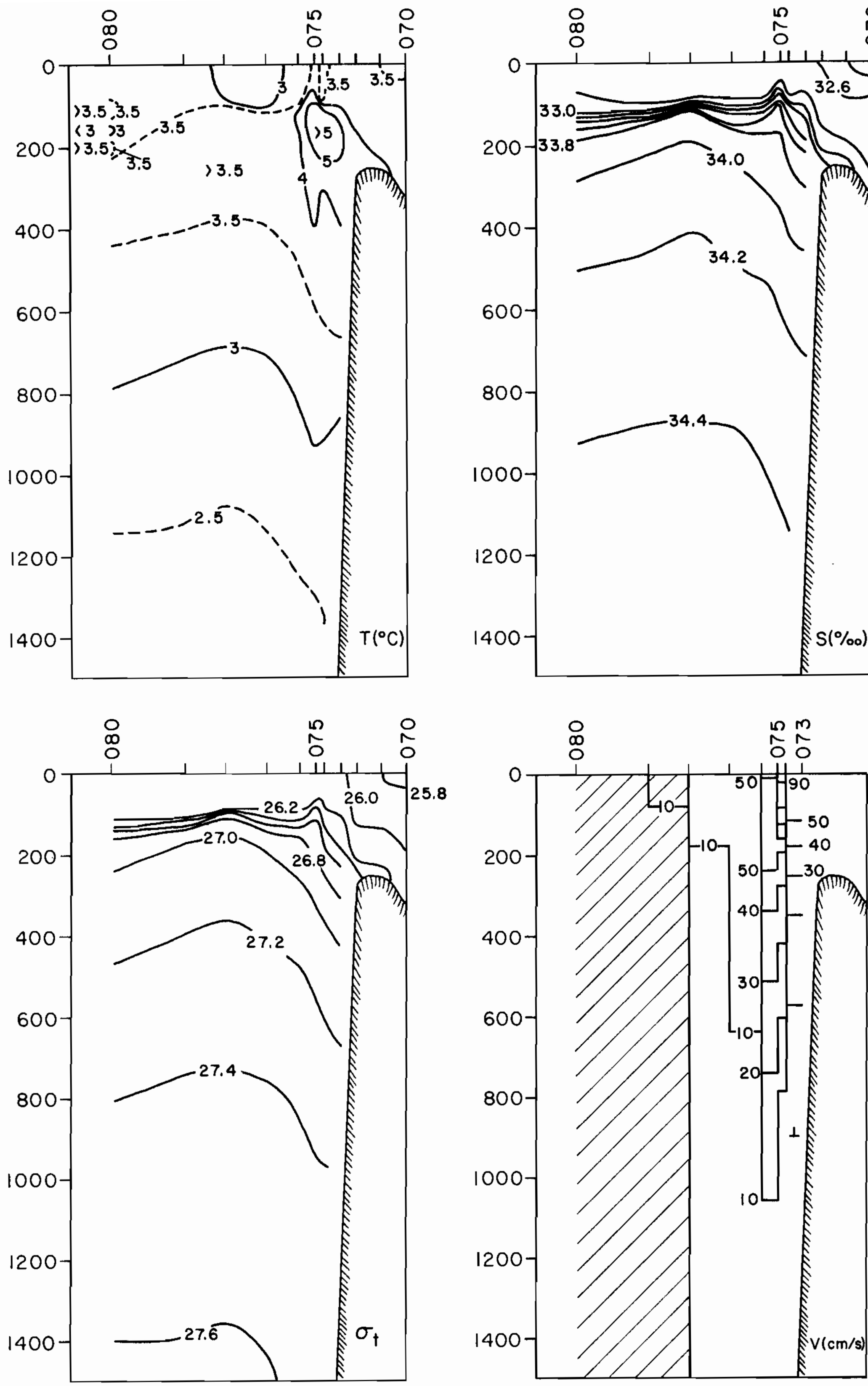

Figure 17. Vertical sections for CTD line VI, casts 070-080 (26-27 February 1980).

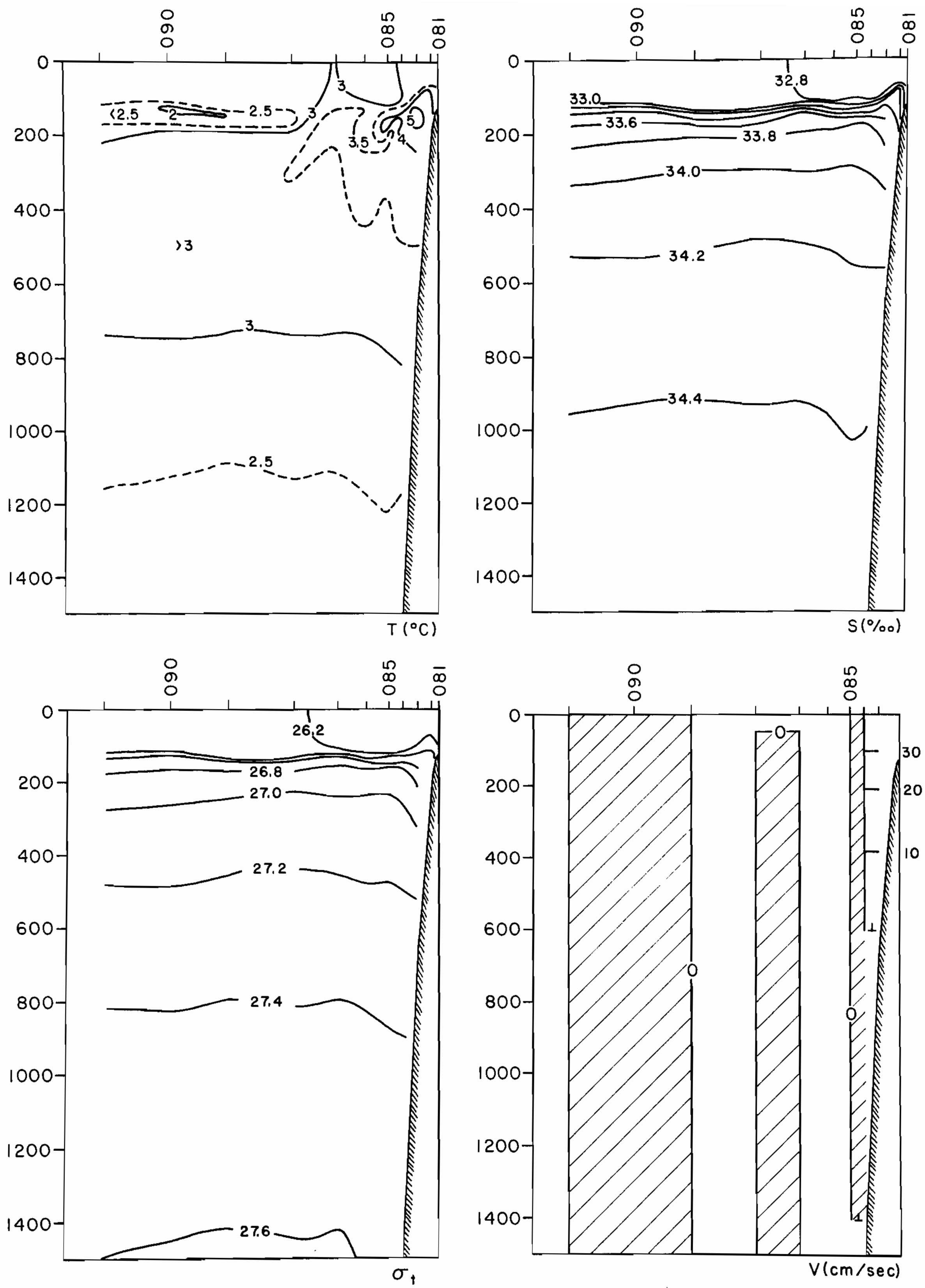

Figure 18. Vertical sections for CTD line VII, casts 081-091 (28-29 February 1980).

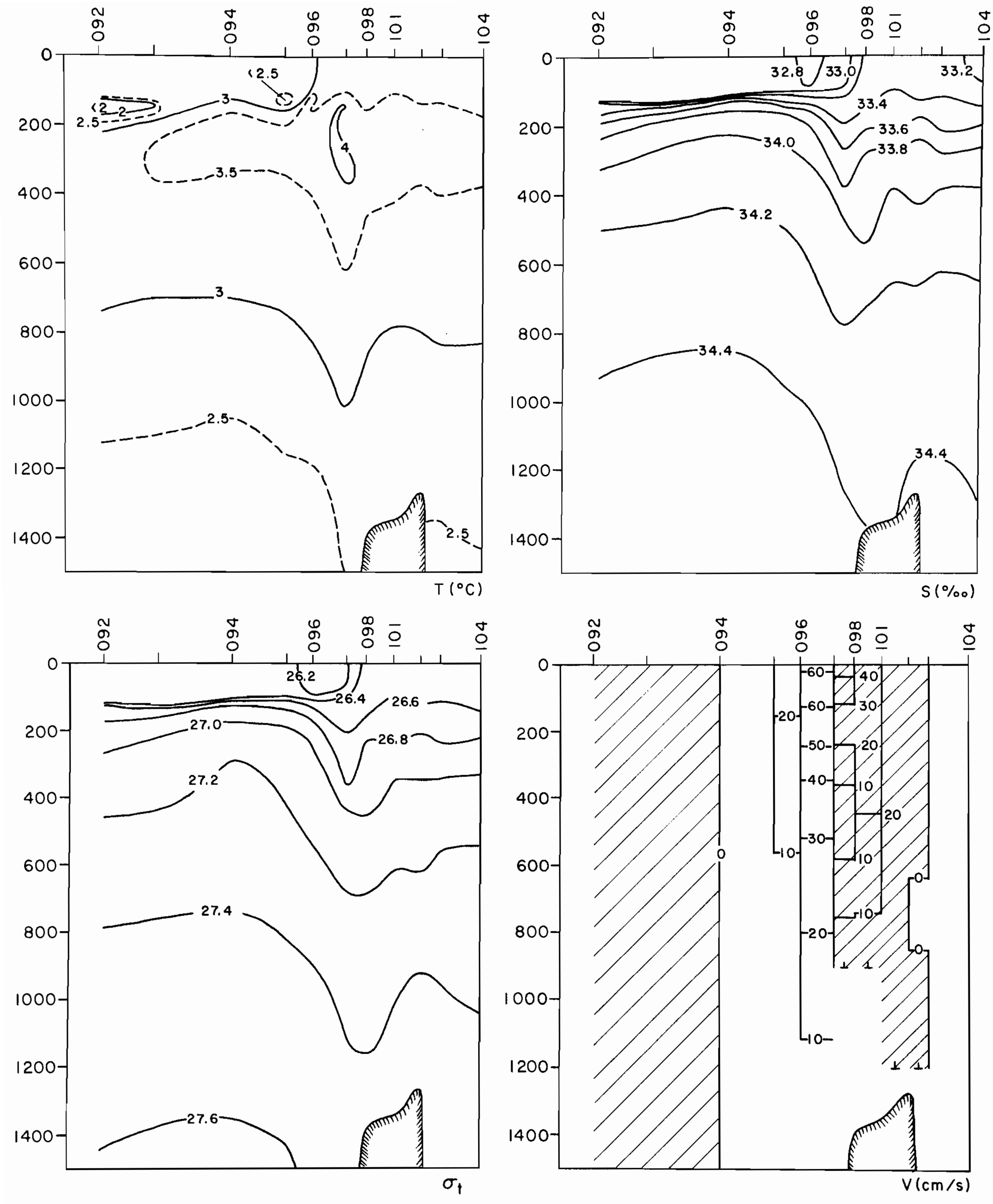

Figure 19. Vertical sections for CTD line VIII, casts 092-104 (1-3 March 1980).

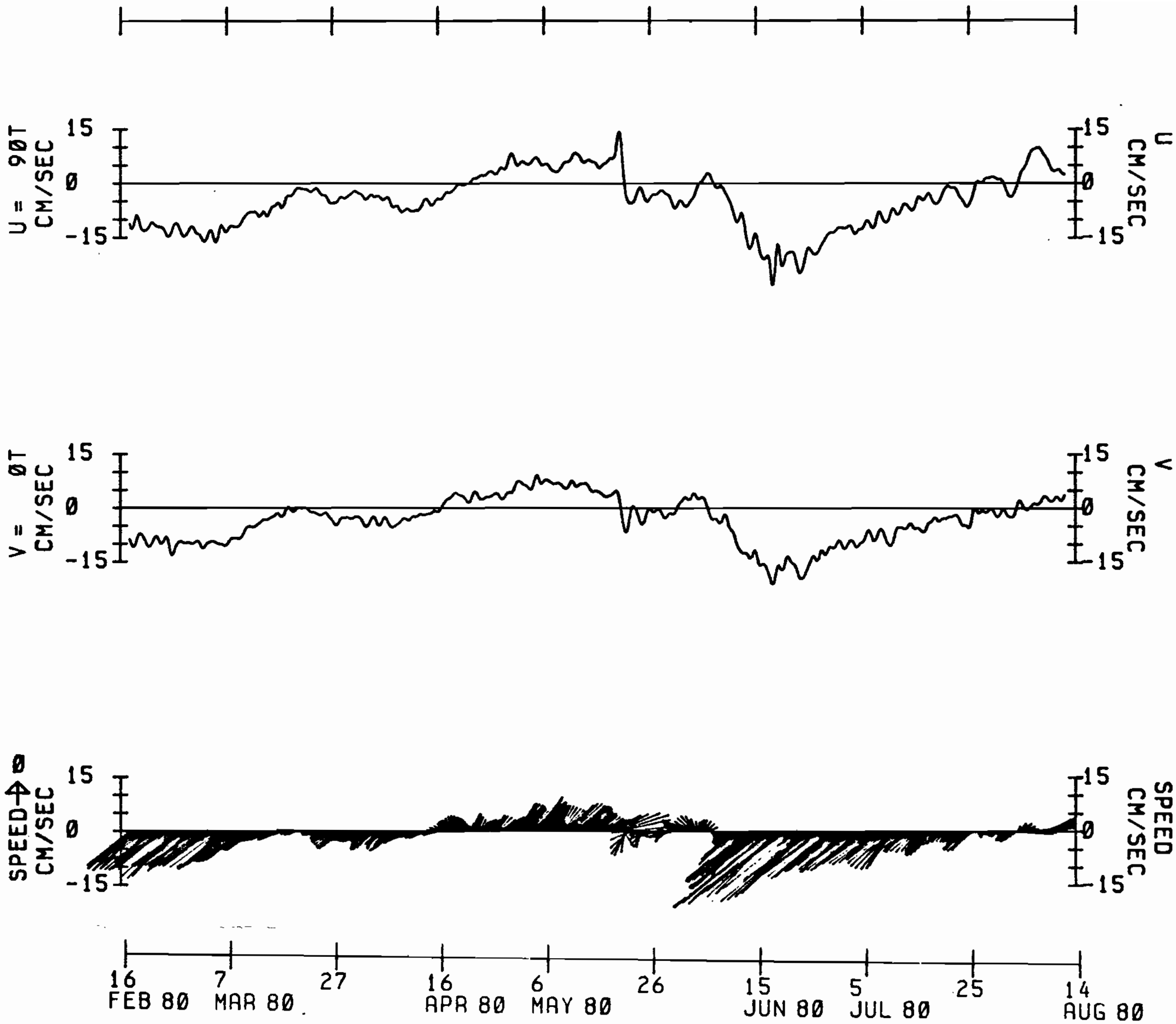

Figure 20. Current velocities (u-components, v-components, and net daily current vectors) at 980 m depth, mooring AS-1.

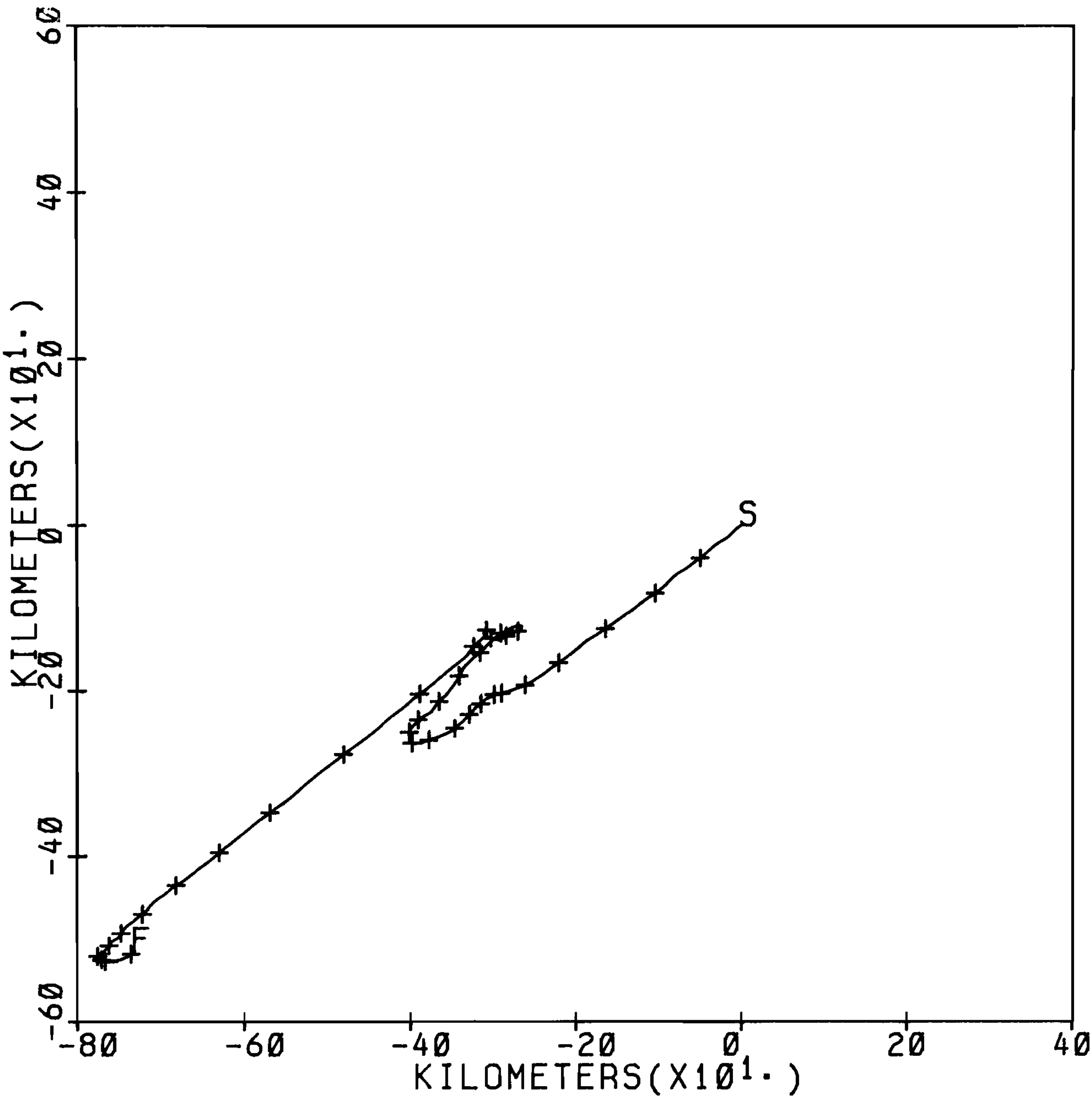

Figure 21. Progressive vector diagram for current data at 980 m depth, mooring AS-1. Start of record and finish are shown by S and F. Five-day intervals are shown by crosses.

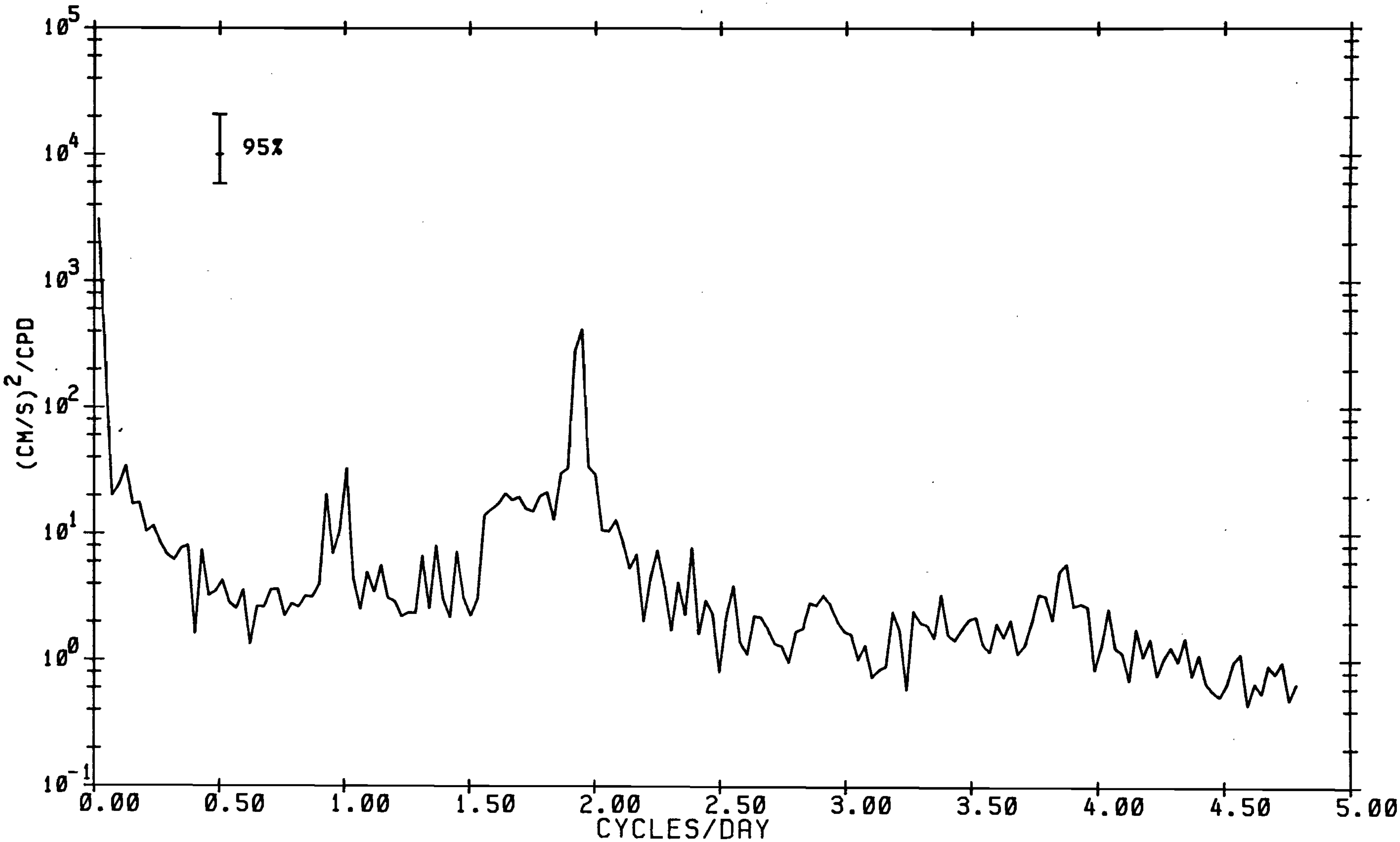

Figure 22. Total kinetic energy spectra for current data at 980 m depth, mooring AS-1; 2.9-hour filter applied to 181-day record; 20 degrees of freedom.

Acknowledgments

R. Reed (Chief Scientist during the cruise) and J.D. Schumacher gave much appreciated guidance in the preparation of this report.

This study was supported in part by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration under which a multiyear program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) office.

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