NOAA Technical Memorandum NMFS-AFSC-8

Winter Oceanographic Conditions in the Eastern Gulf of Alaska, January-February 1986

by
Bruce L. Wing

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

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U.S. DEPARTMENT OF COMMERCE
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January 1993

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ABSTRACT

In 1986, Eastern Gulf of Alaska oceanographic conditions in January-February (the beginning of the Pacific halibut *(Hippoglossus stenolepis)* and sablefish *(Anoplopoma fimbria)* spawning period) were determined from 32 stations east of long. 140°W between lat. 56°N and lat. 58°N. A well-mixed surface layer characterized by temperatures near 6°C and salinities of 32.25-32.75% was present throughout most of the study area. West of the continental slope, this surface layer extendedto the permanent pycnocline at 50-150 m. The pycnocline was weakest over the continental slope and absent over the continental shelf. Below the pycnocline to 1,000 m, temperatures decreased from 6.0°C to less than 3.5°C and salinities increased from 33.75% to greater than 34.25%.

A northward-flowing subsurface current was present along the continental slope at or below the pycnocline. This current was distinguished by weak thermal maxima from 6.5° to 7.0°C at 125-150 m. These core temperatures diminished from south to north. The eastern boundary of the current appeared to be the continental slope. I hypothesizes that this subsurface current is the Haida Current whose surface manifestation was erased by the storm and terrestrial runoff conditions of the 1985-86 winter.

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CONTENTS

INTRODUCTION

Currents of the eastern Gulf of Alaska flow north from the Queen Charlotte Islands, B.C., toward Prince William Sound, Alaska, before converging to form the westward flowing Alaskan Stream. The Alaska Current, a weak eastern boundary current seaward of the continental shelf, is typically several hundred kilometers wide. Over the continental slope and shelf, large topographic features, freshwater runoff, coastal winds, and atmospheric pressure gradients produce localized currents, mesoscale eddies, and meanders. The resultant baroclinic features may be intermittent and of short duration (e.g., Glacier Bay Plume extension; Wing 1979), seasonal (e.g., Haida Current; Thomson and Emery 1986), or persist for more than a year (e.g., Sitka Eddy; Tabata 1982). Interannual variability of the strength and duration of these features may contribute to variations in Southeast Alaska salmonid (Oncorhynchus spp.) migration patterns (Hamilton and Mysak 1986) and to year-class strength of groundfish along the British Columbia and Alaska coasts (Tabata 1982; Thomson and Emery 1986; Karinen and Wing 1987).

Systematic observations of oceanographic variables in the Gulf of Alaska during December through March have been infrequent, with few stations sampled east of long. 140°W and over the continental shelf between lat. 54° and 59°N (Tabata 1982). This area of the Gulf of Alaska includes important winter spawning grounds of Pacific halibut, *Hippoglossus* stenolepis (Thompson and van Cleve 1936), and sablefish, *Anoplopoma fimbria* (Bracken 1982). Sablefish spawn from January to March along the British Colombia continental slope (Kendall and Matarese 1987); and probably the same or slightly later in Southeast Alaska. Because the spawning biology of sablefish and the oceanography of this critical habitat are not understood, the January-February 1986 cruise of the NOAA research vessel *Miller Freeman* investigated oceanographic conditions and the reproductive state of sablefish at the beginning of their spawning season. Examination of trawl-caught sablefish during the cruise revealed that few female sablefish had reached spawning condition. Plankton sampling (neuston tows and oblique bongo net tows to 300 m) during the cruise captured no sablefish larvae and only 2 sablefish eggs. This report presents results of conductivity-temperature-depth (CTD) profile observations during the cruise, giving evidence for the absence of the Sitka Eddy in January 1986 and the presence of a warm northward-flowing subsurface current along the continental slope.

DATA AND METHODS

Seven days (28 January through 3 February 1986) were devoted primarily to oceanographic profiling and ichthyoplankton sampling east of long. 139°30'W between lat. 56°30' and 58°OO'N. Thirty-two stations were positioned on a 30' longitude by 30' latitude grid (Fig. 1) to provide coverage of both the continental shelf and the assumed Sitka Eddy area.

Oceanographic profiles were obtained with Plessey Model 6040' CTD units and recorded on nine-track data tapes and analog strip charts. The quality of CTD observations was monitored throughout the cruise by sampling with Niskin bottles equipped with reversing thermometers. The CTD casts were made to 1,000 m at stations beyond the continental shelf break and to within 10-15 m of the sea bottom (sea conditions permitting) over the continental shelf.

The CTD data tapes were analyzed for computation of salinity, temperature., density (measured as sigma-t), and dynamic height values by the National Ocean Service, Ocean Assessments Division, Alaska Office. Specialized computer programs were used to graph salinity, temperature, and sigma-t profiles with l-m resolution for each station (Appendix); salinity, temperature, and sigma-t sections for each east-west transect; and contour plots of sea surface temperature and dynamic height topography.

RESULTS

During the survey, surface waters were generally well mixed with isopycnal conditions from the surface to 50-150 m. Beyond the continental shelf, mixed-layer temperatures were 5.7°-6.3°C, salinities were 32.50-32.75%, and sigma-t was less than 25.75 (Figs. 2-5). Below the surface layer was a strong pycnocline characterized by a 1% salinity increase over approximately 50 m. Weak subsurface temperature maxima of 6.5°-7.1°C at or near the pycnocline were observed at most stations beyond the continental shelf break. Along the continental slope, the pycnocline was not as sharply defined as it was further offshore. Below the pycnocline, temperatures decreased with depth to a low of about 3.5°C, salinities increased to near 34.30%, and sigma-t increased to between 27.26 and 27.45 at 900-1,000 m.

'Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

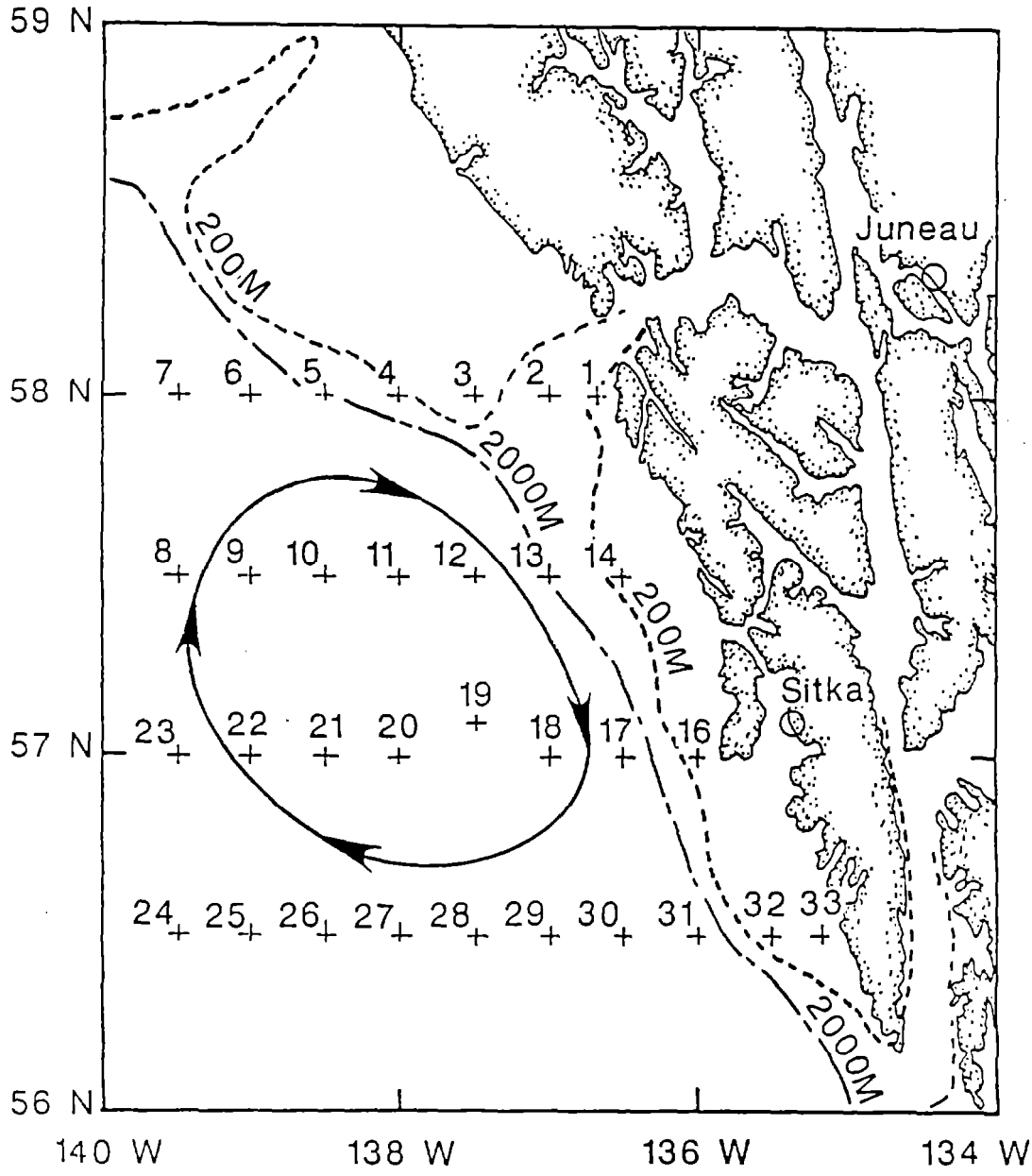

Figure 1. --Location of oceanographic stations occupied by the RV Miller Freeman, 27 January-4 February 1986. (--- = 200 m contour, -- = 2,000 m contour, ⟶ = Sitka Eddy, when present.)

Visual examination of the east-west sections (Figs. 2-5) did not reveal evidence of the Sitka Eddy during the survey period. The Sitka Eddy is characterized by a warm temperature core with a strong depression of the halocline and pycnocline at the center of the eddy (Tabata 1982). Sea-surface property contours (Fig. 6) and dynamic height contours (Fig. 7) do not show evidence of the eddy. The dynamic height contours indicated a general northwesterly flow at 0, 150, and 300 m.

The most prominent oceanographic feature during the cruise was a subsurface current flowing northwest along the continental slope. This current was evident by relatively warm (6.5°-7.1°C) thermal maxima at about 125-150 m (Figs. 2-5). At stations nearest to the continental slope, the thermal maximum appeared to be associated with the top. of the pycnocline at the 25.75 sigma-t surface; although farther offshore the maxima were closer to the 26.2 sigma-t surface. Core temperatures within this current decreased from south to north. The dynamic height anomaly of the 150 decibar surface relative to the 1,000 decibar surface (Fig. 7B) shows this current was strongest at about long. 137°W. The subsurface current did not intrude onto the shelf, thus the continental slope appears to form its eastern boundary. The western boundary of the current may be 80-90 km west of the shelf break where salinity and sigma-t contours rise slightly toward the surface. Because CTD casts were to a maximum depth of only 1,000 m, and stations were approximately 30 km apart along the transects, it was not possible to define a surface of no motion from which to determine the velocity of this current. If levels of no motion are assumed at 900 m at lat. 56°30'N and 500 m at lat. 57°30'N, I estimate current velocities of 32 and 19 cm/sec, respectively.

DISCUSSION

Sitka Eddy

The Sitka Eddy may form as early as January-February or as late as June-July (Mysak 1985). Although the eddy does not form each year, it may have a life span of 10 to 17 months when present (Tabata 1982). Initially the Sitka Eddy could transport planktonic eggs and larvae offshore and eventually return them to the area near the point of entry. In the absence of the Sitka Eddy, any transport of sablefish eggs and larvae away from suspected spawning areas is probably a result of currents along the upper continental slope.

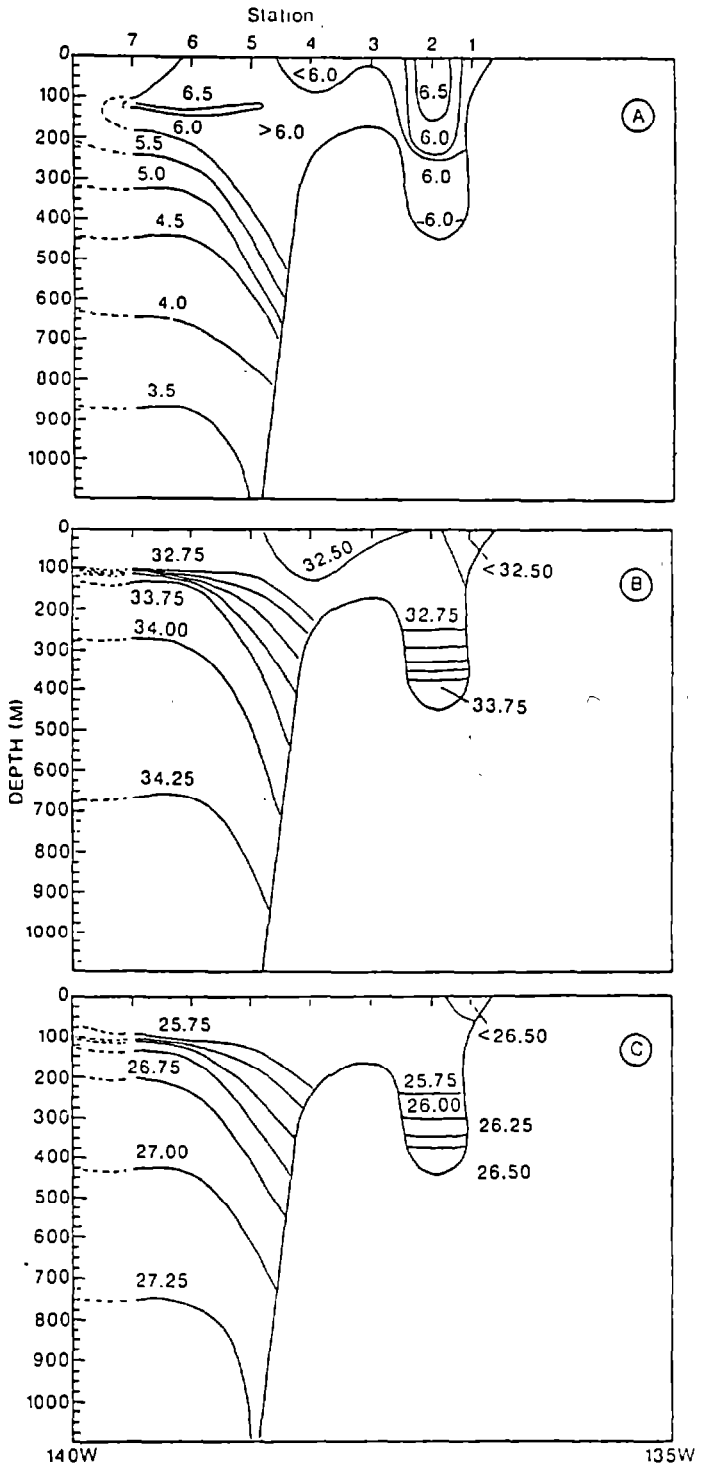

Figure 2. --Contours of temperature (A), salinity (B), and density as sigma-t (C) along section at lat. 58°00'N, January 1986.

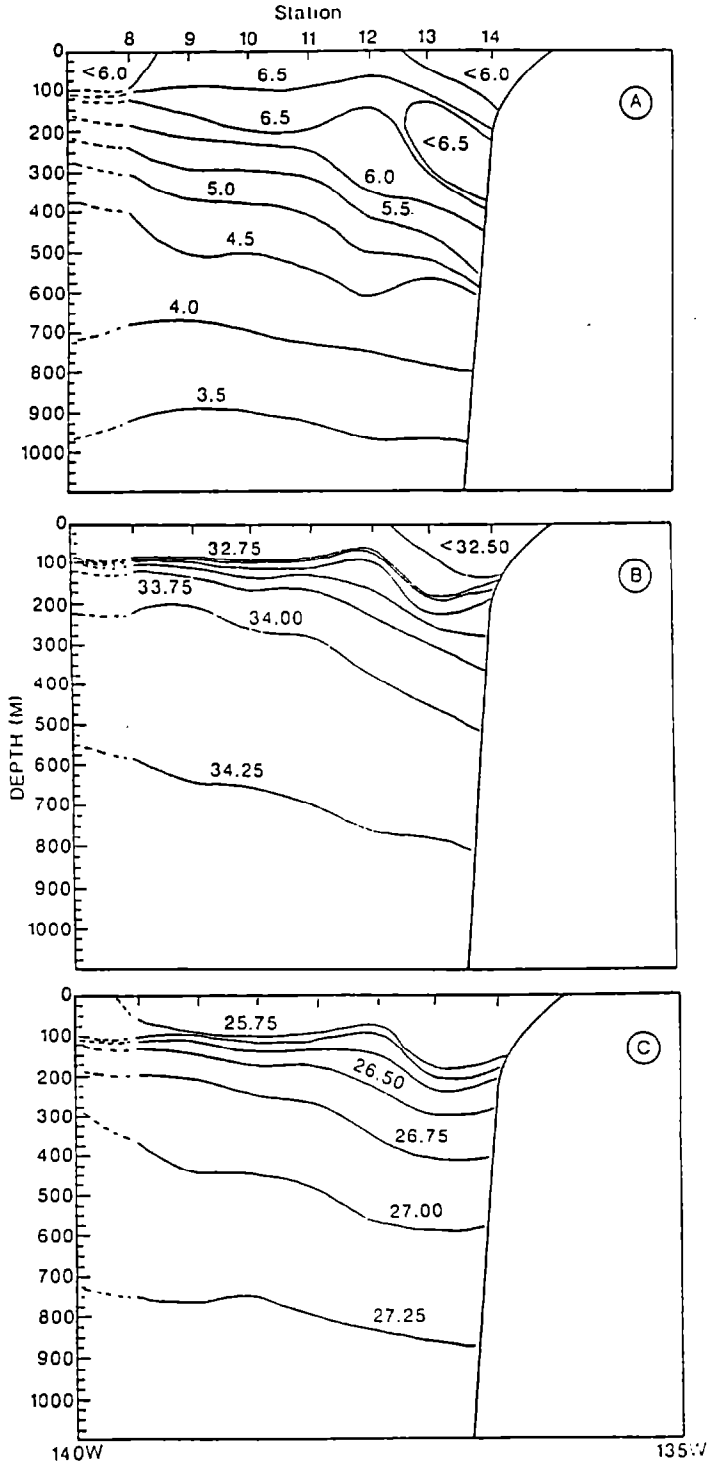

Figure 3. --Contours of temperature (A), salinity (B), and density as sigma-t (C) along section at lat. 57°30'N, January 1986.

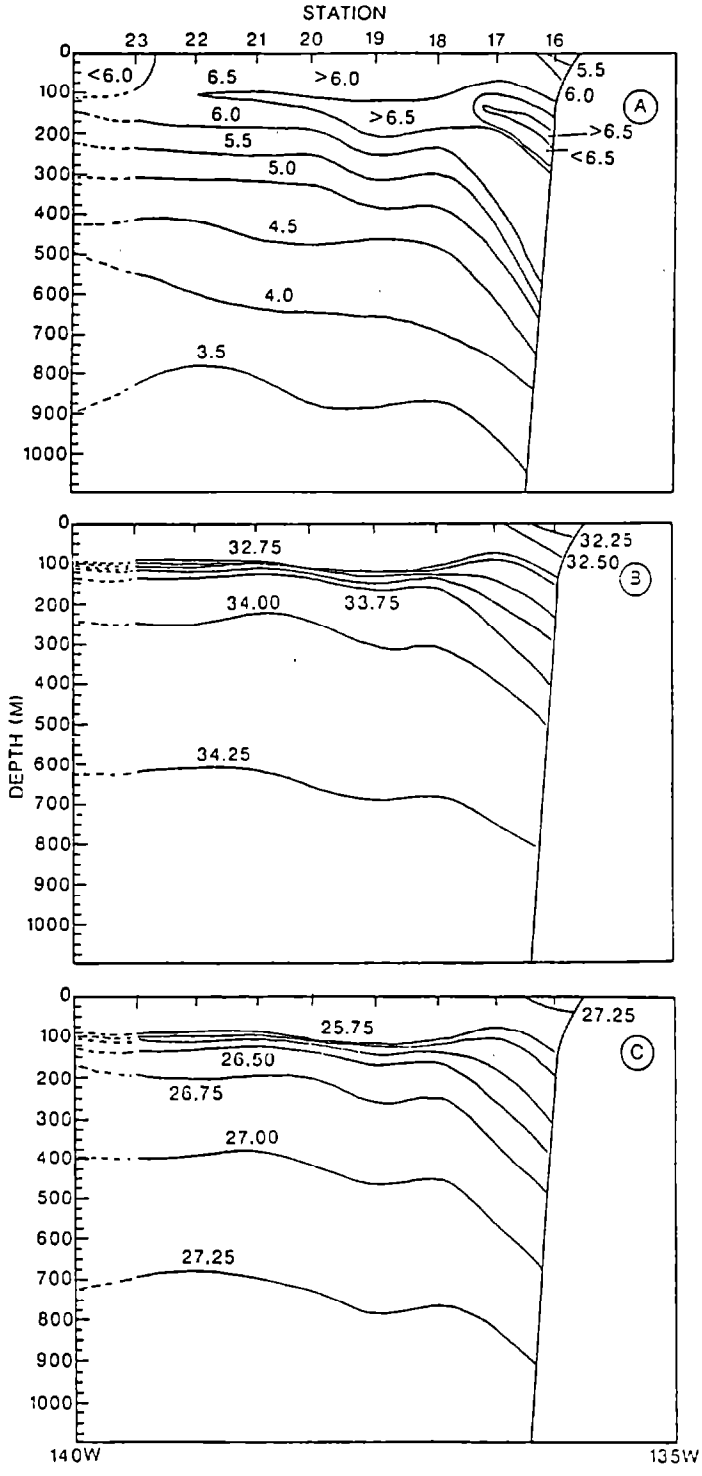

Figure 4.--Contours of temperature (A), salinity (B), and density as sigma-t (C) along section at lat. 57°00'N, January 1986.

a

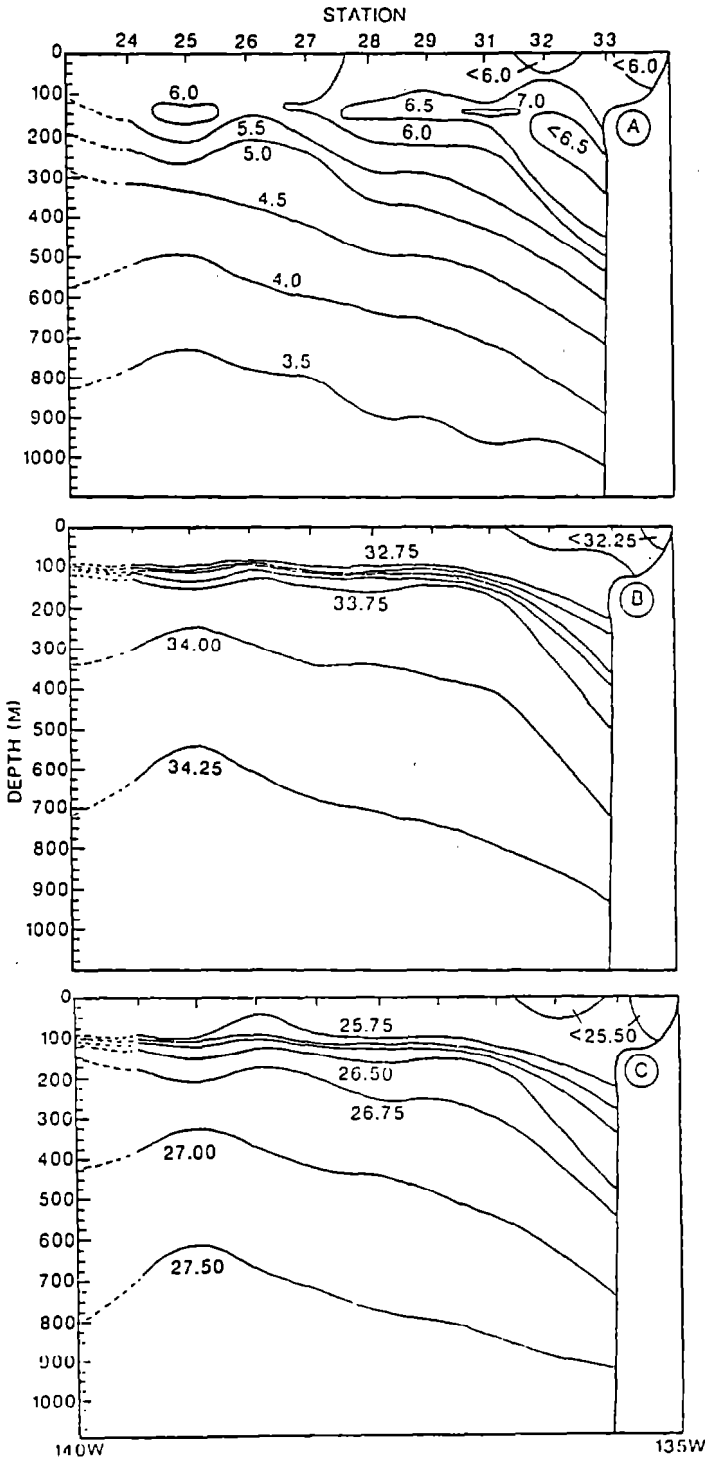

Figure 5. --Contours of temperature (A), salinity (B), and density as sigma-t (C) along section at lat. 56°30'N, January-February 1986.

The most recent intensive coverage of the southeastern Alaska coast was the Gulf of Alaska Survey (GAS) by the United Stated Coast Guard vessel *Campbell* in September 1976. Eleven transects (118 stations) were surveyed between the Queen Charlotte Islands, British Columbia, and Yakutat, Alaska. The Sitka Eddy may have been present in September 1976, as shown by depressed salinity and sigma-t contours on three transects between Sitka and Cape Spencer, Alaska, although the warm core was not present.

Source of Subsurface Current

The subsurface slope current present in January-February 1986 may be a seasonal feature of the eastern Gulf of Alaska and the Alaska Current, or, like the Sitka Eddy, may be intermittent. The subsurface maxima which characterize the slope current were not present in the GAS data, but they have been noted in winter profiles from the eastern Gulf of Alaska (Robinson 1957). Similar phenomena are observed in the western Gulf of Alaska[3]. There are neither sufficient seasonal nor historical data to definitively identify the origin of the warm water along the continental slope in January 1986. Possible sources are the California Undercurrent, the Alaska Current, and the Haida Current.

California Undercurrent

The California Undercurrent does not appear to be a likely source, although it is believed to flow with the Alaska Current from Canada to the Aleutian Islands (Reid 1965). The California Undercurrent has been identified as far north as Dixon Entrance (Gardner 1982) and may contribute to the Alaska Coastal Current (Cooney and Coyle 1985). Wooster and Jones (1970) and Gardner (1982) report the California Undercurrent's warm, high salinity, low oxygen core to be associated with the 26.54 sigma-t surface at approximately 200-250 m. Although the California Undercurrent may surface in the winter as the Davidson Current, its salinities appear to be too high to be the Alaskan subsurface current, which has a core at about the 25.8 sigma-t suface.

---

[2]USCG Oceanographic Unit, unpubl. data. 1977. Washington, D.C. USCG Oceanographic Unit Bldg. 159 E. Navy Yard Annex, Wash. D.C. 20590.

[3]Dr. D. Musgrave, School of Fisheries and Ocean Sciences, Univ. of Alaska Fairbanks, 905 Koyukuk Ave., Fairbanks, AK 99775-1080, pers. commun., August 1991.

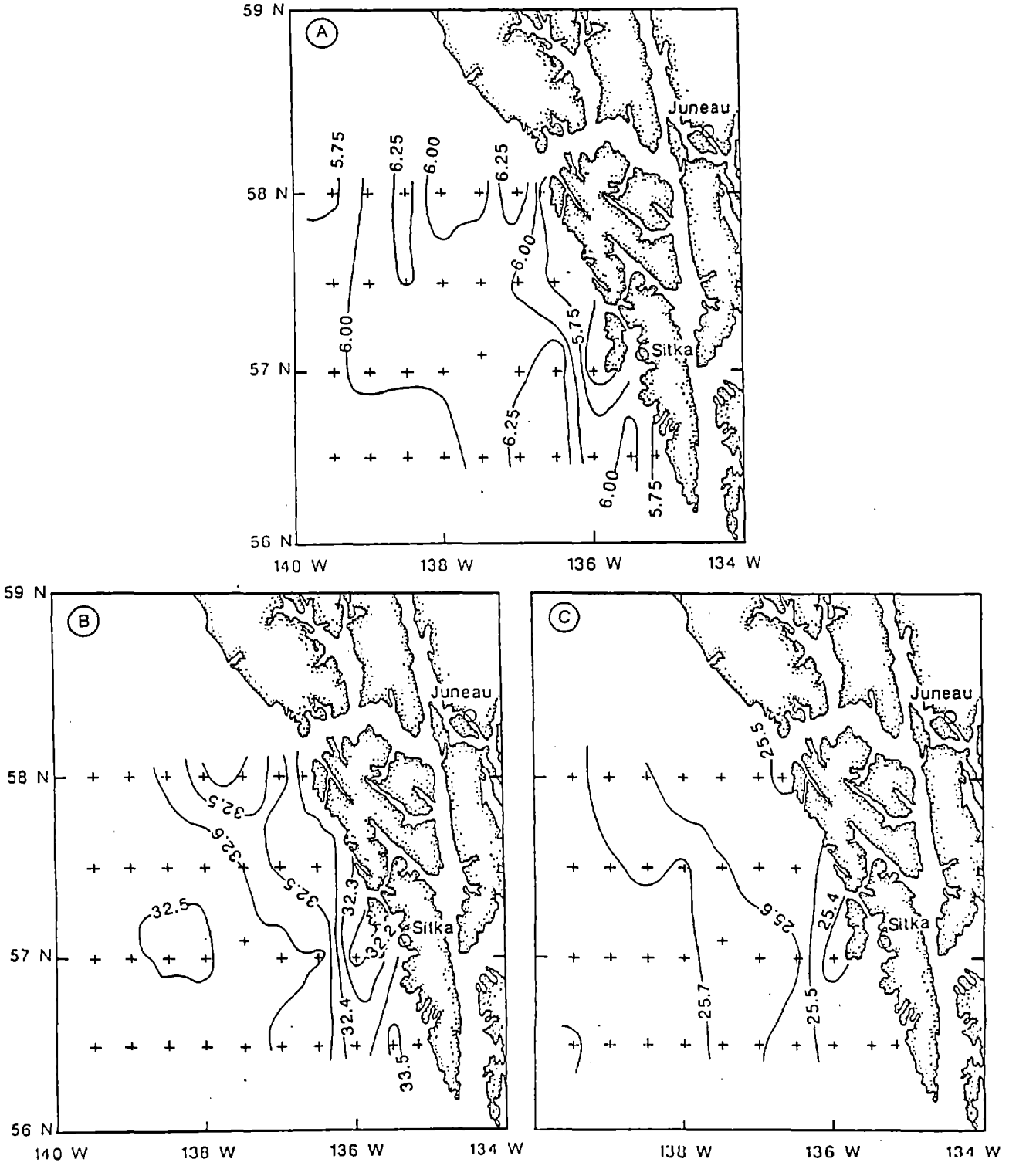

Figure 6.--Contours of surface terperature (A), surface salinity (B), and surface density as sigma-t (C), January-February 1986.

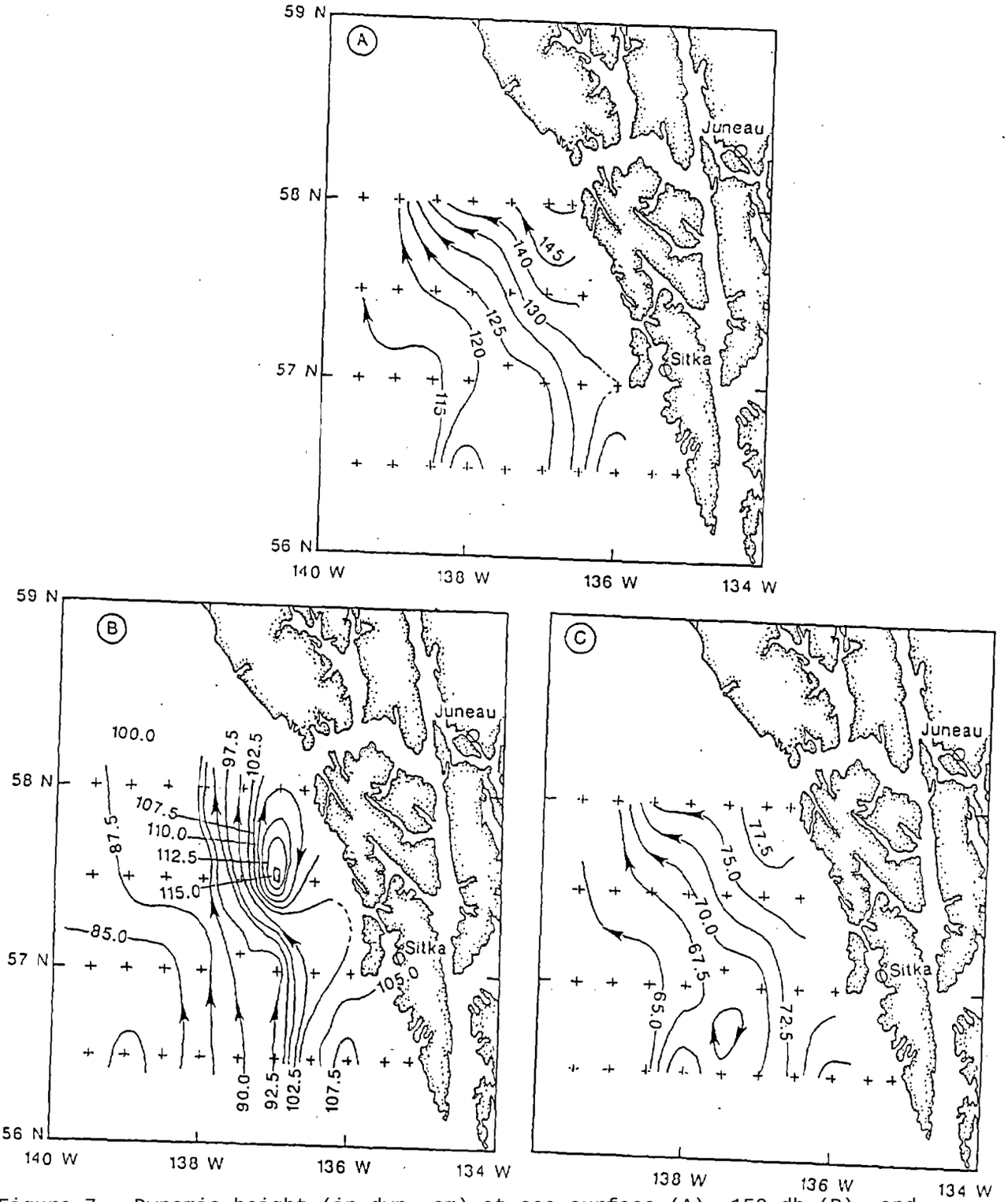

Figure 7.--Dynamic height (in dyn. cm) at sea surface (A), 150 db (B), and 300 db (C); relative to the 1000 db surface, January-February 1986.

Maska Current

The Alaska Current is a relatively weak, broad current flowing northward beyond the continental shelf and forming the eastern boundary of the Alaska Gyre. The Alaska Current draws its surface thermal and salinity properties from the eastern Subarctic Current and Dilute Domain of Favorite et al. (1976). During much of the spring and summer, it can be recognized as a warm, high salinity tongue extending northward along the 26.2 sigma-t surface (Barkley 1968) and at the surface as an offshore warm water tongue. This warm-water tongue associated with the Alaska Current has an axis 160-480 km offshore, and is present in all months (Robinson 1957). In the winter, the warm-water tongue is evident as a positive thermal gradient near 125 m. Robinson's winter thermal profiles of the Alaska Current are most similar to the profiles observed in January-February 1986 at those stations 80-160 km offshore. Published data are too sparse to determine if the subsurface slope current is a winter intensification of the Alaska Current, although the sharp decline of the pycnocline between stations 12 and 13 (Fig. 3C) and between stations 30 and 31 (Fig. 5C) may mean that the two currents are separate and that, on the average, the Alaska Current was centered 80 km west of the slope subsurface current.

Haida Current

The subsurface current observed in January-February 1986 may be the Haida Current described by Thomson and Emery (1986). Thomson and Emery (1986) do not detail the subsurface characteristics of the Haida Current or its relationship to the Alaska Current. The Haida Current is a warm-cored surface current originating off the northern Queen Charlotte Islands. Near-surface temperatures in the Haida Current core may be up to l°C above with salinities 0.1% below ambient levels within the upper 100 m. It flows northward along the continental slope to at least the southern edge of the 1986 survey area and may extend to Yakutat, Alaska. The Haida Current appears to be only 20-30 km wide, extending from the surface to about 500 m. It develops during the winter between October and April and has its maximum flow (15-25 cm/sec) from November through February. When present, the Haida Current occupies approximately the same position as the warm-cored subsurface current in the 1986 data.

The 0.5°-l°C surface temperature elevation of the Haida Current was not present in 1986. The 30-km interval of our stations, however, may have missed the narrow surface manifestation of the Haida Current. Additionally, as the Haida Current flows northward, it will mix with surrounding waters and have a weaker surface signature at its northern extent. Alternatively, strong storm conditions providing heavy freshwater runoffs from the adjacent coastal areas may have diluted the surface signature of the Haida Current. Ingraham

(1979) indicates that in the summer, coastal dilution extends throughout the survey area. Although coastal dilution is usually minimal during the winter, the months preceding the January-February 1986 survey were characterized by above average temperatures and precipitation (DOC 1986, 1987). December 1985 and January 1986 had record or near-record high runoffs that exceeded the average peak spring runoffs (VanMaanen et al. 1988). These conditions may have resulted in freshwater runoffs equivalent to summer conditions. Strong storms prior to and during the cruise, with concomitant wind mixing, could have produced isopycnal surface conditions, thus removing features of the Haida Current above 100 m.

The Haida Current may have a major influence on the groundfish fisheries of the continental slope area by affecting development and feeding rates of larvae, juveniles, and adult fishes by raising the water temperatures at the upper edge of the slope. The eggs of winter spawning Pacific halibut and sablefish could be carried 15-30 km per day by the current. Sablefish eggs are believed to have an incubation period of 2-3 weeks (Kendall and Matarese 1987); thus, hatching areas could be considerably distant from spawning areas, depending on the strength of the current. Interannual variation of these currents may be one of the factors determining whether or not larval fish are transported to nursery areas.

SUMMARY

In late January and early February 1986, oceanographic conditions in the eastern Gulf of Alaska were characterized by well-mixed surface waters in the upper 50-100 m. Temperatures within the surface layer ranged from 5.5° to 6.3°C, being coldest near shore and at stations farthest offshore. Salinities in this layer were generally 32.50-32.75% offshore and less than 32.50% over the continental shelf. Below the isopycnal surface layer, the permanent pycnocline at 100-150 m was strongest at stations west of the continental slope and weakest over the slope. In the pycnocline, thermal maxima of 6.5°-7.0°C were present. Below the pycnocline, temperature decreased with depth from 6.0° to 3.5°C and salinities increased from 33.75 to 34..30% at 1000 m.

The observed distributions of temperatures and salinities indicate that the Alaska Current was 80-160 km offshore and that a northward flowing subsurface current was present at 100-300 m along the continental slope. The relationship of this subsurface current to the Alaska Current is not known. It may be a subsurface manifestation of the Haida Current, which forms in the winter and flows northward from the Queen Charlotte Islands along Southeast Alaska.

ACKNOWLEDGMENTS

I thank the crew of the NOAA research vessel *Miller Freeman* for courtesies extended during the cruise. Survey Technicians Carol Dewitt and Daniel Dougherty took all the CTD casts and associated physical observations. Dr. David A. Hale, National Ocean Service (Office of Oceanography and Marine Assessment, Ocean Assessments Division, Alaska Office, Anchorage), edited the CTD data tapes and prepared the initial computer graphics displaying the data. Drs. James Schumacher and Ronald Reed of the NOM Pacific Marine Environmental Laboratory and Drs. David Musgrave and Thomas Royer of the Institute of Marine Sciences, University of Alaska Fairbanks, reviewed the manuscript and gave valued suggestions on presentation and interpretation of the data.

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APPENDIX

Depth profiles and data summaries for stations occupied in the eastern Gulf of Alaska, 28 January to 4 February 1986.

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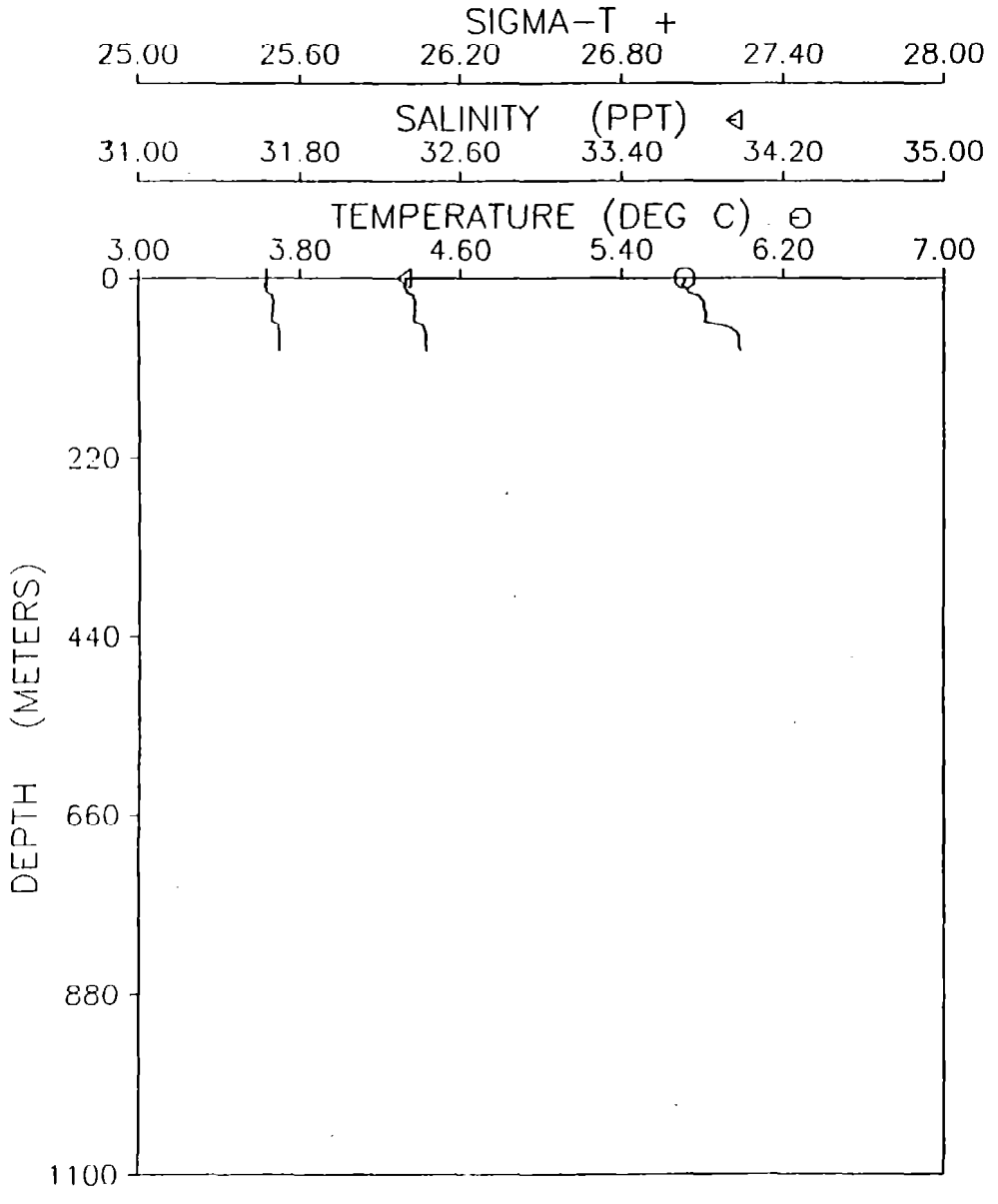
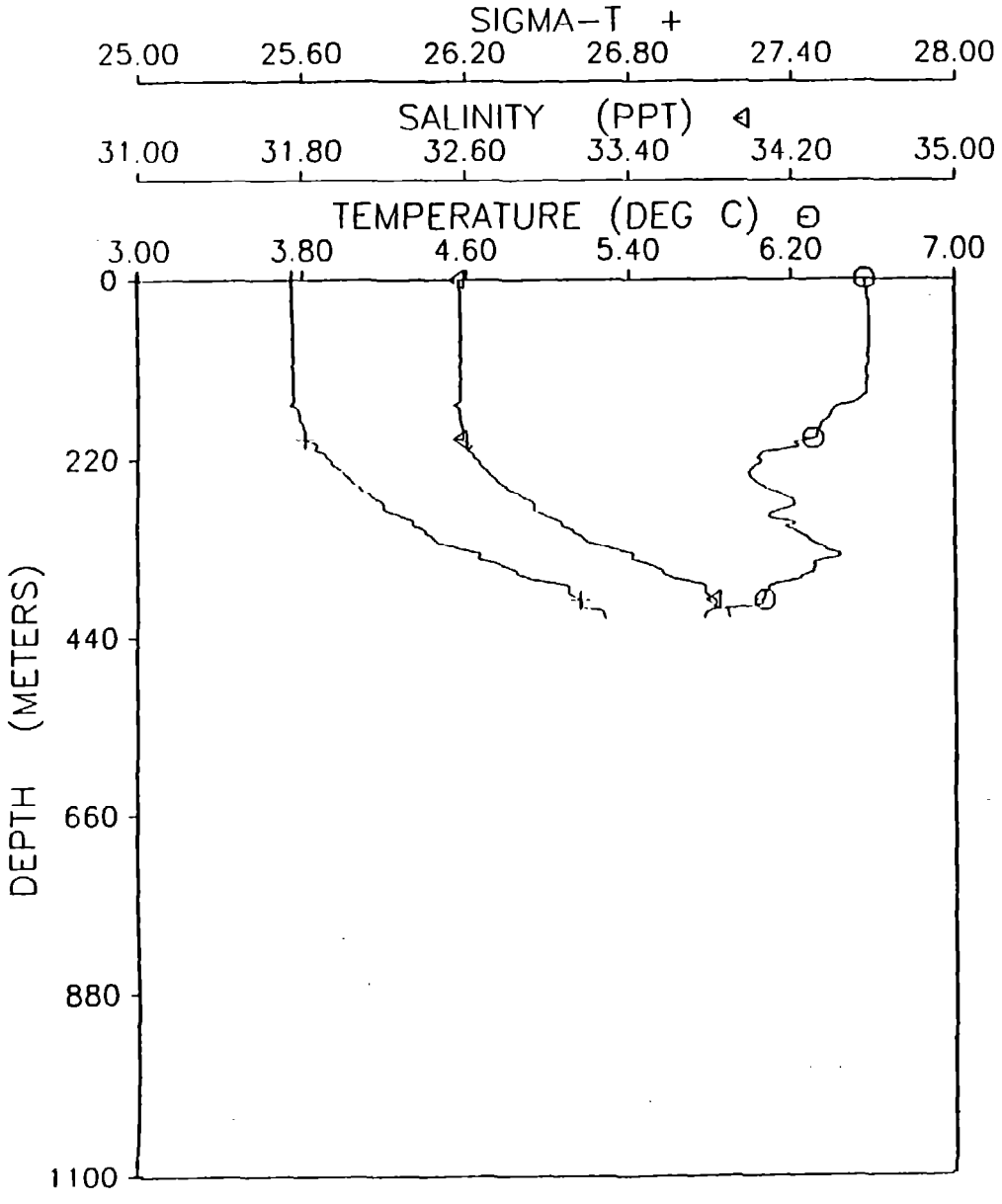


STATION: 1
CAST NUMBER: 0016

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 28 JAN 86
POSITION: 58 0.0 N, 136 40.2 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	5.71	32.33	25.48
10	5.70	32.32	25.47
20	5.77	32.36	25.50
30	5.81	32.38	25.50
50	5.82	32.37	25.50
75	5.98	32.43	25.52

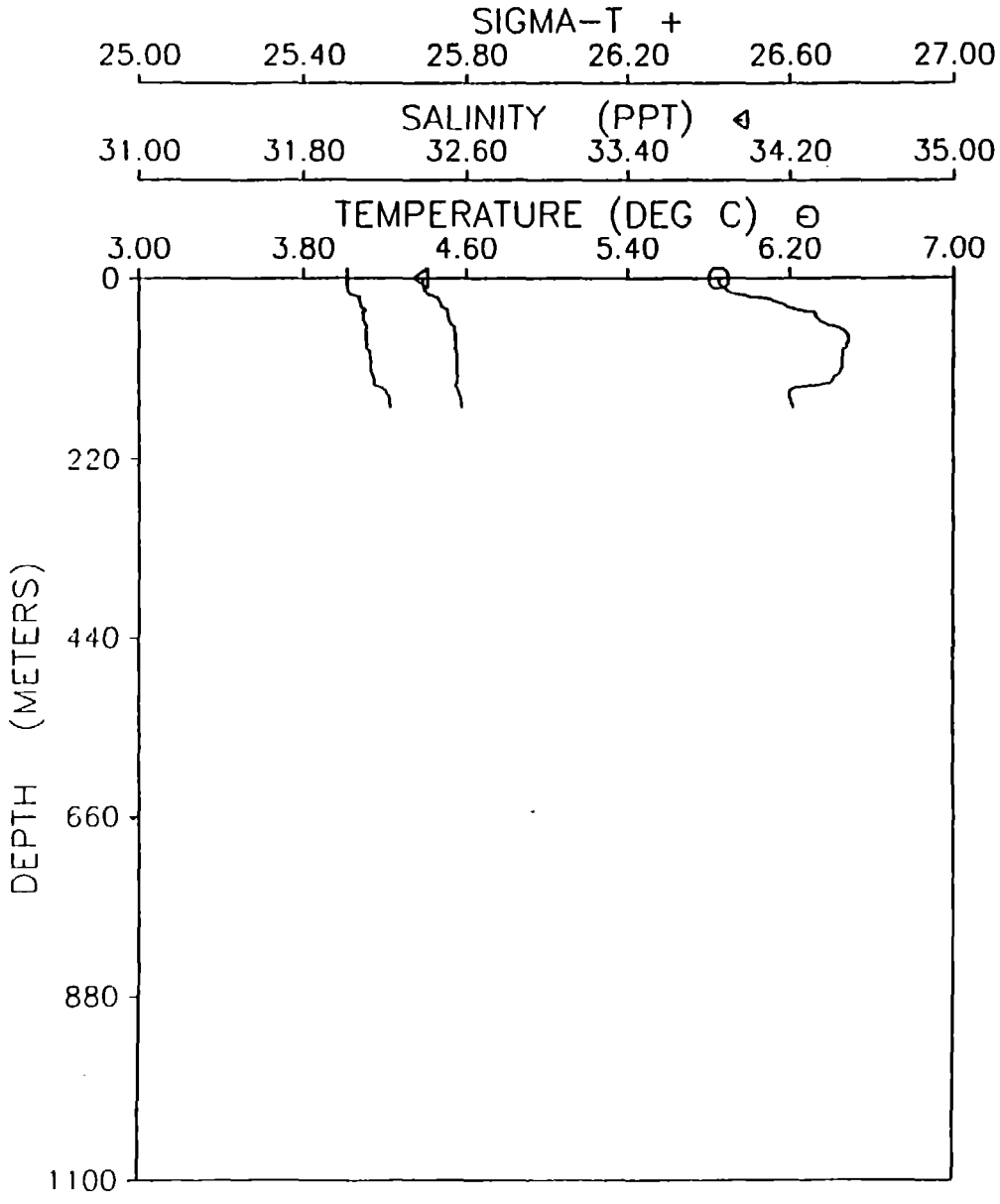


STATION: 2
CAST NUMBER: 0017

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 28 JAN 86
POSITION: 58 0.3 N, 136 59.7 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.56	32.56	25.56
10	6.56	32.56	25.56
20	6.57	32.57	25.56
30	6.58	32.57	25.56
50	6.58	32.57	25.56
75	6.58	32.57	25.56
100	6.58	32.57	25.56
125	6.57	32.57	25.56
150	6.54	32.57	25.56
175	6.38	32.56	25.58
200	6.29	32.57	25.60
250	6.02	32.74	25.77
300	6.19	33.06	26.00
400	6.06	33.83	26.62

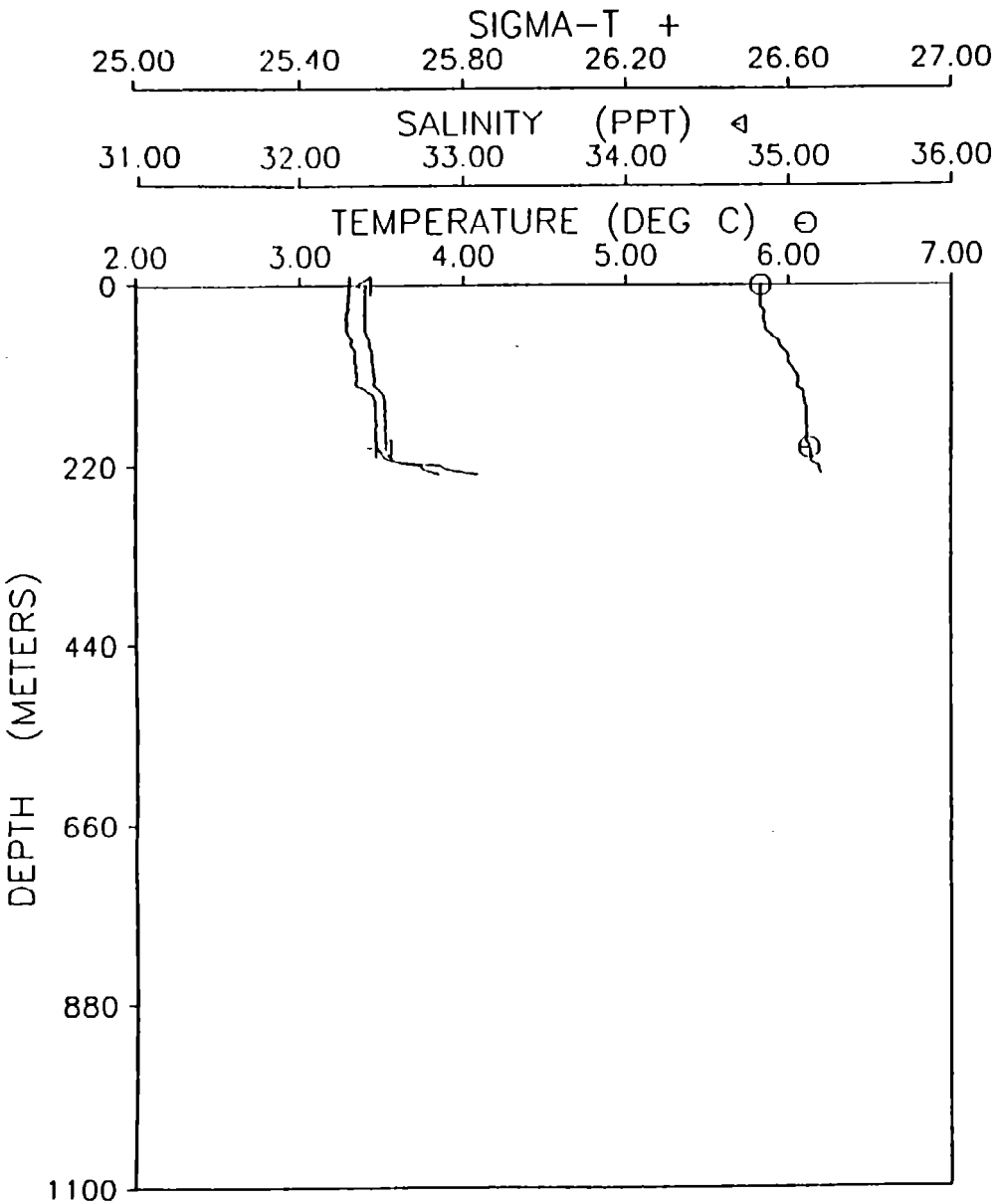


STATION: 3
CAST NUMBER: 0018

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 28 JAN 86
POSITION: 58 0.0 N, 137 29.7 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	5.85	32.39	25.51
10	5.87	32.39	25.50
20	5.94	32.41	25.51
30	6.14	32.47	25.54
50	6.34	32.51	25.55
75	6.49	32.54	25.55
100	6.46	32.56	25.57
125	6.41	32.56	25.58
150	6.21	32.58	25.61

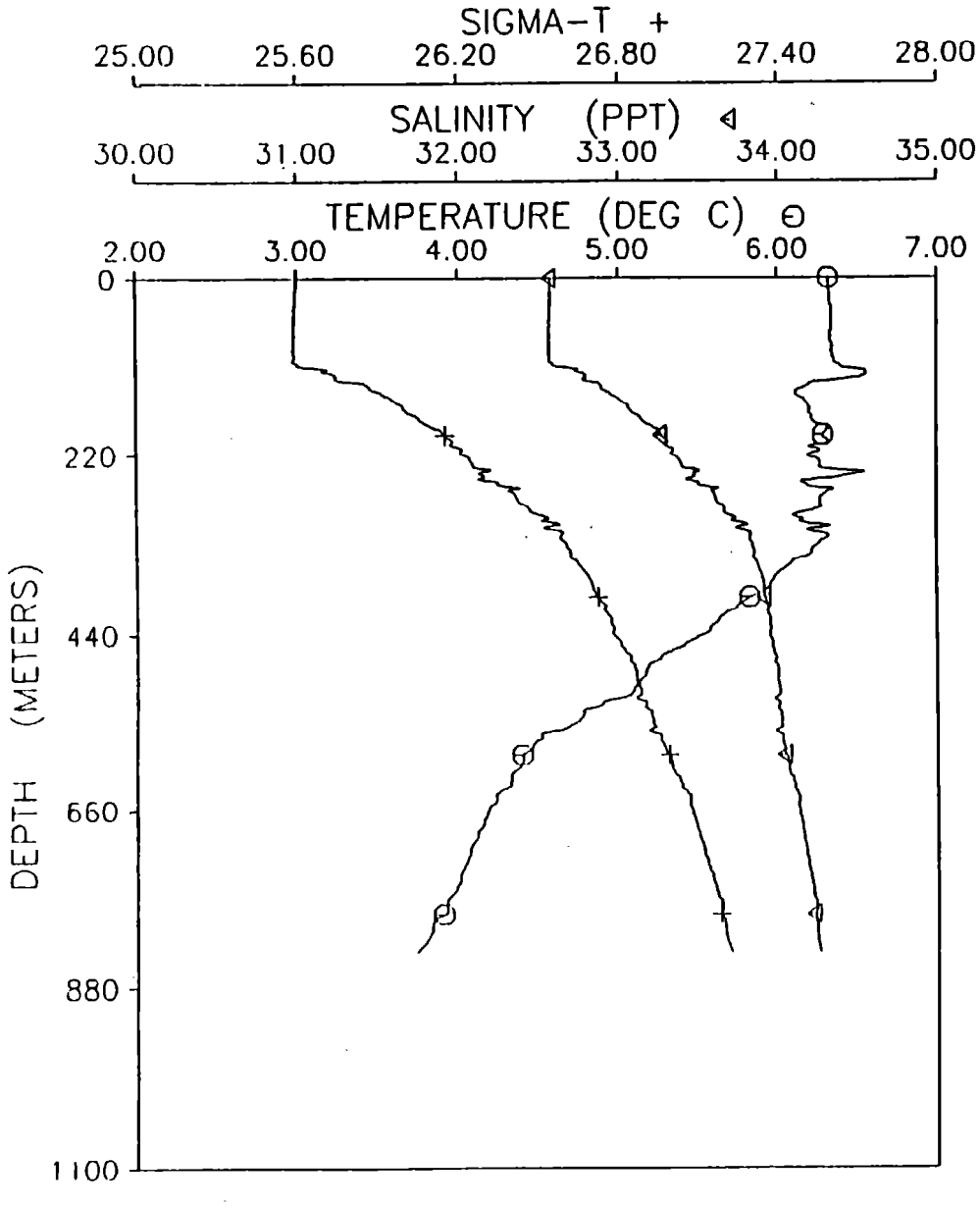


STATION: 4
CAST NUMBER: 0019

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 28 JAN 86
POSITION: 57 59.9 N, 138 0.6 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	5.83	32.40	25.52
10	5.83	32.40	25.52
20	5.83	32.40	25.52
30	5.85	32.40	25.52
50	5.86	32.40	25.51
75	5.95	32.43	25.53
100	6.02	32.45	25.54
125	6.05	32.48	25.55
150	6.11	32.53	25.59
175	6.12	32.53	25.59
200	6.14	32.54	25.59

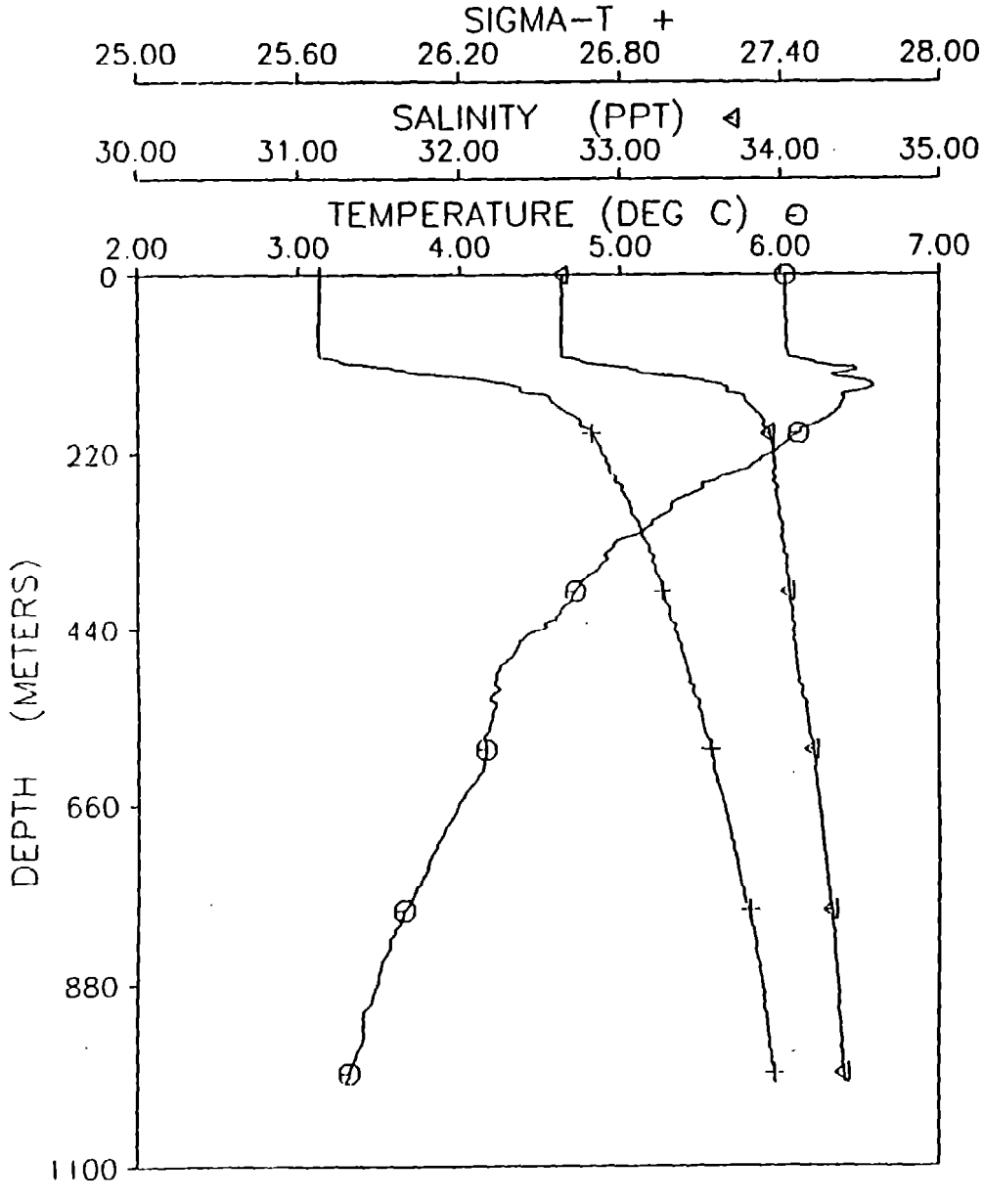


STATION: 5
CAST NUMBER: 0020

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 28 JAN 86
POSITION: 58 0.0 N, 138 30.6 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.32	32.58	25.60
10	6.32	32.58	25.60
20	6.33	32.57	25.59
30	6.33	32.58	25.60
50	6.34	32.57	25.59
75	6.34	32.57	25.59
100	6.35	32.58	25.59
125	6.54	32.81	25.75
150	6.13	32.98	25.94
175	6.22	33.13	26.05
200	6.29	33.28	26.16
250	6.41	33.49	26.31
300	6.12	33.74	26.54
400	5.82	33.93	26.73
500	5.16	34.01	26.87
600	4.40	34.06	27.00
700	4.12	34.15	27.10
800	3.90	34.23	27.18

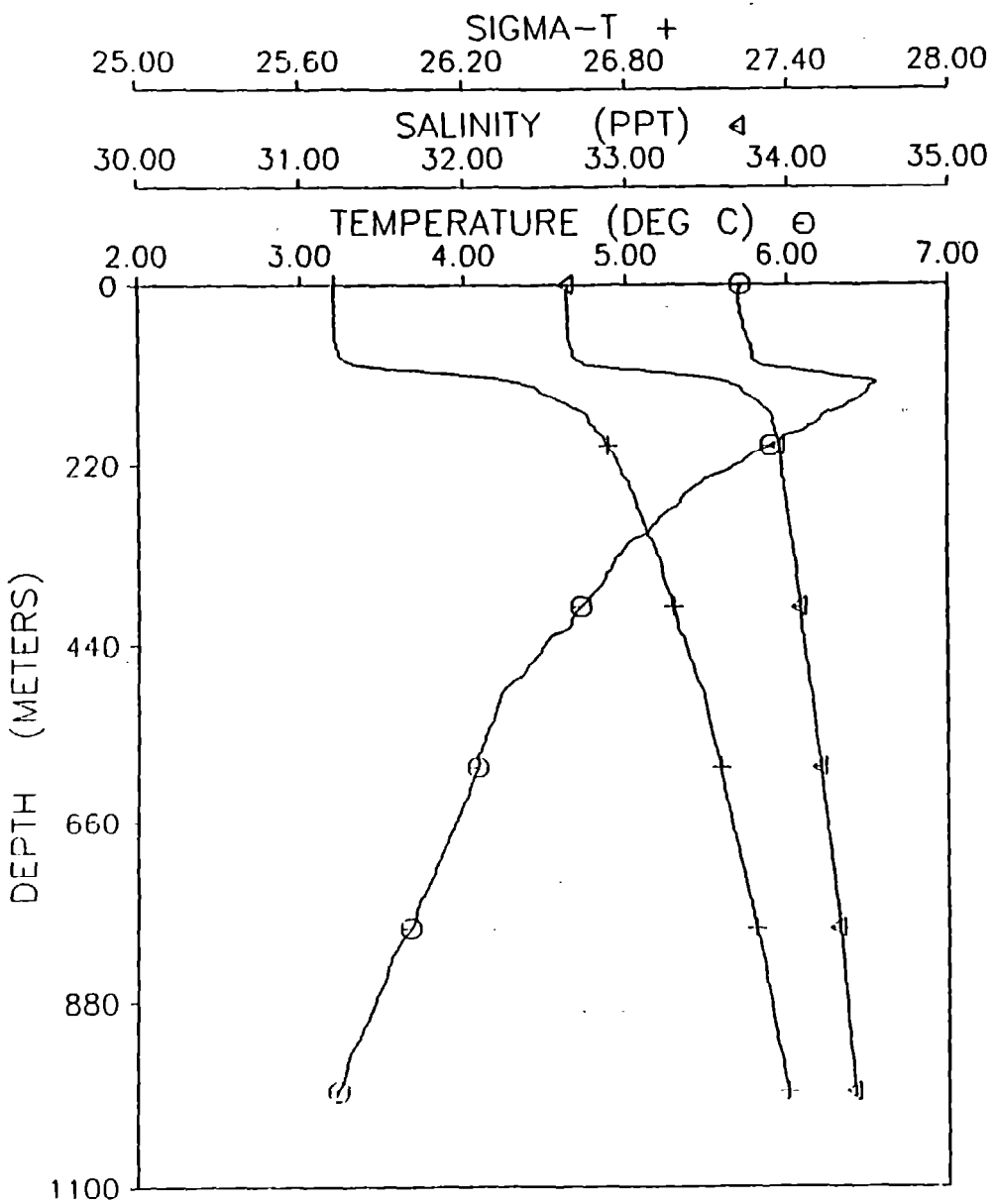


STATION: 6
CAST NUMBER: 0021

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 28 JAN 86
POSITION: 58 0.0 N, 139 0.8 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.03	32.64	25.68
10	6.03	32.63	25.68
20	6.03	32.63	25.68
30	6.03	32.63	25.68
50	6.03	32.63	25.68
75	6.04	32.63	25.68
100	6.05	32.63	25.67
125	6.33	33.19	26.08
150	6.39	33.76	26.52
175	6.32	33.87	26.62
200	6.11	33.94	26.70
250	5.68	33.96	26.77
300	5.28	33.99	26.85
400	4.73	34.07	26.97
500	4.25	34.12	27.06
600	4.17	34.22	27.14
700	3.91	34.26	27.21
800	3.66	34.33	27.29
900	3.48	34.38	27.34
1000	3.32	34.40	27.38

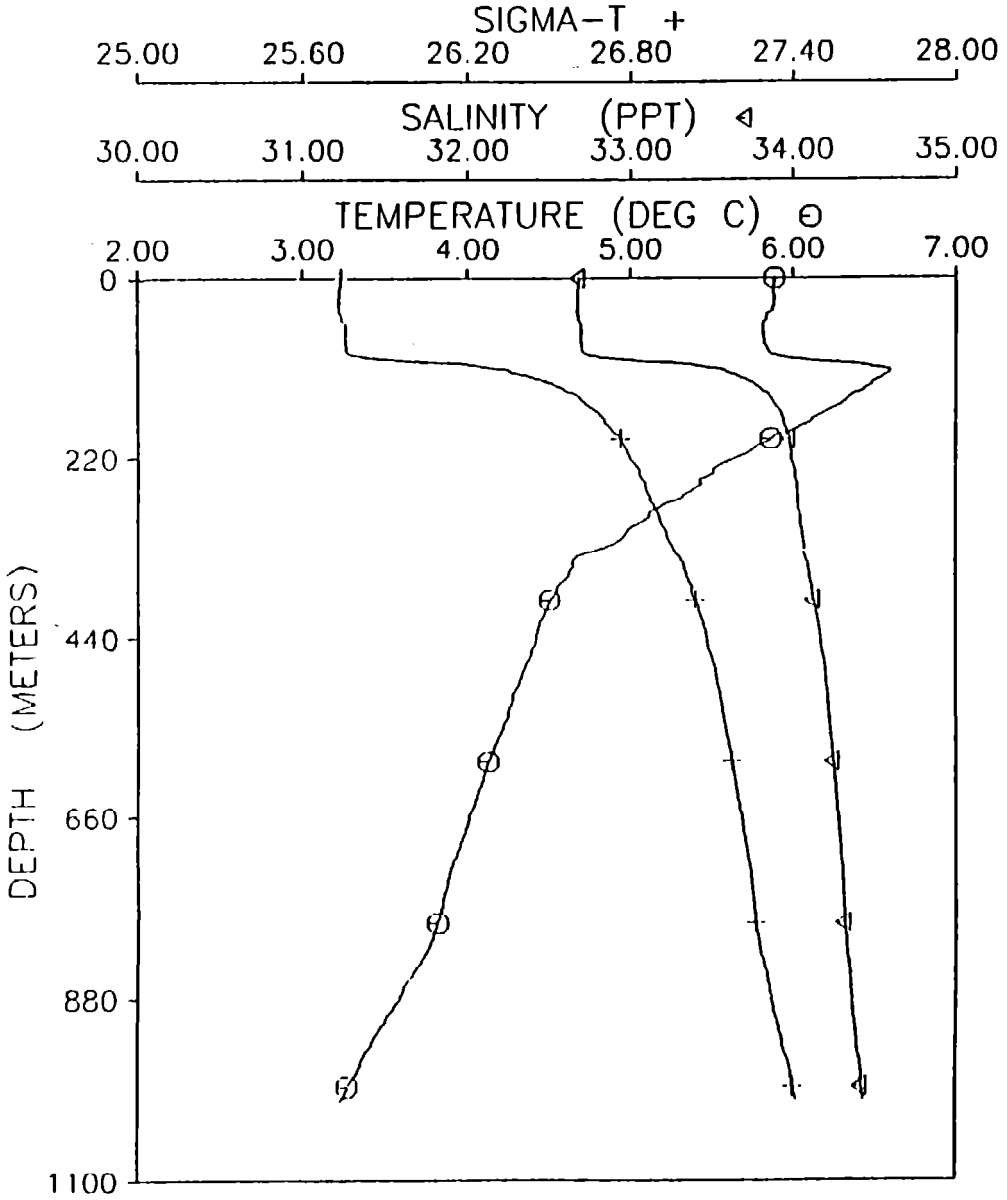


STATION: 7
CAST NUMBER: 0022

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 29 JAN 86
POSITION: 57 59.9 N, 139 30.1 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	5.71	32.64	25.72
10	5.70	32.64	25.72
20	5.70	32.64	25.72
30	5.71	32.64	25.72
50	5.73	32.64	25.72
75	5.78	32.66	25.73
100	5.87	32.83	25.86
125	6.51	33.71	26.47
150	6.37	33.85	26.60
175	6.14	33.93	26.69
200	5.89	33.95	26.74
250	5.43	33.98	26.82
300	5.17	34.02	26.88
400	4.73	34.09	26.98
500	4.26	34.15	27.08
600	4.09	34.22	27.16
700	3.89	34.27	27.22
800	3.68	34.32	27.28
900	3.44	34.37	27.34
1000	3.24	34.42	27.40

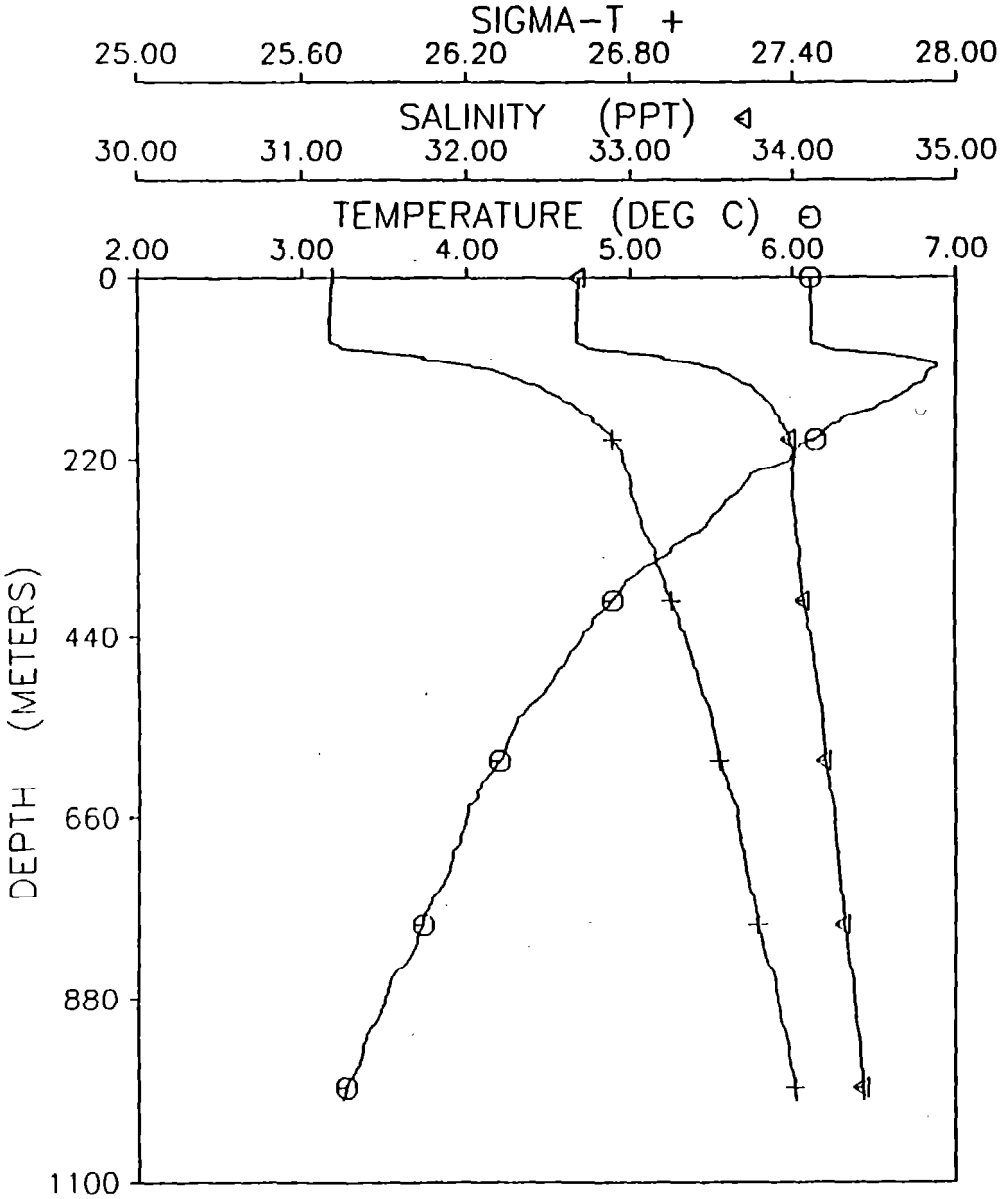


STATION: 8
CAST NUMBER: 0023

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 29 JAN 86
POSITION: 57 30.0 N, 139 30.2 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	5.89	32.69	25.74
10	5.88	32.68	25.74
20	5.88	32.68	25.73
30	5.88	32.68	25.73
50	5.84	32.68	25.74
75	5.83	32.70	25.76
100	6.03	32.94	25.92
125	6.52	33.72	26.47
150	6.34	33.88	26.62
175	6.12	33.95	26.71
200	5.86	33.98	26.77
250	5.43	34.02	26.85
300	5.09	34.05	26.91
400	4.51	34.14	27.05
500	4.33	34.21	27.12
600	4.14	34.26	27.18
700	3.97	34.29	27.23
800	3.83	34.32	27.26
900	3.56	34.37	27.33
1000	3.28	34.43	27.40

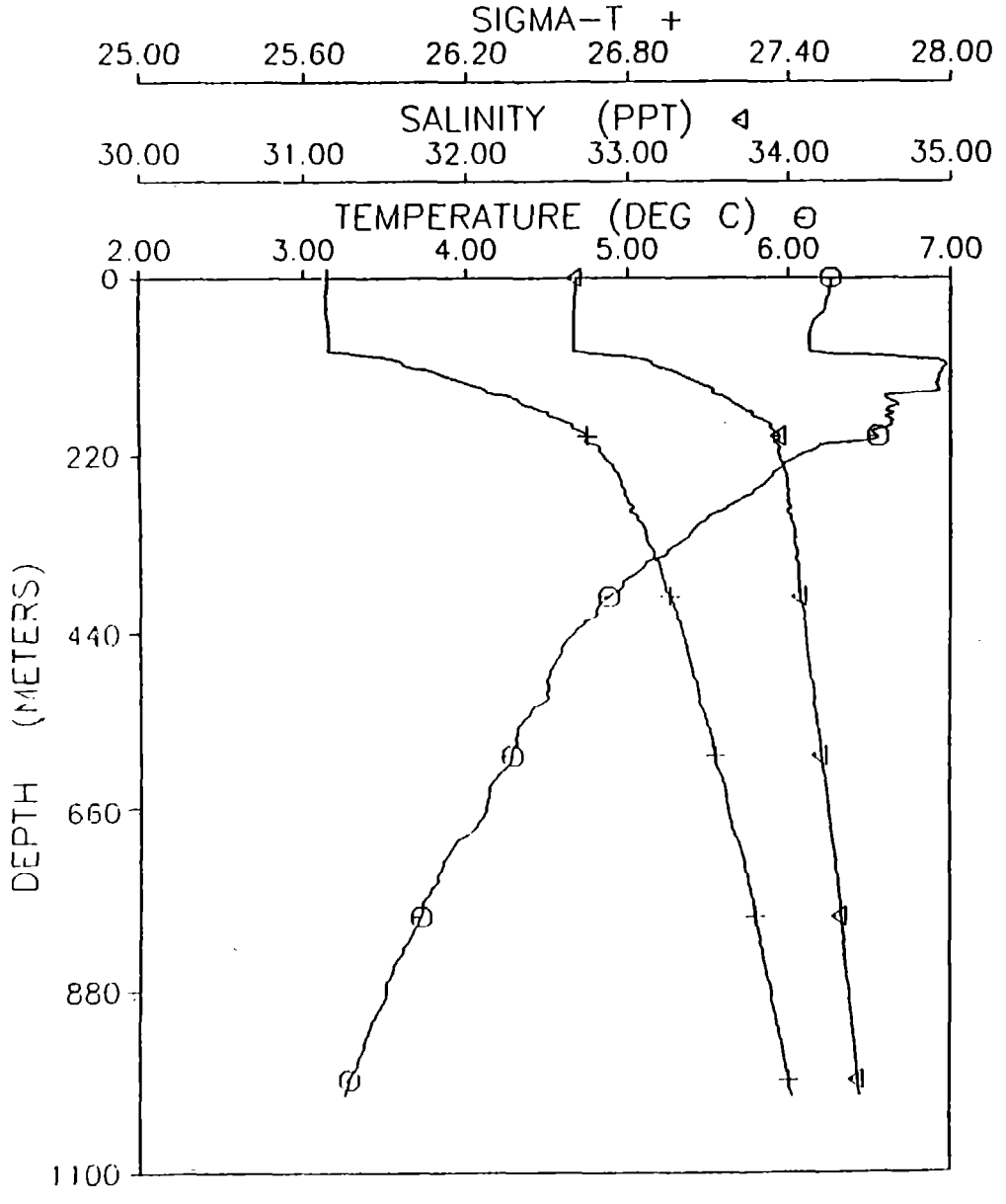


STATION: 9
CAST NUMBER: 0024

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 29 JAN 86
POSITION: 57 30.2 N, 139 0.5 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.11	32.69	25.71
10	6.11	32.68	25.71
20	6.11	32.68	25.70
30	6.11	32.68	25.70
50	6.12	32.67	25.70
75	6.12	32.67	25.70
100	6.73	33.22	26.05
125	6.81	33.66	26.39
150	6.62	33.84	26.56
175	6.30	33.93	26.67
200	6.13	33.99	26.74
250	5.73	34.01	26.81
300	5.49	34.03	26.85
400	4.90	34.09	26.96
500	4.54	34.16	27.06
600	4.21	34.21	27.14
700	3.96	34.28	27.22
800	3.74	34.33	27.28
900	3.49	34.39	27.35
1000	3.27	34.44	27.42

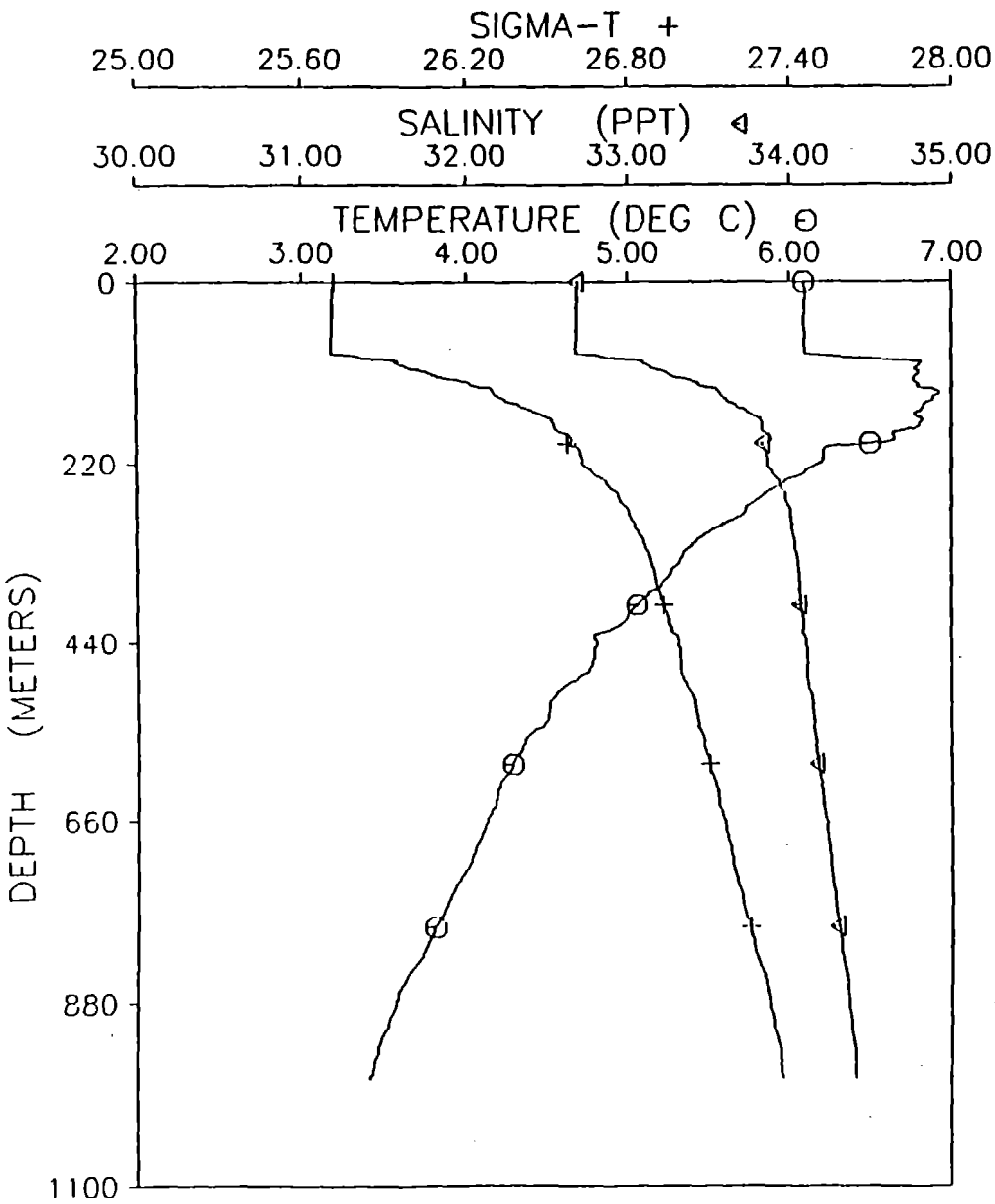


STATION: 10
CAST NUMBER: 0025

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 29 JAN 86
POSITION: 57 30.0 N, 138 30.9 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.26	32.68	25.69
10	6.26	32.68	25.69
20	6.25	32.67	25.68
30	6.24	32.67	25.68
50	6.19	32.67	25.69
75	6.13	32.67	25.70
100	6.62	32.97	25.87
125	6.93	33.36	26.14
150	6.60	33.60	26.37
175	6.59	33.79	26.52
200	6.55	33.95	26.65
250	5.90	33.99	26.77
300	5.50	34.02	26.84
400	4.87	34.08	26.96
500	4.51	34.14	27.05
600	4.29	34.21	27.13
700	3.98	34.27	27.21
800	3.73	34.33	27.28
900	3.51	34.38	27.34
1000	3.29	34.44	27.41

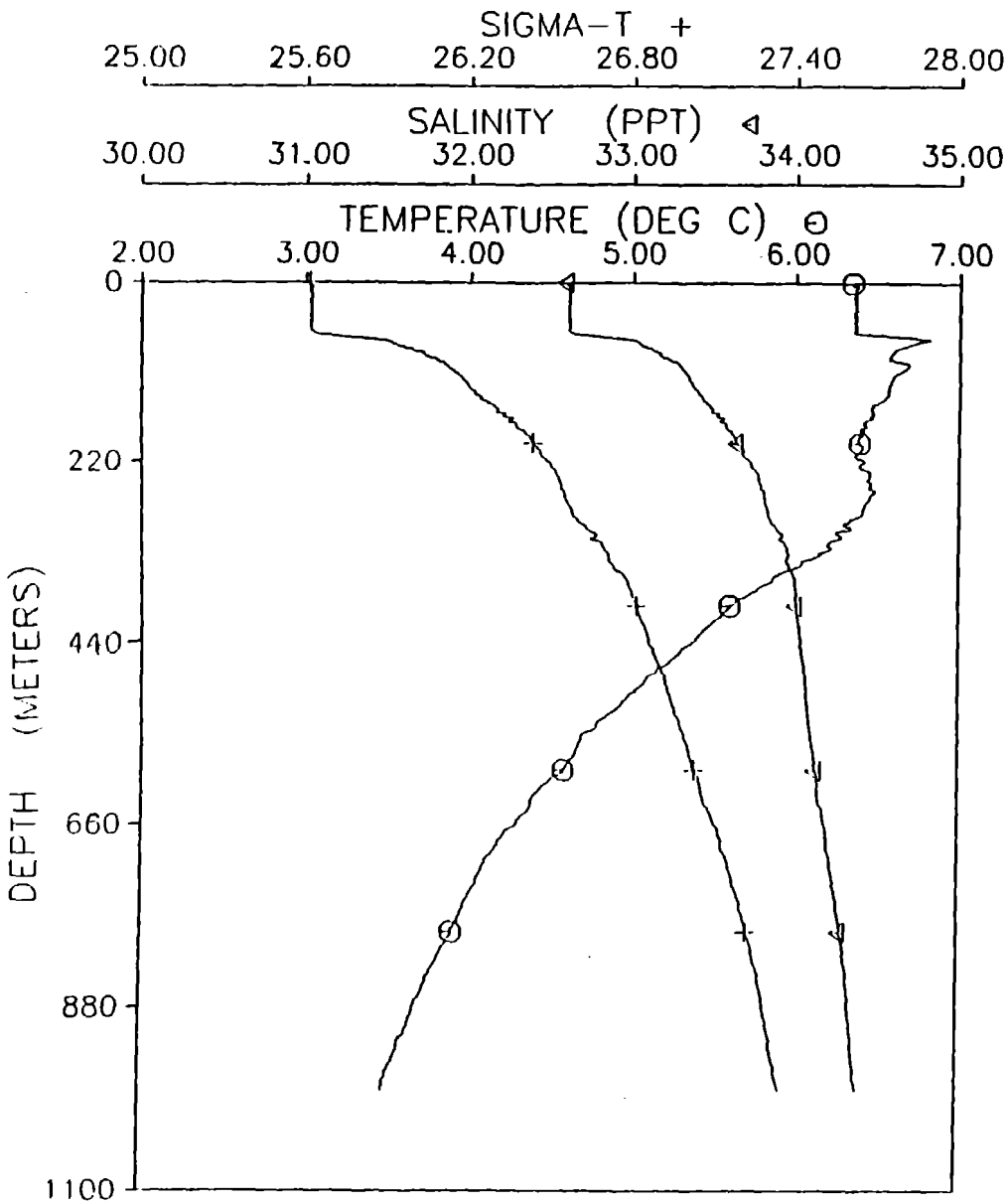


STATION: 11
CAST NUMBER: 0026

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 29 JAN 86
POSITION: 57 29.6 N, 138 0.6 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.09	32.69	25.72
10	6.10	32.68	25.71
20	6.10	32.68	25.71
30	6.09	32.68	25.71
50	6.09	32.68	25.71
75	6.09	32.68	25.71
100	6.82	33.08	25.93
125	6.78	33.43	26.21
150	6.84	33.65	26.37
175	6.80	33.83	26.53
200	6.43	33.83	26.57
250	5.95	33.94	26.72
300	5.58	34.01	26.83
400	5.06	34.08	26.94
500	4.60	34.12	27.02
600	4.29	34.18	27.11
700	4.05	34.25	27.18
800	3.80	34.31	27.25
900	3.56	34.37	27.33

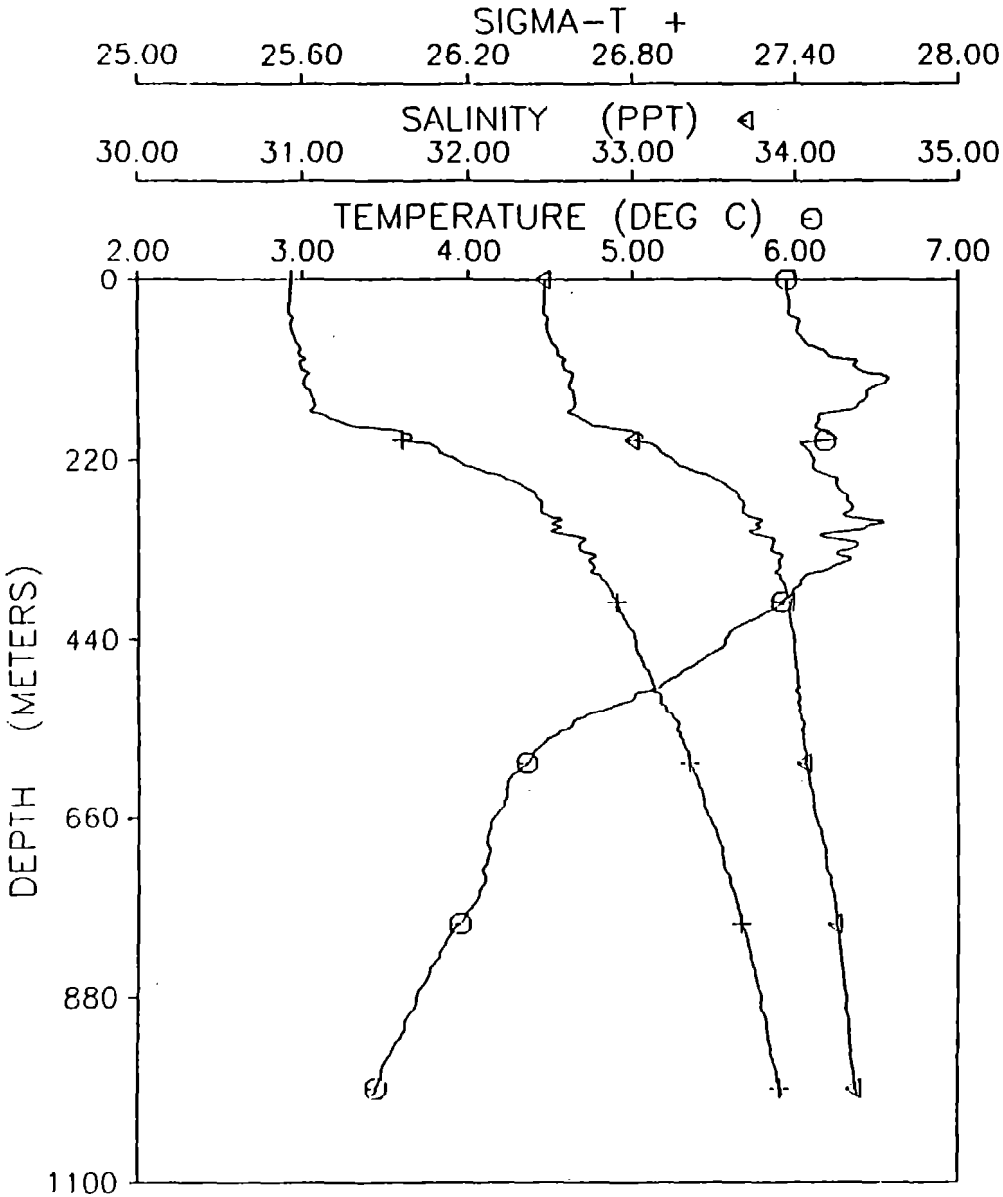


STATION: 12
CAST NUMBER: 0027

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 29 JAN 86
POSITION: 57 30.2 N, 137 29.6 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.34	32.60	25.61
10	6.36	32.61	25.62
20	6.36	32.61	25.62
30	6.36	32.61	25.62
50	6.35	32.61	25.62
75	6.75	33.04	25.91
100	6.68	33.28	26.10
125	6.57	33.36	26.19
150	6.48	33.47	26.28
175	6.41	33.57	26.37
200	6.39	33.65	26.43
250	6.46	33.79	26.54
300	6.29	33.87	26.62
400	5.60	34.01	26.82
500	5.03	34.07	26.93
600	4.58	34.13	27.03
700	4.14	34.20	27.13
800	3.89	34.28	27.22
900	3.65	34.33	27.29

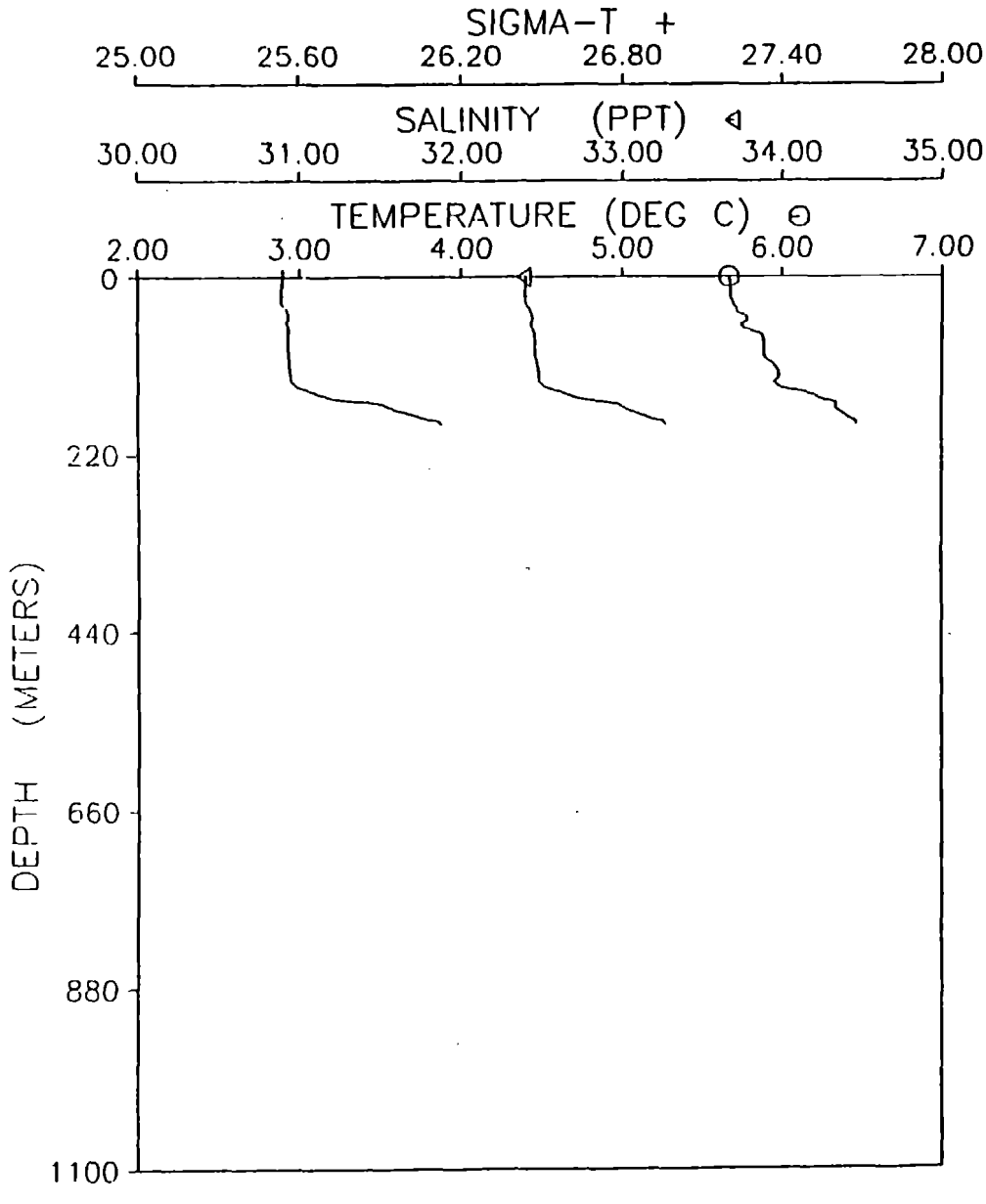


STATION: 13
CAST NUMBER: 0028

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 29 JAN 86
POSITION: 57 29.4 N, 137 1.6 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	5.95	32.47	25.56
10	5.95	32.46	25.56
20	5.96	32.46	25.55
30	5.96	32.46	25.55
50	6.02	32.49	25.57
75	6.05	32.50	25.57
100	6.38	32.59	25.60
125	6.56	32.63	25.61
150	6.42	32.65	25.64
175	6.15	32.72	25.73
200	6.09	33.03	25.99
250	6.26	33.56	26.38
300	6.55	33.77	26.51
400	5.92	33.97	26.75
500	5.20	34.02	26.88
600	4.36	34.07	27.01
700	4.11	34.18	27.12
800	3.94	34.26	27.20
900	3.69	34.32	27.27
1000	3.45	34.38	27.35

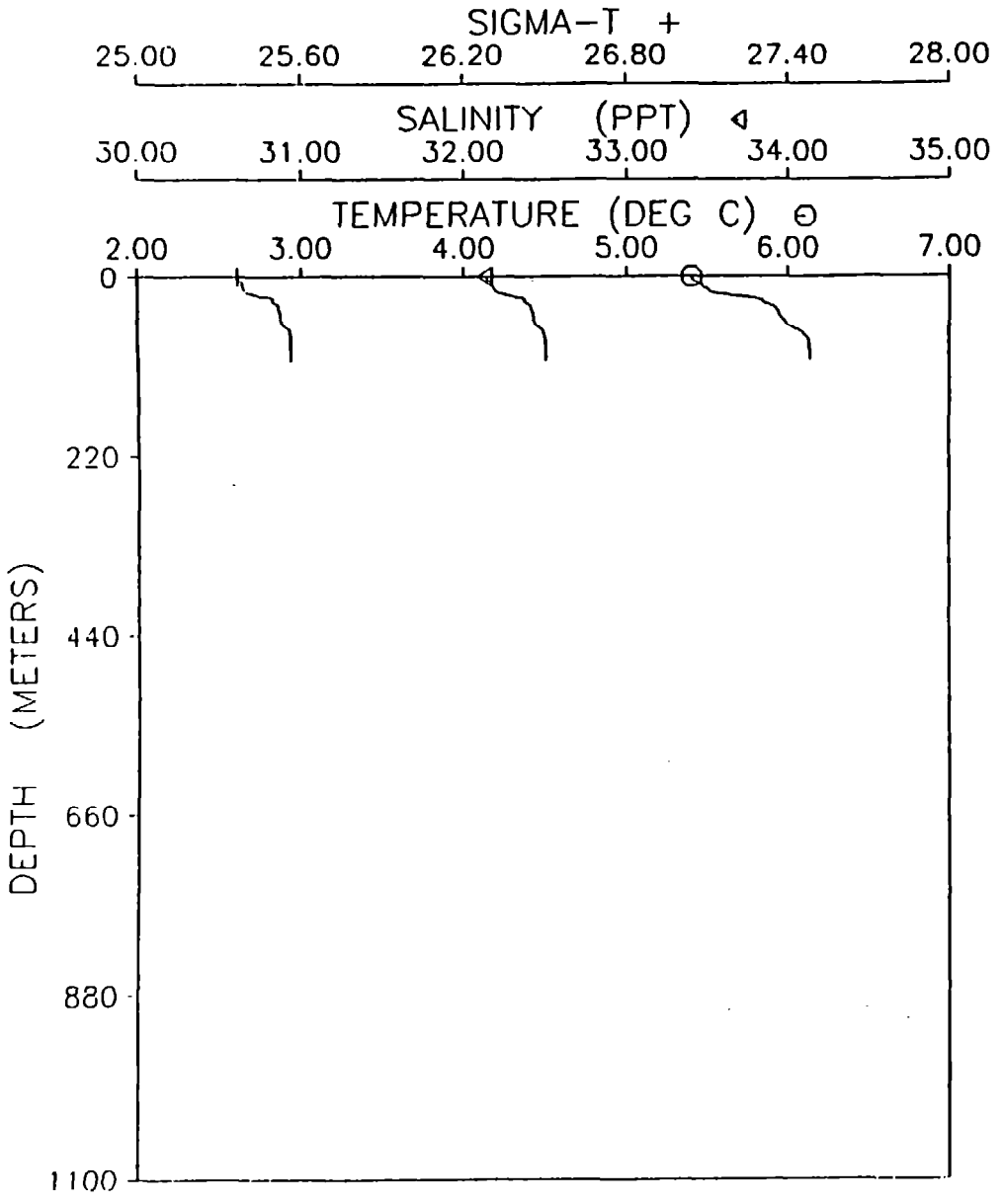


STATION: 14
CAST NUMBER: 0029

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 30 JAN 86
POSITION: 57 30.0 N, 136 30.0 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	5.67	32.40	25.54
10	5.68	32.39	25.53
20	5.68	32.39	25.53
30	5.69	32.39	25.53
50	5.78	32.44	25.55
75	5.88	32.46	25.56
100	5.89	32.46	25.56
125	5.98	32.49	25.57
150	6.21	32.68	25.69
175	6.40	33.14	26.03

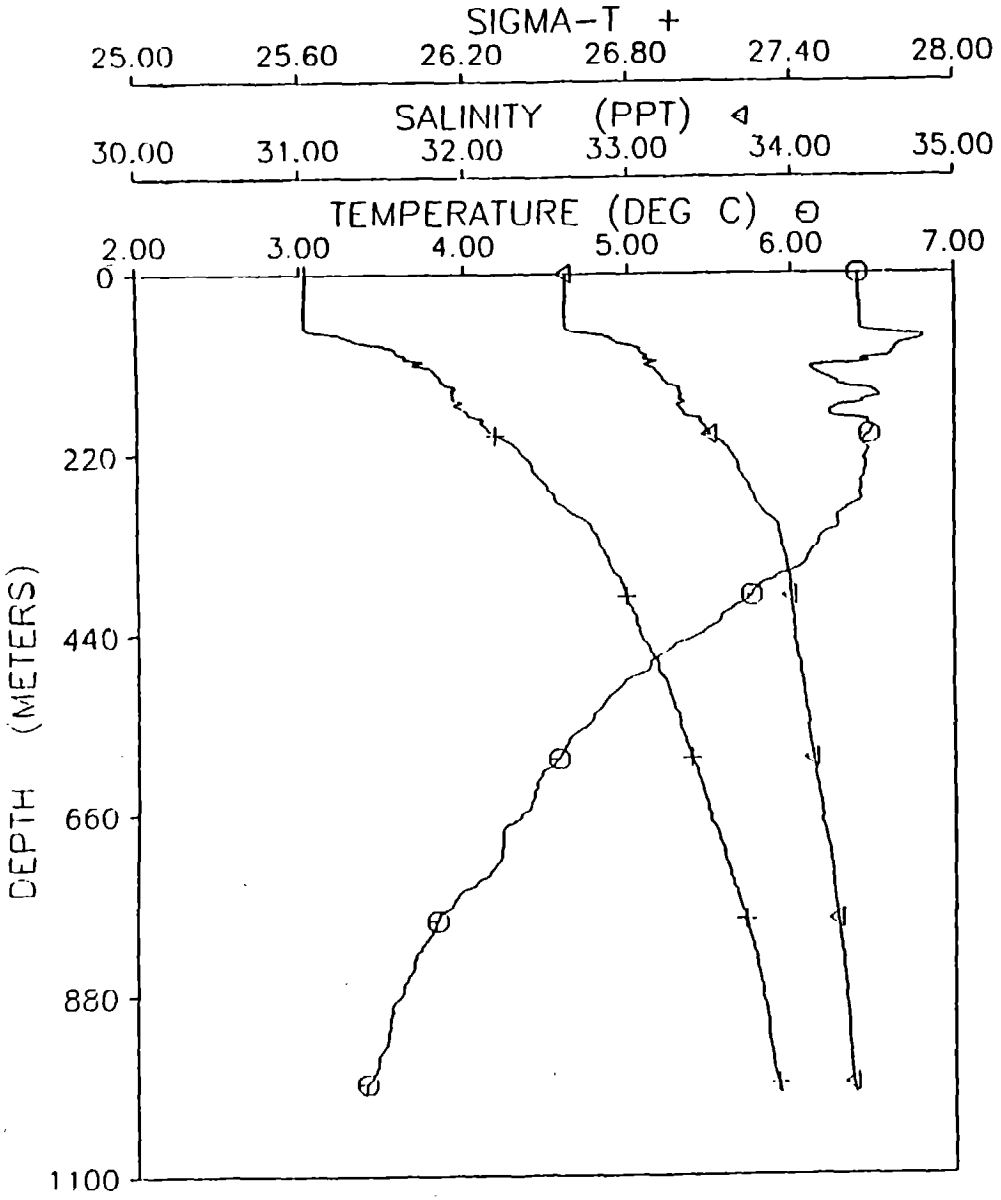


STATION: 16
CAST NUMBER: 0030

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 30 JAN 86
POSITION: 57 0.0 N, 135 59.6 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	5.40	32.15	25.37
10	5.47	32.17	25.38
20	5.55	32.22	25.41
30	5.84	32.37	25.49
50	5.95	32.42	25.52
75	6.11	32.50	25.56
100	6.14	32.50	25.56

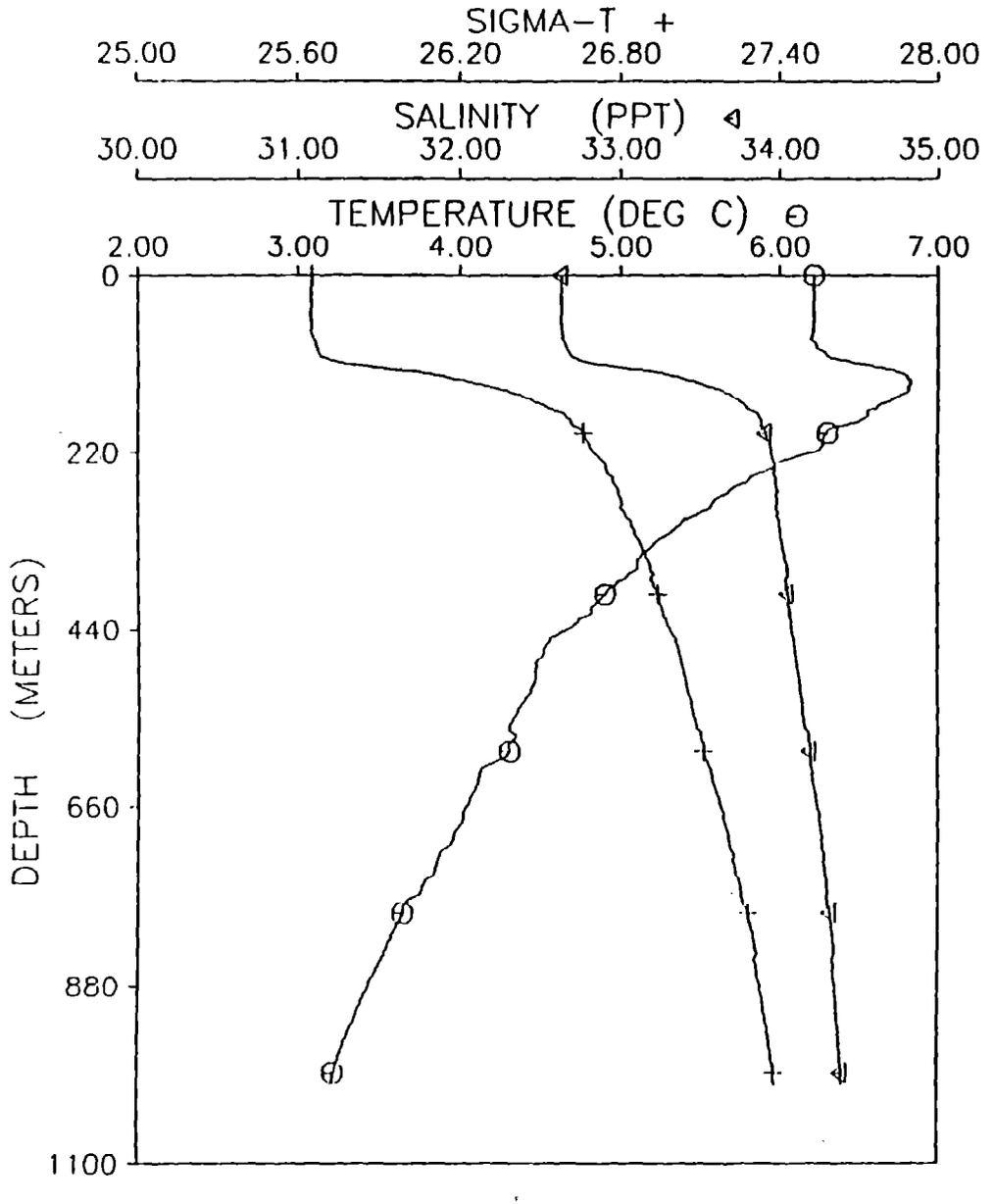


STATION: 17
CAST NUMBER: 0031

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 30 JAN 86
POSITION: 57 0.4 N, 136 29.2 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.41	32.62	25.62
10	6.41	32.62	25.62
20	6.41	32.61	25.62
30	6.41	32.62	25.62
50	6.42	32.61	25.61
75	6.71	32.82	25.74
100	6.61	33.11	25.98
125	6.19	33.20	26.11
150	6.54	33.32	26.16
175	6.24	33.35	26.22
200	6.47	33.51	26.32
250	6.45	33.70	26.47
300	6.28	33.86	26.61
400	5.75	34.00	26.80
500	5.00	34.07	26.94
600	4.57	34.13	27.03
700	4.24	34.21	27.13
800	3.84	34.28	27.23
900	3.57	34.33	27.30
1000	3.41	34.38	27.35

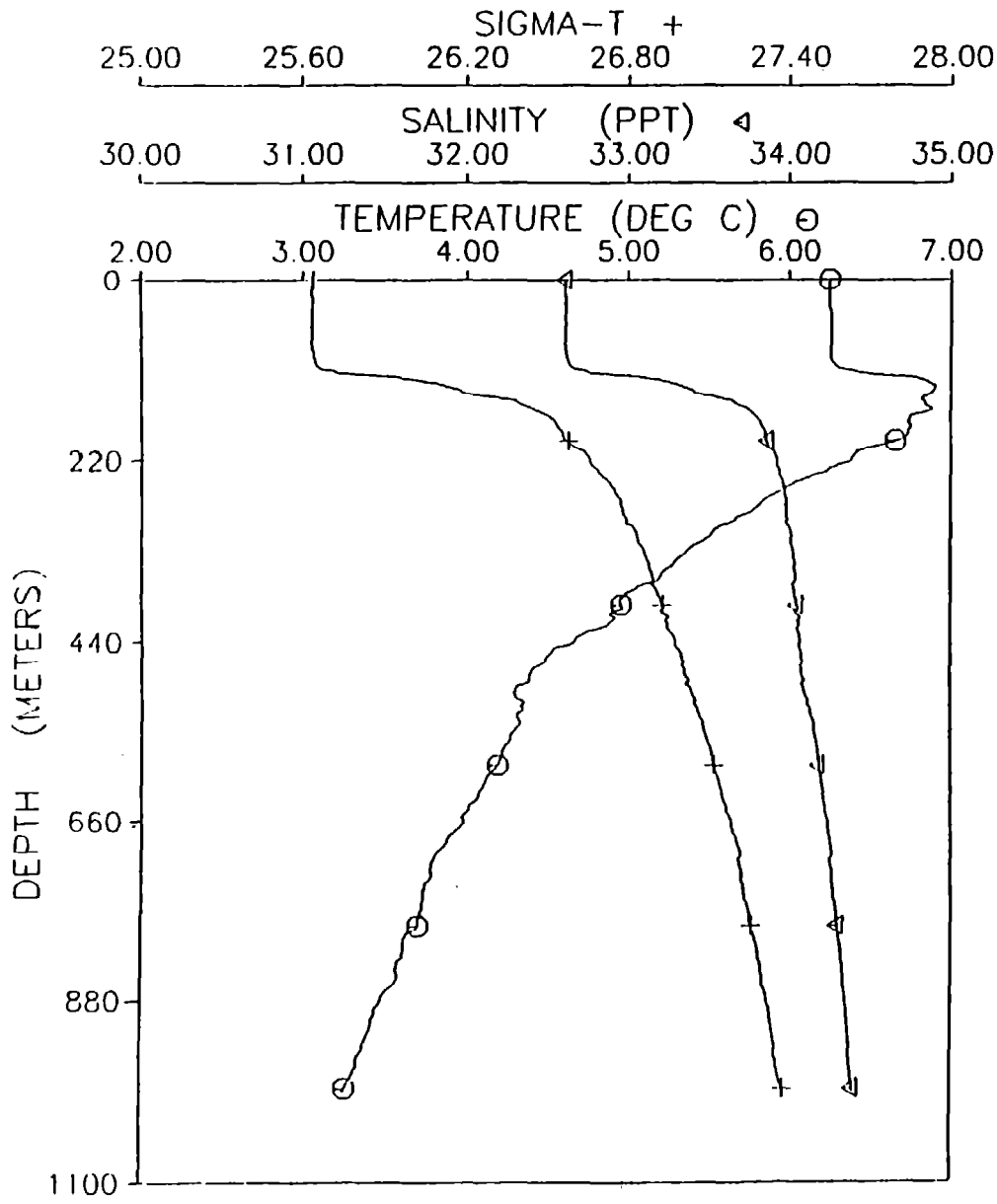


STATION: 18
CAST NUMBER: 0032

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 30 JAN 86
POSITION: 57 0.7 N, 136 58.3 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	6.22	32.63	25.65
10	6.22	32.63	25.65
20	6.22	32.63	25.65
30	6.22	32.62	25.65
50	6.22	32.62	25.65
75	6.21	32.63	25.66
100	6.30	32.68	25.68
125	6.79	33.29	26.10
150	6.77	33.69	26.42
175	6.56	33.87	26.59
200	6.30	33.92	26.66
250	5.86	33.97	26.76
300	5.49	33.99	26.82
400	4.91	34.06	26.94
500	4.47	34.13	27.04
600	4.30	34.20	27.12
700	3.97	34.27	27.21
800	3.65	34.33	27.28
900	3.41	34.36	27.34
1000	3.22	34.40	27.39

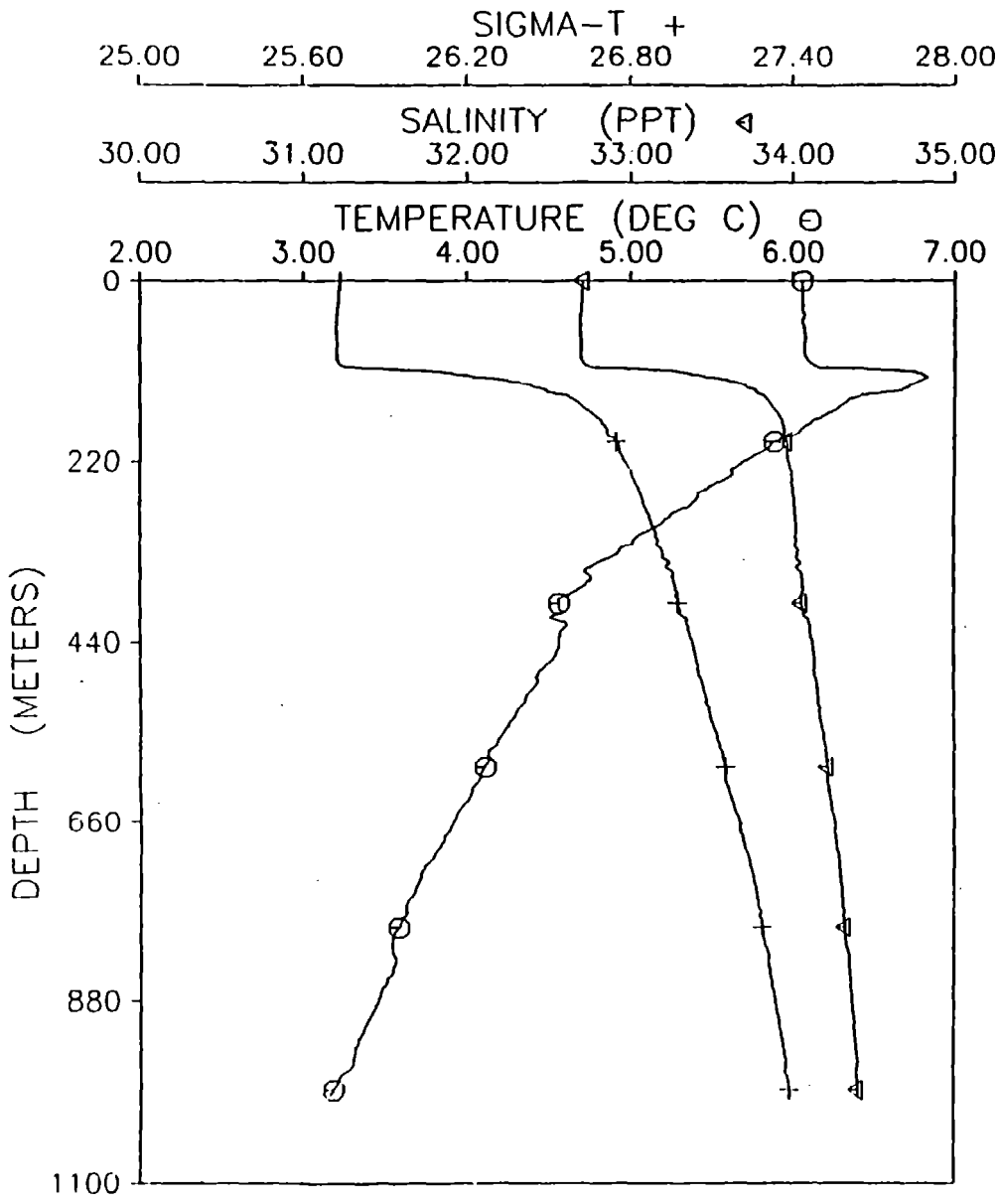


STATION: 19
CAST NUMBER: 0033

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 30 JAN 86
POSITION: 57 5.5 N, 137 29.3 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.25	32.62	25.64
10	6.25	32.61	25.63
20	6.25	32.61	25.63
30	6.25	32.61	25.64
50	6.26	32.61	25.63
75	6.26	32.61	25.63
100	6.26	32.62	25.64
125	6.84	33.21	26.03
150	6.83	33.65	26.38
175	6.74	33.83	26.53
200	6.65	33.88	26.58
250	6.03	33.97	26.74
300	5.63	33.98	26.79
400	4.96	34.06	26.93
500	4.31	34.09	27.03
600	4.18	34.19	27.13
700	3.86	34.26	27.21
800	3.71	34.30	27.26
900	3.45	34.36	27.33
1000	3.27	34.40	27.38

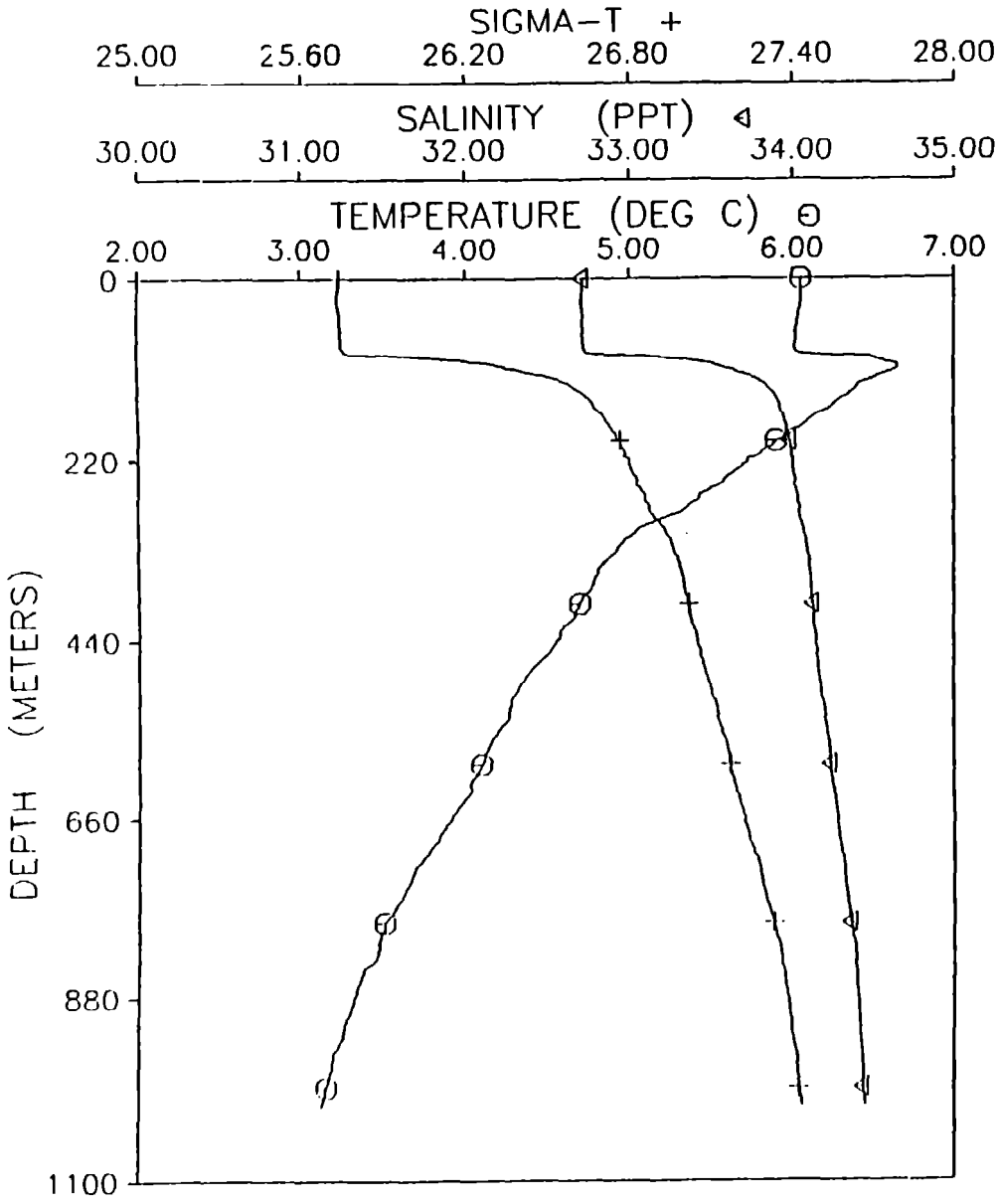


STATION: 20
CAST NUMBER: 0034

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 31 JAN 86
POSITION: 57 1.1 N, 138 1.3 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.06	32.71	25.74
10	6.06	32.71	25.73
20	6.06	32.70	25.73
30	6.06	32.70	25.73
50	6.06	32.69	25.72
75	6.08	32.70	25.73
100	6.10	32.71	25.73
125	6.77	33.65	26.39
150	6.33	33.86	26.61
175	6.12	33.94	26.70
200	5.88	33.97	26.75
250	5.52	34.00	26.82
300	5.20	34.03	26.88
400	4.57	34.06	26.98
500	4.42	34.16	27.07
600	4.11	34.22	27.16
700	3.84	34.27	27.23
800	3.59	34.32	27.29
900	3.45	34.37	27.34
1000	3.20	34.40	27.39

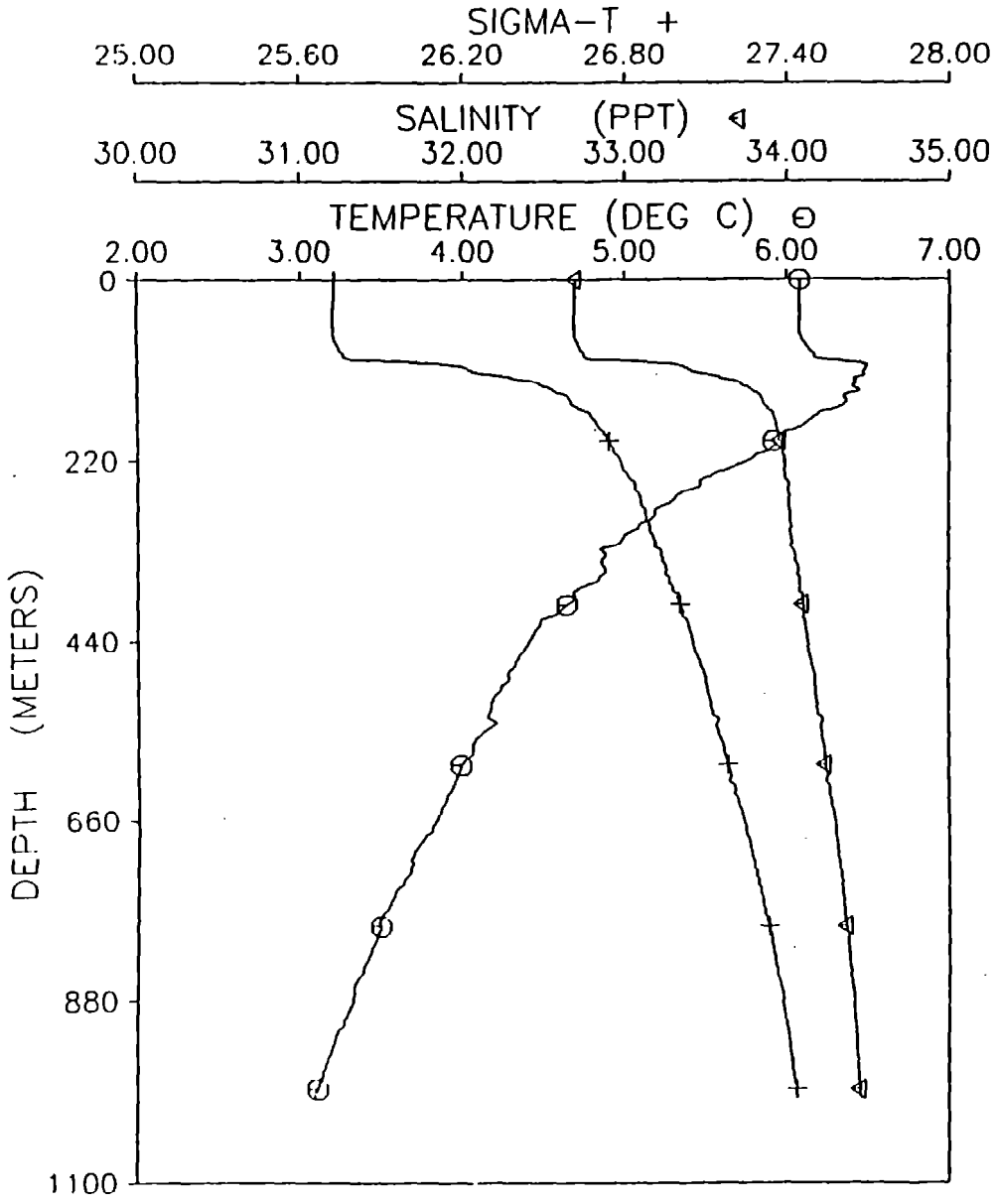


STATION: 21
CAST NUMBER: 0035

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 31 JAN 86
POSITION: 56 59.9 N, 138 29.1 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	6.05	32.72	25.74
10	6.05	32.71	25.74
20	6.05	32.71	25.74
30	6.05	32.71	25.74
50	6.03	32.72	25.75
75	6.02	32.72	25.75
100	6.52	33.33	26.17
125	6.48	33.80	26.54
150	6.28	33.91	26.66
175	6.10	33.95	26.71
200	5.90	33.99	26.77
250	5.58	34.02	26.83
300	5.15	34.06	26.91
400	4.70	34.13	27.02
500	4.34	34.18	27.10
600	4.10	34.24	27.17
700	3.81	34.31	27.25
800	3.51	34.37	27.33
900	3.31	34.42	27.39
1000	3.16	34.44	27.43

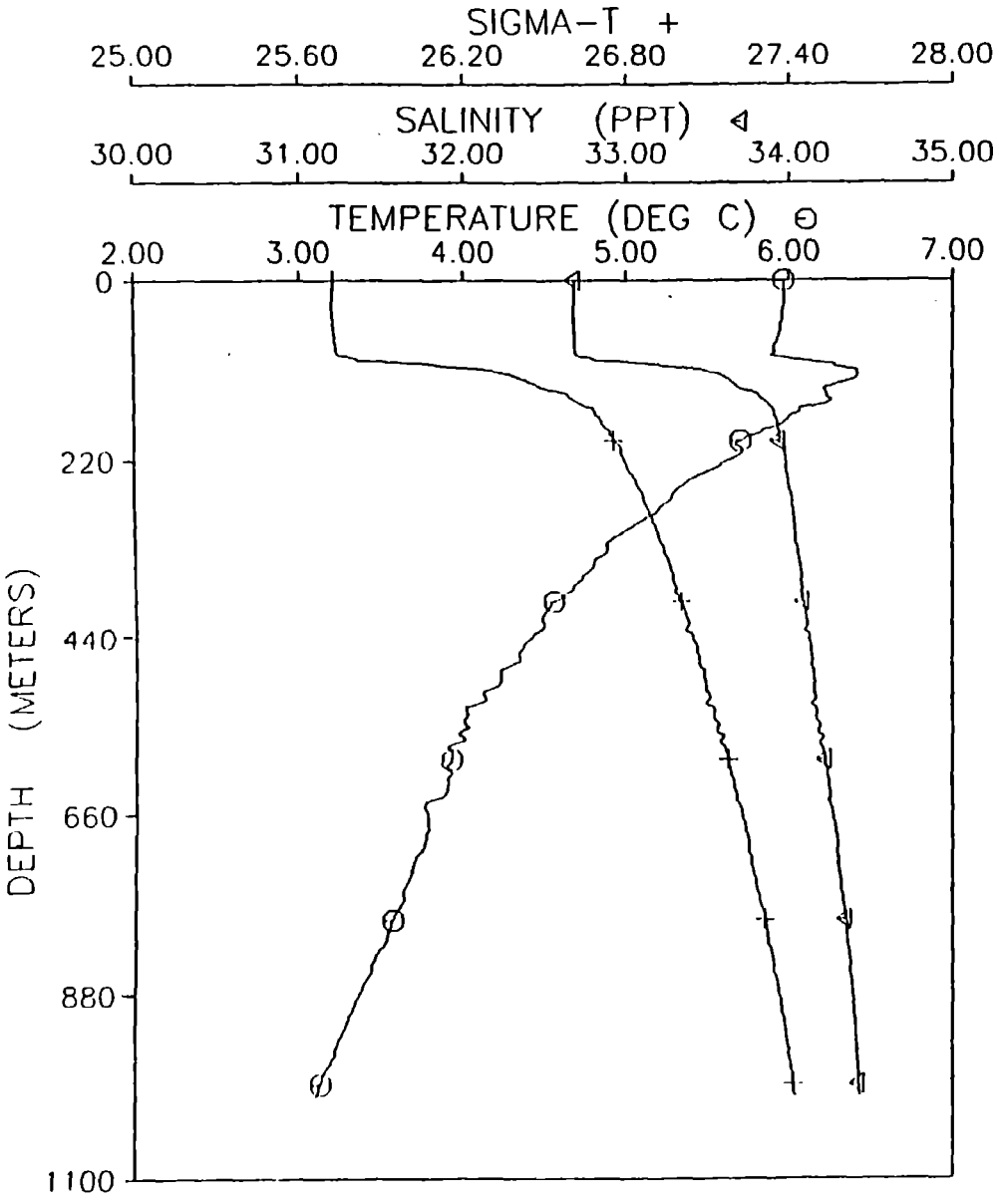


STATION: 22
CAST NUMBER: 0036

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 31 JAN 86
POSITION: 56 59.7 N, 139 0.0 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.08	32.70	25.73
10	6.08	32.70	25.72
20	6.08	32.70	25.72
30	6.08	32.70	25.72
50	6.08	32.69	25.72
75	6.10	32.71	25.73
100	6.24	32.90	25.87
125	6.41	33.65	26.43
150	6.37	33.85	26.60
175	6.14	33.94	26.70
200	5.93	33.97	26.75
250	5.47	34.01	26.84
300	5.10	34.03	26.90
400	4.65	34.11	27.01
500	4.24	34.18	27.11
600	3.99	34.24	27.18
700	3.72	34.31	27.26
800	3.49	34.37	27.33
900	3.30	34.42	27.39
1000	3.11	34.45	27.44

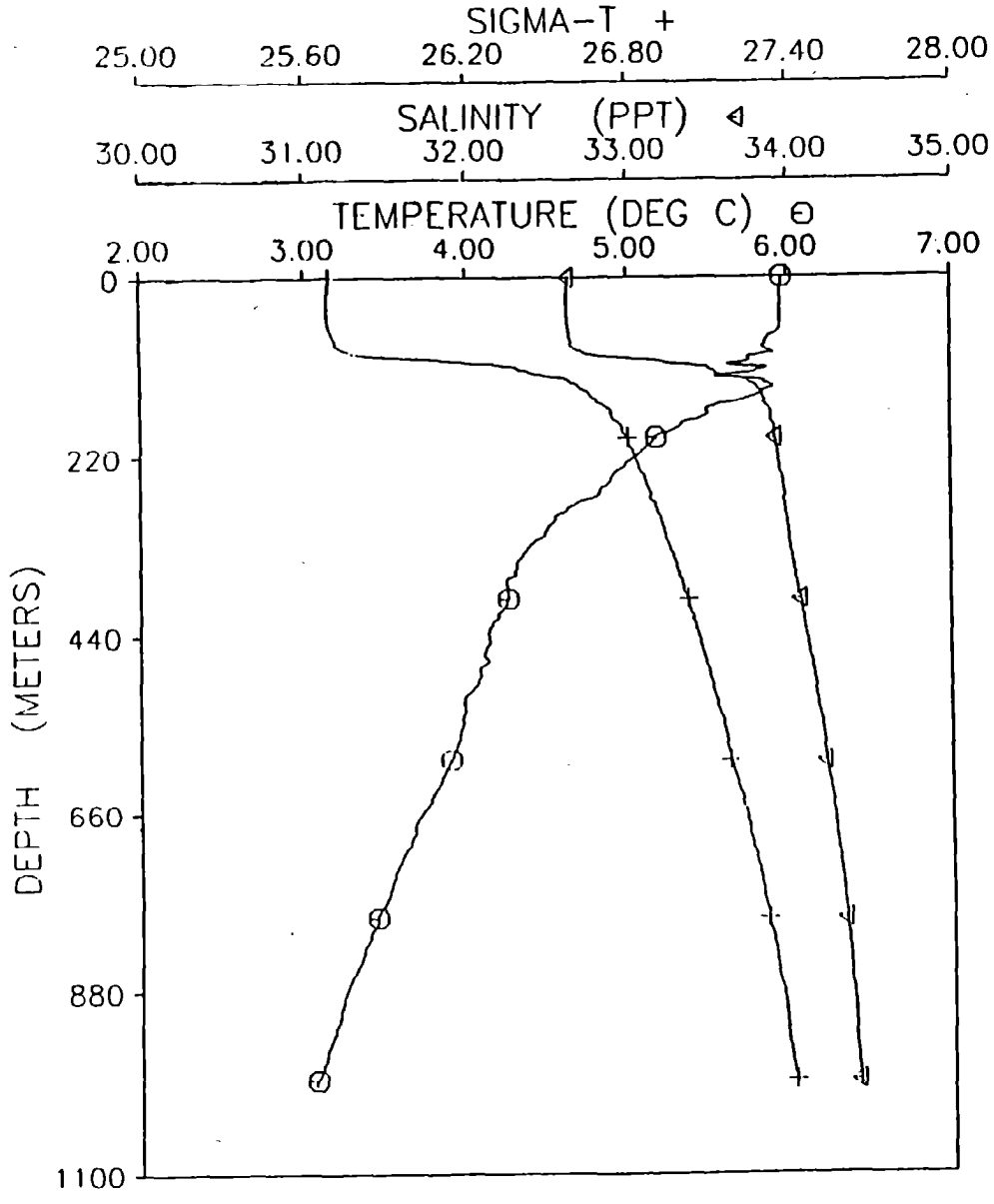


STATION: 23
CAST NUMBER: 0037

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 31 JAN 86
POSITION: 56 59.9 N, 139 29.6 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	5.97	32.68	25.73
10	5.97	32.68	25.72
20	5.97	32.68	25.72
30	5.97	32.68	25.72
50	5.96	32.68	25.72
75	5.93	32.68	25.73
100	6.10	32.91	25.89
125	6.37	33.65	26.43
150	6.26	33.86	26.62
175	5.97	33.93	26.71
200	5.69	33.95	26.76
250	5.38	34.00	26.84
300	5.08	34.03	26.90
400	4.55	34.10	27.01
500	4.23	34.17	27.10
600	3.93	34.23	27.18
700	3.77	34.30	27.25
800	3.56	34.35	27.32
900	3.34	34.40	27.38
1000	3.12	34.44	27.42

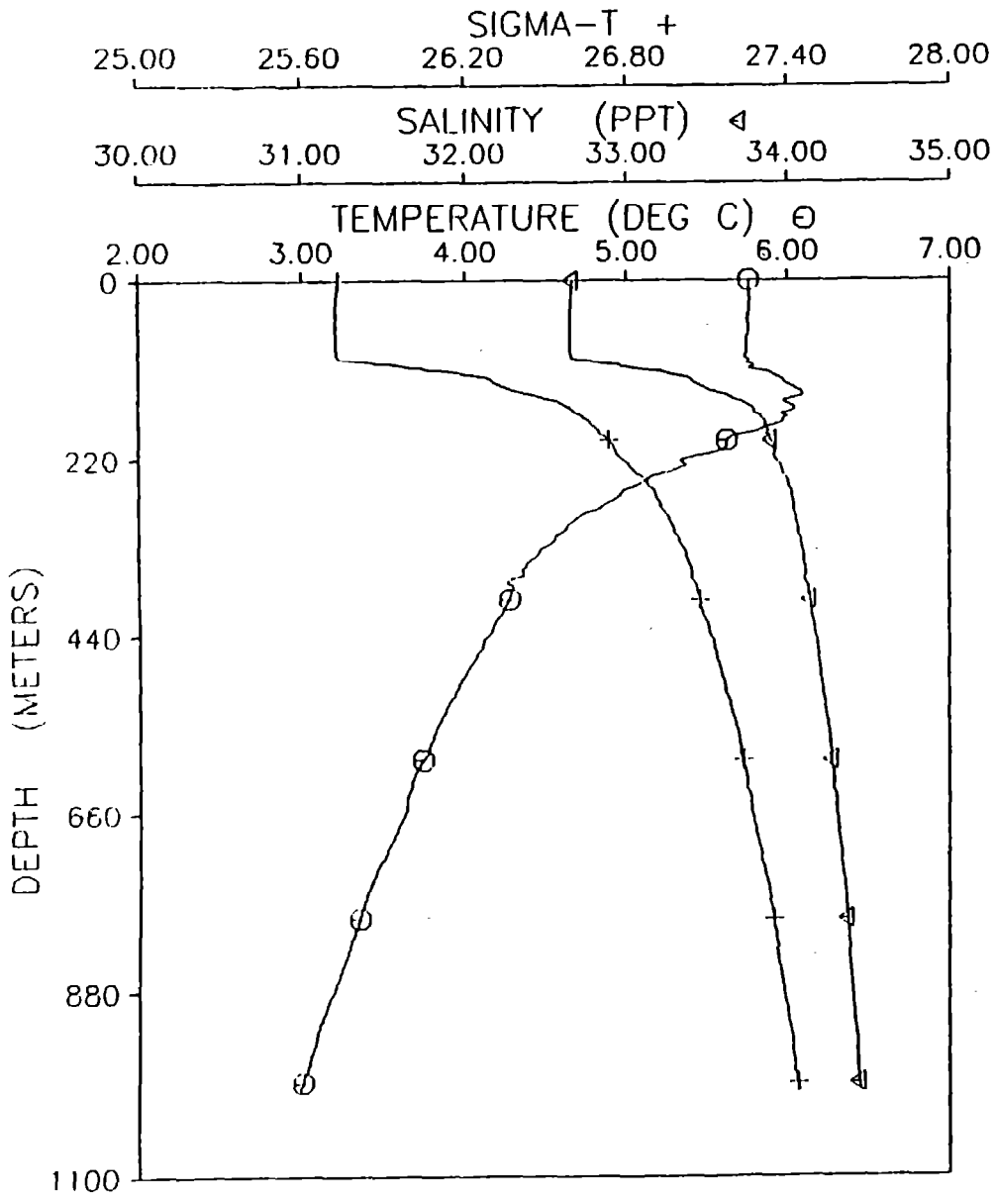


STATION: 24
CAST NUMBER: 0038

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 31 JAN 86
POSITION: 56 29.8 N, 139 28.7 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	5.97	32.64	25.69
10	5.96	32.63	25.69
20	5.96	32.63	25.69
30	5.97	32.63	25.68
50	5.96	32.63	25.69
75	5.88	32.65	25.71
100	5.76	32.98	25.99
125	5.71	33.71	26.57
150	5.76	33.85	26.68
175	5.47	33.91	26.75
200	5.19	33.93	26.81
250	4.91	33.97	26.87
300	4.57	34.00	26.93
400	4.27	34.08	27.03
500	4.08	34.17	27.11
600	3.91	34.23	27.18
700	3.66	34.29	27.26
800	3.45	34.34	27.32
900	3.24	34.39	27.38
1000	3.08	34.42	27.42

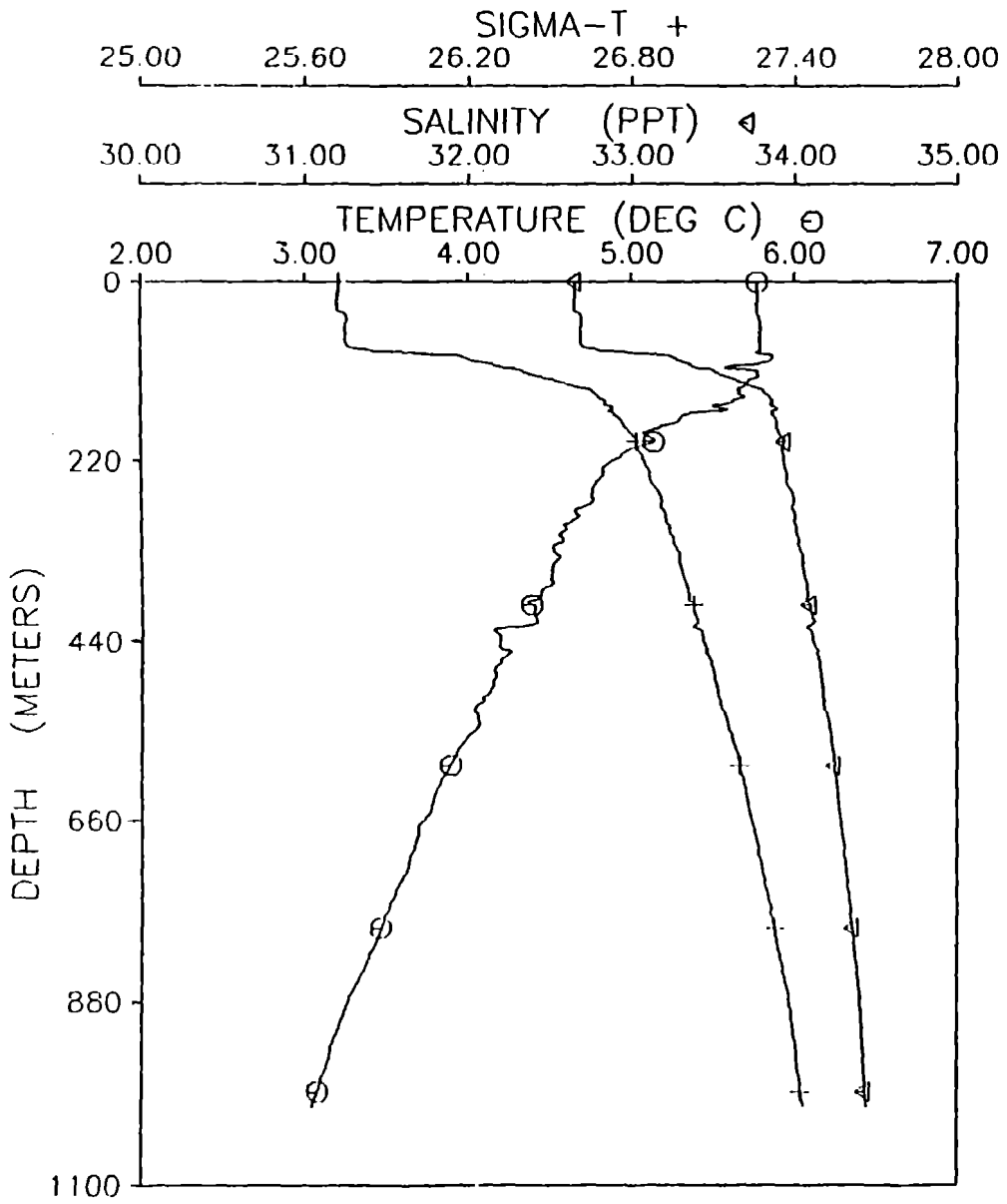


STATION: 25
CAST NUMBER: 0039

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 31 JAN 86
POSITION: 56 29.9 N, 138 59.9 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	5.76	32.66	25.74
10	5.76	32.66	25.73
20	5.76	32.65	25.73
30	5.76	32.65	25.73
50	5.75	32.65	25.73
75	5.75	32.65	25.72
100	5.76	32.78	25.83
125	5.98	33.42	26.30
150	5.98	33.72	26.55
175	5.98	33.87	26.66
200	5.63	33.91	26.74
250	5.13	34.01	26.87
300	4.69	34.06	26.97
400	4.28	34.15	27.08
500	3.98	34.22	27.17
600	3.75	34.28	27.24
700	3.57	34.33	27.30
800	3.36	34.38	27.36
900	3.17	34.41	27.40
1000	3.01	34.45	27.45

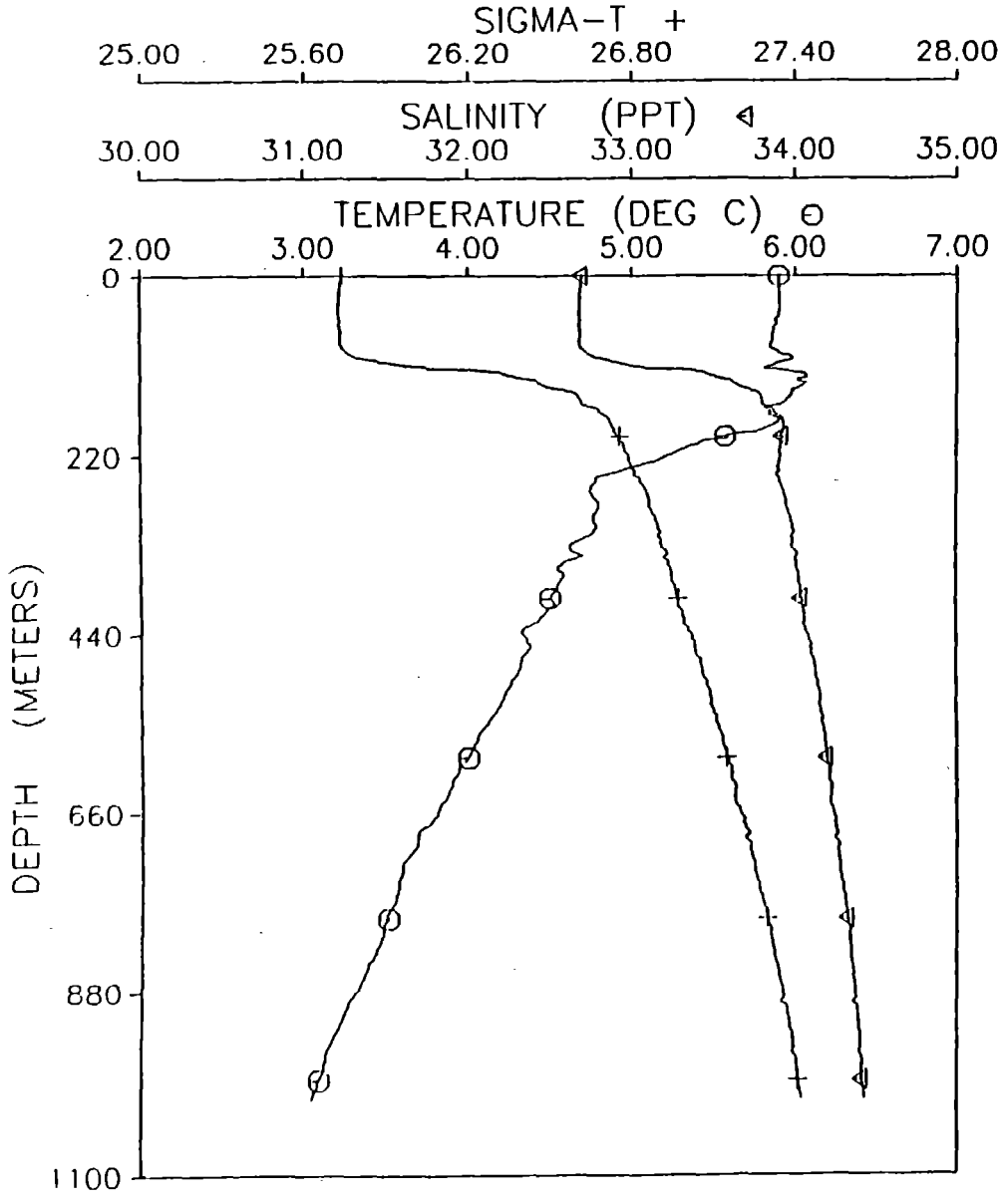


STATION: 26
CAST NUMBER: 0040

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 01 FEB 86
POSITION: 56 30.8 N, 138 30.2 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	5.77	32.65	25.73
10	5.77	32.65	25.72
20	5.77	32.65	25.72
30	5.77	32.65	25.72
50	5.79	32.69	25.76
75	5.79	32.69	25.75
100	5.80	33.33	26.26
125	5.70	33.69	26.55
150	5.61	33.86	26.70
175	5.26	33.90	26.77
200	5.14	33.94	26.82
250	4.78	33.96	26.88
300	4.58	34.01	26.93
400	4.41	34.10	27.03
500	4.15	34.18	27.12
600	3.88	34.24	27.20
700	3.67	34.31	27.27
800	3.46	34.36	27.33
900	3.25	34.40	27.39
1000	3.08	34.43	27.43

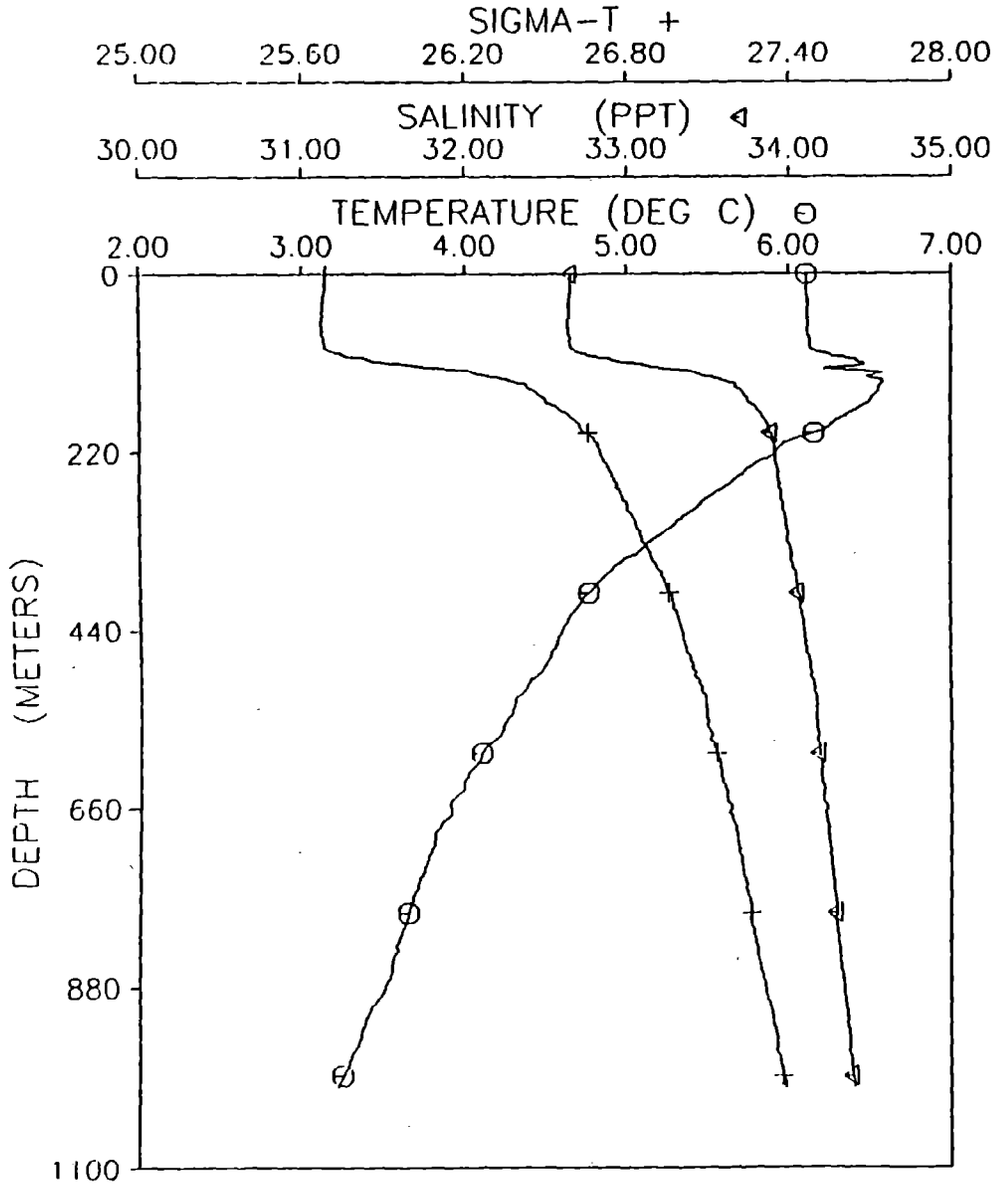


STATION: 27
CAST NUMBER: 0041

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 01 FEB 86
POSITION: 56 30.1 N, 137 59.6 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	5.90	32.69	25.74
10	5.90	32.68	25.73
20	5.90	32.69	25.74
30	5.91	32.68	25.73
50	5.90	32.68	25.73
75	5.86	32.68	25.74
100	5.98	32.76	25.78
125	6.08	33.52	26.37
150	5.97	33.80	26.60
175	5.89	33.92	26.71
200	5.60	33.93	26.76
250	4.78	33.91	26.83
300	4.77	33.98	26.89
400	4.52	34.05	26.98
500	4.28	34.14	27.07
600	3.99	34.20	27.15
700	3.69	34.25	27.22
800	3.50	34.33	27.30
900	3.28	34.37	27.36
1000	3.08	34.42	27.41

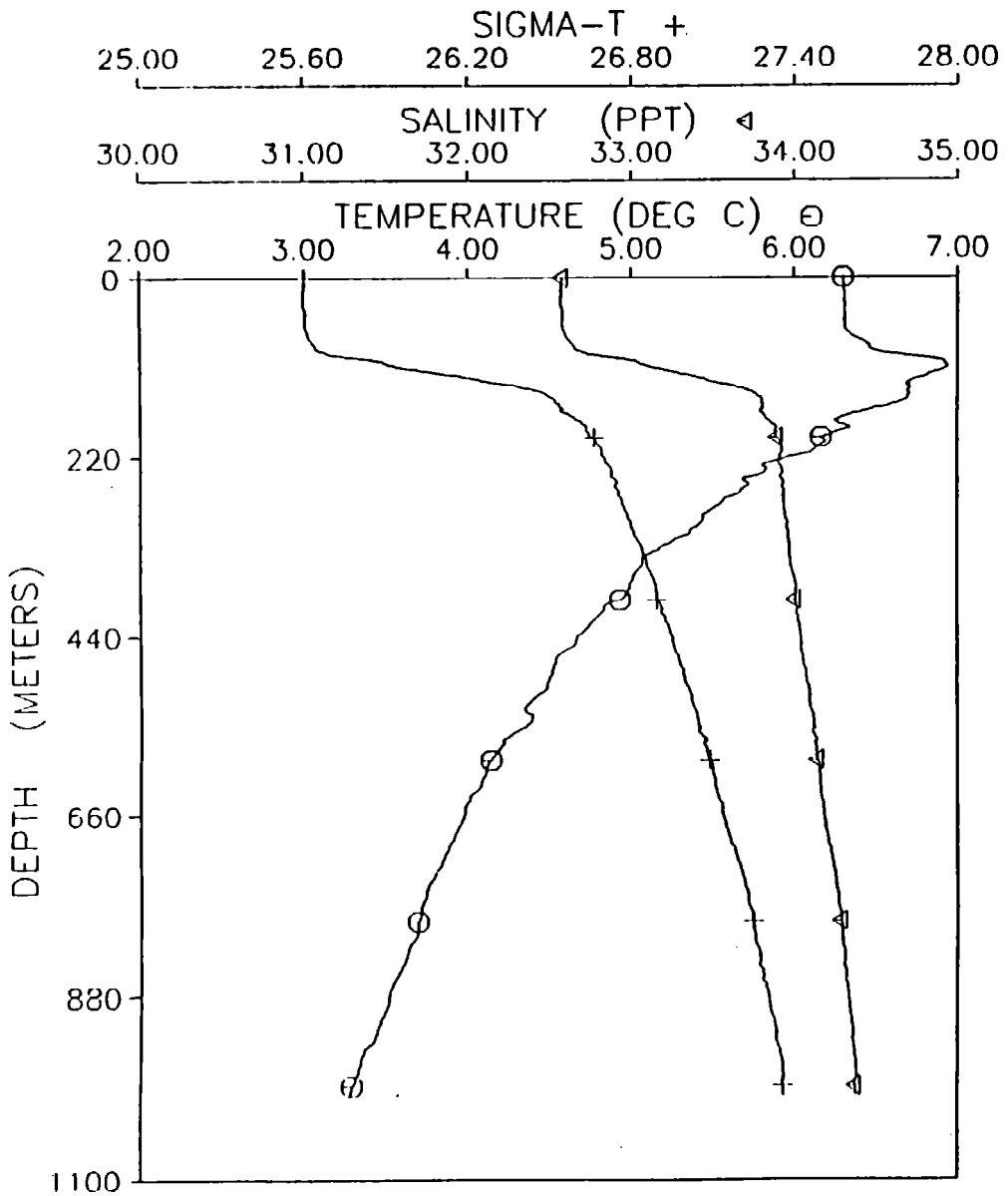


STATION: 28
CAST NUMBER: 0042

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 01 FEB 86
POSITION: 56 29.8 N, 137 28.9 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.11	32.66	25.69
10	6.11	32.65	25.68
20	6.11	32.65	25.68
30	6.12	32.65	25.68
50	6.12	32.64	25.68
75	6.12	32.64	25.67
100	6.25	32.75	25.75
125	6.54	33.44	26.25
150	6.54	33.72	26.48
175	6.36	33.83	26.58
200	6.14	33.90	26.67
250	5.72	33.94	26.75
300	5.38	33.98	26.82
400	4.77	34.06	26.96
500	4.45	34.13	27.05
600	4.10	34.19	27.13
700	3.81	34.25	27.21
800	3.65	34.30	27.26
900	3.49	34.34	27.32
1000	3.25	34.40	27.38

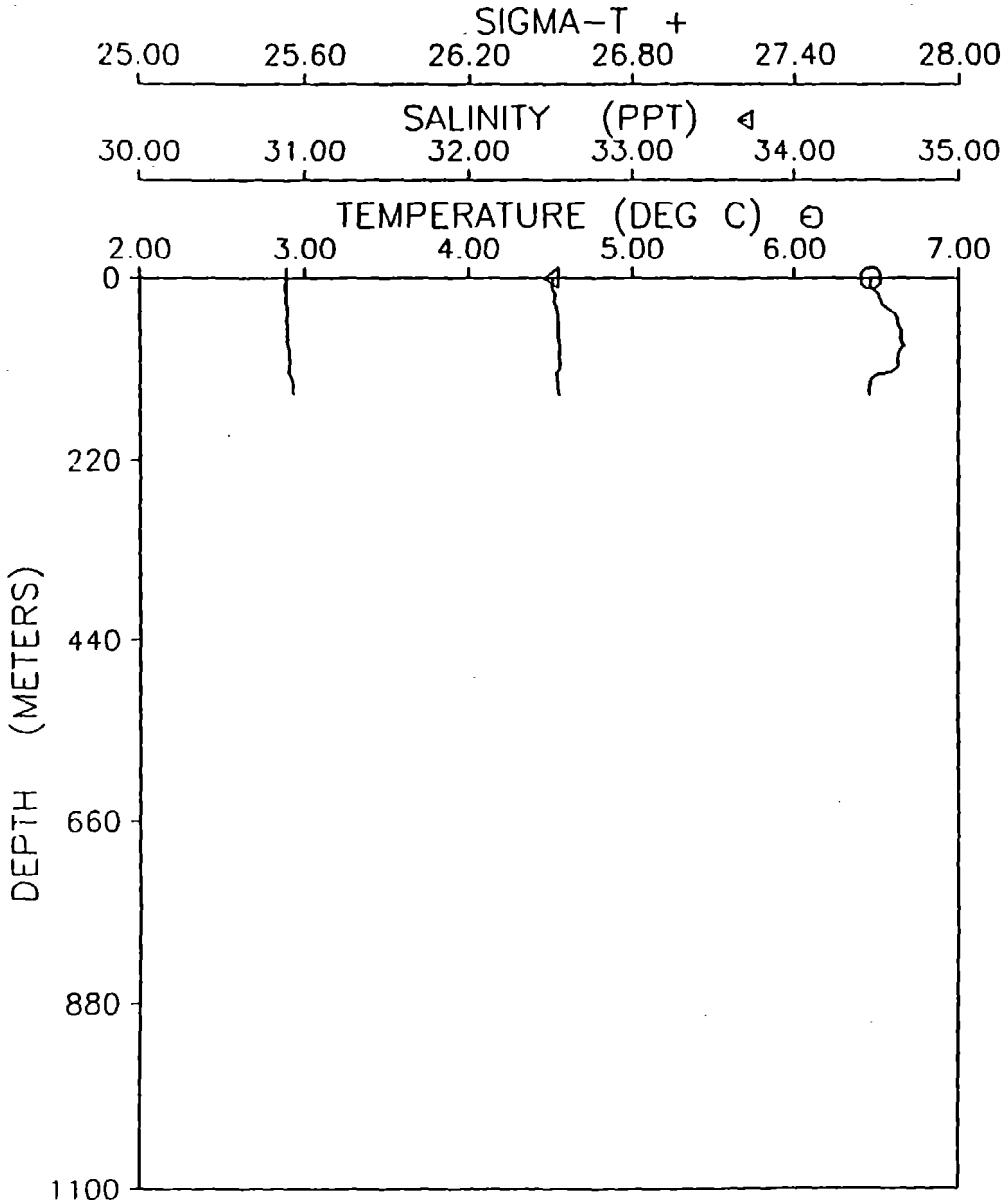


STATION: 29
CAST NUMBER: 0043

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 01 FEB 86
POSITION: 56 29.7 N, 136 59.5 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	6.30	32.58	25.60
10	6.31	32.57	25.60
20	6.31	32.57	25.60
30	6.31	32.57	25.60
50	6.31	32.58	25.60
75	6.38	32.61	25.62
100	6.82	32.95	25.83
125	6.75	33.46	26.24
150	6.70	33.80	26.52
175	6.28	33.83	26.60
200	6.18	33.91	26.67
250	5.69	33.93	26.75
300	5.45	33.96	26.80
400	4.91	34.01	26.90
500	4.51	34.08	27.00
600	4.15	34.15	27.09
700	3.91	34.21	27.17
800	3.70	34.29	27.25
900	3.51	34.34	27.31
1000	3.29	34.38	27.36

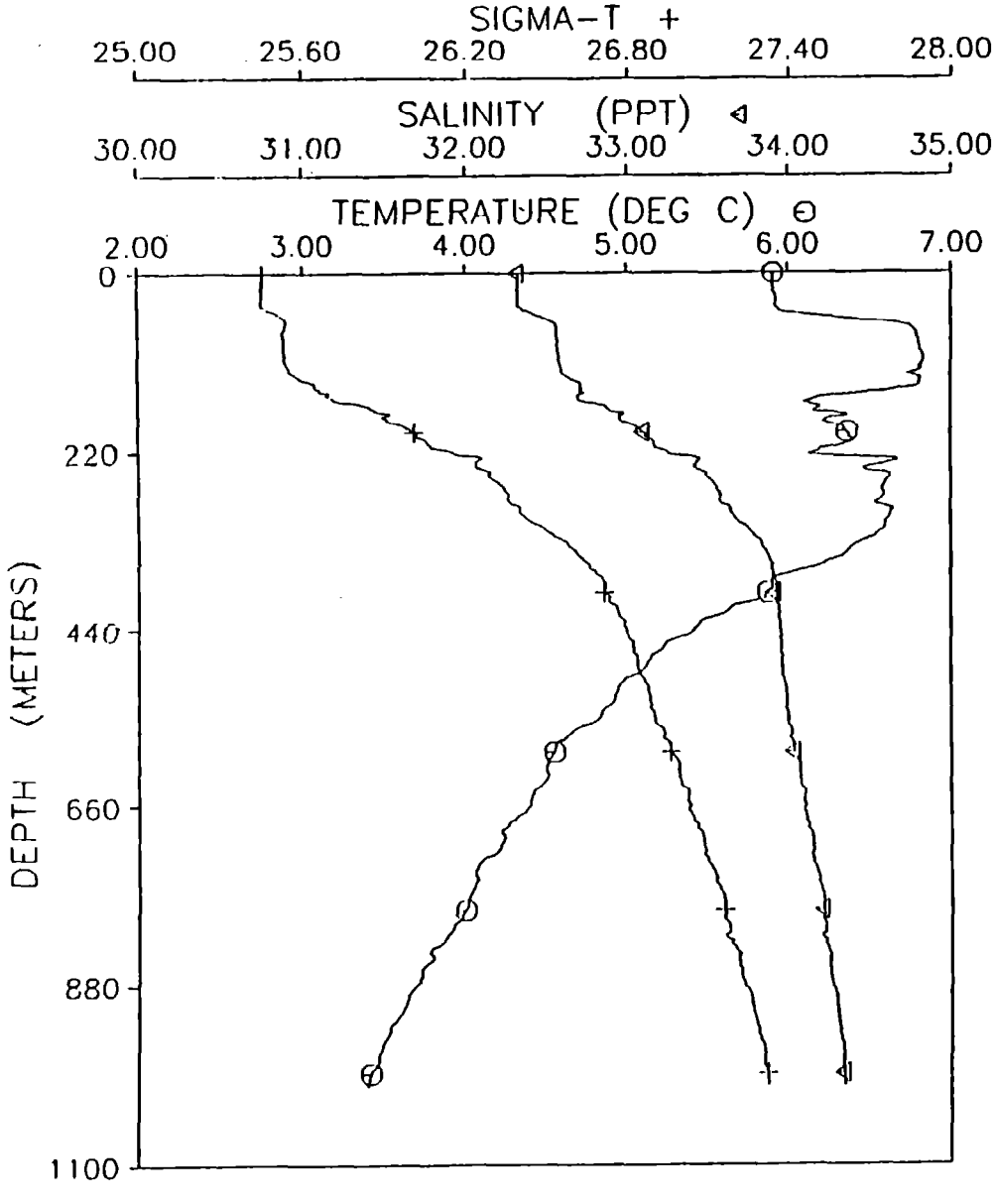


STATION: 32
CAST NUMBER: 0044

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 02 FEB 86
POSITION: 56 29.8 N, 135 30.2 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	6.47	32.52	25.53
10	6.47	32.51	25.52
20	6.52	32.53	25.53
30	6.53	32.52	25.53
50	6.63	32.54	25.53
75	6.65	32.55	25.54
100	6.63	32.56	25.55
125	6.47	32.54	25.56

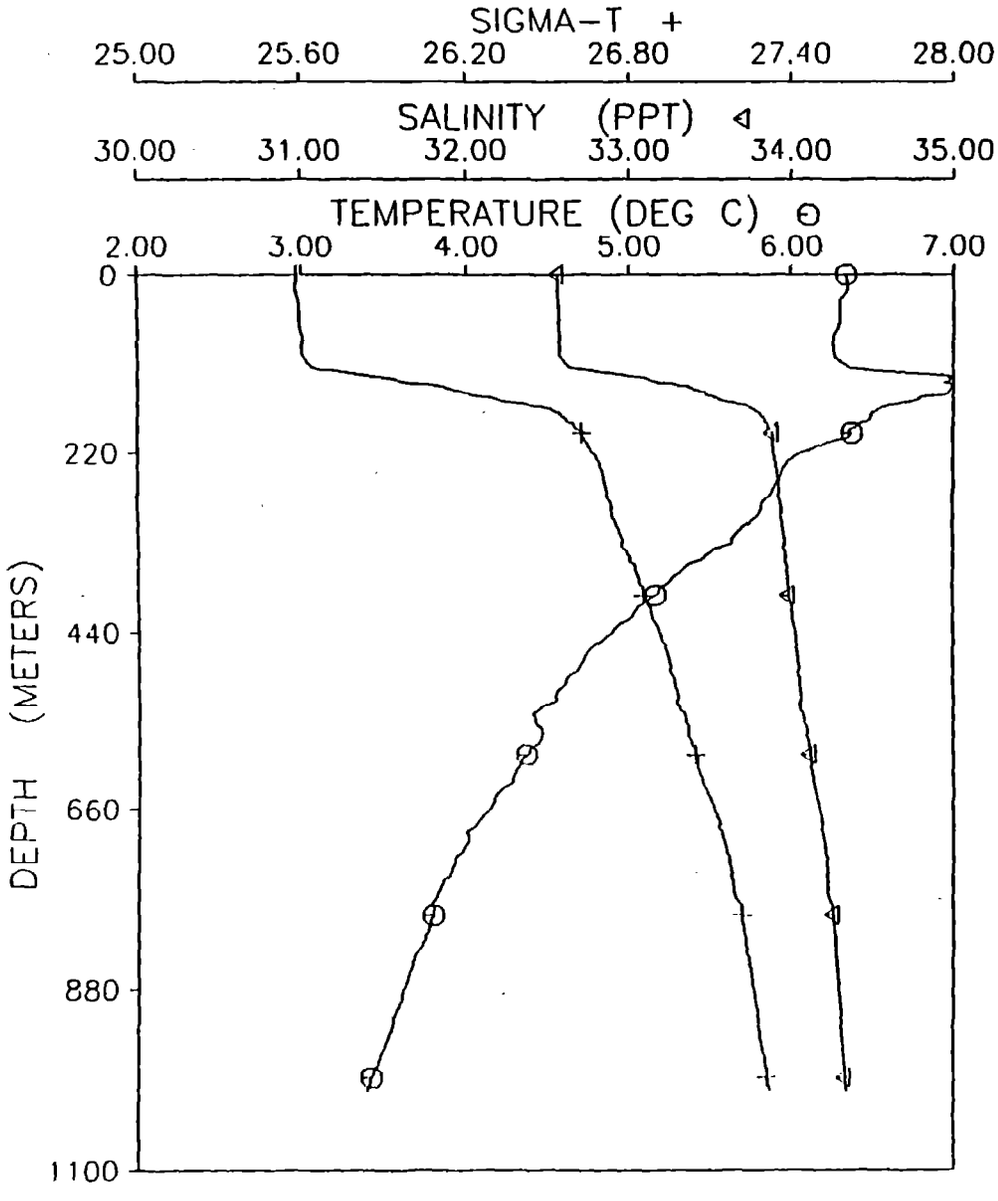


STATION: 31
CAST NUMBER: 0045

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF-86-01
DATE: 03 FEB 86
POSITION: 56° 29.9 N, 136° 1.3 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA-T
0	5.91	32.33	25.45
10	5.91	32.32	25.45
20	5.91	32.33	25.45
30	5.93	32.33	25.45
50	6.02	32.42	25.51
75	6.78	32.56	25.53
100	6.82	32.58	25.53
125	6.75	32.60	25.56
150	6.47	32.73	25.70
175	6.30	32.99	25.93
200	6.37	33.13	26.03
250	6.62	33.50	26.29
300	6.63	33.66	26.41
400	5.87	33.93	26.72
500	5.07	33.97	26.85
600	4.55	34.04	26.97
700	4.22	34.14	27.08
800	3.99	34.22	27.17
900	3.66	34.29	27.26
1000	3.42	34.35	27.33

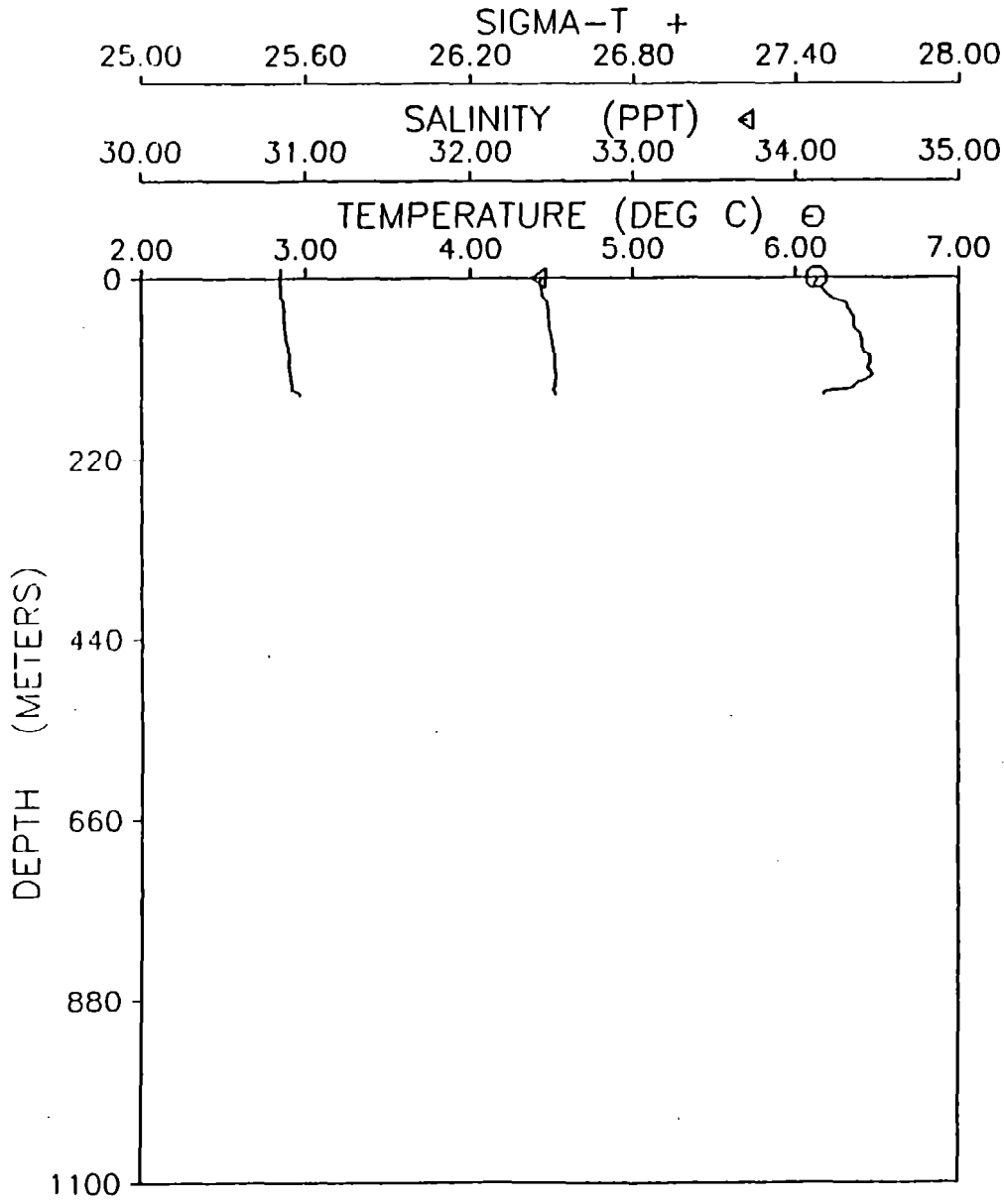


STATION: 30
CAST NUMBER: 0047

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 03 FEB 86
POSITION: 56 30.1 N, 136 30.7 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	6.34	32.56	25.58
10	6.35	32.56	25.58
20	6.34	32.56	25.58
30	6.31	32.56	25.59
50	6.30	32.56	25.59
75	6.27	32.57	25.60
100	6.27	32.57	25.60
125	6.76	32.90	25.80
150	7.07	33.48	26.21
175	6.50	33.80	26.54
200	6.37	33.89	26.63
250	5.94	33.92	26.70
300	5.80	33.94	26.74
400	5.16	33.99	26.86
500	4.64	34.05	26.97
600	4.37	34.13	27.05
700	4.01	34.20	27.15
800	3.80	34.26	27.22
900	3.61	34.30	27.27
1000	3.43	34.34	27.32

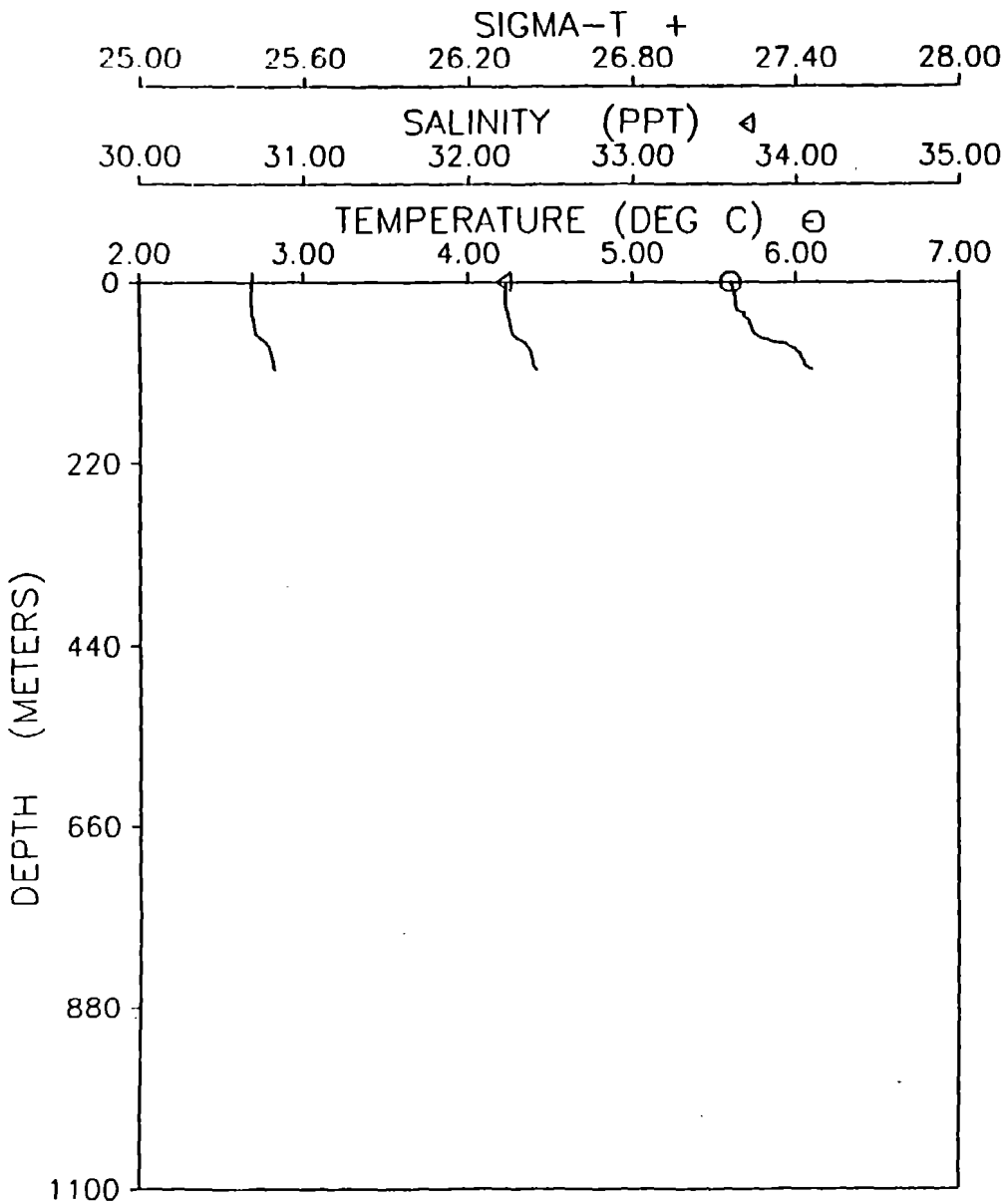


STATION: 32
CAST NUMBER: 0048

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 03 FEB 86
POSITION: 56 29.7 N, 135 30.2 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	6.13	32.44	25.51
10	6.12	32.43	25.51
20	6.20	32.44	25.51
30	6.30	32.47	25.52
50	6.36	32.48	25.52
75	6.41	32.50	25.53
100	6.46	32.53	25.54
125	6.44	32.53	25.55

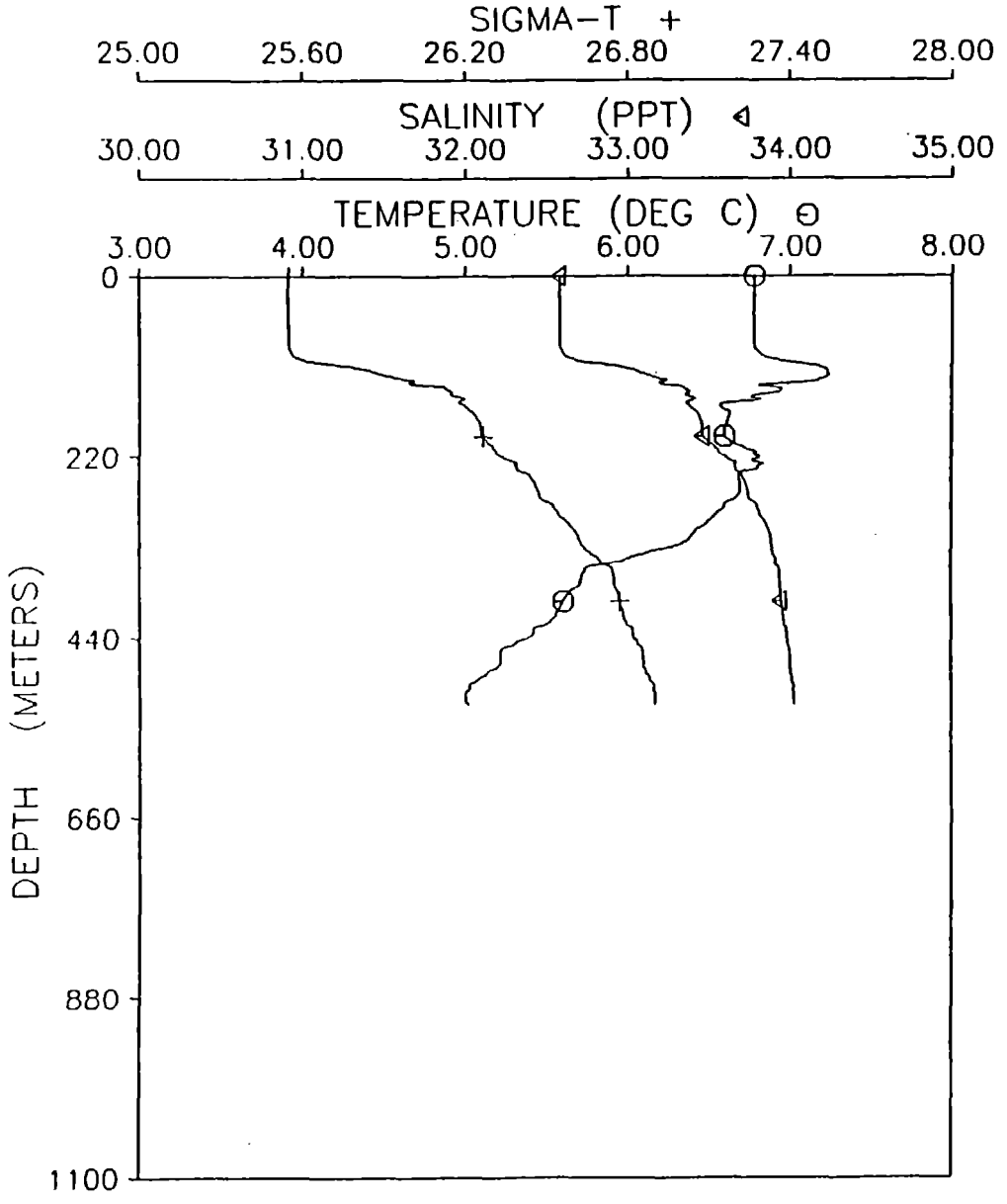


STATION: 33
CAST NUMBER: 0049

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 03 FEB 86
POSITION: 56 30.1 N, 135 10.2 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	5.60	32.23	25.41
10	5.61	32.23	25.41
20	5.63	32.23	25.41
30	5.63	32.23	25.41
50	5.72	32.25	25.42
75	5.91	32.35	25.47
100	6.05	32.39	25.49

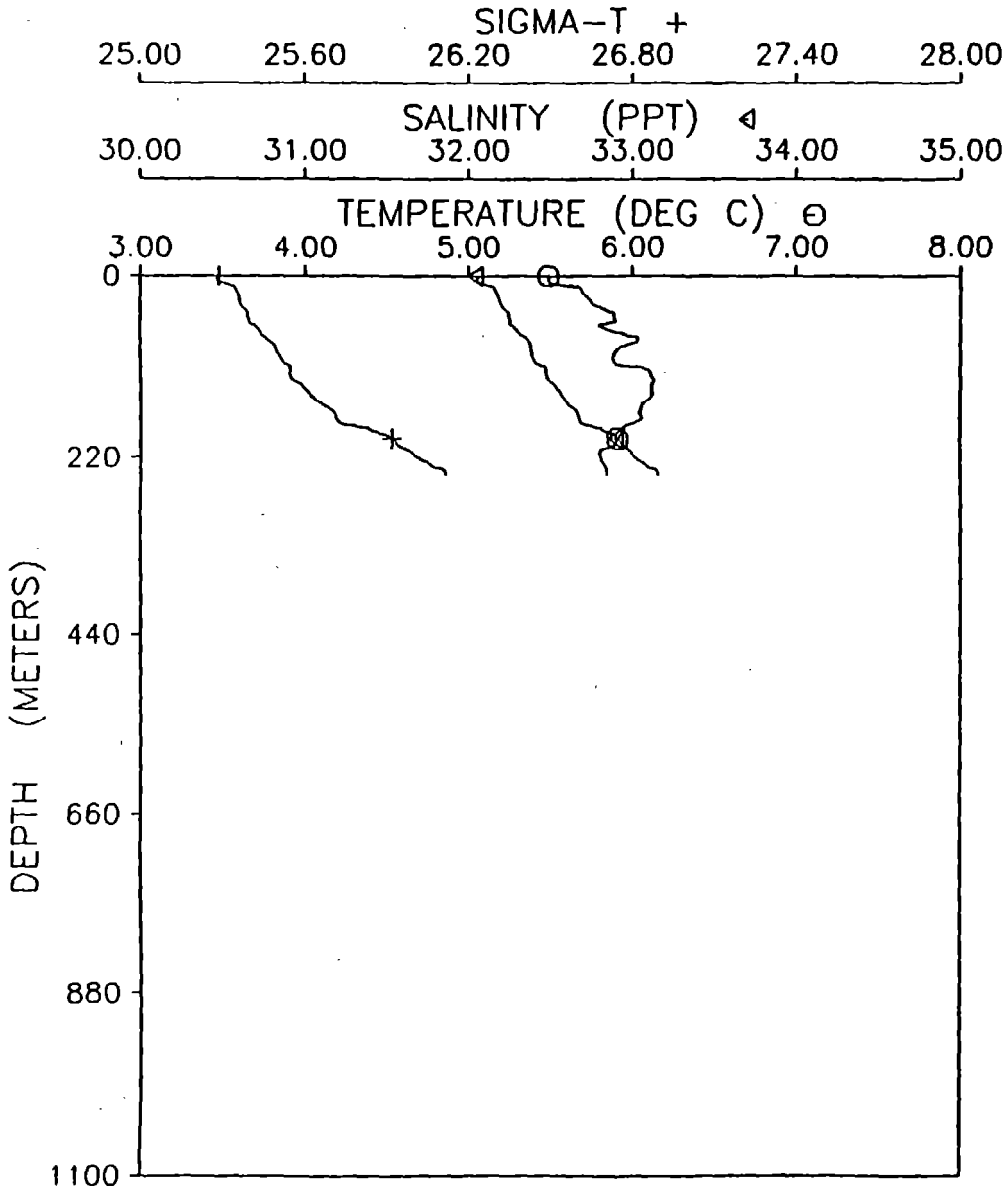


CAST NUMBER: 0050*

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 03 FEB 86
POSITION: 56 3.7 N, 135 32.1 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	6.78	32.59	25.55
10	6.78	32.59	25.55
20	6.78	32.58	25.55
30	6.78	32.59	25.55
50	6.78	32.59	25.55
75	6.78	32.59	25.55
100	6.84	32.62	25.57
125	7.24	33.15	25.93
150	6.76	33.39	26.18
175	6.63	33.44	26.24
200	6.60	33.47	26.27
250	6.69	33.72	26.45
300	6.52	33.85	26.57
400	5.61	33.96	26.78
500	5.07	34.02	26.89



CAST NUMBER: 0051*

SHIP: MILLER FREEMAN
CRUISE NUMBER: MF–86–01
DATE: 04 FEB 86
POSITION: 56 11.1 N, 135 10.4 W

DATA SUMMARY

DEPTH	TEMP	SALINITY	SIGMA–T
0	5.49	32.06	25.29
10	5.53	32.10	25.31
20	5.70	32.17	25.35
30	5.74	32.19	25.36
50	5.89	32.25	25.39
75	6.01	32.35	25.45
100	5.88	32.39	25.51
125	6.12	32.48	25.55
150	6.11	32.58	25.63
175	6.06	32.68	25.71
200	5.91	32.92	25.92

*CTD casts 0050 and 0051 were made during trawl sets, southeast of the oceanographic stations shown on Figure 1.

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AFSC-

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5 GUTTORMSEN, M., R. NARITA, J. GHARRETT, G. TROMBLE, and J. BERGER. 1992. Summary of observer sampling of domestic groundfish fisheries in the northeast Pacific Ocean and Eastern Bering Sea, 1990, 281 p. NTIS No. PB93-159085.

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