

AD-A081 606

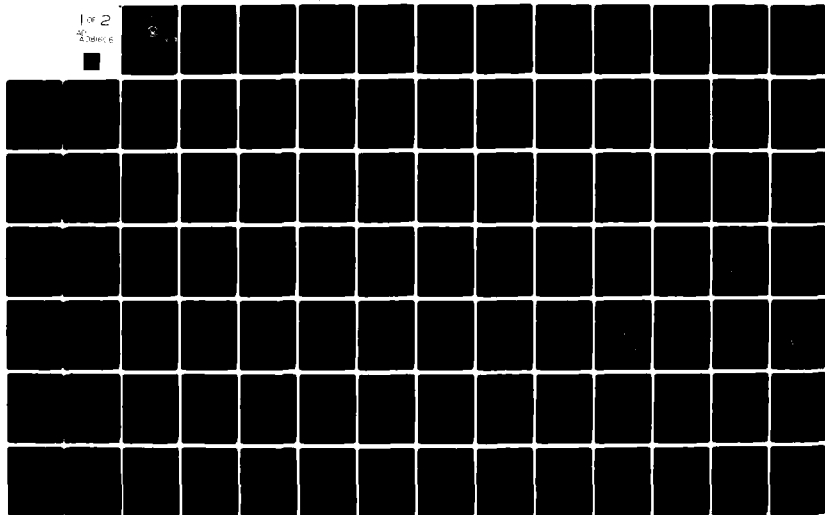
NAVAL POSTGRADUATE SCHOOL MONTEREY CA
MEASUREMENT OF THE CALIFORNIA COUNTERCURRENT. (U)
JUN 79 K CODDINGTON

F/G 8/3

UNCLASSIFIED

NL

1 of 2
AD-A081 606



AD A 081 606

LEVEL *(Handwritten signature)*
NAVAL POSTGRADUATE SCHOOL
Monterey, California



DTIC
ELECTE
S MAR 14 1980 **D**
A

THESIS

MEASUREMENT OF THE
CALIFORNIA COUNTERCURRENT

by

Keith Coddington

June 1979

Thesis Advisors:

J. B. Wickham
S. P. Tucker

Approved for public release; distribution unlimited.

DDC FILE COPY

86 3 10 128

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Measurement of the California Countercurrent		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis June 1979
7. AUTHOR(s) Keith Coddington		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12) 136		12. REPORT DATE Jun 79 13. NUMBER OF PAGES 135
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) California Countercurrent California Undercurrent Davidson Current California Current		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Direct measurements by moored current meters and indirect measurements from geostrophy are compared and discussed for a region over the continental slope off central California during the Davidson Current period. During that same period vertical temperature and salinity profiles were made at 23 stations on four separate cruises in the study area south of Monterey, California. These arrays of		

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

#20 - ABSTRACT - CONTINUED

moored current meters simultaneously recorded the flow of the current at specified levels.

The California Countercurrent was found to be present in the region of study during the entire observation period. Its offshore position and extent, its intensity and its vertical location and extent varied in a way largely consistent with its reported behavior in other locations along the U.S. West Coast.

SEARCHED	INDEXED
SERIALIZED	FILED
JAN 3 1961	
FBI - SAN FRANCISCO	
A	

DD Form 1473
S/N 0102-014-6601

UNCLASSIFIED

2 SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Approved for public release; distribution unlimited.

Measurement of the
California Countercurrent

by

Keith Coddington
Lieutenant, United States Coast Guard
B.S., United States Coast Guard Academy, 1973

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OCEANOGRAPHY

from the

NAVAL POSTGRADUATE SCHOOL

June 1979

Author

Keith Coddington

Approved by:

Steven P. Tucker

Thesis Co-Advisor

James B. Williams

Thesis Co-Advisor

Dale F. Rieffert

Chairman, Department of Oceanography

William M. Folger

Dean of Science and Engineering

ABSTRACT

Direct measurements by moored current meters and indirect measurements from geostrophy are compared and discussed for a region over the continental slope off central California during the Davidson Current period.

During that same period vertical temperature and salinity profiles were made at 23 stations on four separate cruises in the study area south of Monterey, California. These arrays of moored current meters simultaneously recorded the flow of the current at specified levels.

The California Countercurrent was found to be present in the region of study during the entire observation period. Its offshore position and extent, its intensity and its vertical location and extent varied in a way largely consistent with its reported behavior in other locations along the U.S. West Coast.

TABLE OF CONTENTS

I.	INTRODUCTION -----	13
	A. THE CALIFORNIA CURRENT SYSTEM -----	13
	B. PREVIOUS STUDIES OF THE CALIFORNIA UNDERCURRENT -----	14
	C. STATEMENT OF THE PROBLEM -----	19
II.	AREA OF INVESTIGATION -----	24
III.	SALINITY-TEMPERATURE-DEPTH OBSERVATIONS -----	27
	A. INSTRUMENTATION AND DATA COLLECTION -----	27
	B. RESULTS -----	28
	C. DISCUSSION OF WATERMASS PROPERTIES AND GEOSTROPHY -----	29
IV.	DIRECT CURRENT OBSERVATIONS -----	54
	A. INSTRUMENTATION AND DATA COLLECTION -----	54
	B. DISCUSSION OF DIRECT CURRENT MEASUREMENTS -	58
V.	COMPARISON OF GEOSTROPHY WITH DIRECT CURRENT MEASUREMENTS -----	70
VI.	CONCLUSIONS -----	73
	APPENDIX A: NOYFB PROGRAM -----	76
	APPENDIX B: TEMPERATURE, SIGMA-T, SOUND SPEED, AND SIGMA-T AND SALINITY SUPERIMPOSED VERTICAL SECTIONS -----	99
	BIBLIOGRAPHY -----	131
	INITIAL DISTRIBUTION LIST -----	134

LIST OF TABLES

TABLES	PAGE
I. Latitude, longitude and depth of stations --	26
II. Comparison of current meter and geostrophic current velocities on 27 November 1978 and 8 January 1979 -----	75

LIST OF FIGURES

FIGURE		PAGE
1.	Temperature-salinity curves from selected stations (Sverdrup and Johnson, 1941) -----	21
2.	Diagram showing T-S curves defining percentage southern water (Sverdrup and Johnson, 1941) ----	21
3.	Mean dynamic topography of the sea surface reference 500 db during January off California and Baja California (Hickey, 1978) -----	22
4.	Mean dynamic topography of the 200 db surface reference 500 db during January off California and Baja California (Hickey, 1978) --	22
5.	Temperature-salinity relationships for selected stations in California undercurrent (Wooster and Jones, 1970) -----	23
6.	Chart indicating area of investigation and stations -----	25
7.	Salinity (‰) on a vertical section for the Cape San Martin line on 27-28 November 1978 ----	34
8.	Salinity (‰) on a vertical section for the Slate Rock line on 27-28 November 1978 -----	35
9.	Salinity (‰) on a vertical section for the Cape San Martin line on 8-9 January 1979 -----	36
10.	Salinity (‰) on a vertical section for the Slate Rock line on 8-9 January 1979 -----	37
11.	Salinity (‰) on a vertical section for the Cape San Martin line on 22-23 January 1979 -----	38
12.	Salinity (‰) on a vertical section for the Slate Rock line on 22-23 January 1979 -----	39
13.	Salinity (‰) on a vertical section for the Cape San Martin line on 21-22 February 1979 ----	40
14.	Salinity (‰) on a vertical section for the Slate Rock line on 21-22 February 1979 -----	41
15.	Dynamic topography of the 100/500 db surface on 27-28 November 1978 -----	42

FIGURE		PAGE
16.	Dynamic topography of the 200/500 db surface on 27-28 November 1978 -----	42
17.	Dynamic topography of the 300/500 db surface on 27-28 November 1978 -----	42
18.	Dynamic topography of the 100/500 db surface on 8-9 January 1979 -----	43
19.	Dynamic topography of the 200/500 db surface on 8-9 January 1979 -----	43
20.	Dynamic topography of the 300/500 db surface on 8-9 January 1979 -----	43
21.	Dynamic topography of the 100/500 db surface on 22-23 January 1979 -----	44
22.	Dynamic topography of the 200/500 db surface on 22-23 January 1979 -----	44
23.	Dynamic topography of the 300/500 db surface on 22-23 January 1979 -----	44
24.	Dynamic topography of the 100/500 db surface on 21-22 February 1979 -----	45
25.	Dynamic topography of the 200/500 db surface on 21-22 February 1979 -----	45
26.	Dynamic topography of the 300/500 db surface on 21-22 February 1979 -----	45
27.	Vertical section of the normal component of geostrophic velocity for the Cape San Martin line on 27-28 November 1978 -----	46
28.	Vertical section of the normal component of geostrophic velocity for the Slate Rock line on 27-28 November 1978 -----	47
29.	Vertical section of the normal component of geostrophic velocity for the Cape San Martin line on 8-9 January 1979 -----	48
30.	Vertical section of the normal component of geostrophic velocity for the Slate Rock line on 8-9 January 1979 -----	49

FIGURE		PAGE
31.	Vertical section of the normal component of geostrophic velocity for the Cape San Martin line on 22-23 January 1979 -----	50
32.	Vertical section of the normal component of geostrophic velocity for the Slate Rock line on 22-23 January 1979 -----	51
33.	Vertical section of the normal component of geostrophic velocity for the Cape San Martin line on 21-22 February 1979 -----	52
34.	Vertical section of the normal component of geostrophic velocity for the Slate Rock line on 21-22 February 1979 -----	54
35.	Array configuration -----	57
36.	Progressive vector diagram for the current meter at station 2 at 220 meters depth from 25 July 1978 to 28 August 1978 -----	63
37.	Progressive vector diagram for the current meter at station 2 at 190 meters depth from 20 September 1978 to 27 November 1978 -----	64
38.	Progressive vector diagram for the current meter at station 2 at 100 meters depth from 27 November 1978 to 22 January 1979 -----	65
39.	Progressive vector diagram for the current meter at station 2 at 175 meters depth from 27 November 1978 to 22 January 1979 -----	66
40.	Progressive vector diagram for the current meter at station 2 at 300 meters depth from 27 November 1978 to 22 January 1979 -----	67
41.	Progressive vector diagram for the current meter at station 5 at 140 meters depth from 27 November 1978 to 22 January 1979 -----	68
42.	Progressive vector diagram for the current meter at station 5 at 215 meters depth from 27 November 1978 to 22 January 1979 -----	69
43.	Temperature ($^{\circ}$ C) on a vertical section for the Cape San Martin line on 27-28 November 1978 -	99
44.	Temperature ($^{\circ}$ C) on a vertical section for the Slate Rock line on 27-28 November 1978 -----	100

FIGURE		PAGE
45.	Temperature (°C) on a vertical section for the Cape San Martin line on 8-9 January 1979 -----	101
46.	Temperature (°C) on a vertical section for the Slate Rock line on 8-9 January 1979 -----	102
47.	Temperature (°C) on a vertical section for the Cape San Martin line on 22-23 January 1979 -----	103
48.	Temperature (°C) on a vertical section for the Slate Rock line on 22-23 January 1979 -----	104
49.	Temperature (°C) on a vertical section for the Cape San Martin line on 21-22 February 1979 -----	105
50.	Temperature (°C) on a vertical section for the Slate Rock line on 21-22 February 1979 -----	106
51.	Sigma-t on a vertical section for the Cape San Martin line on 27-28 November 1978 -----	107
52.	Sigma-t on a vertical section for the Slate Rock line on 27-28 November 1978 -----	108
53.	Sigma-t on a vertical section for the Cape San Martin line on 8-9 January 1979 -----	109
54.	Sigma-t on a vertical section for the Slate Rock line on 8-9 January 1979 -----	110
55.	Sigma-t on a vertical section for the Cape San Martin line on 22-23 January 1979 -----	111
56.	Sigma-t on a vertical section for the Slate Rock line on 22-23 January 1979 -----	112
57.	Sigma-t on a vertical section for the Cape San Martin line on 21-22 February 1979 -----	113
58.	Sigma-t on a vertical section for the Slate Rock line on 21-22 February 1979 -----	114
59.	Sound speed (m/sec) on a vertical section for the Cape San Martin line on 27-28 November 1978 -	115
60.	Sound speed (m/sec) on a vertical section for the Slate Rock line on 27-28 November 1978 -----	116
61.	Sound speed (m/sec) on a vertical section for the Cape San Martin line on 8-9 January 1979 ----	117

FIGURE		PAGE
62.	Sound speed (m/sec) on a vertical section for the Slate Rock line on 8-9 January 1979 -----	118
63.	Sound speed (m/sec) on a vertical section for the Cape San Martin line on 22-23 January 1979 --	119
64.	Sound speed (m/sec) on a vertical section for the Slate Rock line on 22-23 January 1979 -----	120
65.	Sound speed (m/sec) on a vertical section for the Cape San Martin line on 21-22 February 1979 -	121
66.	Sound speed (m/sec) on a vertical section for the Slate Rock line on 21-22 February 1979 -----	122
67.	Sigma-t and salinity (‰) superimposed on a vertical section for the Cape San Martin line on 27-28 November 1978 -----	123
68.	Sigma-t and salinity (‰) superimposed on a vertical section for the Slate Rock line on 27-28 November 1978 -----	124
69.	Sigma-t and salinity (‰) superimposed on a vertical section for the Cape San Martin line on 8-9 January 1979 -----	125
70.	Sigma-t and salinity (‰) superimposed on a vertical section for the Slate Rock line on 8-9 January 1979 -----	126
71.	Sigma-t and salinity (‰) superimposed on a vertical section for the Cape San Martin line on 22-23 January 1979 -----	127
72.	Sigma-t and salinity (‰) superimposed on a vertical section for the Slate Rock line on 22-23 January 1979 -----	128
73.	Sigma-t and salinity (‰) superimposed on a vertical section for the Cape San Martin line on 21-22 February 1979 -----	129
74.	Sigma-t and salinity (‰) superimposed on a vertical section for the Slate Rock line on 21-22 February 1979 -----	130

ACKNOWLEDGMENT

The author would like to express his sincere appreciation to his thesis advisors, Professor S.P. Tucker and Professor J.B. Wickham. Their knowledge and expertise in this project was only surpassed by their willingness to freely devote their time.

Special appreciation is extended to the Captain, W.W. Reynolds, and crew of the R/V ACANIA. Their highly skilled seamanship provided for smooth array installation and retrieval. Appreciation is also extended to Mr. Tim Stanton for his assistance in translating the current meter tapes.

Finally, a devoted thanks to my wife, Michelle, for her patience and understanding during this time.

I. INTRODUCTION

A. THE CALIFORNIA CURRENT SYSTEM

In the past decade eastern boundary currents and coastal upwelling have come under considerable scrutiny. This is due in part to their influence on the fishing industry and various other economic enterprises. Examples of eastern boundary current systems are the California, the Peru, the Benguela and the Canary Current Systems.

One eastern boundary current system, the California Current system is made up of an equatorward surface flow which extends along the entire west coast of the United States and Baja California and a counterflow, poleward, sometimes beneath this, at others on the surface shoreward of it. The equatorward surface flow is fed by the North Pacific Current, i.e. the northern limb of the North Pacific Gyre, and is known as the California Current. The poleward flow may be submerged, when it is then termed the California Undercurrent, or, at certain times of the year it may appear at the surface, when it is called the Davidson Current.

Reid, Roden and Wyllie (1958) apply the term California Current to all southward flow in the North Pacific Gyre. It is common to define the boundary of the California Current at a distance 1000 kilometers from shore (Hickey, 1978). High velocities are generally not encountered in this cold water mass.

The California Undercurrent is a poleward flow of water, the temperature and salinity of which is slightly higher than that of the surrounding water and which is usually found shoreward of the southward flowing California Current. It is much narrower and has a maximum of northward flow at intermediate depth. It is uncertain whether the Davidson Current is superimposed on the California Undercurrent, suppressing the core to great depths, or whether the Davidson Current is actually the expression of the undercurrent at the surface (Hickey, 1978).

The California Undercurrent is present year round and, with the onset of north-northwest winds and upwelling along California, it is found predominately below 200 meters. It is characterized by relatively high temperature, salinity and phosphate and low dissolved oxygen concentrations because of its southern origin. The undercurrent has been intensely studied off Oregon, Washington, and Southern California, but direct current measurements are lacking for the Central California region.

B. PREVIOUS STUDIES OF THE CALIFORNIA UNDERCURRENT

The California Undercurrent was first discussed by Sverdrup and Fleming (1941). During their cruises in 1937, they defined "northern water" on a T-S curve which showed an increase in salinity with decreasing temperature (Figure 1, curve C131). The T-S curve for "southern water" showed salinity relatively constant as temperature decreased (Figure 1,

curves 5.3 and B III, 31). They constructed a chart, defining percentage of southern water for given T-S pairs (Figure 2). Using these parameters they traced southern water as far north as Cape Mendocino. They also found that the southern water was close to the coast and was concentrated in the northward flowing current. They also showed the existence of the northward flowing undercurrent by means of dynamic heights.

Reid, Roden, and Wyllie (1958) expanded on Sverdrup and Fleming (1941) and Sverdrup, et al. (1942). They concluded the evidence for the undercurrent was of two sorts: (1) The warm or more saline subsurface water of low oxygen content suggested southern origin; and (2) geostrophic flow at the 200 decibar surface with respect to both the 500 and 1000 decibar surfaces indicated a northward flowing current, 30-60 miles in width near the coast north of 30°N and somewhat wider to the south.

Direct measurements of the undercurrent was made by Reid (1962, 1963) and Reid and Schwartzlose (1962) using drogues. Their results indicated the existence of a northward flowing current at 200 meters depth off Monterey, California, and Baja California. During the winter they found that a northward flow existed at the surface.

As a part of a California Cooperative Oceanic Fisheries Investigation (CALCOFI) study Wyllie (1966) showed the existence of a northward flowing undercurrent on the basis of dynamic topography. Wyllie's charts of mean monthly dynamic

topography on the 200 decibar surface relative to 500 decibars provide the best description of the flow of the undercurrent in January south of Cape Mendocine (Figures 3 and 4).

From Point Conception northward stronger subsurface flow was observed in winter than in summer. The weakest flow occurred from March to May. Pavlova (1966) found that during the spring, when the undercurrent appears to be absent at the usual depth of about 200 meters, it may be present at depths exceeding 500 meters. Pavlova also concluded that the undercurrent actually reaches the surface during late fall and winter, when it is known as the Davidson Current. Wyllie's data supported these conclusions.

Wooster and Jones (1970) found that a characteristic of the undercurrent was a relatively high salinity bulge centered at sigma-t equal 26.54 (150 cl/t) on the T-S diagram (Figure 5). They also gave some evidence for an inter-annual variation in the northward extent of a given isohaline. They pointed out that a coastal deepening of isotherms and isopycnals and rising of isohalines are characteristics of the poleward undercurrent.

In the last ten years the study of the undercurrent has been concentrated north of Cape Mendocino and to some extent in the vicinity of Monterey, California. Mooers, Collins and Smith (1976) in their study of upwelling off the Oregon coast found a northward flow along the continental slope between 300 and 1000 meters. They suggested that it may exist

at greater depths and may extend from the continental slope to perhaps 500 kilometers from shore. Their primary observations were conducted during the same year and season as those of Wooster and Jones (1970). Mooers, et al, (1976) found that during July 1975, the near surface flow was predominately southward, and the near bottom flow alternated between northward and southward. In August and September 1965 and 1966 the near bottom flow was predominately northward.

Huyer and Smith (1976) and Halpern, Smith and Reed (1978) used direct measurements of current on the slope and shelf to describe the seasonal developments of the undercurrent off the coast of Oregon. Huyer and Smith's (1976) data suggest that the northward flow is present at depths greater than 400 meters in the spring but increases in speed and vertical extent as the season progresses. That the undercurrent was found at the shelf edge by summer is consistent with Pavlova's (1966) findings for northern California. Halpern, Smith, and Reed's (1978) current meter results support those of Huyer and Smith (1976). The data of both these studies suggest that the shelf and slope undercurrents were portions of the same flow.

Eddies are frequently observed off the coast of Vancouver Island, B.C. Mysak (1977) in conjunction with his study of the undercurrent suggests that the eddies are produced by baroclinic instability of the California Undercurrent. For the undercurrent he found a northward flow along the

continental slope but a southward flow farther offshore. Thus, off Vancouver Island the northward flowing California Undercurrent is essentially confined to the continental slope. The main core of the current at that latitude occurs around 300 meters.

Off Monterey, California, the undercurrent has been studied by Molnar (1972), Hughes (1975), Greer (1975), and Wickham (1975). Wickham (1975) used drogues and a continuous measuring salinity-temperature-depth profiler (STD). For August three main results were found in conjunction with the undercurrent: (1) At both 50 meters and 200 meters geostrophy and drogues both indicate that there is a narrow band of poleward flowing water near the shelf edge; (2) both drogues and geostrophy also indicate that there is a complex flow farther west which seems to split the poleward flow into two branches; and (3) there is a broader poleward flow still farther west which is centered at 40-50 kilometers from the shelf edge.

An analytical model by McCreary (1977) indicated that, due to local wind forcing, the pycnocline tilts alongshore to balance the meridional component of the wind and results in an alongshore flow. This disturbance is not confined to the coast but propagates offshore and northward as a Kelvin-Rossby wave carrying along with it both the pycnocline deformation and the alongshore flow.

Hickey (1978) has examined most of the data to date. She found that the northward subsurface flow is generally

found off the west coast of North America over the continental slope. The flow on the 200 decibar surface is most continuous alongshore and strongest (south of Point Conception only) in summer and early fall. It is weakest and least continuous in the spring. North of Point Conception, the flow on the 200 decibar surface is stronger during winter than during summer and fall. She found that the depth of the high-speed core varied seasonally and that the flow appeared to have a jet-like structure, both vertically and horizontally and appeared to extend to the bottom over the slope. This is in agreement with McCreary (1977) who called this jet-like flow, quasi-geostrophic. In support of Wooster and Jones (1970), Hickey (1978) found that the salinity and temperature at the core of the undercurrent generally decreased from about 34.6‰ and 9.5°C off Baja California to about 33.9‰ and 7°C off Vancouver Island.

The flow from the surface to a depth of about 500 meters is confined to the continental slope, but the overall width of the region of northward flow has not been firmly established. The relationship between the undercurrent jet that occurs over the upper slope and the slower broader flow that occurs deeper in the water column farther offshore is uncertain.

C. STATEMENT OF THE PROBLEM

The presence of southern water can be inferred from isohalines, isotherms, and isopleths of sound speed; and the geostrophic current can be inferred from isopycnals. The

current can also be found through direct measurements by means of current meters. Wickham (1975) noted that a comparison of geostrophic observations with direct measurements of current would test the utility of geostrophy to describe flow in areas of complexity, such as off Monterey, California.

The initial objective of this study was to collect data by both means. This involved setting up stations where salinity, temperature and depth measurements could be taken and moored current meter arrays could be maintained. The thesis addresses the problems associated with the assembly and maintenance of the moored current arrays, the collection of salinity, temperature and depth data, and the analysis and interpretation of the direct and indirect current observations.

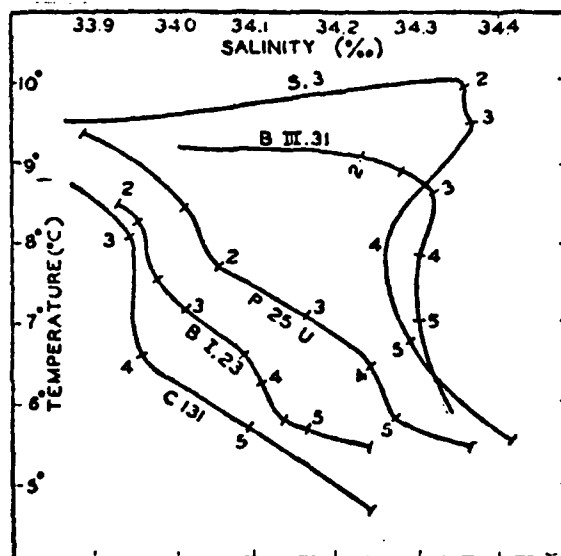


Figure 1. Temperature-salinity curves selected stations (Sverdrup and Johnson, 1941).

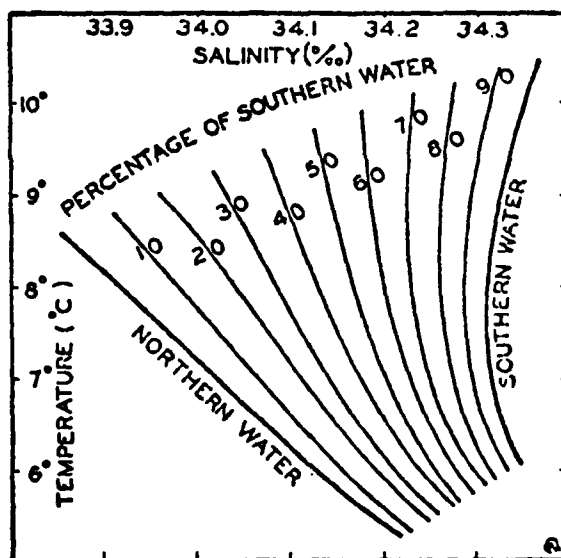


Figure 2. Diagram showing T-S curves defining percentage southern water (Sverdrup and Johnson, 1941).

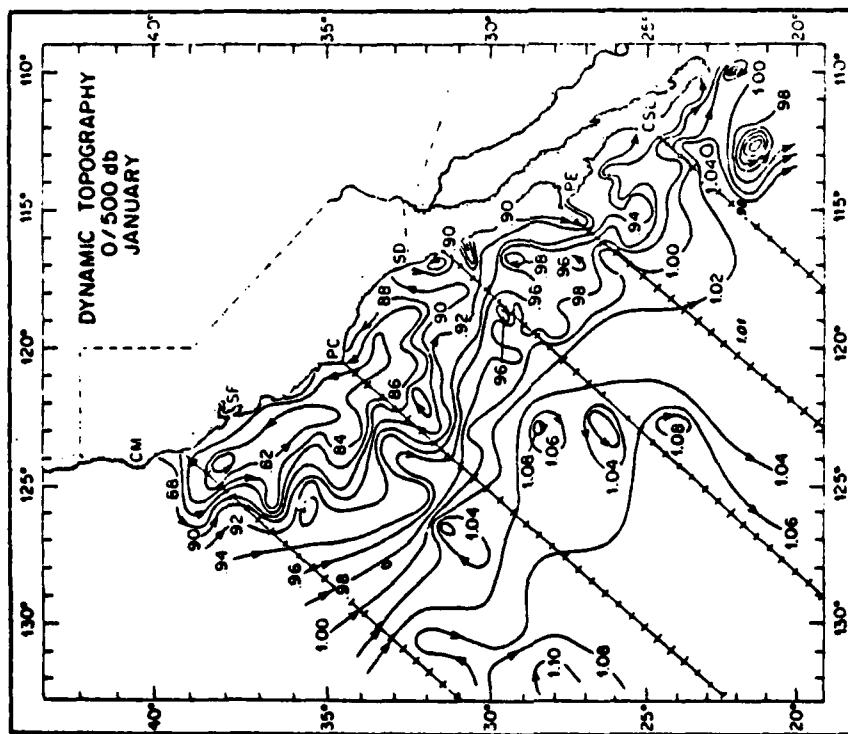


Figure 3. Mean dynamic topography of the sea surface off California and Baja California relative to 500 db during January, contoured from data given by Wyllie (1966). Contour interval is 0.02 dynamic meters (Hickey, 1978).

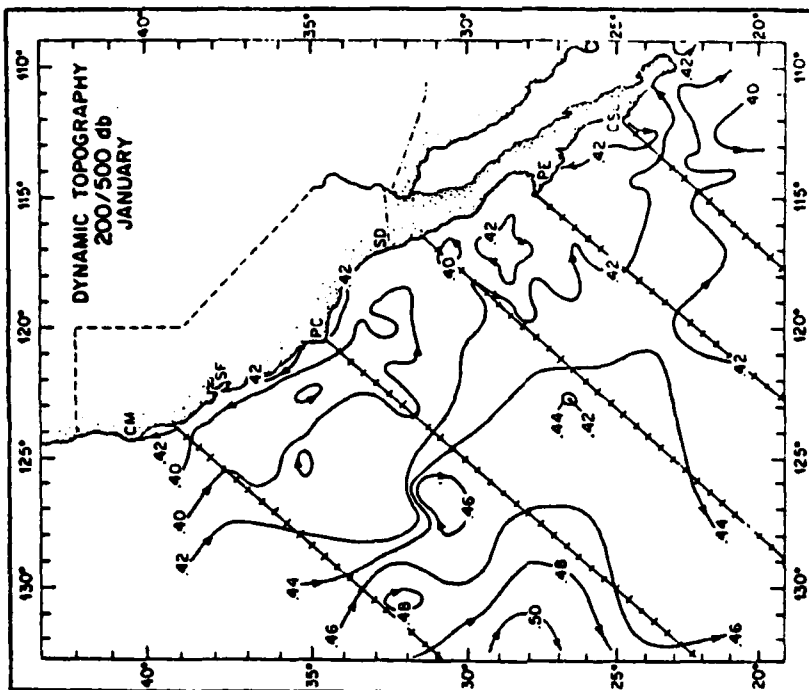


Figure 4. Mean dynamic topography of the 200 db surface relative to 500 db off California and Baja California during January, contoured from data given by Wyllie (1966). Contour interval is 0.02 dynamic meters (Hickey, 1978).

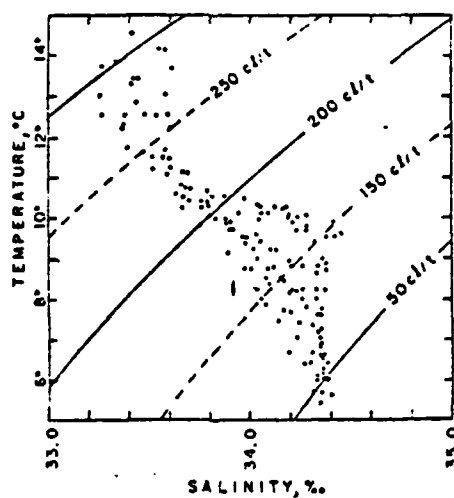


Figure 5. Temperature-salinity relationships for selected stations in California undercurrent (Wooster and Jones, 1970).

II. AREA OF INVESTIGATION

The area of investigation is south of Monterey, California, as shown in Figure 6. Two lines of stations were established. The station locations and water depths are listed in Table I.

One of the reasons for positioning the stations on this part of the California coast is the relative simplicity of the bathymetric features. The depth contours run approximately parallel to the coast, and the shelf break is close to the coast. Another, but crucial, reason for using this part of the California coast is that it is less heavily fished than the areas immediately to the north and to the south. The current meter arrays are entirely subsurface with no surface markers. The presence of fishing activity increases the possibility of array damage or loss which we have tried to minimize through our selection of the study area.

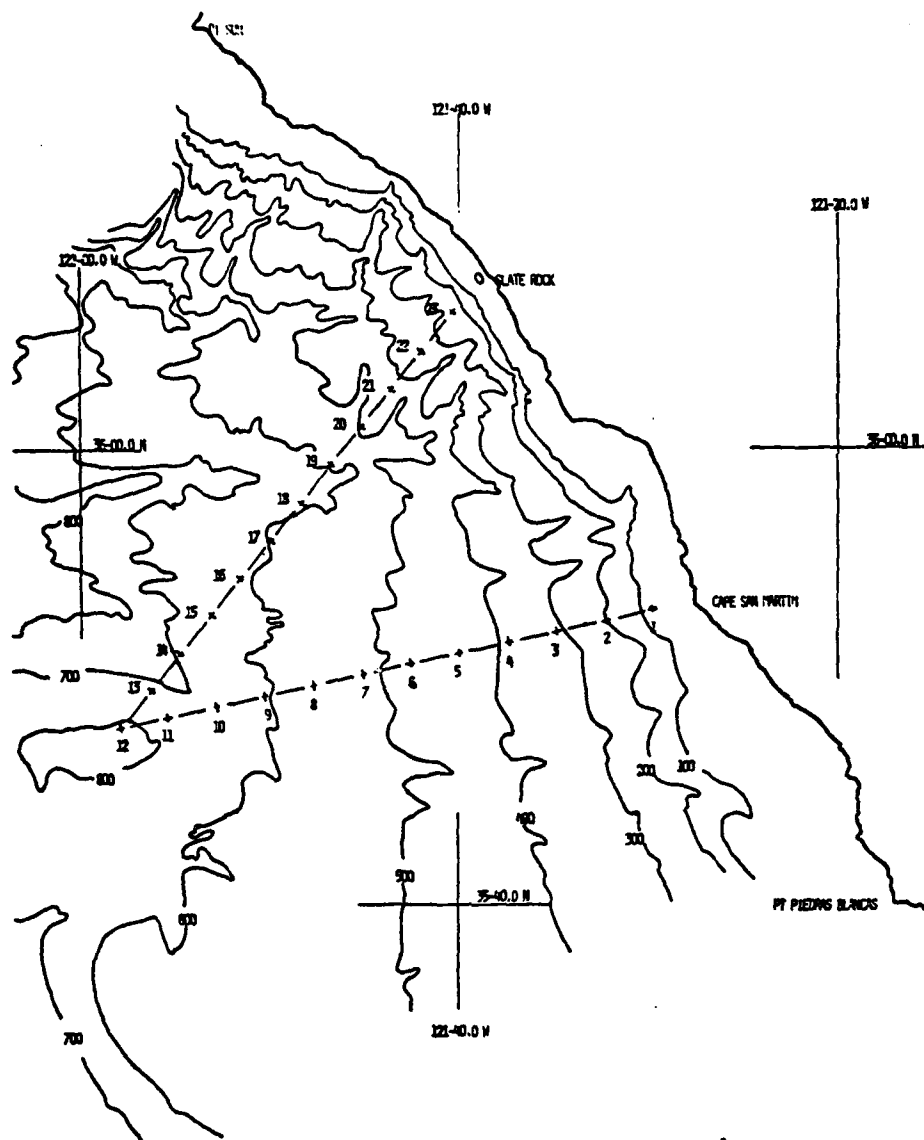


Figure 6. Chart indicating area of investigation and stations. Depth contours in fathoms.

TABLE I

<u>STATION</u>	<u>LATITUDE</u>	<u>LONGITUDE</u>	<u>DEPTH (METERS)</u>
1	35-53.0	121-29.8	100
2	35-52.5	121-32.3	357
3	35-52.1	121-34.7	520
4	35-51.6	121-37.4	668
5	35-51.1	121-39.9	759
6	35-50.7	121-42.4	833
7	35-50.2	121-45.0	915
8	35-49.7	121-47.6	988
9	35-49.2	121-50.1	1061
10	35-48.7	121-52.7	1150
11	35-48.3	121-55.4	1182
12	35-47.8	121-57.7	1044
13	35-49.5	121-56.1	1274
14	35-51.1	121-54.6	1183
15	35-52.7	121-53.0	1146
16	35-54.3	121-51.3	1089
17	35-55.9	121-49.9	1080
18	35-57.6	121-48.3	1098
19	35-59.3	121-47.8	997
20	36-00.9	121-45.2	842
21	36-02.5	121-43.5	732
22	36-04.3	121-42.0	560
23	36-05.9	121-40.2	350

III. SALINITY-TEMPERATURE-DEPTH OBSERVATIONS

A. INSTRUMENTATION AND DATA COLLECTION

Watermass data was collected on four separate cruises of the R/V ACANIA, the oceanographic vessel of the Naval Postgraduate School. The cruises were on 27-28 November 1978, 8-9 January 1979, 22-23 January 1979, and 21-22 February 1979. During each cruise all 23 stations were occupied. Sampling of watermass properties was done where possible to 500 meters, the reference level used by CALCOFI (Wyllie, 1966).

For each cruise the primary instrument, a Bisset Berman Model 9006 STD, was used for delineating the vertical distributions of temperature and salinity. Nansen bottles and reversing thermometers provided independent measurements to check the calibration of the STD. Expendible bathythermograph (XBT) drops and surface temperature observations were made also at each station.

The analog recorder usually used with the Model 9006 STD was replaced on these cruises. The three separated signal frequencies were sent through a Hewlett-Packard Model 57307A VHF Switch with a 20 milisecond settling time to a Hewlett-Packard Model 5328A Universal Counter. The resulting binary coded decimal output was then read into the random access memory of a Hewlett-Packard 9831A desktop computer. After each complete profile the data was transferred to magnetic

tape. Profiles were recorded for both the descent and ascent of the STD.

Spikes in the salinity trace are known to be caused by a poorly matched time constant between the conductivity sensor and the platinum resistance thermometer used in the STD to correct the conductivity measurements to salinity. Salinity spikes were eliminated by comparison of descent and ascent profiles and XBT profiles. This was done by hand during examination of the profiles.

B. RESULTS

The results for each cruise are shown as vertical sections for both the Cape San Martin line and the Slate Rock line. Vertical sections are drawn for: salinity, temperature, sigma-t, sound speed, geostrophic currents, and sigma-t and salinity together. The dynamic topography of the 100 db, 200 db, and 300 db surfaces relative to 500 decibars is also given for the four separate cruises.

Salinity and temperature sections were contoured using data stored on the magnetic tapes from the HP 9831A computer after the salinity spikes had been removed. Sigma-t, geostrophic shear, and dynamic heights were calculated using the library computer program HYDRO, available at the Naval Postgraduate School for the IBM 360 computer. Sound speed was calculated using Wilson's equations (Wilson, 1960), available in the same program.

From the calculation of geostrophic shear mean values for four station intervals were found. This was done to

reduce the non-geostrophic contributions to the calculations which are inversely proportional to the distance over which geostrophic shear is averaged. Thus, resolution is diminished in order to give a more accurate picture of the larger scale circulation features.

Dynamic heights were smoothed in a similar manner. Values were averaged over three station heights. For station 12 the mean value was found using stations 11, 12, and 13. For the coastal stations 1 and 23 only two stations were used in the averaging, i.e., stations 1 and 2 and stations 22 and 23. For the coastal stations with less than 500 meters of water the stations were treated as if the depth were 500 meters and dynamic topographies were extrapolated from the first station seaward with such depth.

There are no results for stations 21, 22, and 23 during the cruise of 21-22 February 1979, as these stations were lost due to failure of the data recording equipment. On the same cruise there were four stations at five nautical mile intervals added to the west of station 12. This allowed computation of geostrophic shear out to station 12.

C. DISCUSSION OF WATERMASS PROPERTIES AND GEOSTROPHY

The presence of souther water is indicated by the distributions in two cross-sections of salinity, temperature, sigma-t, and sound speed on the series of four cruises. The current structure for the same series is deduced from geostrophic current sections and from dynamic topography at

three different levels, both currents and topographies being referred to 500 decibars. Direct current measurements are discussed later in Section IV.

Water with relatively high southern watermass properties is present below the pycnocline on the first cruise on 27-28 November 1978. This is particularly evident on the salinity sections, Figures 7 and 8. Both show a bulge of high salinity water below 200 meters, on Figure 7 for example between stations 3 and 10. The associated temperature and sound speed sections (Appendix B) also indicate the presence of southern water in this region. On this cruise the southern water characteristics appear below 200 meters and from about 4 kilometers to 38 kilometers offshore over the continental slope.

Geostrophy, Figures 27 and 28, indicates northward flow in the upper layers with a surface maximum of 25 to 30 cm/sec. The current appears to have two branches with weaker southward flow between them. Wickham (1975) found similar indications of branched flow farther offshore for his August data in the latitude of Monterey, and these were confirmed by drogue drifts. This branched northward flow is further shown at each of the three levels of contoured dynamic topography (100, 200, and 300 decibars, Figures 15, 16, and 17). Some southward flow appears at all three levels from stations 15 to 18. This is a small-scale feature and might not be real since small scales are not well resolved by geostrophy.

Comparison will be made in Section V between geostrophic and direct current measurements.

The cruise of 8-9 January 1979 also showed southern water; but, as Figures 9 and 10 show, the bulge of high salinity occurs farther west. The associated temperature and sound speed sections (Appendix B) also show this westward displacement of the southern water. Below 200 meters this southern water is found 15 kilometers farther offshore than on the last cruise. Although Pavlova (1966) and Hickey (1978) indicated the countercurrent moves offshore in the spring, our observations were made during the winter season. McCreary's (1977) view of the current's variations as manifestations of baroclinic Kelvin-like waves is consistent with this offshore movement.

Geostrophy in the cross-sections for 8-9 January 1979 (Figures 29 and 30) also shows the northward flow farther offshore. There is still a maximum at the surface, but with an increase in velocity to 70 cm/sec normal to the Cape San Martin line and 35 cm/sec normal to the Slate Rock line. There is an indication that this may be the shoreward branch of the northward flow found during the first cruise, as southward flow appears on the offshore edge of both sections. Dynamic topography (Figures 18, 19, and 20) shows this same pattern. At the 100 db level (Figure 18) the flow is intense and northward between stations 3 and 9. To the west of station 9 the flow intensity drops off sharply and southward flow appears between stations 13 and 15. To the east of

station 3 the dynamic topography is generally flat with northward flow indicated. At the 200 db level (Figure 19) the flow is weaker but is still northward between stations 3 and 9. Southward flow is now more evident between stations 13 and 15. At the 300 db level (Figure 20) the flow is southward with only a trace of northward flow between stations 15 and 17.

The cruise on 22-23 January 1979 shows reductions in southern water characteristics. All indicators, i.e., isopleths of salinity, temperature, sigma-t, and sound speed, are nearly parallel with only small horizontal gradients. Note that the 34.20 ‰ isohaline which in November lay in places higher in the water column than 200 meters is now at a depth of 300 meters, except within a few kilometers of the slope. This may indicate that southern water has moved seaward or deeper beyond the range of observations.

Geostrophy shows slight westward propagation of the northward flow (Figures 31 and 32, also, 21, 22, and 23). The flow appears slower, 20 cm/sec, and more diffuse. At the 200 db level (Figure 22) southward flow now exists shoreward of station 4. At the 300 db level (Figure 23) the flow has become more diffuse and the southern flow is now shoreward of stations 5 and 20.

The observations for the cruise of 21-22 February 1979 indicate an increase in salinity below 200 meters (Figures 13 and 14), the 34.20 ‰ isohaline having risen to a depth of 250 meters over most of both sections. The dynamic topography

(Figures 24, 25, and 26) now indicates a northward flow at stations 2 and 3 at the 200 db and 300 db levels. The geostrophic sections do not show this since the station averaging interval used in their construction does not permit calculations shoreward of station 4. This flow at the eastern stations and below 200 meters may be the start of the undercurrent.

An immediate observation must be made: The regions with indications of southern water and the regions where northward flow is indicated by geostrophy do not exactly coincide. For all the cruises considered, geostrophy shows a northward surface flow, in some instances with flow as great as 70 cm/sec, even though the watermass characteristics in some regions are not southern. This is not too surprising, since near the boundaries between watermasses, eddies and entrainment of anomalous water is common. The observed variations in salinity and velocity may also have alternative explanations. Passing eddies or meanders in the countercurrent might give results similar to those just discussed.

In the following section the currents inferred from geostrophy are compared to those measured directly by moored current meter arrays along the Cape San Martin line.

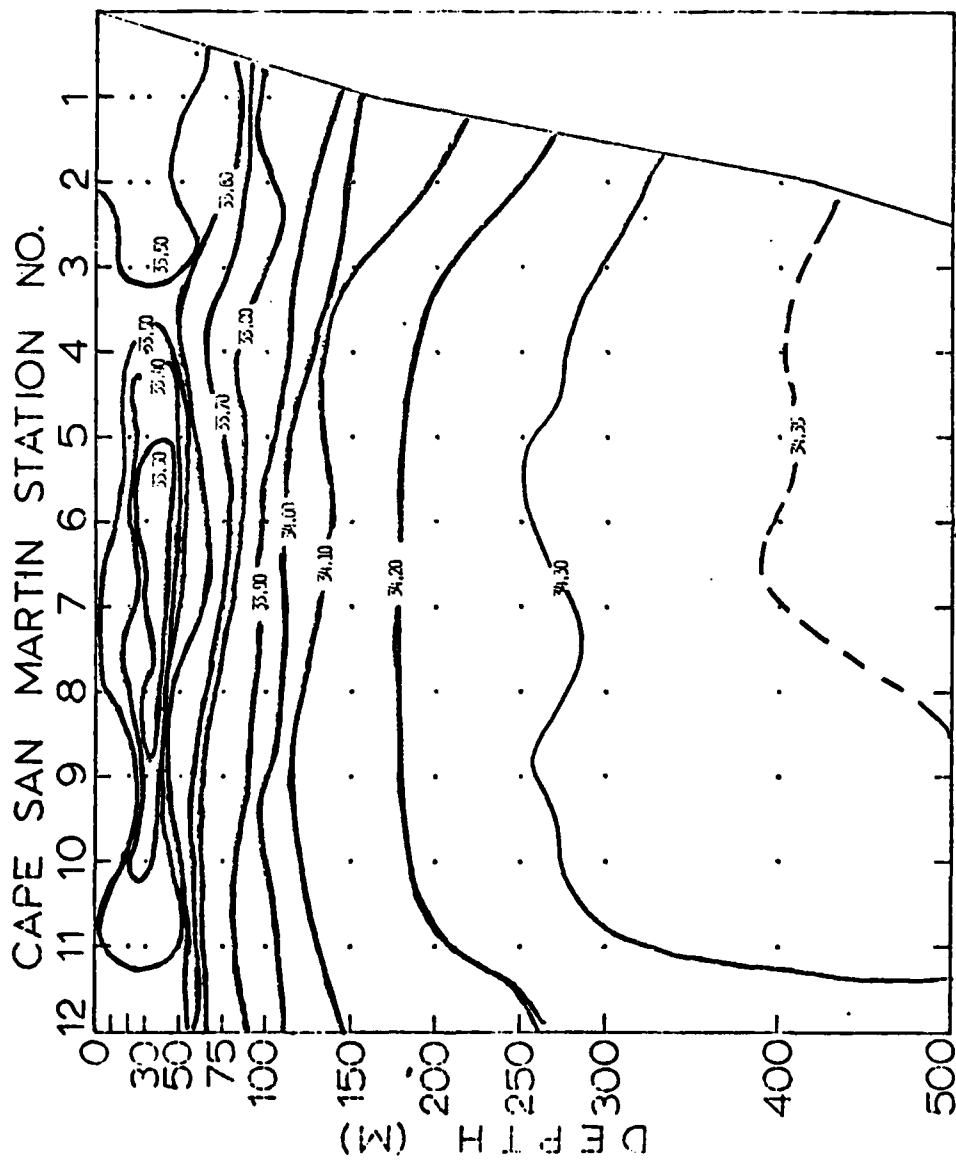


Figure 7. Salinity (‰) on a vertical section for the Cape San Martin line on 27-28 November 1978.

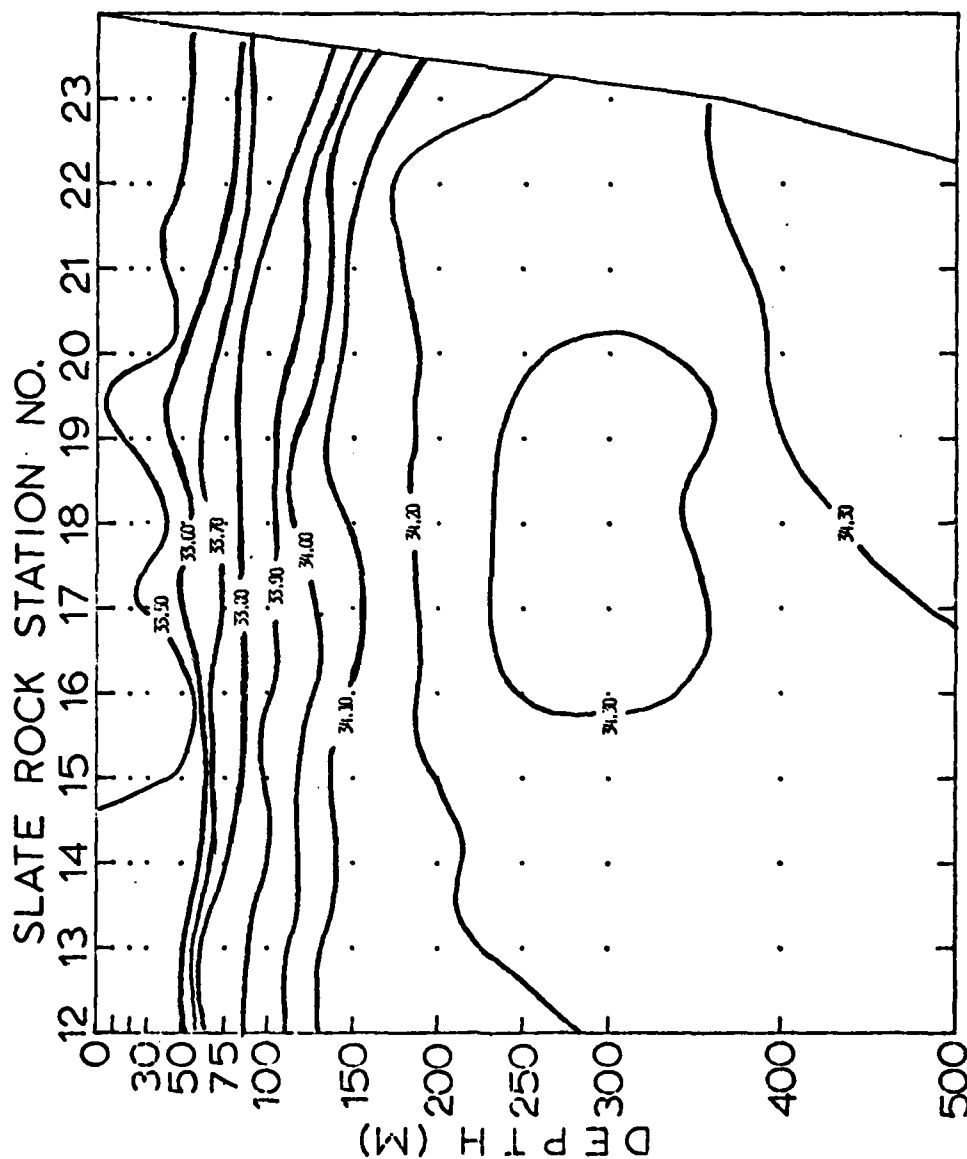


Figure 8. Salinity (‰) on a vertical section for the Slate Rock line on 27-28 November 1978.

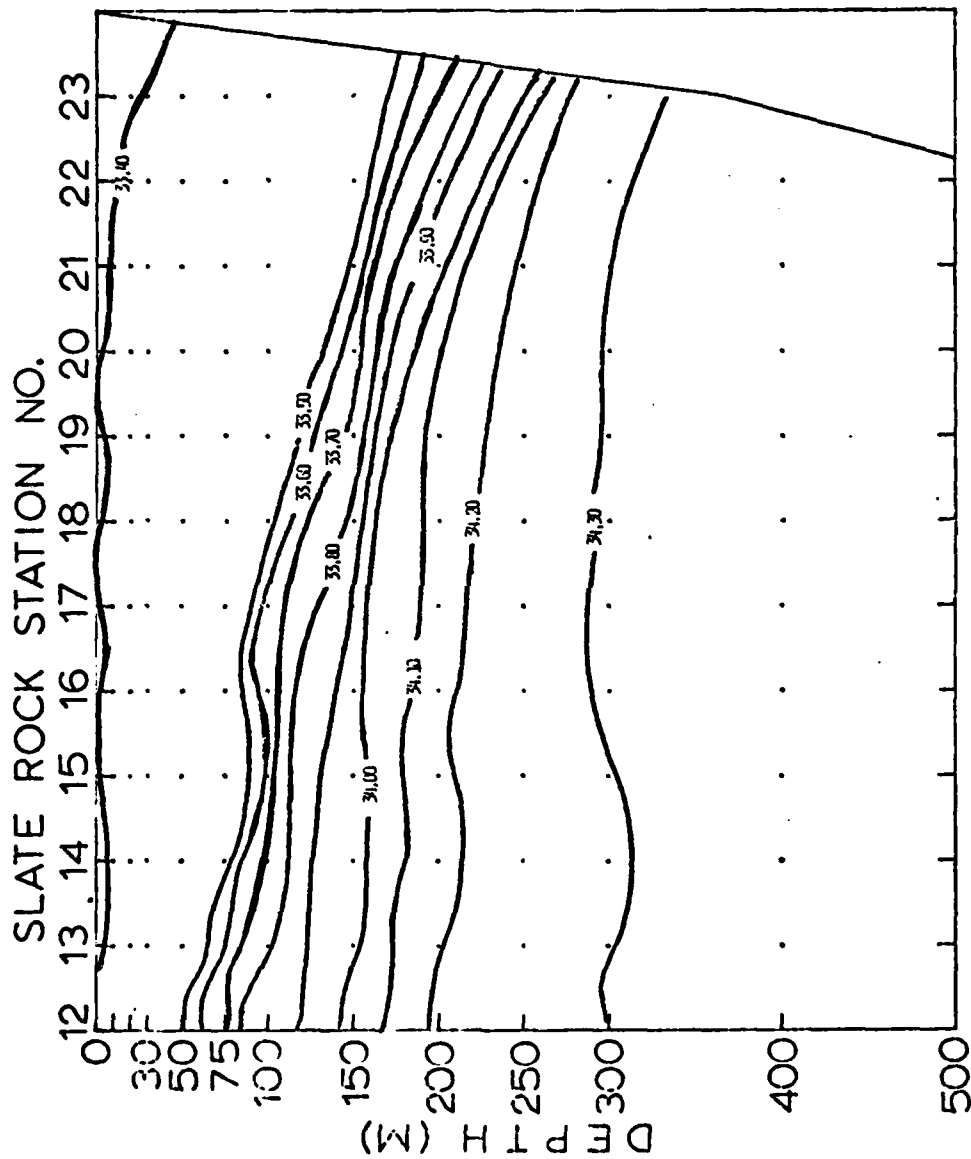


Figure 10. Salinity (‰) on a vertical section for the Slate Rock line on 8-9 January 1979.

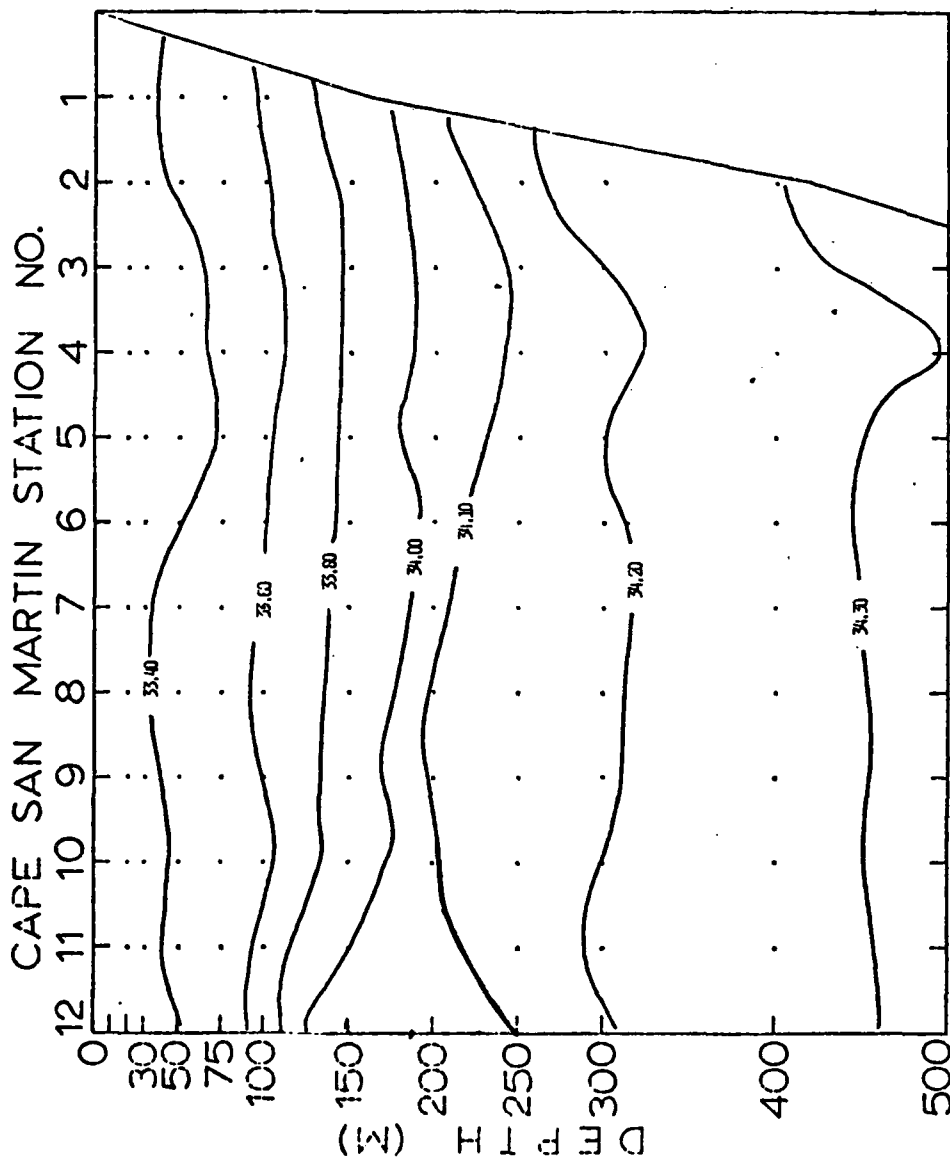


Figure 11. Salinity (‰) on a vertical section for the Cape San Martin line on 22-23 January 1979.

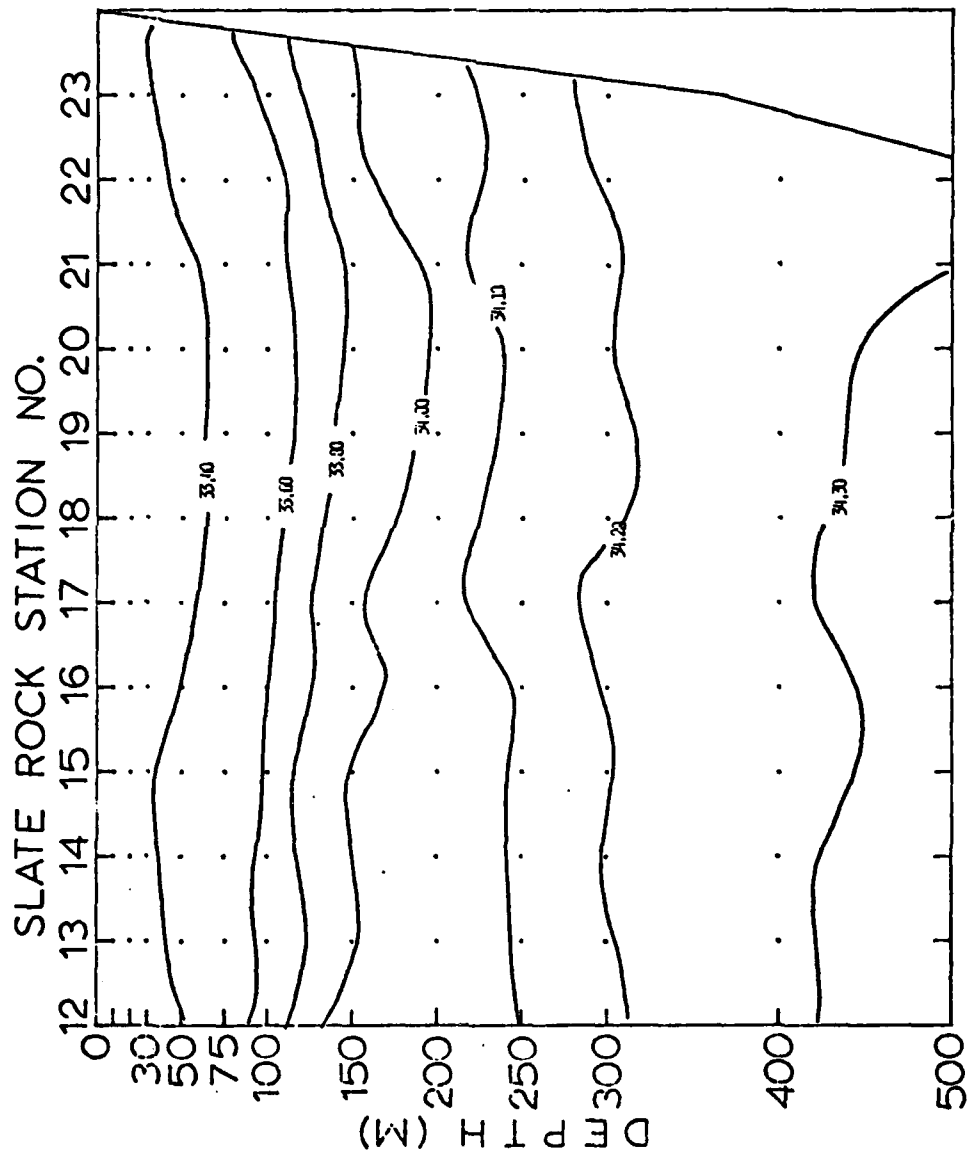


Figure 12. Salinity (‰) on a vertical section for the Slate Rock line on 22-23 January 1979.

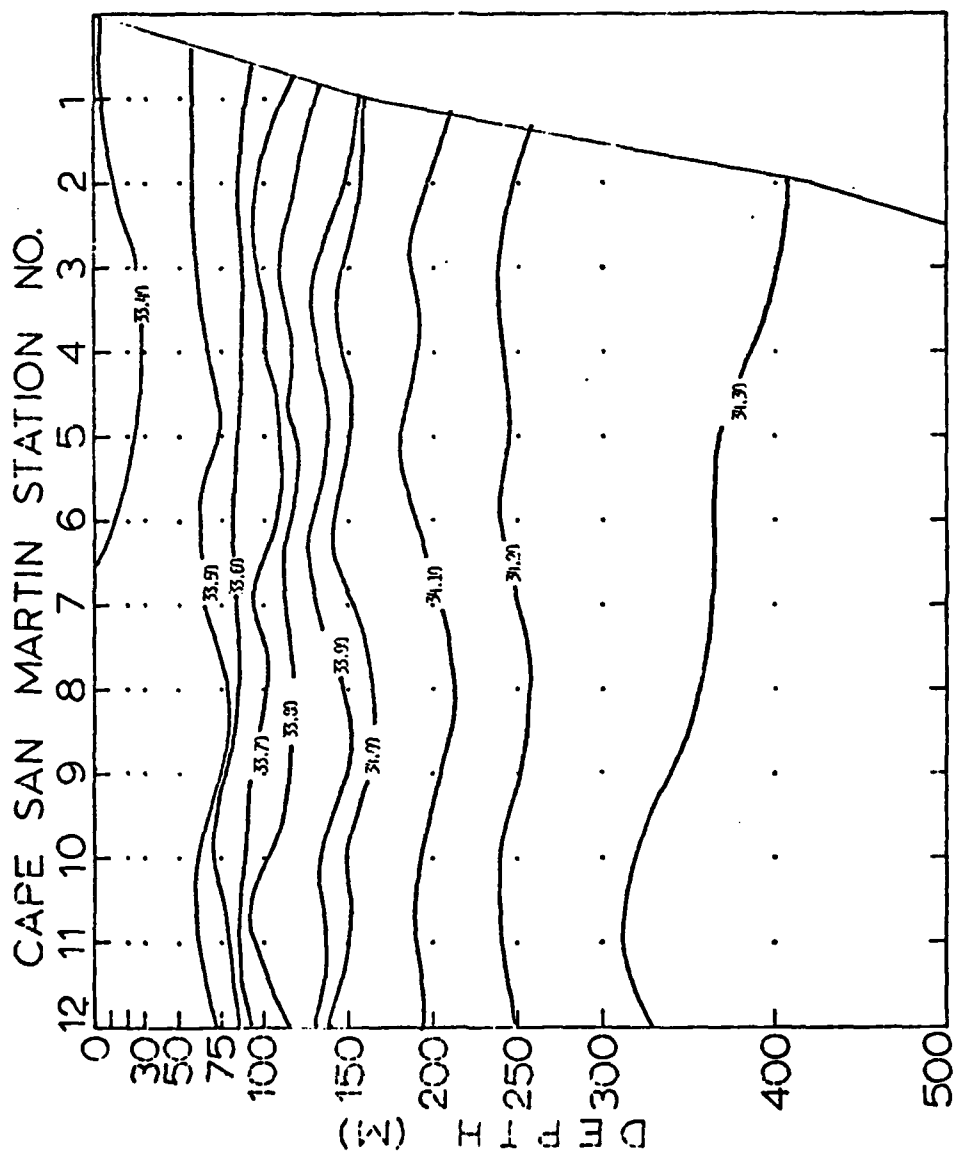


Figure 13. Salinity (‰) on a vertical section for the Cape San Martin line on 21-22 February 1979.

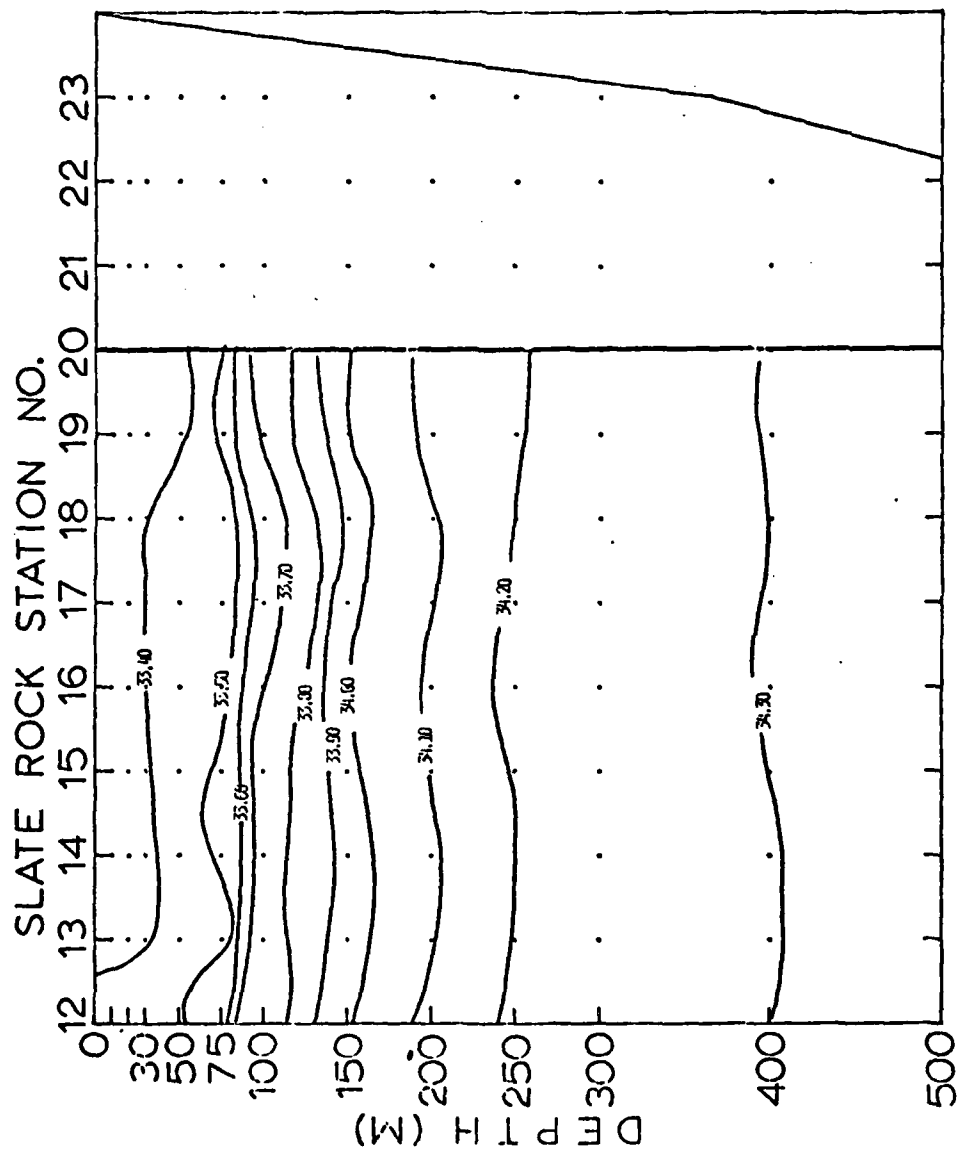


Figure 14. Salinity (%∞) on a vertical section for the Slate Rock line on 21-22 February 1979.

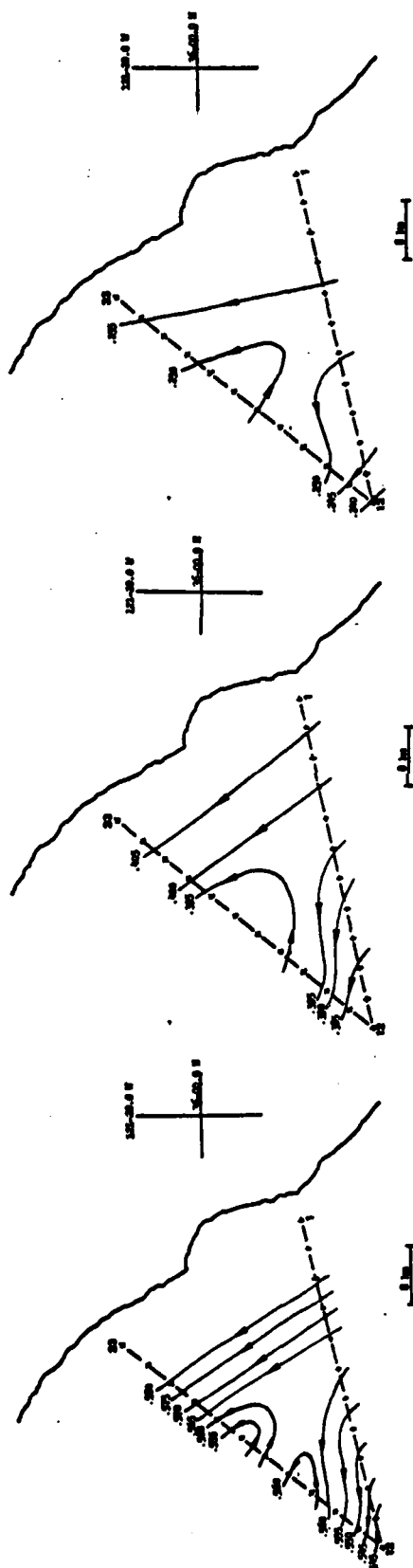


Figure 15. Dynamic topography of the 100/500 decibar surface of the 200/500 decibar surface on 27-28 November 1978. Units are in dynamic meters

Figure 16. Dynamic topography of the 200/500 decibar surface of the 300/500 decibar surface on 27-28 November 1978. Units are in dynamic meters

Figure 17. Dynamic topography of the 300/500 decibar surface of the 300/500 decibar surface on 27-28 November 1978. Units are in dynamic meters

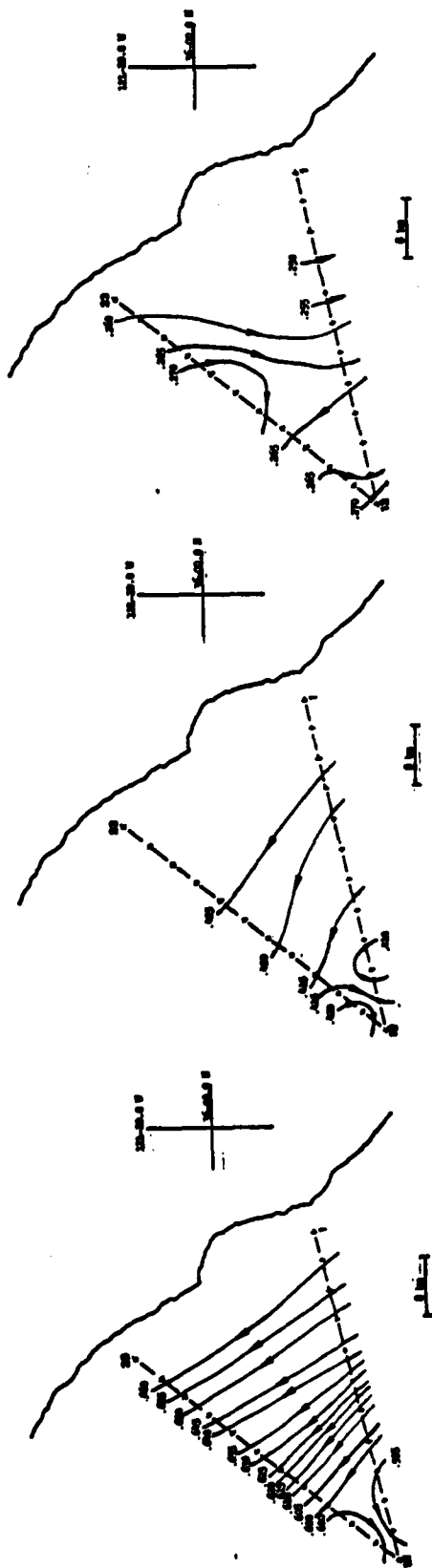


Figure 18. Dynamic topography of the 100/500 decibar surface on 8-9 January 1979. Units are in dynamic meters.

Figure 19. Dynamic topography of the 200/500 decibar surface on 8-9 January 1979. Units are in dynamic meters.

Figure 20. Dynamic topography of the 300/500 decibar surface on 8-9 January 1979. Units are in dynamic meters.

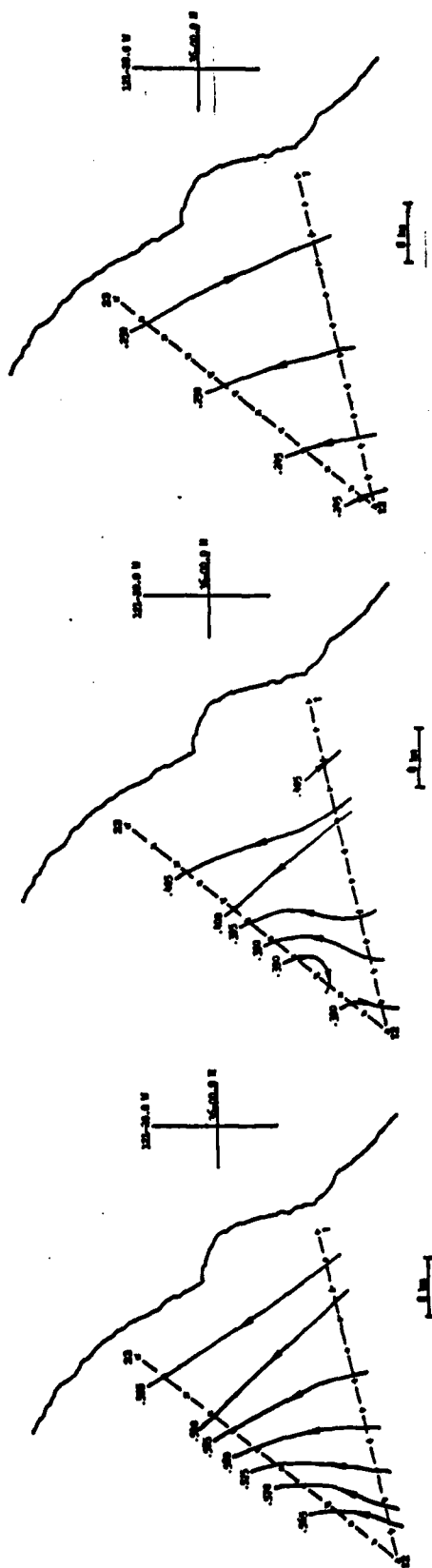


Figure 21. Dynamic topography of the 100/500 decibar surface on 22-23 January 1979. Units are in dynamic meters.

Figure 22. Dynamic topography of the 200/500 decibar surface on 22-23 January 1979. Units are in dynamic meters.

Figure 23. Dynamic topography of the 300/500 decibar surface on 22-23 January 1979. Units are in dynamic meters.

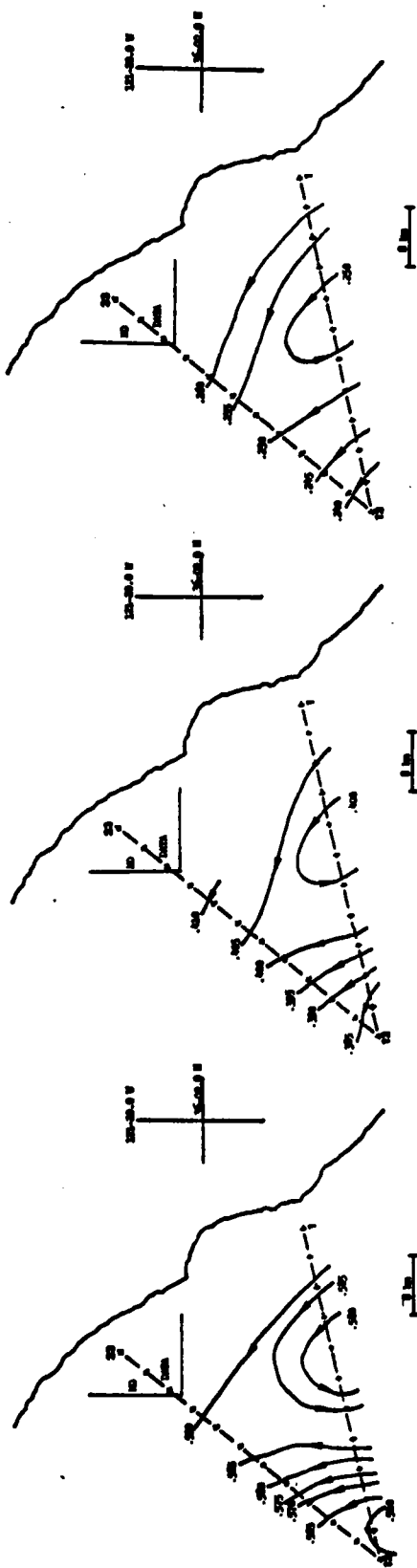


Figure 24. Dynamic topography of the 100/500 decibar surface on 21-22 February 1979. Units are in dynamic meters.

Figure 25. Dynamic topography of the 200/500 decibar surface on 21-22 February 1979. Units are in dynamic meters.

Figure 26. Dynamic topography of the 300/500 decibar surface on 21-22 February 1979. Units are in dynamic meters.

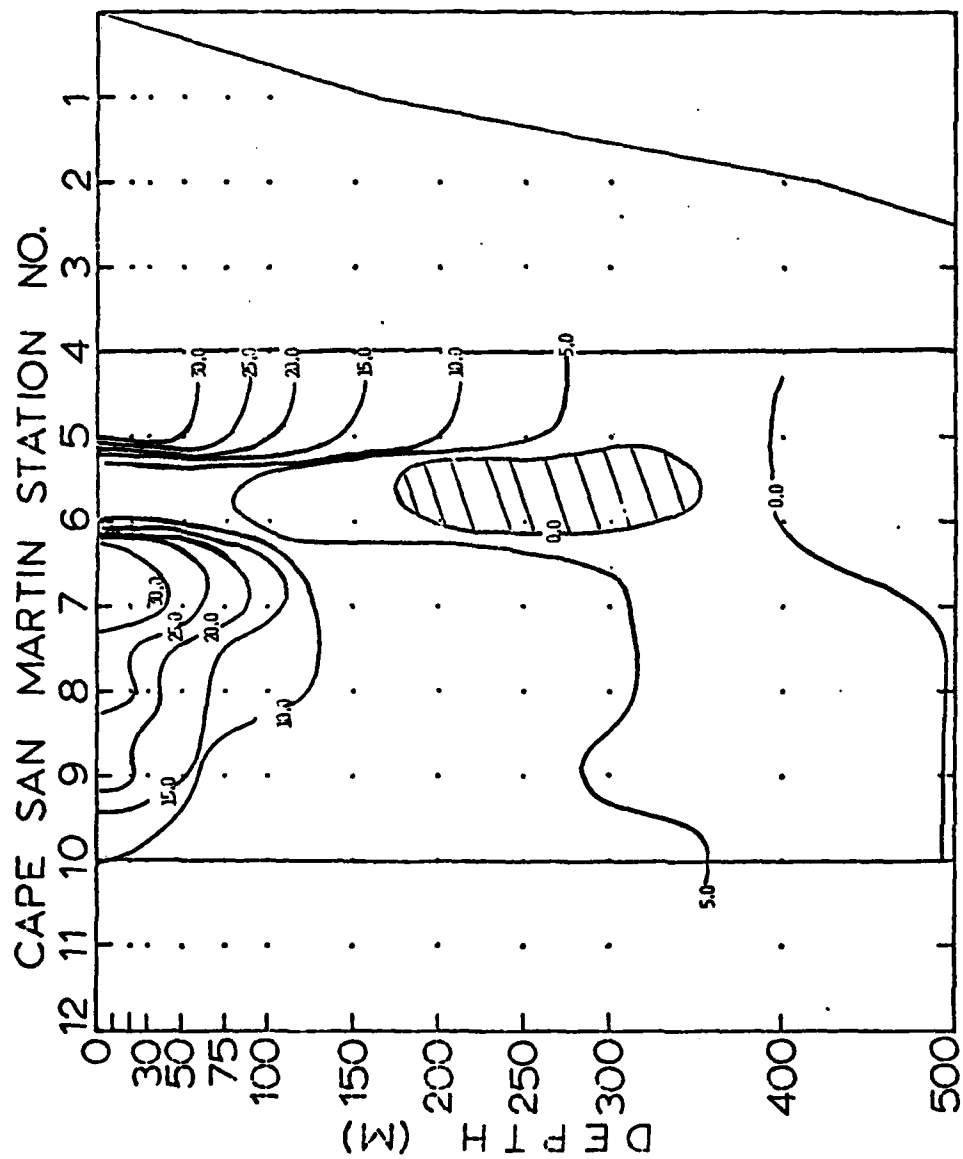


Figure 27. Vertical section of the normal component of geostrophic velocity in cm/sec for the Cape San Martin line on 27-28 November 1978. Southward flow indicated by cross hatched area.

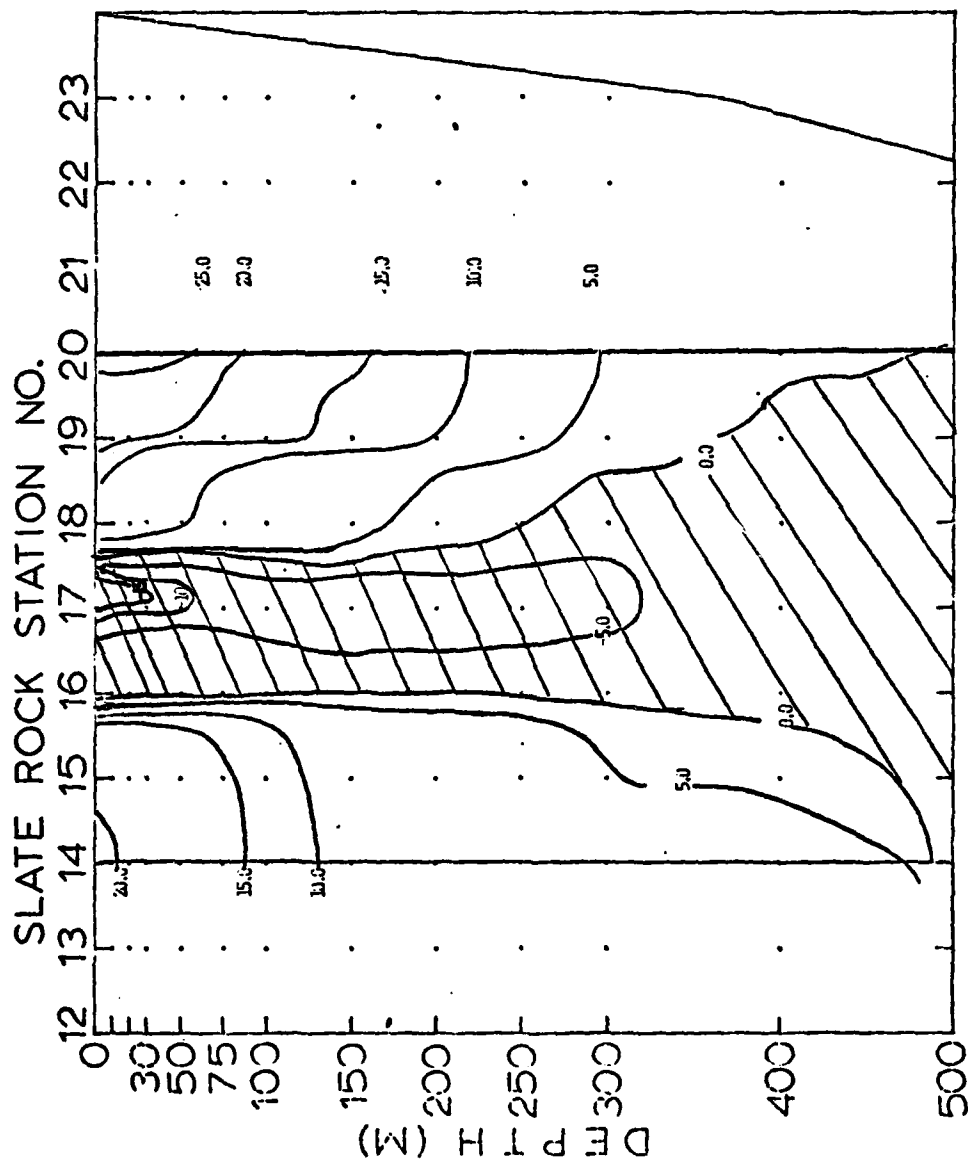


Figure 28. Vertical section of the normal component of geostrophic velocity in cm/sec for the Slate Rock line on 27-28 November 1978. Southward flow indicated by cross hatched area.

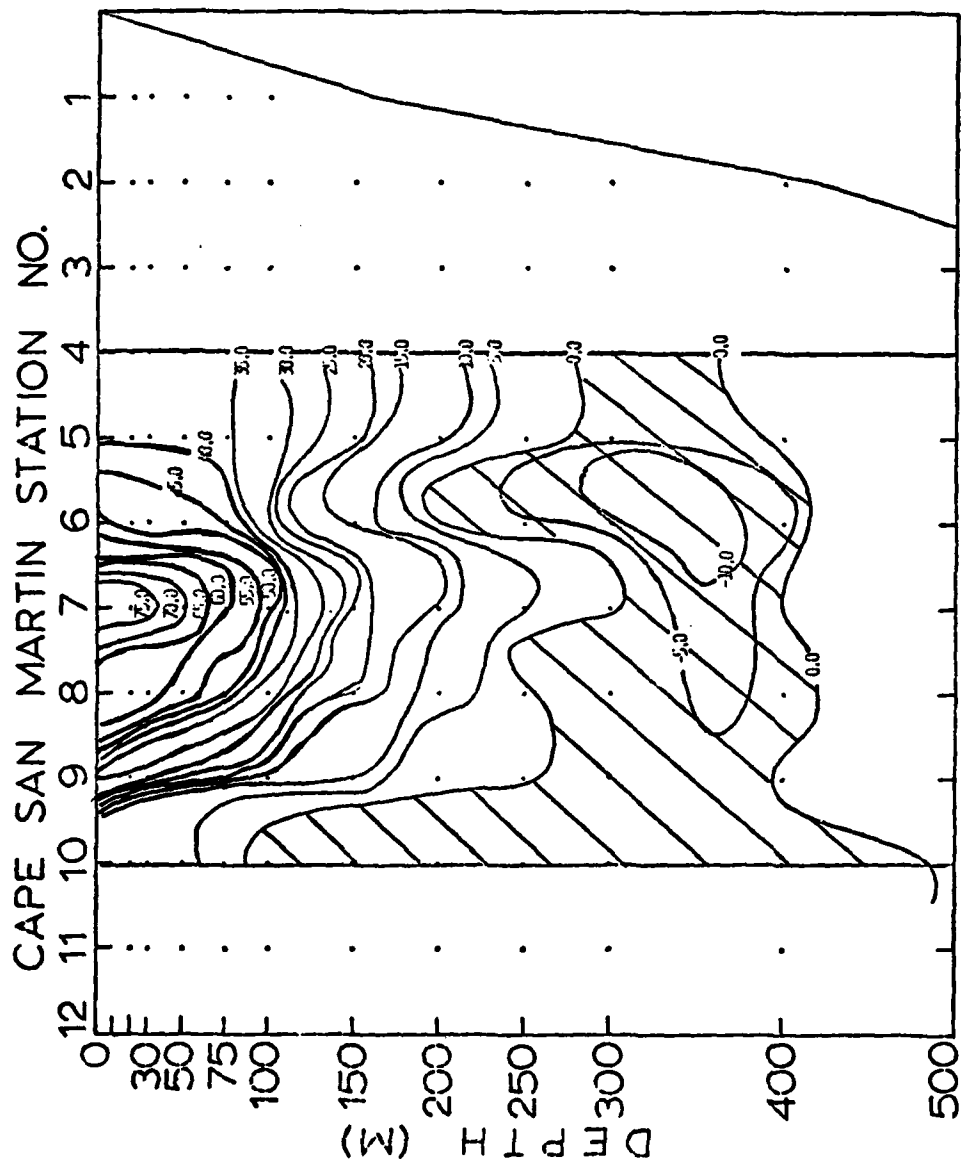


Figure 29. Vertical section of the normal component of geostrophic velocity in cm/sec for the Cape San Martin line on 8-9 January 1979. Southward flow indicated by cross hatched area.

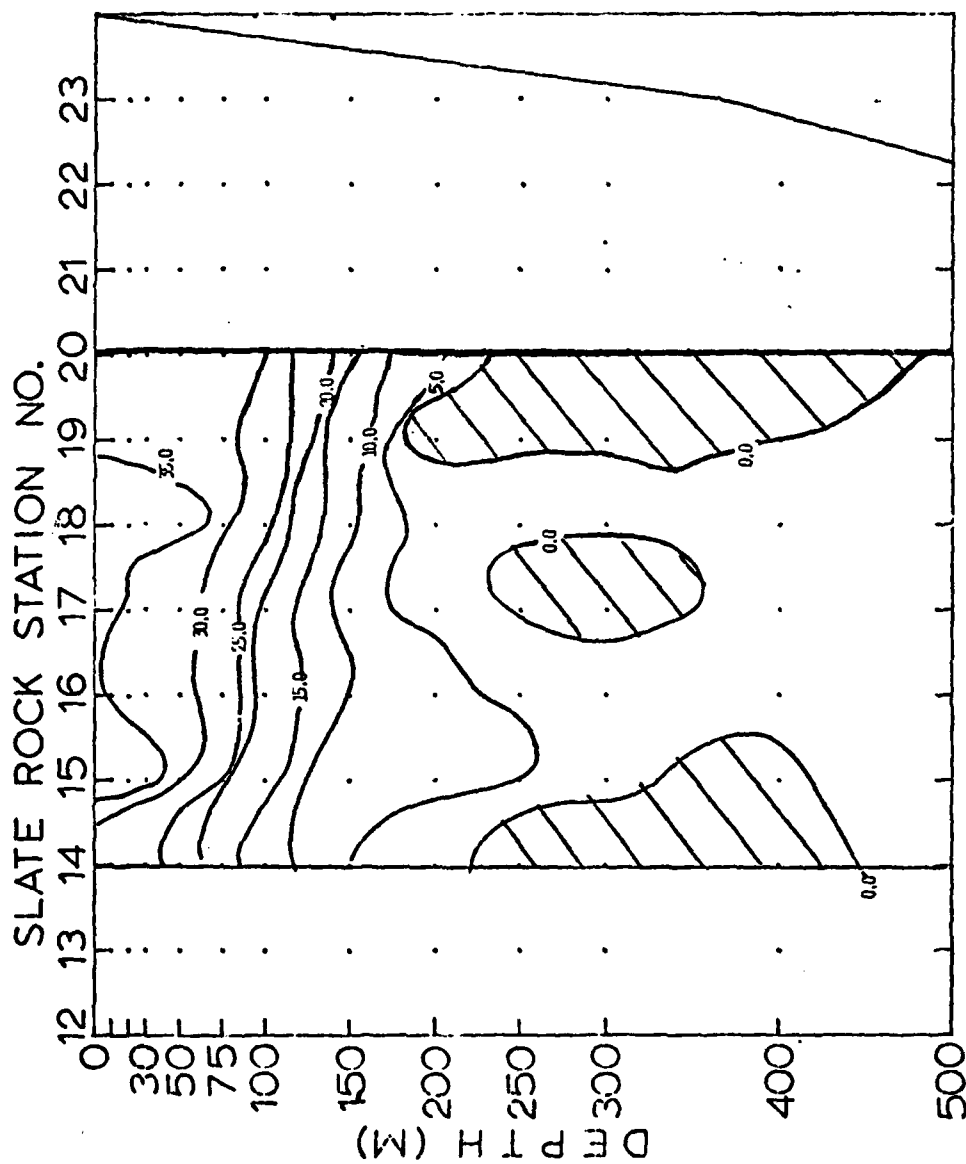


Figure 30. Vertical section of the normal component of geostrophic velocity in cm/sec for the Slate Rock line on 8-9 January 1979. Southward flow indicated by cross hatched area.

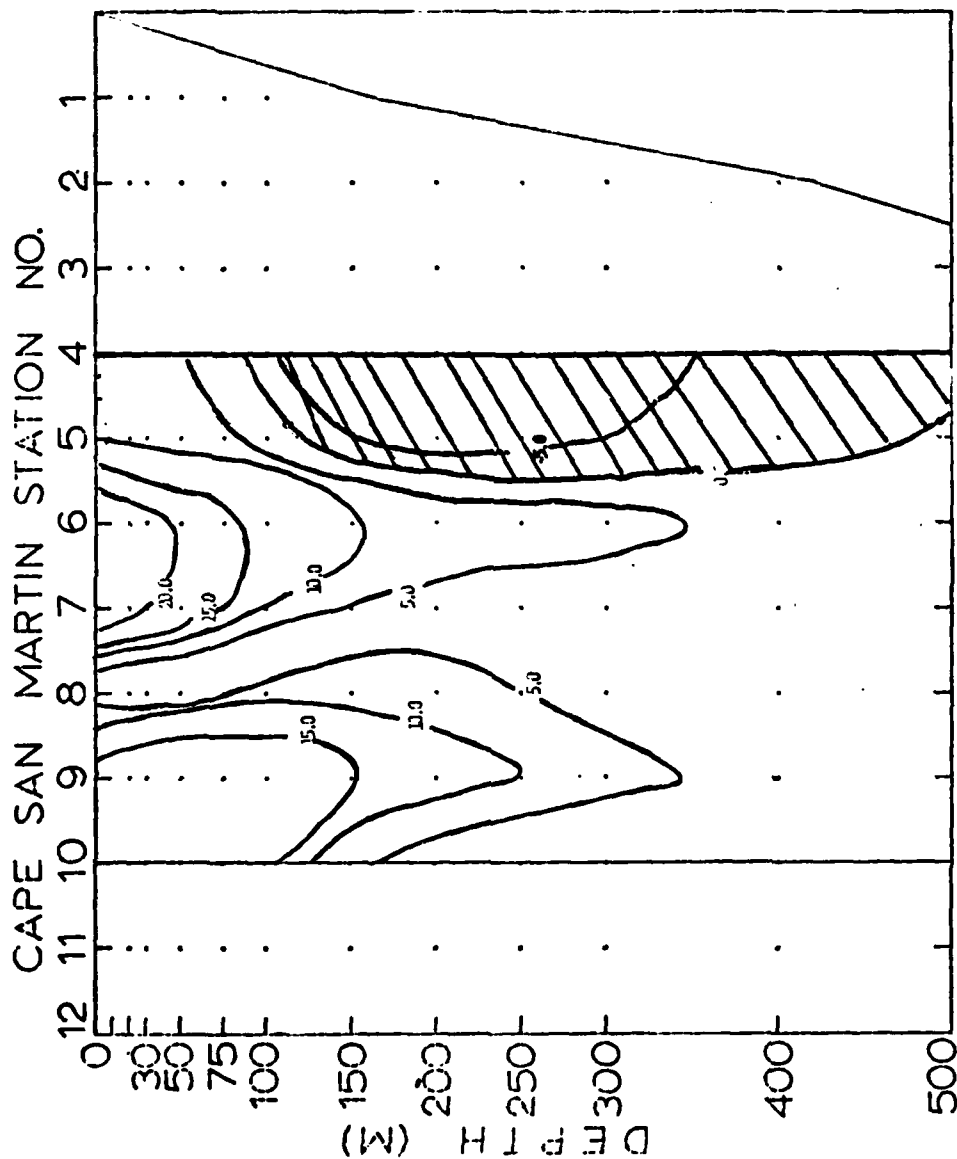


Figure 31. Vertical section of the normal component of geostrophic velocity in cm/sec for the Cape San Martin line on 22-23 January 1979. Southward flow indicated by cross hatched area.

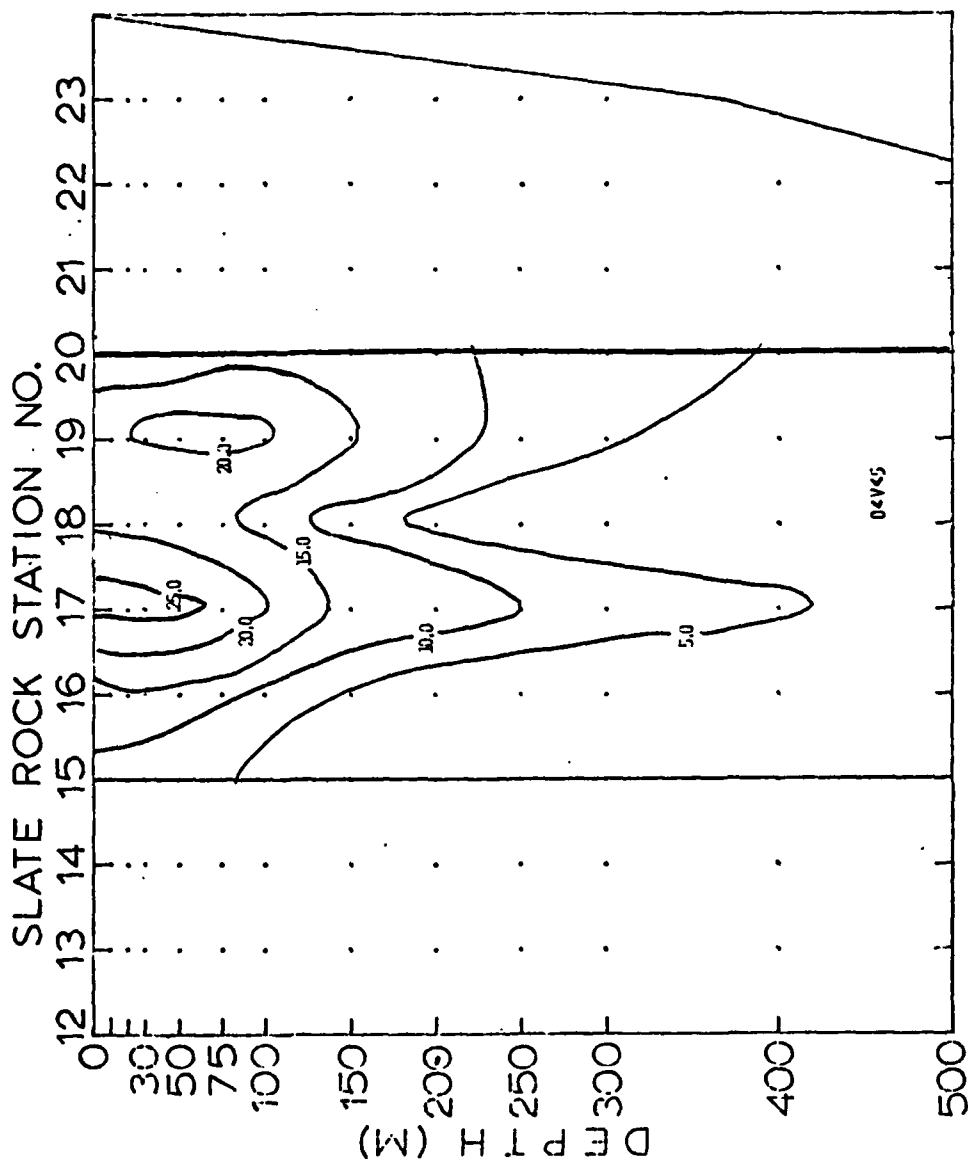


Figure 32. Vertical section of the normal component of geostrophic velocity in cm/sec for the Slate Rock line on 22-23 January 1979. Southward flow indicated by cross hatched area.

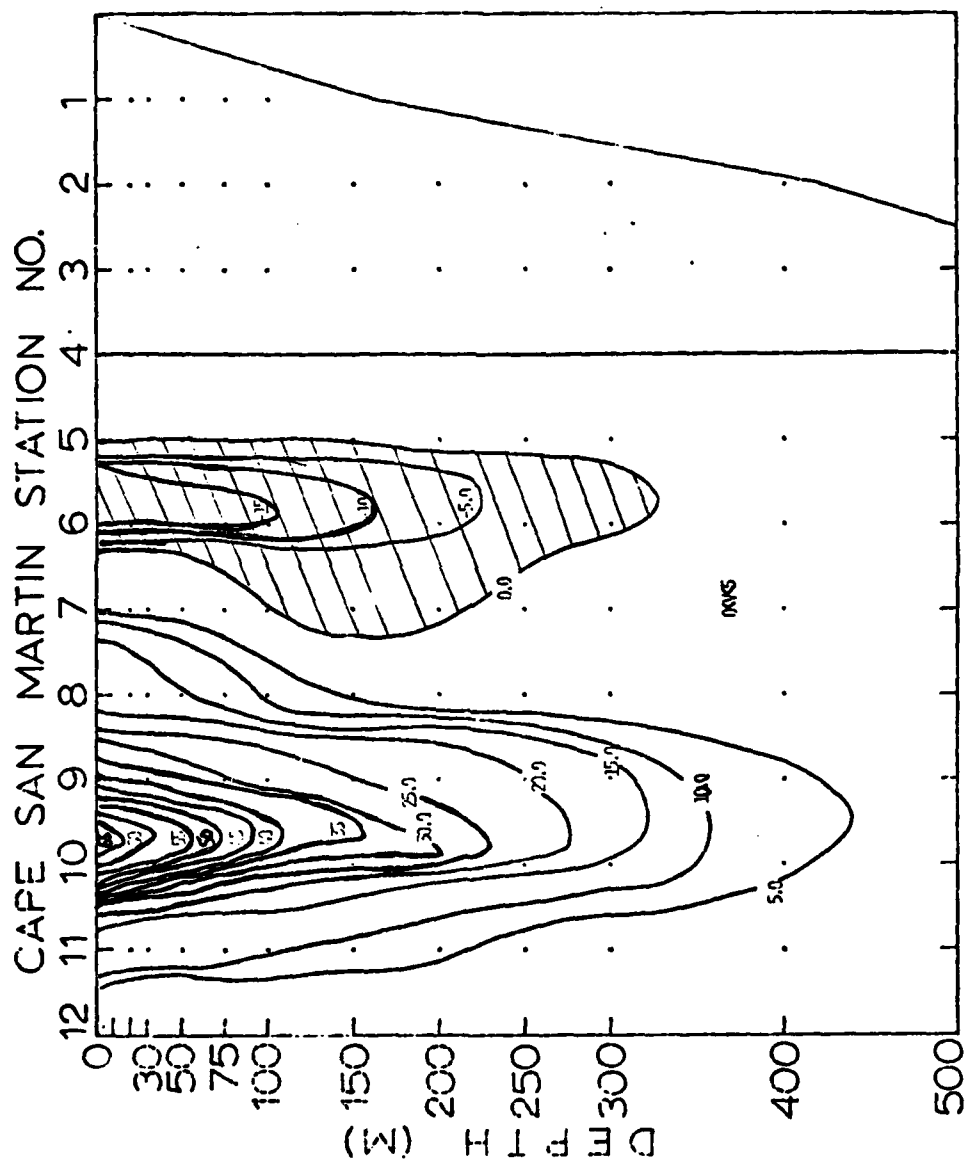


Figure 33. Vertical section of the normal component of geostrophic velocity in cm/sec for the Cape San Martin line on 21-22 February 1979. Southward flow indicated by cross hatched area.

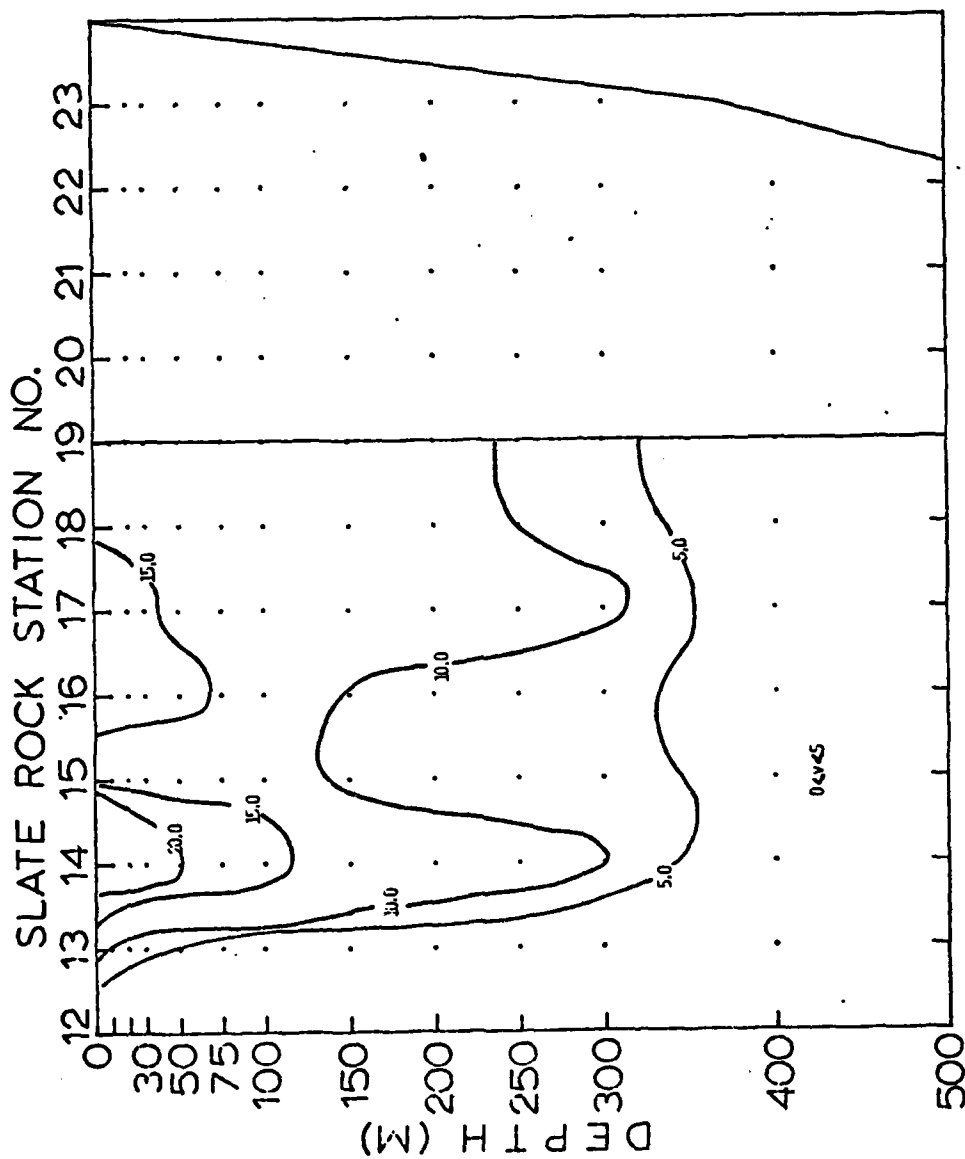


Figure 34. Vertical section of the normal component of geostrophic velocity in cm/sec for the Slate Rock line on 21-22 February 1979. Southward flow indicated by cross hatched area.

IV. DIRECT CURRENT OBSERVATIONS

A. INSTRUMENTATION AND DATA COLLECTION

Data collection was begun with the first array installed on 25 July 1978. This array contained one meter. The array was placed in 371 meters of water at approximately the position of station 2 (Figure 6) and remained in the water for one month. The second array was also placed near station 2 in 354 meters of water on 20 September 1978. The array contained one meter and remained in the water for two months. The meters from both the first and second array were placed at approximately 200 meters depth. Two larger arrays were installed on 27 November 1978. They contained three meters each and were installed in water of 353 meters depth near station 2 and 777 meters depth near station 5. The meters were situated at depths of 100, 175, and 300 meters. Both arrays remained in place until 22 January 1979.

Organization of each array was done by means of the NOYFB computer program. The original program was written by Donald Moller of the Woods Hole Oceanographic Institution in Fortran II for the Hewlett-Packard 2100 series. The program has been rewritten in Fortran IV for compatibility with the IBM 360 computer and is given in Appendix A. Through the use of on line terminals the program gives the operator a description of the mooring and its performance from an

operational point of view. Given environmental data and mooring components, the program presents the operator with mooring behavior information for evaluation of collected data as well as array design modifications. Step by step instructions for program operation are displayed to the user with the sequence determined by his selection of options. Standard mooring component characteristics (buoyancy, cross-sectional areas, elastic properties, etc.) are written into the program. These components are those used by Woods Hole Oceanographic Institution. Components which are non-standard with respect to the program are added during initialization or may be changed by an option.

The current meter used in these arrays is the Aanderaa Recording Current Meter Model 4 (RCM4). It is a self-contained instrument for recording speed, direction, and temperature of ocean currents with conductivity and pressure options. The RCM4 has a depth capability of 2000 meters. The RCM4 uses a rotor type current speed sensor, a magnetic compass, and a thermistor. An electro-mechanical encoder (analog to digital converter) samples and converts the measurements to binary digital signals which are then recorded on 1/4-inch magnetic tape. A sampling interval of 10 minutes was chosen for our meters. Input parameters for the RCM4 into the NOYFB program are: $W(I) = -64.66$ (buoyancy per meter length) and $A(I) = +0.065$ (area of component in square meters per meter length).

The array is arranged as in Figure 35 with no surface markers in order to keep all array elements out of the region of strong surface wave action. An acoustic release is used for retrieval of the arrays. It is an AMF Acoustic Release/Pinger Model 242, which is activated acoustically and also has a reply pinger used for interrogation and, if necessary, as a locating beacon.

Buoyancy for the array is provided by Benthos glass spheres. The glass spheres are 17-inches in diameter, housed in plastic hard hats and are capable to a depth of 6700 meters. They provide 55 pounds of buoyancy each and are connected together in pairs with 3/8-inch galvanized chain.

The wire finally used was 5/32-inch, 7x7 stainless steel wire, breaking strength about 2400 pounds, and stainless Nicopress fillings around plastic thimbles. Although the initial arrays used 1/4-inch galvanized wire with copper Nicopress fittings for terminations. Zinc anodes were attached to all Nicopress fittings, following a technique developed at Oregon State University (OSU). After one month of immersion the zincs on some of the wire fittings had almost totally disappeared. It was feared that a longer use would have led to corrosion of the copper Nicopress fittings and possibly to the loss of the array. It was then decided to use stainless steel wire. Again, following the technique developed at OSU, plastic 1/2-inch thimbles are used at all eye terminations. Galvanized anchor shackles with stainless steel cotterpins were used as connectors for

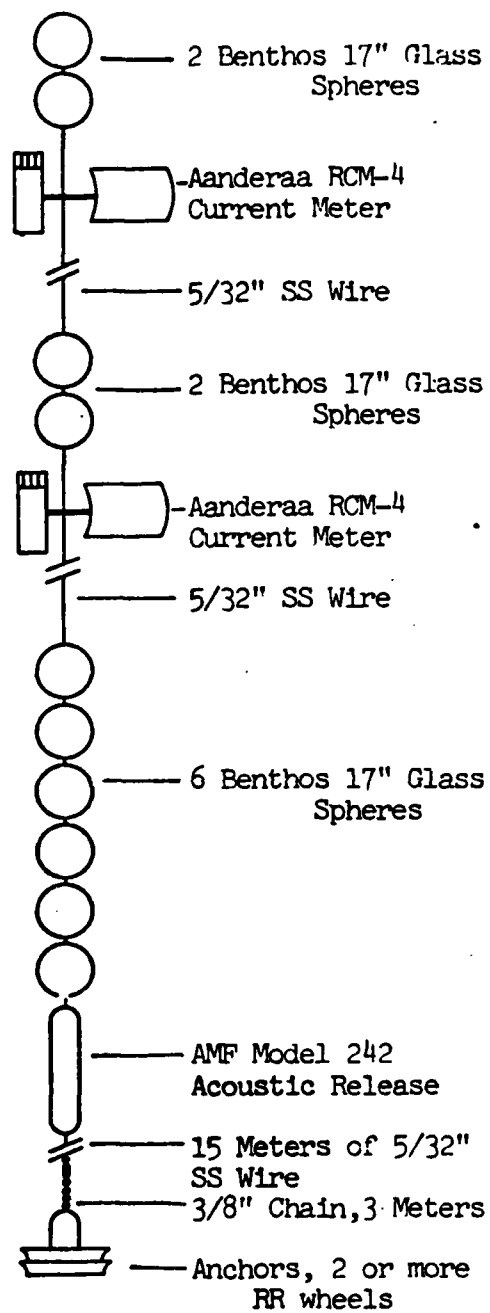


Figure 35. Array configuration.

the various components. Zincs are maintained on the meters and release as a protection against their corrosion. Input parameters for the wire into the NOYFB program are:

$W(I) = -0.1225$ (weight of component in pounds per meter length), $A(I) = +0.00397$ (diameter in meters), $RBS(I) = +2400.0$ (rated breaking strength in pounds), and $AW(I) = +0.065$ (cross sectional metal area of wire in square inches).

Below each release is a 15-meter section of wire, 3-meter section of 3/8 inch chain and the weights. Weight is provided by scrap railroad wheels which have a weight of about 600 pounds per wheel in water. Two wheels are used for the shallow arrays and three for the deeper arrays.

Placement of arrays was done from the R/V ACANIA by the method of stringing the array out behind the ship, upper-most components first, and dropping the anchor last. As an added precaution a 7-foot cargo parachute was attached to the anchors to slow their rate of descent.

B. DISCUSSION OF DIRECT CURRENT MEASUREMENTS

All data obtained with the current meters was converted to speed and direction using Aanderaa calibration constants and consolidated on a single IBM compatible tape.

Current speed and direction were used to construct progressive vector diagrams. Vertical and horizontal scales are equal in these diagrams. The vertical axis is zero degrees, magnetic north. The coast in the study area is aligned approximately in a 305° magnetic direction.

The current at station 2 during the period 25 July to 28 August 1978 is depicted by the progressive vector diagram shown in Figure 36. This meter was at 220 meters depth. During its operation the average overall current was 336° magnetic at 7.6 cm/sec. With respect to the alignment of the coast this shows a slight onshore component.

The semidiurnal components in the currents are visible upon close examination (the crosses on the diagram appear at two-day intervals). Two reversals of current which last four-days each can be seen at the top of the figure.

The second meter was installed in September (Figure 37) at the same location, station 2, but at a depth of 190 meters. It was in operation from 20 September to 27 November 1978. For this period the progressive vector diagram is shown in Figure 37, and the crosses are located at three-day intervals. The mean flow was 318° magnetic at 2.9 cm/sec. During the middle of the observation period numerous reversals of flow appear. These oscillations suggest that the meter was near a frontal zone and that its position alternated between sides of that zone, perhaps as a meander or eddy in the counter-current moved through the station's position. The mean flow over the seventy days is dominated by the countercurrent flowing nearly parallel to the coast.

Figures 38 through 42 are progressive vector diagrams for the arrays in operation from 27 November 1978 to 22 January 1979 on moorings at stations 2 and 5. The crosses

in all these figures are at three-day intervals. Semi-diurnal components are again visible.

Figures 38, 39, and 40 are for the array at station 2. The upper meter was at 100 meters depth (Figure 38). The mean flow at this level was toward 337° magnetic at 12.8 cm/sec, a moderately strong onshore and northward flow. On the 8th of January the flow changes from northward to southward for three days. The next meter was at 175 meters depth (Figure 39). The mean flow was toward 321° magnetic at 3.2 cm/sec. This small mean value is deceiving; it results from a period of mainly southward flow during the first nine days and oscillations during the last part of the period. The speed during the middle of the period was at a maximum of 25 cm/sec during a three-day period. Thus, although the oscillations result in a small value for the local time-averaged flow, weakening of the countercurrent is not necessarily implied. The oscillations may simply imply a spatially fluctuating front in the region.

The bottom meter on this array was at 300 meters (Figure 40). The mean flow at this level was towards 151° magnetic at 1.8 cm/sec. During most of the period the flow appears weak and fluctuating. The oscillations are mainly in two directions, northward and southward parallel to the coast. The meter appears to be astride the front separating the countercurrent and the southward flow. As the countercurrent meanders the meter moves from one flow to the other. In summary the current is moderately strong and northward at

the surface and weak at mid-depth with the exception of the strong northward flow during the middle of the period. The oscillations during the first and last days and at the lower meter indicate a moving shear zone between the countercurrent and the southward flow.

Figures 41 and 42 are for the array installed at station 5 and operating in the interval 27 November 1978 through 22 January 1979. The upper meter was at 140 meters depth (Figure 41). The mean flow was toward 319° magnetic at 12.3 cm/sec. As can be seen, the flow is almost exclusively northward, parallel to the coast, during the entire period. The exception is a three-day interval at the start with southward flow.

At 215 meters (Figure 42) the mean flow was toward 308° magnetic at 6.3 cm/sec. This reduction of the mean from the upper meter is largely due to the southward flows during the first nine days and an eight-day period beginning about 1 January. During these reversals the flow maintains its new direction and intensity without multiple oscillations. The sharp, clear change in flow indicates reversal from countercurrent to southward flow with no lingering of the front in the region of the meter. This pattern is similar to that at station 2 with a weakening of flow with depth and the appearance of southward flow at the deeper meters.

In summary the mean flow at the surface during the period of 27 November 1978 through 22 January 1979 is northward with an onshore component and a surface maximum of speed. At mid-depth the current has maintained its direction

with reduced speed. At the deeper meters the flow is variable in direction and speed, indications of a frontal region separating northward and southward flow.

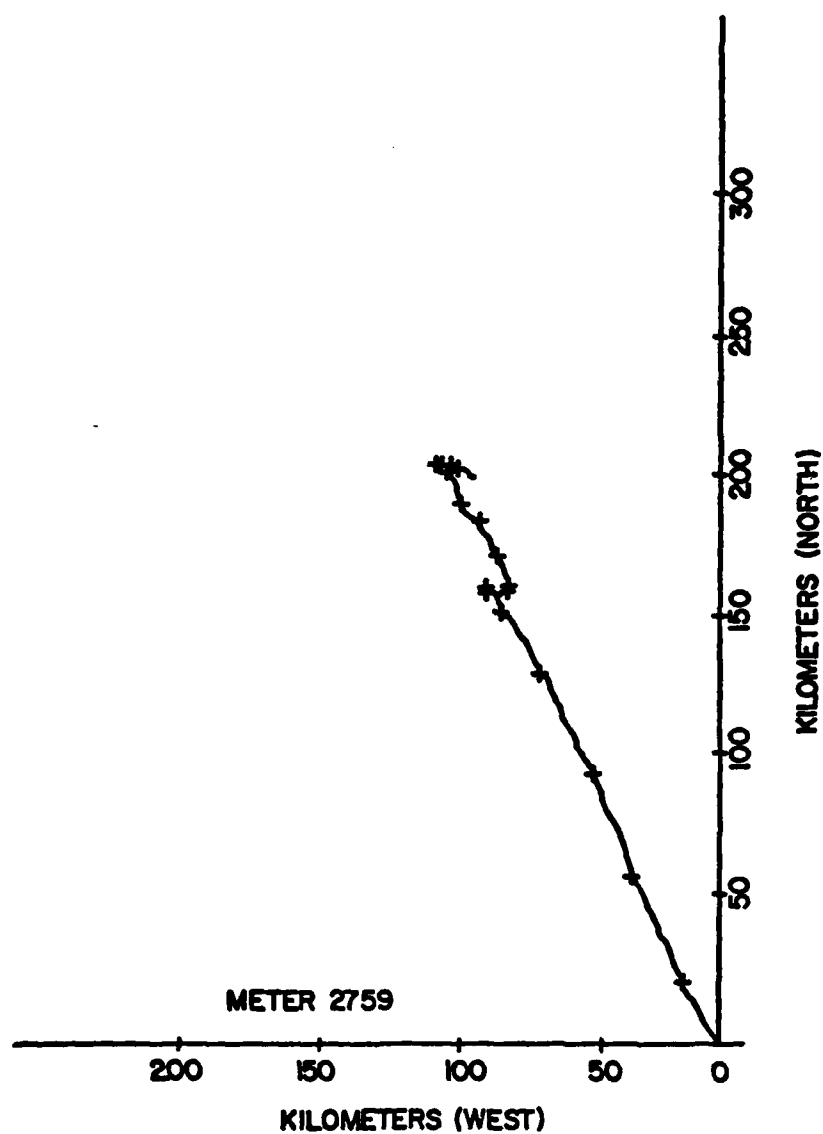


Figure 36. Progressive vector diagram for the current meter at 220 meters depth at station 2 from 25 July 1978 to 28 August 1978. Crosses are positioned at 2 day intervals. Vertical axis indicates Magnetic North.

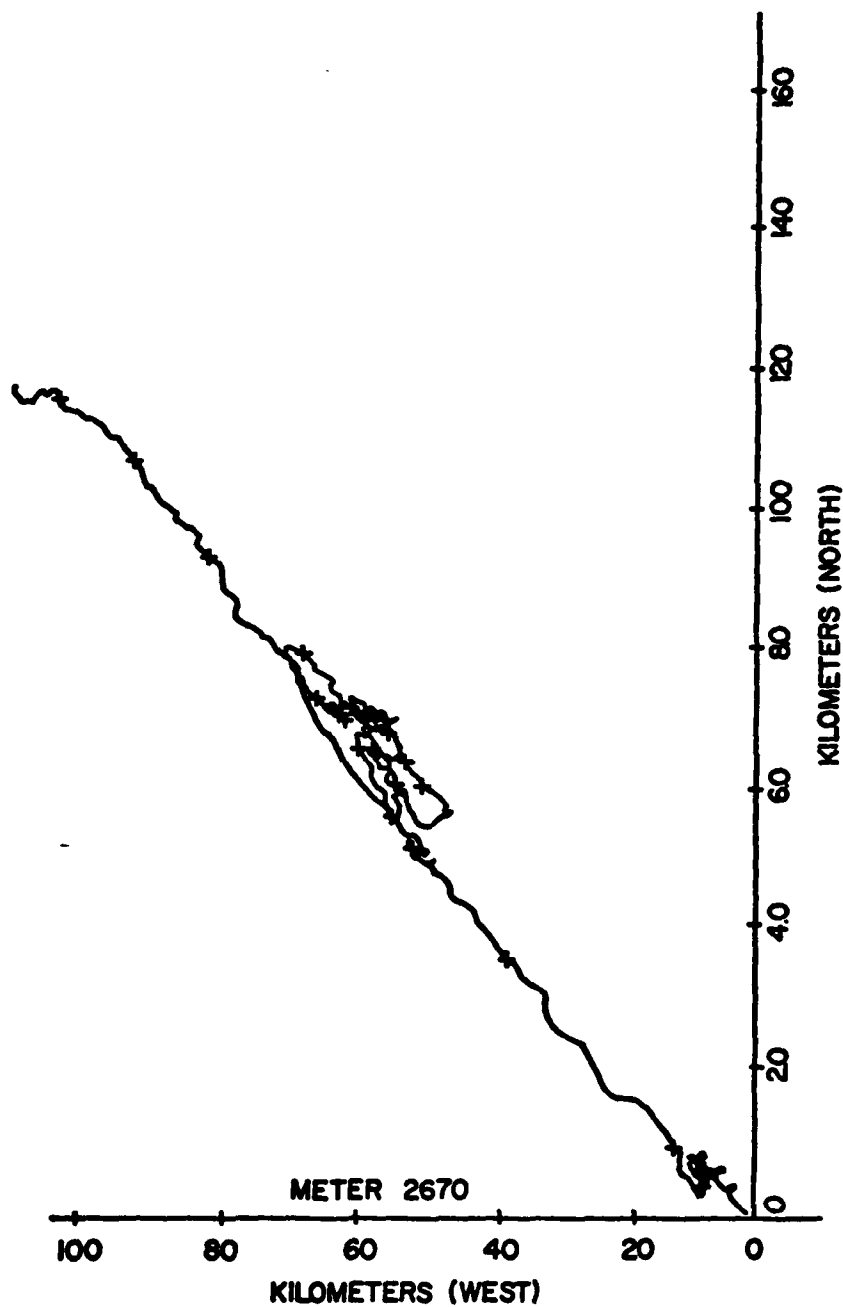


Figure 37. Progressive vector diagram for the current meter at 190 meters depth at station 2 from 20 September 1978 to 27 November 1978. Crosses are positioned at 3 day intervals. Vertical axis indicates Magnetic North.

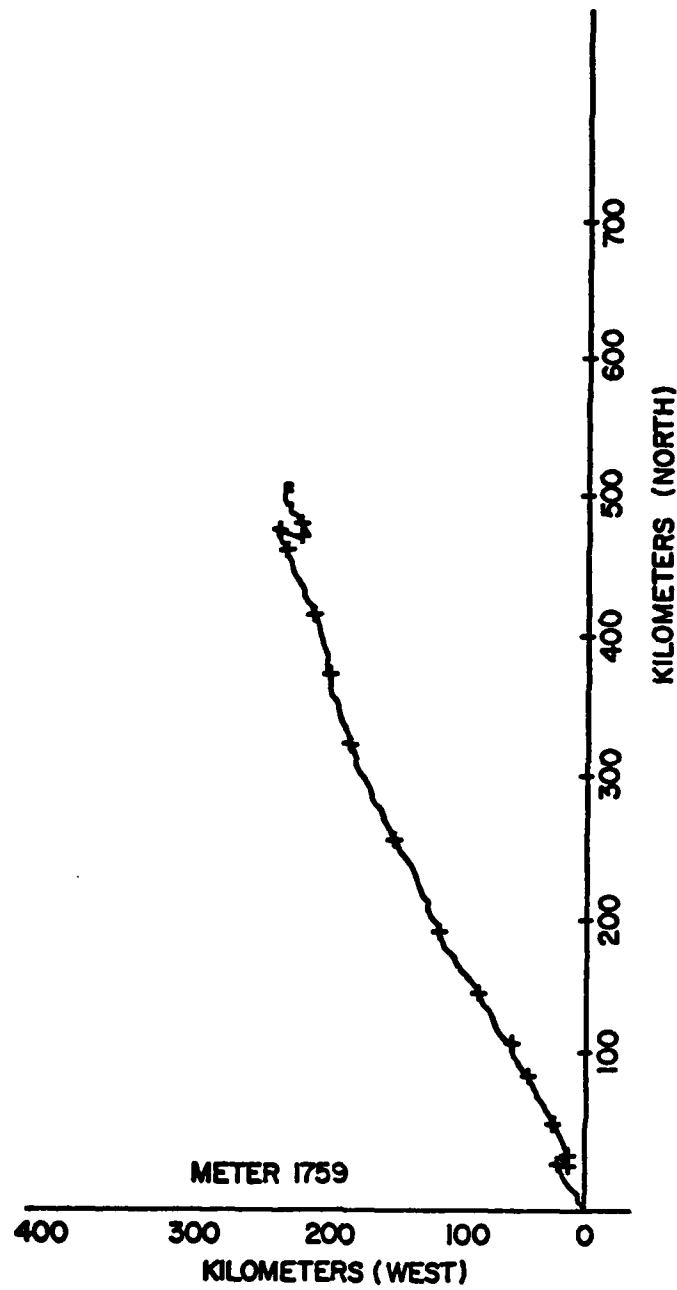


Figure 38. Progressive vector diagram for the current meter at 100 meters depth at station 2 from 27 November 1978 to 22 January 1979. Crosses are positioned at 3 day intervals. Vertical axis indicates Magnetic North.

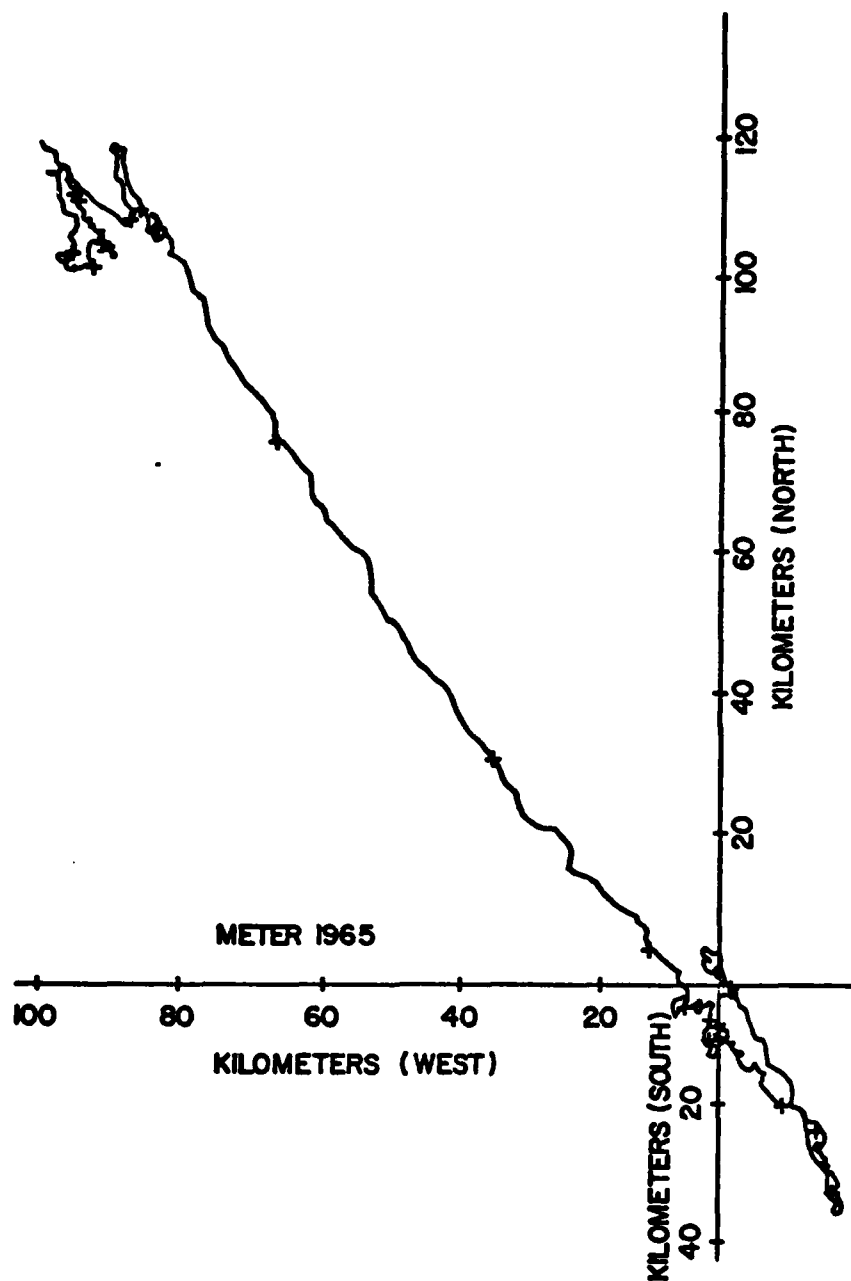


Figure 39. Progressive vector diagram for the current meter at 175 meters depth at station 2 from 27 November 1978 to 22 January 1979. Crosses are positioned at 3 day intervals. Vertical axis indicates Magnetic North.

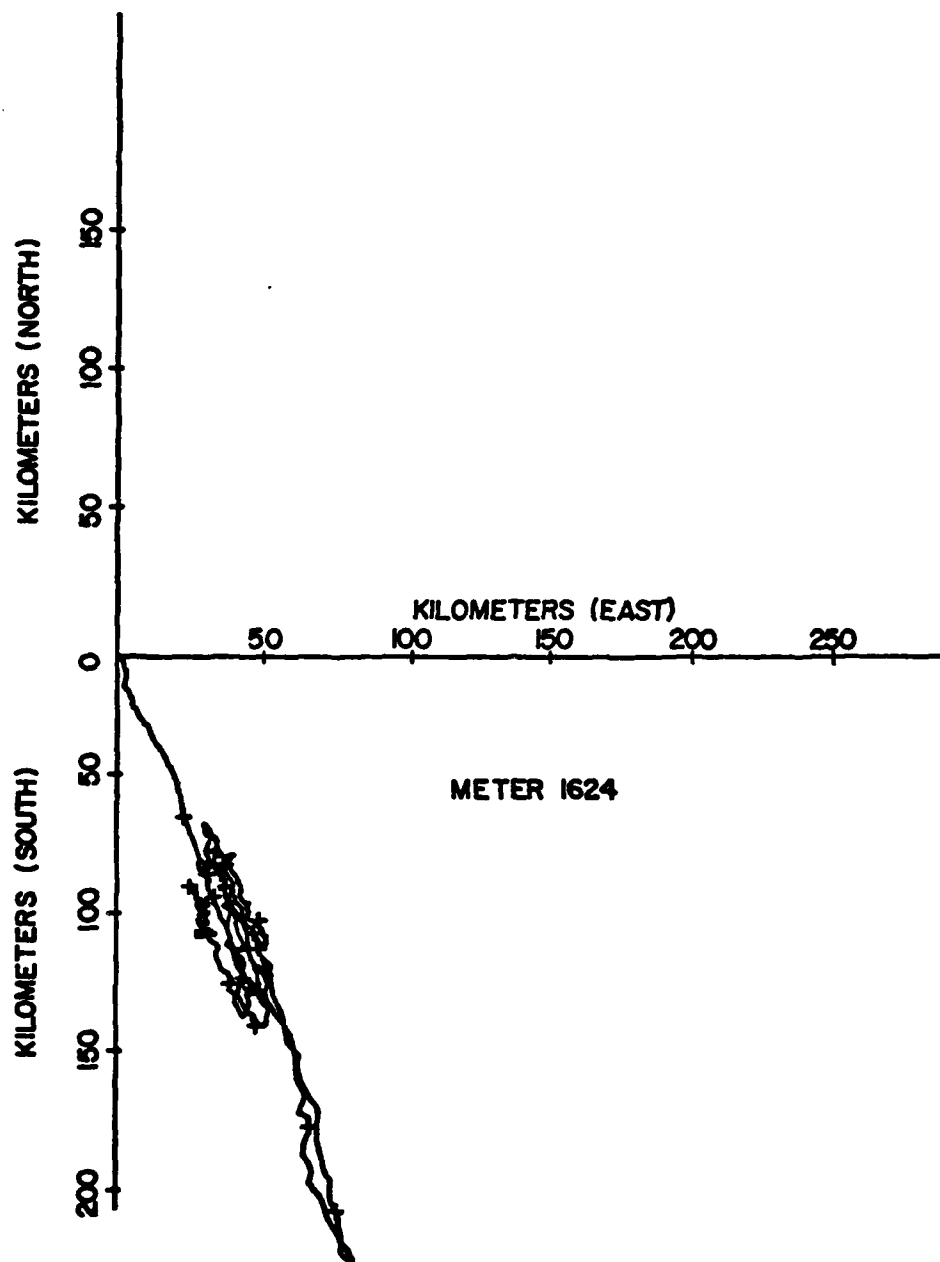


Figure 40. Progressive vector diagram for the current meter at 300 meters depth at station 2 from 27 November 1978 to 22 January 1979. Crosses are positioned at 3 day intervals. Vertical axis indicates Magnetic North.

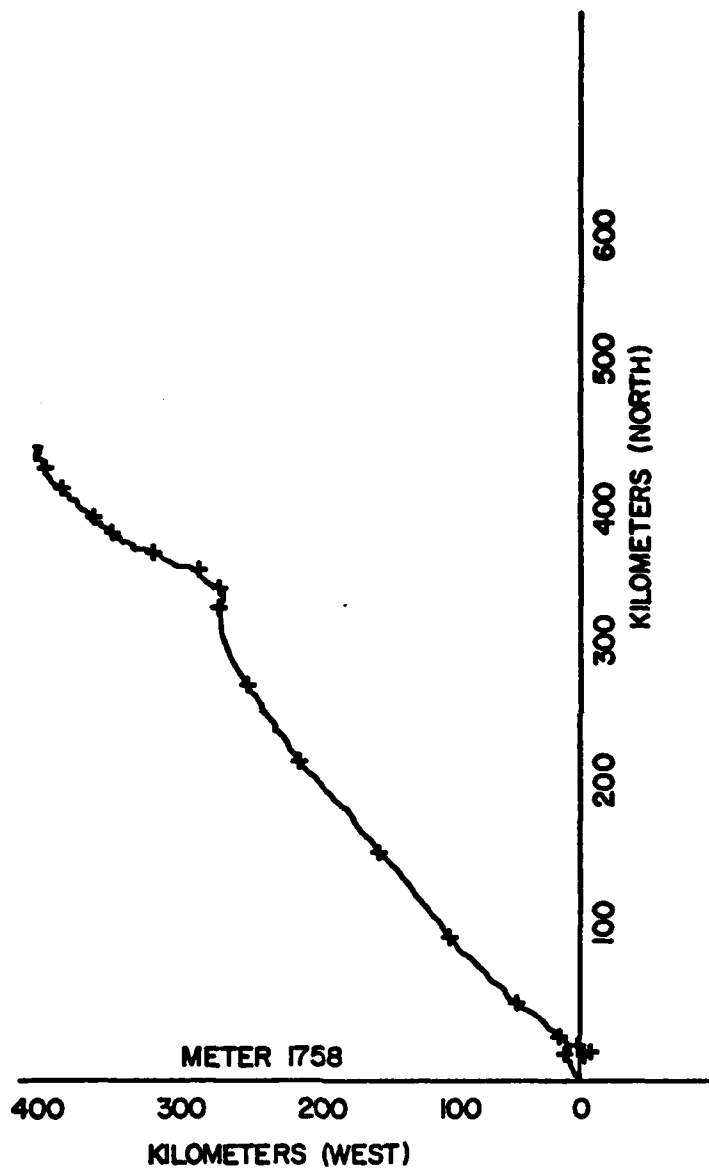


Figure 41. Progressive vector diagram for the current meter at 140 meters depth at station 5 from 27 November 1978 to 22 January 1979. Crosses are positioned at 3 day intervals. Vertical axis indicates Magnetic North.

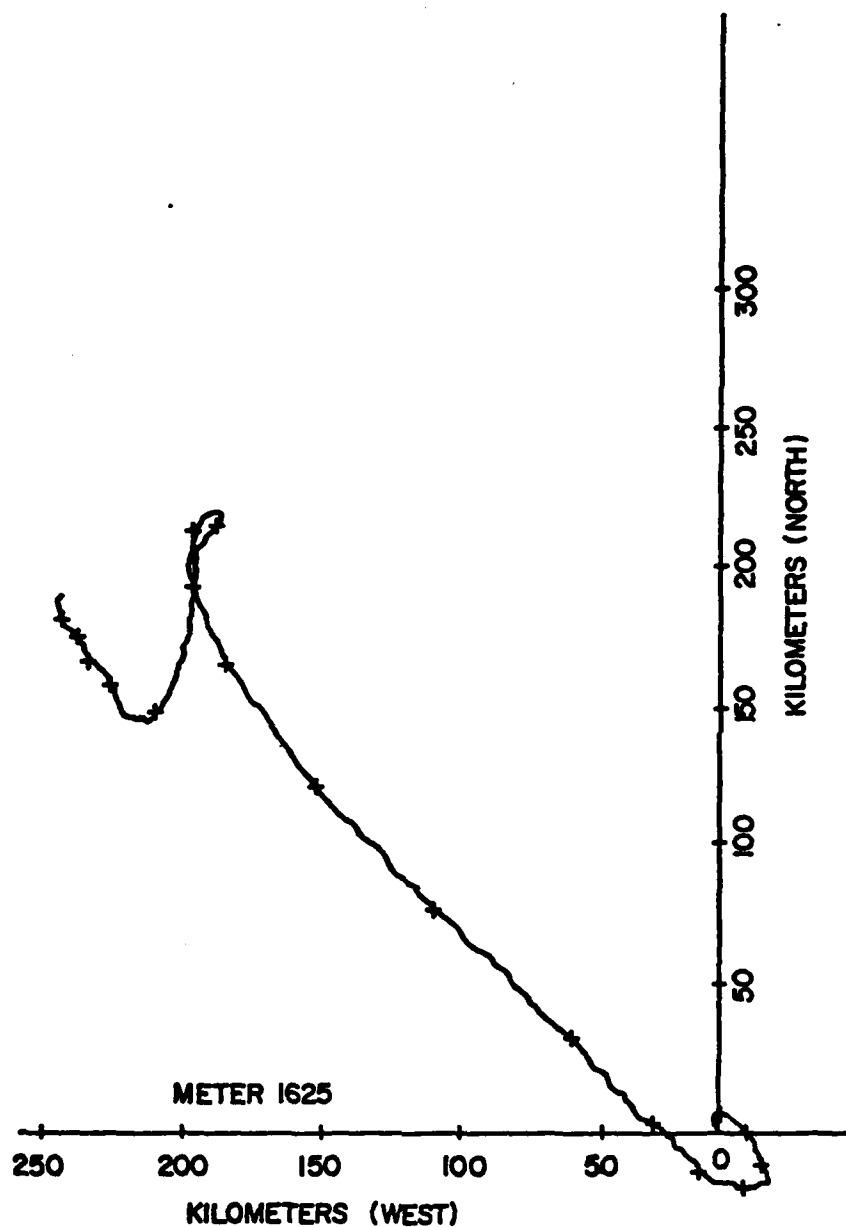


Figure 42. Progressive vector diagram for the current meter at 215 meters depth at station 5 from 27 November 1978 to 22 January 1979. Crosses are positioned at 3 day intervals. Vertical axis indicates Magnetic North.

V. COMPARISON OF GEOSTROPHY WITH DIRECT CURRENT MEASUREMENTS

The two methods of inferring currents, indirect (geostrophy) and direct (current metering) coincided on 27 November 1978 and 8 January 1979. There were vertical profiling for watermass properties on the Cape San Martin line and simultaneous direct measurements at stations 2 and 5 of that line.

The mean velocity from the current meters was found for a 24-hour period bracketing the time during which watermass properties were sampled. This was accomplished by computing: $\bar{V}(t) = \frac{\vec{R}(t+12) - \vec{R}(t-12)}{24}$ where $\vec{R}$ is the position vector at the given time taken from a list of the values used to produce the progressive vector diagram. This 24-hour averaging was done so as to smooth the high frequency non-geostrophic contributions to the flow while retaining larger scales. It must be expected that this averaging process does not smooth out all non-geostrophic components. Those which remain contribute to differences between the direct (current meter) and indirect (geostrophic) velocity measurements.

The mean metered velocities at stations 2 and 5 on both 27 November 1978 and 8 January 1979 are compared to those velocities found by geostrophy in Table II.

As seen in Table II, on 27 November 1978 at station 2, there is general agreement on the direct and indirect measurement of velocities at 100 and 175 meters. At 300 meters the

methods of measurement indicate opposite flow directions. Dynamic topography indicates the region to be fairly flat with adjacent northward flow. The current meter shows a moderate southward flow of 10 cm/sec. This bottom meter is the meter which showed obvious non-geostrophic components, frequent oscillations between northward and southward flow. On the same data at station 5, the table shows strong agreement between the two methods of measurement. Geostrophy indicates a slightly stronger flow and the current meters show more of an onshore flow.

On 8 January 1979 at station 2, there is poor correlation of the current from the two measurement methods. Geostrophy indicates the region, at mid and lower depths, to be fairly flat with weak flow. Direction can only be inferred from that at station 4 (Figures 19 and 20). At the 100 meter level the current meter shows an onshore southward flow while geostrophy indicates northward flow parallel to the coast. At station 5 one can see reasonable agreement between the two methods of measurement (Table II). Current meters show uniform speed with depth and geostrophy indicates weakening of the flow with depth.

In summary there is general agreement between the two methods of measurement. It must be remembered that geostrophic calculations for station 2 were based on extrapolations and to that extent are uncertain. Further, the averaging of the current over 24 hours does not remove all non-geostrophic components, especially in the periods of

strong fluctuations. The geostrophic current, as expected, is a more useful estimate of the flow in this variable regime during the relatively quiet (i.e., steady) flow periods.

VI. CONCLUSIONS

In summarizing the current and watermass variations, the time interval between cruises is used for an initial breakdown. Currents are described by geostrophy at the time of each cruise and by current meter measurements during the intervals. Watermass properties are known only at cruise times.

From 27 November 1978 to 8 January 1979, near the level of 100 meters, there is an increased halocline slope downward toward the coast and an intense northward flow spreading westward. This spreading flow also occurs at 200 and 300 meters. Below 300 meters, southward flow develops. A salinity maximum at 300 meters occurs near the center of the station lines in November and at the western edge in early January.

From 8 January 1979 to 22 January 1979 the halocline levels off and becomes less intense. At 100 meters the northward flow has weakened and at 200 meters remains unchanged. From 300 to 500 meters there is a reduction in salinity due to horizontal advection, vice vertical, of low salinity water. There is also reduced southward flow below 300 meters during this interval.

These results by indirect measurements are consistent with direct (current meters) methods. At 100 meters northward flow spreads westward from 27 November 1978 to 22

January 1979. At about 1 January this flow shows an increased westward component, i.e. it crosses contours into deeper water. Vertical extent of the northward flow also increases during this period. Southward flow is present at mid-depth until 6 December when it turns northward at both stations 2 and 5. At 300 meters, a frontal region separating northward and southward flow, the flow is southward until early December when much oscillating dominates the rest of the period.

Indications are that the flow is branched and northward at the surface, consistent with Wickham's (1975) findings farther north. Presence of a surface maximum, Davidson Current, during the winter is almost universally consistent with the observations of other investigators. Westward propagation of the flow tends to support McCreary's (1977) model.

From 22 January 1979 to 21 February 1979 there is an increase in salinity at all levels. The northward jet shows further westward movement.

Measurement of the currents is still in progress. A 3-meter array was installed farther west at station 7 and in April 1979 was increased to a 4-meter array. Arrays are also being maintained at stations 2 and 5. Along with current meter measurements, simultaneous measurements of watermass properties are made at regular intervals.

TABLE II

COMPARISON OF CURRENT METER AND GEOSTROPHIC CURRENT
VELOCITIES ON 27 NOVEMBER 1978 AND 8 JANUARY 1979

Date	Station	Depth (meters)	Current Meters		Geostrophy	
			θ (1) direction (ref. Mag N)	V (1) (cm/sec)	θ (2) direction (ref. Mag N)	V (3) (cm/sec)
27 November	2	100	331°	16.2	310°	strong
		175	352°	2.9	305°	moderate
		300	112°	10.0	335°	weak
27 November	5	140	337°	9.5	310°	15.1
		215	339°	4.7	305°	9.1
8 January	2	100	076°	4.8	310°	strong
		175	249°	6.8	variable	weak
		300	332°	38.3	variable	weak
8 January	5	140	300°	16.6	310°	25.1
		215	240°	16.9	285°	weak

NOTES

- (1) θ and V (current Meters) found using $\frac{\vec{R}(t+12) - \vec{R}(t-12)}{24}$ where $\vec{R}$ is the position vector at the given time taken from a list of values used to produce the progressive vector diagram.
- (2) θ (geostrophy) found from dynamic topographies.
- (3) V (geostrophy) $V = \frac{V_n}{\cos \theta}$ where V_n is the normal component of velocity from geostrophic cross sections and θ is the angle from the normal.

APPENDIX A

```

PROGRAM NOYFB
PROGRAM NYOFB, REVISED VERSION OF:
REVISION 9.1, MARCH 1975
REVISED OCTOBER 1978 BY K. CODDINGTON
FOR USE WITH IBM 360 COMPUTER
WRITTEN IN FORTRAN IV LANGUAGE
REQUIRES SUBROUTINES CALC,CONST,TRANS,PTIO
REQUIRES FUNCTION JCD

DETERMINE THE STATIC CONFIGURATION OF SUB-SURFACE
MOORINGS WHEN ACTED UPON BY NON-COPLANAR CURRENT PROFILES

MAIN PROGRAM CONTROLS I/O AND OPTION SELECTION
SENSE SWITCH OPTIONS ARE INDICATED BY ISSW(I) WHERE 1=ON AND 2=OFF
S.S. - 1 - ON - LIST INPUT PARAMETERS
      - 2 - ON - OUTPUT SEGMENTAL STATS
      - 3 - ON - OUTPUT SUPPLEMENTAL STATS
      - 4 - ON - OUTPUT SUMMARY MOORING STATISTICS
      - 5 - ON - OUTPUT COMPONENT CHARACTERISTICS
      -10 - ON - OUTPUT TO SOFT COPY DEVICE
      -10 - OFF - OUTPUT TO HARD COPY DEVICE
      -14 - ON - ABORT RUN - GO TO 'PAUSE'

COMMON W(42),A(42),RBS(24),AW(5),E(16)
COMMON IT(65),XL(65),TW(66),CON(5),CD(5)
COMMON DCP(20),CP(20),RCP(20),IHDG(36)
COMMON T1(65),T2(65),T3(65),T4(65),T5(65),T6(65),T7(65)
COMMON IDA(10),IDM(10),DB(10)
COMMON DPT,QN200,D200,FPM,L11,LC,LC3,NEW,TERMW,TERML
COMMON RO,PI,TL,IC,IV,FUDG,RC,SEG,DONE
COMMON TCLIN,TTENS,TROTN,QBKUP,TVELO,ANCR,ANCR4
COMMON ISSW(14)
ISSW(1)=1
ISSW(2)=1
ISSW(3)=1
ISSW(4)=1
ISSW(5)=1
ISSW(6)=1
ISSW(7)=1
ISSW(8)=1
ISSW(9)=1
ISSW(10)=1
ISSW(11)=0
ISSW(12)=0
ISSW(13)=0
ISSW(14)=0

```

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

```

DATA IBLANK/' '
LL = 0
IC = 0
NEW = 15
ISLEW = IBLANK

SET STANDARD WHOI COMPONENT CONSTANTS
CALL CONST

ENTER I/O UNIT REFERENCE NUMBERS
STANDARD U.R.N. FOR WHOI/BUOY COMPUTER ARE LISTED

WRITE (6,1)
FORMAT (10)ENTER FIVE I/O DEVICES',/, 'SOFT COPY,HARD COPY,PAPER PUNY
INCH,KEYBOARD,PAPER READER',/, 'STANDARD URN ARE: 6,8,2,5,2,')
READ (5,600) L01, L02, L03, L1, L11
FORMAT (511)
WRITE (511,46)
FORMAT (10)INITIAL RUN FROM P.T.?: 1-YES, 0-NO')
READ (L1, 601) I
FORMAT (12)
IF (I-1) 59,55,55

INPUT MOORING COMPONENTS AND CONSTANTS FROM PAPER
TAPE OR OTHER SOURCE

55 CALL PTIO
51 WRITE (L01,51) DPT
51 FORMAT (F6.1)
LL = 0
GO TO 105

THE FOLLOWING SECTION PERMITS INPUT OF VARIABLE
PARAMETERS FOR THE INITIAL AND SUBSEQUENT RUNS
FORMAT STATEMENTS DESCRIBE THE OPERATIONS

59 CONTINUE
60 WRITE (L01,2)
2 FORMAT (10)CHANGE COMP. CONSTANTS?: 1-YES,0-NO')
READ (L1, 602) I
FORMAT (12)
IF (I-1) 75,61,61
61 WRITE (L01,3)
62 READ (L1, 603) I,J,X
3 FORMAT (10)ENTER CODING:1-W(1),2-A(1),3-RBS(1),4-AW(1)',/, ' THEN TYN
1PE COMPONENT CODE NO. AND NEW VALUE:}
603 FORMAT (I2, 1X, I2, F10.5)

```

```

NY000490
NY000500
NY000510
NY000520
NY000530
NY000540
NY000550
NY000560
NY000570
NY000580
NY000590
NY000600
NY000610
NY000620
PUNY000630
NY000640
NY000650
NY000660
NY000670
NY000680
NY000690
NY000700
NY000710
NY000720
NY000730
NY000740
NY000750
NY000760
NY000770
NY000780
NY000790
NY000800
NY000810
NY000820
NY000830
NY000840
NY000850
NY000860
NY000870
NY000880
NY000890
NY000900
NY000910
NY000920
NY000930
TYNY000940
NY000950
NY000960

```


NY001450
 NY001460
 NY001470
 NY001480
 NY001490
 NY001500
 NY001510
 NY001520
 NY001530
 NY001540
 NY001550
 NY001560
 NY001570
 NY001580
 NY001590
 NY001600
 NY001610
 NY001620
 NY001630
 NY001640
 NY001650
 NY001660
 NY001670
 NY001680
 NY001690
 NY001700
 NY001710
 NY001720
 NY001730
 NY001740
 NY001750
 NY001760
 NY001770
 NY001780
 NY001790
 NY001800
 NY001810
 NY001820
 NY001830
 NY001840
 NY001850
 NY001860
 NY001870
 NY001880
 NY001890
 NY001900
 NY001910
 NY001920

```

IT(I1) = J
XL(I1) = X
GO TO 195
  CHANGE COMPONENT
850  I1=I+I2
      IT(I1)=J
      XL(I1)=X
      GO TO 810
  INSERT COMPONENT
      I1 = IC
      IF (I1-(I+I2)) 186,186,184
180  XL(I1+1) = XL(I1)
182  IT(I1+1) = IT(I1)
184  I1 = I1-1
      GO TO 182
      XL(I1+1) = X
186  IT(I1+1) = J
      IC = IC+1
      I2 = I2+1
      GO TO 810
  DELETE COMPONENT
      I3 = I+I2
      I4 = IC-1
      DO 192 I1 = I3,I4
      XL(I1) = XL(I1+1)
      IT(I1) = IT(I1+1)
192  CONTINUE
      IC = IC-1
      I2 = I2-1
      WRITE (LO1,811)
810  FORMAT (10NEXT OR 04*)
811  GO TO 153
      WRITE (LO1,4)
195  GO TO 153
      IF (LL-1) 92,340,340
197  WRITE (LO1,101)
      FORMAT (10LINE MEASURED AT 200(D)SQR?: 1-YES, 0-NO*)
10  READ (LI,609) I
609  FORMAT (I2)
      IF (I-1) 95,94,94
      ON 200 = 1.0
      94  D200 = 1.0
  
```

```

95 GO TO 96
96 QN200 = 1.042
97 Q200 = 1.032
98 IF (LL-1) 98,340,340
99 WRITE (LO1,11)
100 FORMAT ('CENTER ANCHOR WT.(+LBS), AREA(M)SQR')
101 READ (LI,610) ANCR, ANCR4
102 FORMAT (F7.2, F5.2)
103 IF (LL-1) 215,340,340
104 WRITE (LO1,19)
105 FORMAT ('CENTER COMMENTS - 1 LINE MAX.')
106 SET 'COMMENT' ARRAY TO BLANKS
107 DO 217 K = 1,36
108 IHDG(K) = 1BLANK
109 CONTINUE
110 READ (LI,35) (IHKG(K),K = 1,36)
111 FORMAT (36(A2))
112 IF (LL-1) 100,340,340
113 WRITE (LO1,41)
114 FORMAT ('CENTER: DEPTH OF WATER (METERS)')
115 READ (LI,611) DPT
116 FORMAT (F6.1)
117 CONTINUE
118 IV = 1
119 WRITE (LO1,12)
120 FORMAT ('INPUT CURRENT PROFILE--DEPTH(METERS), SPEED(CM/SEC), DIRECTION(DEGR)')
121 READ (LI,612) DCP(IV), CP(IV), RCP(IV)
122 FORMAT (F6.1, IX, F4.1, IX, F5.1)
123 IV = IV + 1
124 IF (DCP(IV-1)-DPT) 112,115,115
125 IV = IV - 1
126 IF (LL-1) 120,340,340
127 WRITE (LO1,13)
128 FORMAT ('CHANGE STANDARD CD?: 1-YES, 0-NO')
129 READ (LI,613) I
130 FORMAT (I2)
131 IF (I-1) 130,122,122
132 WRITE (LO1,14)
133 FORMAT ('CENTER: 1-WIRE, 2-LINE, 3-INSTR, 4-BALLS, 5-UNSPEC. THEN CD(1N), CD(T)')
134 READ (LI,614) I, X, Y
135 FORMAT (I2, IX, F3.1, IX, F6.3)
136 IF (I-99) 124,127,127
137 COT(I) = X
138 COT(I) = Y

```

NY001930
 NY001940
 NY001950
 NY001960
 NY001970
 NY001980
 NY001990
 NY002000
 NY002010
 NY002020
 NY002030
 NY002040
 NY002050
 NY002060
 NY002070
 NY002080
 NY002090
 NY002100
 NY002110
 NY002120
 NY002130
 NY002140
 NY002150
 NY002160
 NY002170
 NY002180
 NY002190
 NY002200
 NY002210
 NY002220
 NY002230
 NY002240
 NY002250
 NY002260
 NY002270
 NY002280
 NY002290
 NY002300
 NY002310
 NY002320
 NY002330
 NY002340
 NY002350
 NY002360
 NY002370
 NY002380
 NY002390
 NY002400

```

C
C
C
      IF (I-4) 126,125,126
      Y/PI FOR CDT OF SPHERES ALLOWS USE OF THE
      EQUATION FOR THE TANGENTIAL DRAG OF CYLINDERS
      CDT(I) = Y/PI
125 WRITE (LOI,4)
126 GO TO 123
127 IF (LL-1) 130,340,340
130 WRITE (LOI,15)
135 FORMAT ('O SEGMENT LENGTH(METERS)?')
      READ (LI,615) SEG
615 FORMAT (F7.2)
      IF (LL-1) 200,340,340
200 WRITE (LOI,16)
16 FORMAT ('O AUTO LENGTH ADJUST?:-0 TO 10 COMPCNENTS')
      READ (LI,616) IDZ
616 FORMAT (I2)
      IF (IDZ.EQ.0) GO TO 206
202 WRITE (LOI,17)
17 FORMAT ('O ENTER: CRITICAL COMP., DESIRED DEPTH, ADJUST. COMP.')
      DO 204 I = 1, IDZ
      READ (LI,617) IDA(I), DB(I), IDM(I)
617 FORMAT (I2,IX,F6.1,IX,I2)
      CONTINUE
204 IF (LL-1) 210,340,340
206 WRITE (LOI,18)
210 FORMAT ('O ENTER MAGNITUDE, INCLINATION, AZIMUTH OF P.F.')
18 READ (LI,618) TTENS, TCCLIN, TROTN
618 FORMAT (3F5.1)
      IF (LL-1) 211,340,340
211 WRITE (LOI,42)
42 FORMAT ('O CHANGE IN TERMINATION CONSTANTS?: 1-YES, 0-NO')
619 READ (LI,619) I
      IF (I-1) 213,212,212
212 WRITE (LOI,43)
43 FORMAT ('O ENTER TERM. LENGTH(METER), WT.(LBS)')
      READ (LI,620) TERML, TERMW
620 FORMAT (F6.3,IX,F6.3)
      SET LL=2: INDICATES INITIALIZATION COMPLETE
213 LL=1
      GO TO 340
      C
      C
      C
      START NEW COMPUTATION
      RESET CRITICAL VARIABLES TO 0.0
      C
220 CONTINUE

```

```

NY002410
NY002420
NY002430
NY002440
NY002450
NY002460
NY002470
NY002480
NY002490
NY002500
NY002510
NY002520
NY002530
NY002540
NY002550
NY002560
NY002570
NY002580
NY002590
NY002600
NY002610
NY002620
NY002630
NY002640
NY002650
NY002660
NY002670
NY002680
NY002690
NY002700
NY002710
NY002720
NY002730
NY002740
NY002750
NY002760
NY002770
NY002780
NY002790
NY002800
NY002810
NY002820
NY002830
NY002840
NY002850
NY002860
NY002870
NY002880

```



```

253 IF (ISSW(1)) 254,269,254
254 WRITE (LO,20) ISLEW
    WRITE (LO,35) (IHKG(K),K = 1,36)
    WRITE (LO,33)
33 FORMAT (//28X,18HSEGMENT STATISTICS )
    WRITE (LO,34)
34 FORMAT (//, COMP TYPE LENGTH INCL XEXC. YEXC. C.SPD C.DIR M.AZI UD
    IRAG VDRAG TDRAG')
C
C SUBROUTINE CALC PERFORMS ALL BASIC CALCULATIONS
C
255 CALL CALC
    IF (ISSW(14)) 320,257,320
C
C CHECK DIFFERENCE BETWEEN ASSUMED DEPTH(RC) AND THE
C CALCULATED DEPTH OF THE TOP COMPONENT. LESS THAN 2.0 M.?
C IF YES - CHECK AUTO ADJUST STATUS,
C IF NO - CALC NEW FUDG, SET NEW RC.
C (X-RC)*0.7 TO HASTEN CONVERGENCE IN LARGE CURRENT SHEER
C
257 IF (DONE-1.0) 258,269,269
258 X = DPT-T4(IC)
259 IF (ABS(RC-X)-2.0) 260,259,259
259 FUDG = FUDG+(X-RC)*0.7
    RC = (DPT-TL)+FUDG
    GO TO 255
C
C AUTO ADJUST EVALUATION - CHECK SPECIFIED INSTRUMENT
C DEPTHS, IF AT DESIRED DEPTHS - SET (DONE=2.0) AND
C GO TO OUTPUT, IF DEPTHS ARE INCORRECT - ADJUST
C LENGTH OF (IDM) AND GO TO (220)
C
260 IF (IDZ-1) 266,261,261
261 DO 264 K = 1,IDZ
C
C CHECK AND ADJUST LOWEST ELEMENTS FIRST
C
    J = (IDZ-K)+1
    I = IDA(J)
    Z = ((DPT-T4(IC))+T4(I))-DB(J)
    IF (ABS(Z)-1.0) 264,262,262
262 I = IDM(J)
C
C 99% OF Z TO PARTIALLY ALLOW FOR STRETCH
C
    XL(I) = XL(I)+Z*0.99
    GO TO 220
264 CONTINUE

```

NY003370
 NY003380
 NY003390
 NY003400
 NY003410
 NY003420
 NY003430
 NY003440
 NY003450
 NY003460
 NY003470
 NY003480
 NY003490
 NY003500
 NY003510
 NY003520
 NY003530
 NY003540
 NY003550
 NY003560
 NY003570
 NY003580
 NY003590
 NY003600
 NY003610
 NY003620
 NY003630
 NY003640
 NY003650
 NY003660
 NY003670
 NY003680
 NY003690
 NY003700
 NY003710
 NY003720
 NY003730
 NY003740
 NY003750
 NY003760
 NY003770
 NY003780
 NY003790
 NY003800
 NY003810
 NY003820
 NY003830
 NY003840

```

266 DONE = 0.0
GO TO 245
C
C
IF SS-4 ON OUTPUT SUMMARY OF MOOR. STATS.
265 IF (ISSW(4)) 271,281,271
271 WRITE (LO,20) ISLEW
272 WRITE (LO,35) (IHOG(K),K = 1,36)
273 WRITE (LO,25)
25 FORMAT (22X,20HMOORING STATISTICS - SUMMARY
1// COMP TYPE LENGTH WEIGHT DEPTH INCLIN TENSION EXCUR DRAG
2ACK-UP,)
IRKUP = 0
BKUP = QBKUP
DO 280 K = 1,IC
I1 = IT(K)
IF (IBKUP) 274,274,273
273 BKUP = 0.0
GO TO 276
274 BKUP = BKUP-(XL(K)*W(I1))+TERMW)
IF (IT(K)-35) 276,275,276
275 IRKUP = 2
276 QW = XL(K)*W(I1)
QX = (DPT-T4(IC)) + T4(K)
QY = SQRT((T5(IC)-T5(K))**2+(T6(IC)-T6(K))**2)
WRITE (LO,26) K,IT(K),XL(K),QW,QX,T2(K),
1T3(K),QY,T1(K),BKUP
26 FORMAT (14,3X,12,2X,F6.1,1X,F7.1,2X,F6.1,1X,
1F5.1,3X,F6.1,1X,F6.1,1X,F5.1,1X,F7.1)
IF (ISSW(14)) 320,280,320
280 CONTINUE
C
C
IF SS-3 ON OUTPUT SUPPLEMENTAL STATISTICS
281 IF (ISSW(3)) 282,291,282
282 WRITE (LO,20) ISLEW
283 WRITE (LO,35) (IHOG(K),K = 1,36)
27 WRITE (LO,27)
27 FORMAT (1/24X,23HSUPPLEMENTAL STATISTICS
1//394 COMP TYPE CD(N) AREA STR,LT PERC,STR
232H S.F. XEXCUR VEXCUR LAUNCH TENS )
DO 290 K = 1, IC
I1 = IT(K)
J1 = JCD(I1)
IF (IT(K)-25) 283,284,284
283 QR = RBS(I1)/T3(K-1)
284 QR = 0.0

```

NY003850
 NY003860
 NY003870
 NY003880
 NY003890
 NY003900
 NY003910
 NY003920
 NY003930
 NY003940
 NY003950
 NY003960
 NY003970
 NY003980
 NY003990
 NY004000
 NY004010
 NY004020
 NY004030
 NY004040
 NY004050
 NY004060
 NY004070
 NY004080
 NY004090
 NY004100
 NY004110
 NY004120
 NY004130
 NY004140
 NY004150
 NY004160
 NY004170
 NY004180
 NY004190
 NY004200
 NY004210
 NY004220
 NY004230
 NY004240
 NY004250
 NY004260
 NY004270
 NY004280
 NY004290
 NY004300
 NY004310
 NY004320

```

285 QA = XL(K)*A(I1)
    QS = (T7(K)/XL(K))*100.0
    QSL = T7(K)+XL(K)
    QX = T5(IC)-T5(K)
    QY = T6(IC)-T6(K)
    WRITE (LO,28) K, IT(K),CDN(J1),QA,QSL,QS,QR,
    1QX,QY,TW(K)
28 FORMAT (I4,3X,I2,3X,F3.1,1X,F6.3,2X,F6.1,3X,F5.2,3X,
    1F5.1,F7.1,F7.1,3X,F6.1)
29C CONTINUE
C
C      IF SS-5 ON OUTPUT COMPONENT CHARACTERISTICS
291 IF (ISSW(5)) 292,320,292
292 WRITE (LO,29) ISLEW
    WRITE (LO,35) (IHG(K),K = 1,36)
    WRITE (LO,47)
47 FORMAT (/16X,26H COMPONENT CHARACTERISTICS
    2//,COMP TYPE LENGTH A(I) W(I) RBS(I) AW(I))
    DO 300 K = 1,IC
    11 = IT(K)
    X = 0.0
    Y = 0.0
    IF (IT(K)-6) 293,294,294
293 X = AW(11)
294 IF (IT(K)-25) 295,296,296
295 Y = RBS(11)
296 WRITE (LO,48) K, IT(K),XL(K),A(I1),W(I1),Y,X
48 FORMAT (I4,3X,I2,2X,F6.1,1X,F9.7,1X,F9.5,1X,F7.1,1X,F8.6)
    IF (ISSW(14)) 320,300,320
300 CONTINUE
49 WRITE (LO,49) (E(I),I = 1,16)
    1/2X,6H COMP:8X,3H(1),10X,3H(2),10X,3H(3),10X,3H(4),
    2//, (1 - 5),4(E13.5),/, (6 - 10),4(E13.5),/, (11 - 15),4(
    313.5),/, (16 - 20),4(E13.5)
C
C      END OF RUN
C      PAUSE TO THINK IF SO INCLINED
C      WRITE OPTIONS FOR POSSIBLE CHANGES
C
320 CONTINUE
    WRITE (LO,29)
29 FORMAT (,OPAUSE, RUN=22, END=99)
229 READ (LI,229) IDUMMY
    IF (IDUMMY.EQ.99) GO TO 345
321 IDZ = 0

```

NY004330
 NY004340
 NY004350
 NY004360
 NY004370
 NY004380
 NY004390
 NY004400
 NY004410
 NY004420
 NY004430
 NY004440
 NY004450
 NY004460
 NY004470
 NY004480
 NY004490
 NY004500
 NY004510
 NY004520
 NY004530
 NY004540
 NY004550
 NY004560
 NY004570
 NY004580
 NY004590
 NY004600
 NY004610
 NY004620
 NY004630
 NY004640
 NY004650
 NY004660
 NY004670
 NY004680
 NY004690
 NY004700
 NY004710
 NY004720
 NY004730
 NY004740
 NY004750
 NY004760
 NY004770
 NY004780
 NY004790
 NY004800

```

44      WRITE (LO1,44)
      FORMAT (100,CHANGE,OPTIONS,/,0,1,COMP,CHAR,/,2,STRETCH,CHAR,/,
1,/,3,MOOR,CONFIGURATION,/,4,200(D),SOR,MEASURE,/,5,ANCHOR,/,
2R,WT,/,6,WATER,DEPTH,/,7,CURRENT,PROFILE,/,8,DRAG,COEFF,/,
3FF,/,9,SEGMENT,LENGTH,/,10,AUTO,ADJUST,STATUS,/,11,P.F.,
4AT,TOP,/,12,TERM,CONST,/,13,COMMENTS,/,14,CONTINUE,W/O
5E,CALC,/,15,INPUT,MOOR,FORM PTR,/,16,OUTPUT,MOOR,TO PP,/)
323      READ (LI,621) NEW
621      FORMAT (I2)
C
C      OPTION 1 2 3 4 5 6 7 8 9 10 11 12
GO TO (61,76,150,92,98,100,110,122,130,20C,210,212,
1215,245,55,336,220), NEW
13 14 15 16 59
C
C      OUTPUT EXISTING MOORING AND CONSTANTS TO PAPER TAPE
C
336      CALL PTIO
340      WRITE (LO1,31)
31      FORMAT (100,GO? - (17) OR OPTION? - (1 TO 16)')
345      GO TO 323
STOP
END
SUBROUTINE CALC
SUBROUTINE CALC - USE WITH PROG. NOYFB, REV. 9.1
CALCULATION TO DETERMINE ALL MOORING STATISTICS
COMMON W(42),A(42),RBS(24),AW(5),E(16)
COMMON IT(65),XL(65),TW(66),CDN(5),CDT(5)
COMMON DCP(20),CP(20),RCP(20),IHDG(36)
COMMON TI(65),T2(65),T3(65),T4(65),T5(65),T6(65),T7(65)
COMMON IDA(10),IDM(10),DR(10)
COMMON DPT,QN200,D200,FPM,L11,LC,LC3,NEW,TERMW,TERML
COMMON RD,PI,TL,IC,IV,FUDG,RC,SEG,DONE
COMMON TCLIN,TTENS,TROTN,QBKUP,TVELO,ANCR,ANCR4
COMMON ISSW(14)
C
C      RESET VARIABLES TO INITIALIZE
C
TLD = DPT-TL
DRAG = 0.0
JC = 2
TSTR = 0.0
TVHT = 0.0
CLIN = TCLIN*RD

```

```

NY004810
NY004820
NY004830
NY004840
NY004850
NY004860
NY004870
NY004880
NY004890
NY004900
NY004910
NY004920
NY004930
NY004940
NY004950
NY004960
NY004970
NY004980
NY004990
NY005000
NY005010
NY005020
NY005030
NY005040
NY005050
NY005060
NY005070
NY005080
NY005090
NY005100
NY005110
NY005120
NY005130
NY005140
NY005150
NY005160
NY005170
NY005180
NY005190
NY005200
NY005210
NY005220
NY005230
NY005240
NY005250
NY005260
NY005270
NY005280

```

NY005290
 NY005300
 NY005310
 NY005320
 NY005330
 NY005340
 NY005350
 NY005360
 NY005370
 NY005380
 NY005390
 NY005400
 NY005410
 NY005420
 NY005430
 NY005440
 NY005450
 NY005460
 NY005470
 NY005480
 NY005490
 NY005500
 NY005510
 NY005520
 NY005530
 NY005540
 NY005550
 NY005560
 NY005570
 NY005580
 NY005590
 NY005600
 NY005610
 NY005620
 NY005630
 NY005640
 NY005650
 NY005660
 NY005670
 NY005680
 NY005690
 NY005700
 NY005710
 NY005720
 NY005730
 NY005740
 NY005750
 NY005760

```

PCLIN = CLIN
TTENS = TTENS
ROTN = ROTN*RD
TXEX = 0.0
TYEX = 0.0
CPK = 1.076391E-01

PRIMARY LOOP
DO 570 I = 1,IC
  IL = IT(I)
  DETERMINE DRAG COEFF. SUBSCRIPT (FUNCTION JCD)
  J1 = JCD(IL)
  DETERMINE NO. OF SEGMENTS IN COMPONENT (I)
  500 L = 1+FIX(XL(I)/SEG)
  SECONDARY LOOP FOR SEGMENT CALC.
  505 DC 562 K = 1,L
  SET SEGMENT LENGTH (CLI) AND BUOYANCY (WT)
  CALC. CURRENT: - MEAN DEPTH (DN), SPEED(VN),
  DIRECTION(ROT), FOR EACH SEGMENT
  IF (K-L) 509,507,507
  507 CLI = (XL(I)-SEG*FLOAT(K-1))+TERML
  WT = W(I1)*(CLI-TERML)+TERMW
  GO TO 510
  509 CLI = SEG
  WT = W(I1)*SEG
  510 DN = TLD+(CLI/2.0)+FUDG*((DPT-(TLD+CLI/2.0))/TL)
  ASSIGN DEEPEST CURRENT VALUES IF DN EXCEEDS DPT
  IF (DN-DPT) 514,512,512
  512 VN = CP(IV)*CPK
  ROT = RCP(IV)*RD
  GO TO 519
  514 IF (DN-DCP(JC)) 518,516,516
  516 JC = JC+1
  GO TO 514
  518 VN = (CP(JC-1)+((DN-DCP(JC-1))/(DCP(JC)-DCP(JC-1))))*CPK
  ROT = (RCP(JC-1)+((DN-DCP(JC-1))/(DCP(JC)-DCP(JC-1))))

```

```

NY005770
NY005780
NY005790
NY005800
NY005810
NY005820
NY005830
NY005840
NY005850
NY005860
NY005870
NY005880
NY005890
NY005900
NY005910
NY005920
NY005930
NY005940
NY005950
NY005960
NY005970
NY005980
NY005990
NY006000
NY006010
NY006020
NY006030
NY006040
NY006050
NY006060
NY006070
NY006080
NY006090
NY006100
NY006110
NY006120
NY006130
NY006140
NY006150
NY006160
NY006170
NY006180
NY006190
NY006200
NY006210
NY006220
NY006230
NY006240

1*(RCP(JC)-RCP(JC-1)))*RD
SET ROTN=ROT WHEN TENSION = 0
519 IF (TENS) 522,522,524
522 ROTN = ROT

CALC. DRAG FORCES, TENSION, INCLINATION AND AZIMUTH OF SEG.
ITERATE UNTIL CHANGE LESS THAN 0.1 DEGREES FOR
INCLINATION - LOOP 526 TO 530
MOORING AZIMUTH - LOOP 526 TO 527

524 X = ROTN
524 Y = ROTN
524 Z = TENS*SIN(CLIN)
526 QCLIN = PCLIN
ANINC = QCLIN-CLIN
UTVN = VN*CCS(ROT-ROTN)
VTVN = VN*SIN(ROT-ROTN)
DRGT = A(11)*PI*CLI*CDT(J1)*(SIN(QCLIN)*UTVN)*
1(ABS(SIN(QCLIN)*UTVN))
UDRGN = A(11)*CLI*CDN(J1)*(COS(QCLIN)*UTVN)*
1(ABS(COS(QCLIN)*UTVN))
VDRGN = A(11)*CLI*CDN(J1)*VTVN*ABS(VTVN)
WTT = WT*CCS(QCLIN)
WTN = WT*SIN(QCLIN)
OTENS = TENS*CCS(ANINC)+WTT+DRGT

(-WTN) CHANGE SIGN OF WTN FOR CORRECT SENSE
PCLIN = ATAN ((UDRGN-WTN-TENS*SIN(ANINC))/OTENS)+QCLIN
AVOID /0.0 IN STATEMENT 523
IF (QTENS*SIN(PCLIN)) 523,529,523
523 ROTN = ATAN((VDRGN-Z*SIN(X-Y))/(QTENS*SIN(PCLIN)))+X
529 IF (ISSW(14)) 570,525,570
ASSURE +PCLIN
525 IF (PCLIN) 531,530,527
RATE OF CHANGE IN AZIMUTH < 0.1 DEGREE?
IF (ABS(ABS(X)-ABS(ROTN))-(0.1*RO)) 530,528,528
528 X = ROTN
GO TO 526
527

```

NY005770
 NY005780
 NY005790
 NY005800
 NY005810
 NY005820
 NY005830
 NY005840
 NY005850
 NY005860
 NY005870
 NY005880
 NY005890
 NY005900
 NY005910
 NY005920
 NY005930
 NY005940
 NY005950
 NY005960
 NY005970
 NY005980
 NY005990
 NY006000
 NY006010
 NY006020
 NY006030
 NY006040
 NY006050
 NY006060
 NY006070
 NY006080
 NY006090
 NY006100
 NY006110
 NY006120
 NY006130
 NY006140
 NY006150
 NY006160
 NY006170
 NY006180
 NY006190
 NY006200
 NY006210
 NY006220
 NY006230
 NY006240

COMMON DPT, CN200, D200, FPM, L11, L0, L03, NEW, TERMW, TERML
COMMON RD, PI, TL, IC, IV, FUDG, RC, SEG, DONE
COMMON TCLIN, TTENS, TROTN, QBKUP, TVELO, ANCR, ANCR

TERMW = -2.19
TERML = 0.203
RD = 0.017453293
PI = 3.141592654
FPM = 3.28084

A(I) - AREA OF COMP. IN SQR. METER PER METER LENGTH
(LINE, WIRE, CHAIN = DIAMETER IN METERS)
W(I) - WEIGHT OF COMP. IN POUNDS PER METER LENGTH
(+= POSITIVE BUOYANCY, -= NEGATIVE BUOYANCY)
RBS(I) - RATED BREAKING STRENGTH IN POUNDS
AW(I) - CROSS SECTIONAL METAL AREA OF WIRE IN SQR. INCHES

WIRE CONSTANTS: (1)-3/16', (2)-1/4', (3)-5/16', (4)-3/8', (5)-?
U.S.S.; TORQUE BALANCED JACKETED 3X19 WIRE

A(1) = 6.5786E-03
W(1) = -0.154
RBS(1) = 4000.0
AW(1) = 0.01611
A(2) = 8.3566E-03
W(2) = -0.266
RBS(2) = 6750.0
AW(2) = 0.02738
A(3) = 9.9568E-03
W(3) = -0.41
RBS(3) = 10300.0
AW(3) = 0.04206
A(4) = 1.15824E-02
W(4) = -0.594
RBS(4) = 14800.0
AW(4) = 0.06015
A(5) = 0.0
W(5) = 0.0
RBS(5) = 1.0
AW(5) = 1.0

SAMPSON, SINGLE BRAID DACRON, WHOI SPECS
DACRON LINE CONSTANTS: (6)-3/8', (7)-7/16', (8)-1/2',
(9)-9/16', (10)-5/8',
DIAMETER IS 93.5% OF NOMINAL SIZE

NY007210
NY007220
NY007230
NY007240
NY007250
NY007260
NY007270
NY007280
NY007290
NY007300
NY007310
NY007320
NY007330
NY007340
NY007350
NY007360
NY007370
NY007380
NY007390
NY007400
NY007410
NY007420
NY007430
NY007440
NY007450
NY007460
NY007470
NY007480
NY007490
NY007500
NY007510
NY007520
NY007530
NY007540
NY007550
NY007560
NY007570
NY007580
NY007590
NY007600
NY007610
NY007620
NY007630
NY007640
NY007650
NY007660
NY007670
NY007680

A(6) = 8.90588E-03
 W(6) = -0.0375
 RBS(6) = 5700.0
 A(7) = 1.03902E-02
 W(7) = -0.0516
 RBS(7) = 7000.0
 A(8) = 1.18745E-02
 W(8) = -0.0667
 RBS(8) = 9000.0
 A(9) = 1.33588E-02
 W(9) = -0.0851
 RBS(9) = 11200.0
 A(10) = 1.48431E-02
 W(10) = -0.1082
 RBS(10) = 14000.0

CC

COLUMBIA, SINGLE BRAID PLAITED NYLON, WHOI SPECS
 NYLON LINE CONSTANTS: (11)-3/8", (12)-1/2", (13)-9/16",
 (14)-5/8", (15)-3/4",
 DIAMETER IS 93.5% OF NOMINAL SIZE

A(11) = 8.90588E-03
 W(11) = -0.011
 RPS(11) = 3700.0
 A(12) = 1.18745E-02
 W(12) = -0.0204
 RBS(12) = 6400.0
 A(13) = 1.33588E-02
 W(13) = -0.0261
 RBS(13) = 8200.0
 A(14) = 1.48431E-02
 W(14) = -0.033
 RBS(14) = 10400.0
 A(15) = 1.78118E-02
 W(15) = -0.0457
 RBS(15) = 14200.0

CC

UNSPECIFIED SYNTHETIC LINE : (16)-? THROUGH (20)-?

A(16) = 0.0
 W(16) = 0.0
 RBS(16) = 1.0
 A(17) = 0.0
 W(17) = 0.0
 RBS(17) = 1.0
 A(18) = 0.0
 W(18) = 0.0
 RBS(18) = 1.0

NY007690
 NY007700
 NY007710
 NY007720
 NY007730
 NY007740
 NY007750
 NY007760
 NY007770
 NY007780
 NY007790
 NY007800
 NY007810
 NY007820
 NY007830
 NY007840
 NY007850
 NY007860
 NY007870
 NY007880
 NY007890
 NY007900
 NY007910
 NY007920
 NY007930
 NY007940
 NY007950
 NY007960
 NY007970
 NY007980
 NY007990
 NY008000
 NY008010
 NY008020
 NY008030
 NY008040
 NY008050
 NY008060
 NY008070
 NY008080
 NY008090
 NY008100
 NY008110
 NY008120
 NY008130
 NY008140
 NY008150
 NY008160

NY008170
 NY008180
 NY008190
 NY008200
 NY008210
 NY008220
 NY008230
 NY008240
 NY008250
 NY008260
 NY008270
 NY008280
 NY008290
 NY008300
 NY008310
 NY008320
 NY008330
 NY008340
 NY008350
 NY008360
 NY008370
 NY008380
 NY008390
 NY008400
 NY008410
 NY008420
 NY008430
 NY008440
 NY008450
 NY008460
 NY008470
 NY008480
 NY008490
 NY008500
 NY008510
 NY008520
 NY008530
 NY008540
 NY008550
 NY008560
 NY008570
 NY008580
 NY008590
 NY008600
 NY008610
 NY008620
 NY008630
 NY008640

A(19) = 0.0
 W(19) = 0.0
 RPS(19) = 1.0
 A(20) = 0.0
 W(20) = 0.0
 RPS(20) = 1.0
 CHAIN: (21)-1/4', (22)-3/8', (23)-1/2', (24)-3/4'
 A(21) = 2.74E-02
 W(21) = -2.33
 RPS(21) = 5400.0
 A(22) = 3.7E-02
 W(22) = -5.12
 RPS(22) = 12150.0
 A(23) = 4.8E-02
 W(23) = -9.02
 RPS(23) = 21600.0
 A(24) = 6.85E-02
 W(24) = -19.52
 RPS(24) = 48.6E+03
 CYLINDRICAL INSTRUMENTS:
 DIVISOR IS THE LENGTH OF THE INSTRUMENT (METERS)
 (25)-VAC CM, (26)-850(LT), (27)-850(HEAVY),
 (28)-ENG CM, (29)-INCLINOMETER, (30)-DEPTH REC.,
 (31)-TENSION REC, (32)-TENSAC
 (33)-?, (34)-?, (35)-RELEASE, AMF TRANSPONDING
 A(25) = 0.1579
 W(25) = -75.0/1.9
 A(26) = 0.17917
 W(26) = -40.0/1.8
 A(27) = 0.17917
 W(27) = -50.0/1.8
 A(28) = 0.16043
 W(28) = -40.0/0.8
 A(29) = 0.16043
 W(29) = -40.0/0.8
 A(30) = 0.16043
 W(30) = -40.0/0.8
 A(31) = 0.16043
 W(31) = -40.0/0.8
 A(32) = 0.16875
 W(32) = -70.0/1.6
 A(33) = 0.0
 W(33) = 0.0
 A(34) = 0.0

CC

CCCCCCCC

W(34) = 0.0
 A(35) = 0.1499
 W(35) = -80.0/1.8
 C C C C C
 SPHERICAL INSTRUMENTS:
 DIVISOR IS THE LENGTH OF THE INSTRUMENT (METERS)
 (36)-?, (37)-M/T P/T, (38)-RADIC FLOAT
 A(36) = 0.0
 W(36) = 0.0
 A(37) = 0.207
 W(37) = -18.0/0.4
 A(38) = 0.26
 W(38) = 41.0/1.0
 C C C C C
 SPHERES MOUNTED ON 3/8" CHAIN, 1 METER COMPONENT LENGTH
 (39)-16" SPHERE - 17.5" O.D., (40)-17" SPHERE-18.5" O.D.
 A(39) = 0.25138
 W(39) = 43.5
 A(40) = 0.26962
 W(40) = 53.0
 C C C C C
 UNDEFINED COMPONENTS W/UNIQUE DRAG COEFF.
 (41)-?, (42)-?
 A(41) = 0.0
 W(41) = 0.0
 A(42) = 0.0
 W(42) = 0.0
 C C C C C
 DRAG COEFFICIENTS - CDN-NORMAL, CDT - TANGENTIAL
 (1)-WIRE, (2)-LINE & CHAIN, (3)-INSTRUMENTS,
 (4)-SPHERES, (5)-UNSPECIFIED
 CDN(1) = 1.3
 CDT(1) = 0.007
 CDN(2) = 1.3
 CDT(2) = 0.007
 CDN(3) = 1.2
 CDT(3) = 0.9
 CDN(4) = 0.5
 CDT(4) = 0.5/PI
 CDN(5) = 0.0
 CDT(5) = 0.0
 C C
 STRETCH CHARACTERISTICS

NY008650
 NY008660
 NY008670
 NY008680
 NY008690
 NY008700
 NY008710
 NY008720
 NY008730
 NY008740
 NY008750
 NY008760
 NY008770
 NY008780
 NY008790
 NY008800
 NY008810
 NY008820
 NY008830
 NY008840
 NY008850
 NY008860
 NY008870
 NY008880
 NY008890
 NY008900
 NY008910
 NY008920
 NY008930
 NY008940
 NY008950
 NY008960
 NY008970
 NY008980
 NY008990
 NY009000
 NY009010
 NY009020
 NY009030
 NY009040
 NY009050
 NY009060
 NY009070
 NY009080
 NY009090
 NY009100
 NY009110
 NY009120

NY009130
 NY009140
 NY009150
 NY009160
 NY009170
 NY009180
 NY009190
 NY009200
 NY009210
 NY009220
 NY009230
 NY009240
 NY009250
 NY009260
 NY009270
 NY009280
 NY009290
 NY009300
 NY009310
 NY009320
 NY009330
 NY009340
 NY009350
 NY009360
 NY009370
 NY009380
 NY009390
 NY009400
 NY009410
 NY009420
 NY009430
 NY009440
 NY009450
 NY009460
 NY009470
 NY009480
 NY009490
 NY009500
 NY009510
 NY009520
 NY009530
 NY009540
 NY009550
 NY009560
 NY009570
 NY009580
 NY009590
 NY009600

(1-4)-WIRE, (5-8)-DACRON, (9-12)-NYLON, (13-16)-UNSPECIFIED

E(1) = 1.42E571E-03

E(2) = 20.5E+06

E(3) = 0.0

E(4) = 0.0

E(5) = 2.81E+06

E(6) = 0.607

E(7) = 3.83E+06

E(8) = 0.74

E(9) = 1.56E+05

E(10) = 0.516

E(11) = 1.3262E+05

E(12) = 0.535

E(13) = 0.0

E(14) = 0.0

E(15) = 0.0

E(16) = 0.0

CONTINUE

RETURN

END

SUBROUTINE TRANS

SUBROUTINE TRANS - FOR USE WITH PROG. NOYFB, REV. 9.1
 CALCULATE AND STORE IN ARRAY (TW), PEAK TENSION ON EACH
 COMPONENT EXPERIENCED DURING ANCHOR LAST LAUNCH
 INITIATES EACH RUN BY DETERMINING TOTAL RELAXED LENGTH (TL)
 AND RESERVE BUOYANCY AT COMPONENT NO. 1 (QBKUP)
 CALC. TERMINAL VELOCITY OF FREE FALL ANCHOR (TVELO)

COMMON W(42), A(42), RBS(24), AW(5), E(16)

COMMON IT(65), XL(65), TW(66), CDN(5), CDT(5)

COMMON DCP(20), CP(20), RCP(20), IHDG(36)

COMMON T1(65), T2(65), T3(65), T4(65), T5(65), T6(65), T7(65)

COMMON IDA(10), IDM(10), DB(10)

COMMON DPT, QN200, D200, FPM, L11, L0, L03, NEW, TERMW, TERML

COMMON RD, PI, TL, IC, IV, FUDG, RC, SEG, DONE

COMMON TCLIN, TTENS, TROTN, QBKUP, TVELC, ANCR, ANCR A

X = 0.0

J = 0

DO 420 I = 1, IC

401 I1 = IT(I)

SUM INPUT LENGTHS (TL) AND COMP. BUOYANCIES (T1(I))

T1(I) IS USED FOR TEMPORARY STORAGE

TL = TL + XL(I) + TERML

X = X + TERMW + W(I1) * XL(I)

AD-A081 606

NAVAL POSTGRADUATE SCHOOL MONTEREY CA
MEASUREMENT OF THE CALIFORNIA COUNTERCURRENT. (U)
JUN 79 K CODDINGTON

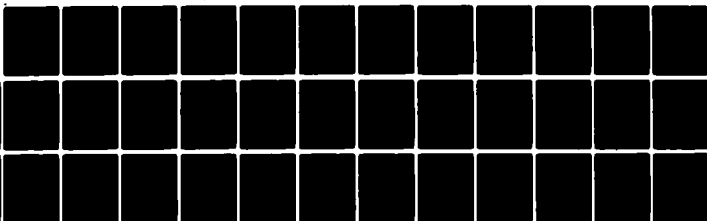
F/G 8/3

UNCLASSIFIED

NL

2 of 2

AD-A081 606



END

DATE

FILMED

4-80

DTIC

NY009610
 NY009620
 NY009630
 NY009640
 NY009650
 NY009660
 NY009670
 NY009680
 NY009690
 NY009700
 NY009710
 NY009720
 NY009730
 NY009740
 NY009750
 NY009760
 NY009770
 NY009780
 NY009790
 NY009800
 NY009810
 NY009820
 NY009830
 NY009840
 NY009850
 NY009860
 NY009870
 NY009880
 NY009890
 NY009900
 NY009910
 NY009920
 NY009930
 NY009940
 NY009950
 NY009960
 NY009970
 NY009980
 NY009990
 NY010000
 NY010010
 NY010020
 NY010030
 NY010040
 NY010050
 NY010060
 NY010070
 NY010080

```

C      T1(I) = X
C      RESERVE BUOYANCY (QBKUP) AT TOP COMP. = SUM OF WEIGHTS
C      OF RELEASE (35) AND ALL COMPONENTS ABOVE IT
C      IF(J-1) 402,405,405
C      402 QBKUP = X
C      IF(I1-35) 405,403,405
C      403 J = 2
C      DETERMINE DRAG COEFF. SUBSCRIPT (J1), FUNCT. JCD
C      405 J1 = JCD(I1)
C      CALC. TOTAL AREA*CD FOR EACH COMPONENT AND SUM
C      GO TO 410 - WIRE, LINE AND CHAIN
C      412 - INSTRUMENTS(CYLINDERS)
C      410 - SPHERES
C      412 - UNSPECIFIED
C      Y = CDT*SURFACE AREA
C      Y = CDT(J1)*PI*A(I1)*XL(I)*FPM**2
C      GO TO (410,410,412,410,412), J1
C      TW(I+1) = TW(I)+Y
C      GO TO 420
C      412 TW(I+1) = TW(I)+(CDN(J1)*(PI/4.0)*A(I1)**2
C      420 1*FPM**2)+Y
C      420 CONTINUE
C      CALC. VELD.**2(VSQ), CD*AREA OF ANCHOR APPLIED
C      THEN CALC. TERMINAL VELOCITY AND TRANSIENT PEAK LOAD
C      VSQ = (ANCR-T1(IC))/(TW(IC+1)+ANCRA*FPM**2*1.15)
C      DO 425 I = 1,IC
C      416 TW(I) = T1(I)+TW(I+1)*VSQ
C      425 CONTINUE
C      TVELO = (SQRT(VSQ)/FPM)*60.0
C      RETURN
C      END
C      SUBROUTINE PTIO
C      SUBROUTINE PTIO - FOR USE WITH PRCG. NOYFB, REV. 9.1
C      INPUT/OUTPUT SUBROUTINE FOR PERMANENT RECORD OF MOORING
C      SPECIFICALLY FOR USE WITH A PAPER TAPE READER AND PAPER TAPE
C      PUNCH BUT USEABLE WITH OTHER I/O DEVICES
C      READS/Writes NUMBER, TYPE AND LENGTH OF MOORING COMPONENTS
C      READS/Writes CONSTANTS AND VARIABLES USED FOR MOORING CONFIG
C      READS/Writes OPERATOR COMMENTS
  
```

NY01 0090
 NY01 0100
 NY01 0110
 NY01 0120
 NY01 0130
 NY01 0140
 NY01 0150
 NY01 0160
 NY01 0170
 NY01 0180
 NY01 0190
 NY01 0200
 NY01 0210
 NY01 0220
 NY01 0230
 NY01 0240
 NY01 0250
 NY01 0260
 NY01 0270
 NY01 0280
 NY01 0290
 NY01 0300
 NY01 0310
 NY01 0320
 NY01 0330
 NY01 0340
 NY01 0350
 NY01 0360
 NY01 0370
 NY01 0380
 NY01 0390
 NY01 0400
 NY01 0410
 NY01 0420
 NY01 0430
 NY01 0440
 NY01 0450
 NY01 0460
 NY01 0470
 NY01 0480
 NY01 0490
 NY01 0500
 NY01 0510
 NY01 0520
 NY01 0530
 NY01 0540
 NY01 0550
 NY01 0560

C
 COMMON W(42), A(42), RBS(24), AW(5), E(16)
 COMMON IT(65), XL(65), TW(66), CDN(5), CDT(5)
 COMMON DCP(20), CP(20), RCP(20), IHG(36)
 COMMON T1(65), T2(65), T3(65), T4(65), T5(65), T6(65), T7(65)
 COMMON IDA(10), IDN(10), DB(10)
 COMMON OPT, QN200, D200, FPM, L1, LC, LC3, NEW, TERMW, TERML
 COMMON RD, P1, TL, IC, IV, FUDG, RC, SEG, DONE
 COMMON TCLIN, ITENS, TRUTN, QBKUP, TVELO, ANCR, ANCR A
 FORMAT (4F13.7)
 36 FORMAT (12, F13.7)
 37 FORMAT (36(A2))
 38 FORMAT (7F8.3, I2)
 39 IF (NEW-15) 1010, 1006, 1000
 1000 WRITE (LO3, 39) DPT, QN200, D200, ANCR, ANCR A, TERMW, TERML, IC
 WRITE (LO3, 36) (W(I), A(I), I = 1, 42), (RBS(I), I = 1, 24),
 1(AW(I), I = 1, 5), (E(I), I = 1, 16), (CDN(I), CDT(I), I = 1, 5)
 DO 1002 I = 1, IC
 WRITE (LO3, 37) IT(I), XL(I)
 1002 CONTINUE
 WRITE (LO3, 38) (IHG(I), I = 1, 36)
 GO TO 1010
 1006 READ (L11, 39) DPT, QN200, D200, ANCR, ANCR A, TERMW, TERML, IC
 READ (L11, 36) (W(I), A(I), I = 1, 42), (RBS(I), I = 1, 24),
 1(AW(I), I = 1, 5), (E(I), I = 1, 16), (CDN(I), CDT(I), I = 1, 5)
 DO 1008 I = 1, IC
 READ (L11, 37) IT(I), XL(I)
 CONTINUE
 1008 CONTINUE
 READ (L11, 38) (IHG(I), I = 1, 36)
 1010 CONTINUE
 RETURN
 END
 FUNCTION JCD(I1)
 FUNCTION JCD - USE WITH PRDG. NOYFB, REV 9.1
 SET SUBSCRIPT FOR COMPONENT DRAG COEFFICIENTS (J1)
 (5) - 41 AND 42
 (4) - 36 THRU 40
 (3) - 25 35
 (2) - 6 24
 (1) - 1 5
 JCD = 5
 IF (I1-41) 483, 487, 487
 483 JCD = 4
 IF (I1-36) 484, 487, 487
 484 JCD = 3
 IF (I1-25) 485, 487, 487

NY010570
NY010580
NY010590
NY010600
NY010610
NY010620

485 JCD = 2 486,487,487
486 IF (I1-6) 486,487,487
487 JCD = 1
CONTINUE
RETURN
END

APPENDIX B

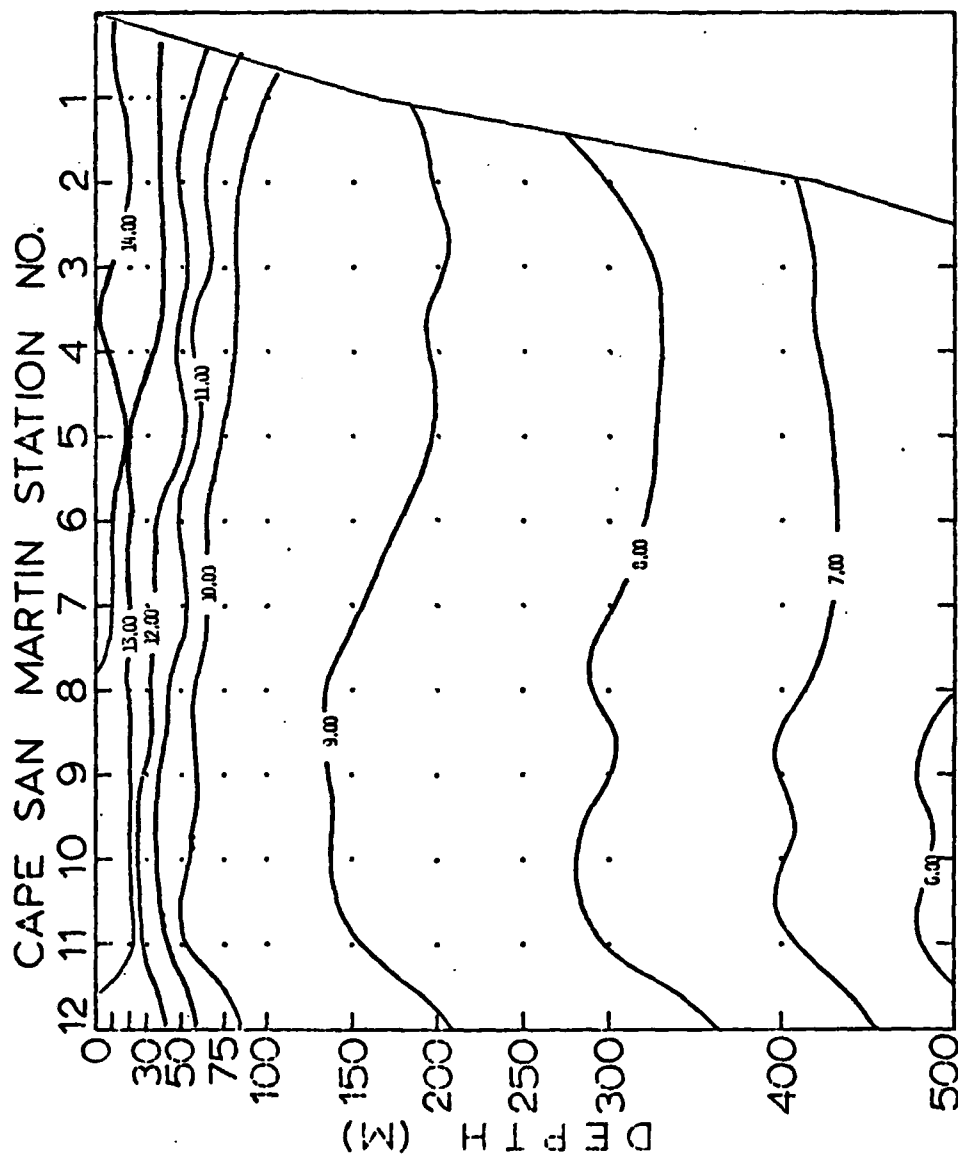


Figure 43. Temperature ($^{\circ}\text{C}$) on a vertical section for the Cape San Martin line on 27-28 November 1978.

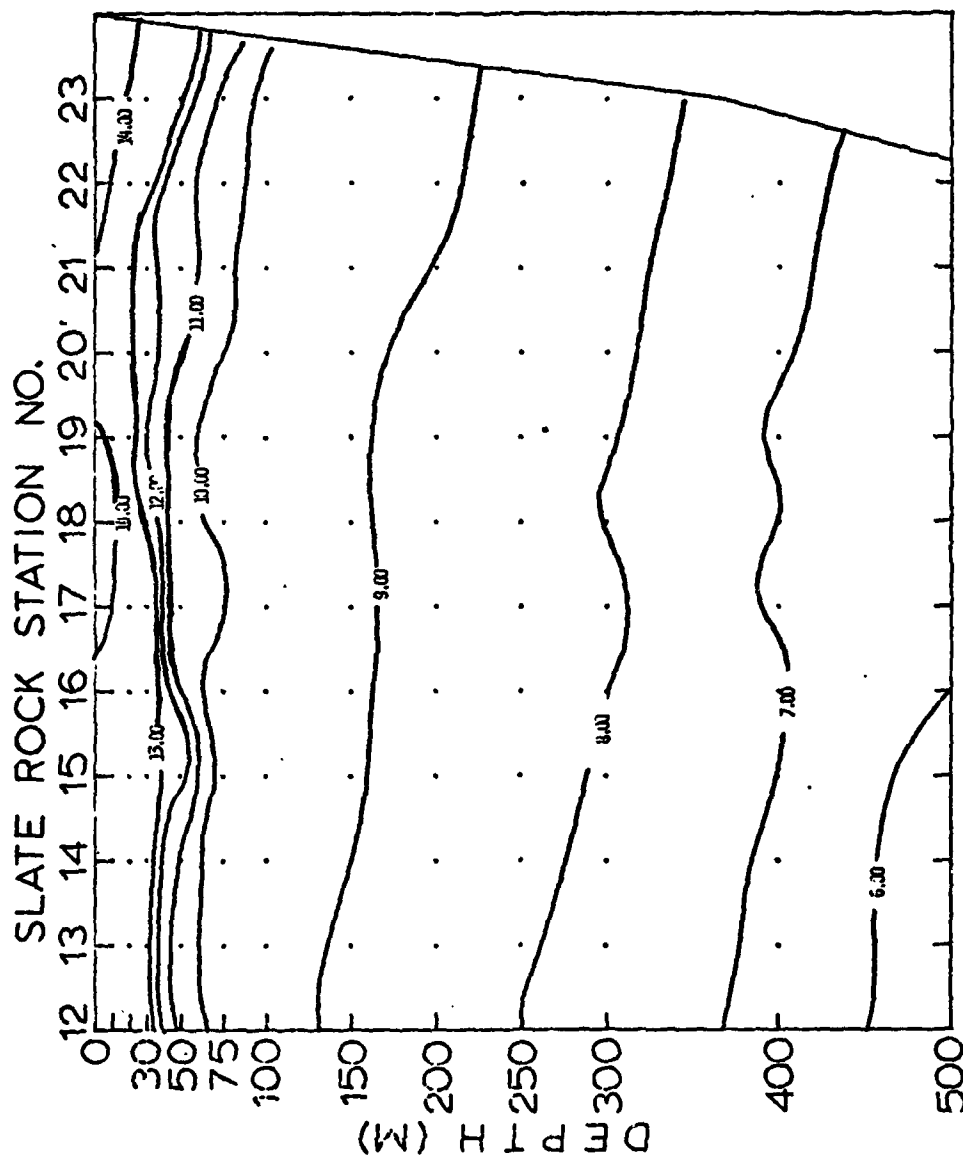


Figure 44. Temperature ($^{\circ}\text{C}$) on a vertical section for the Slate Rock line on 27-28 November 1978.

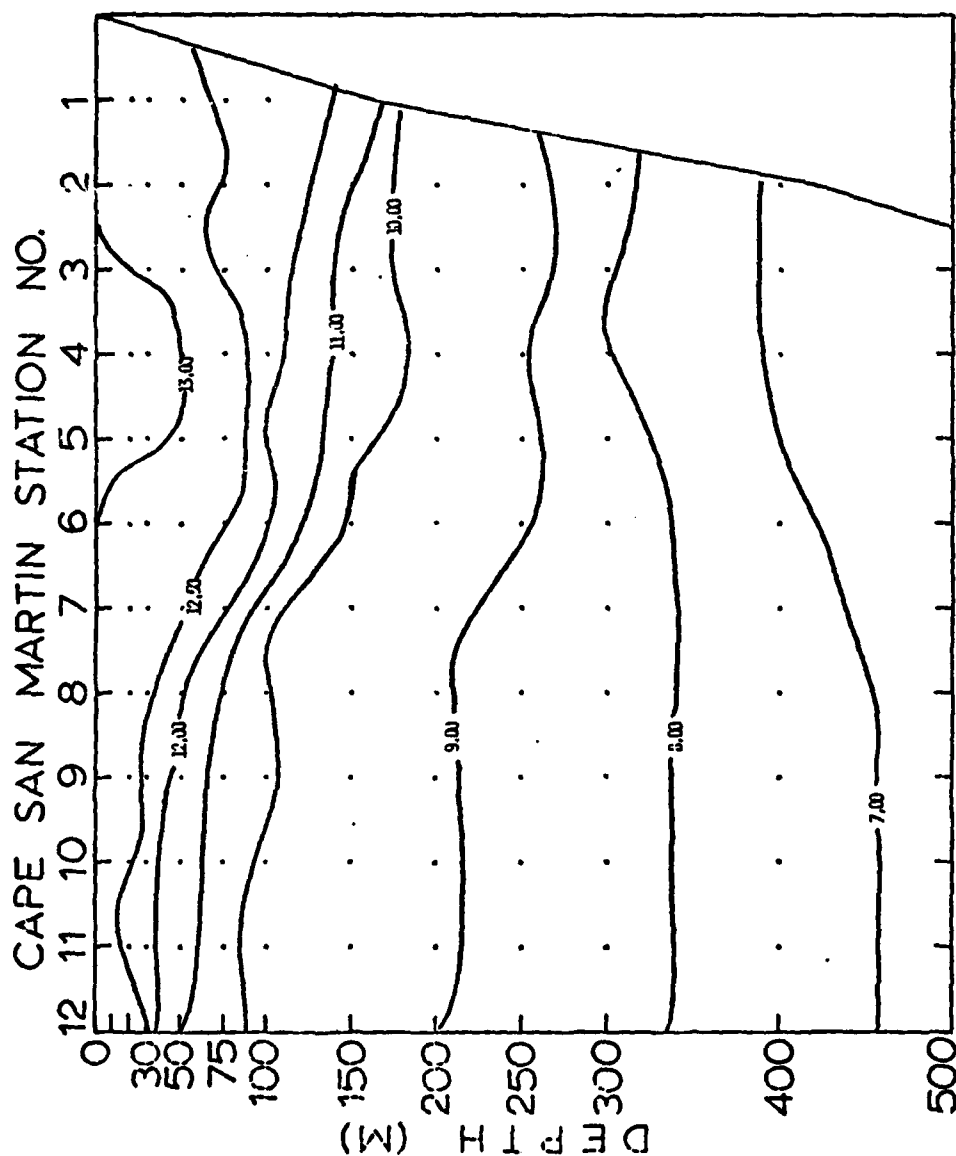


Figure 45. Temperature ($^{\circ}\text{C}$) on a vertical section for the Cape San Martin line on 8-9 January 1979.

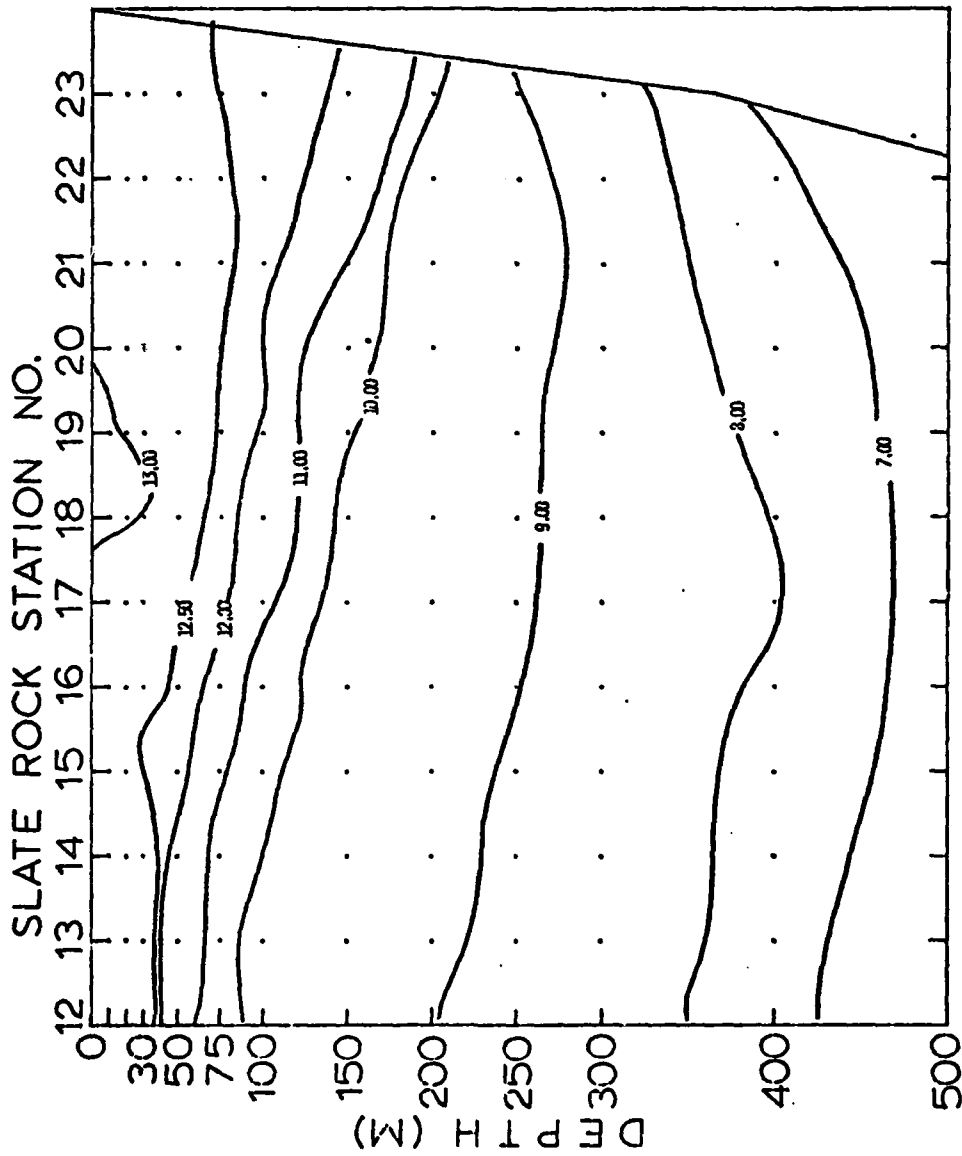


Figure 46. Temperature (°C) on a vertical section for the Slate Rock line on 8-9 January 1979.

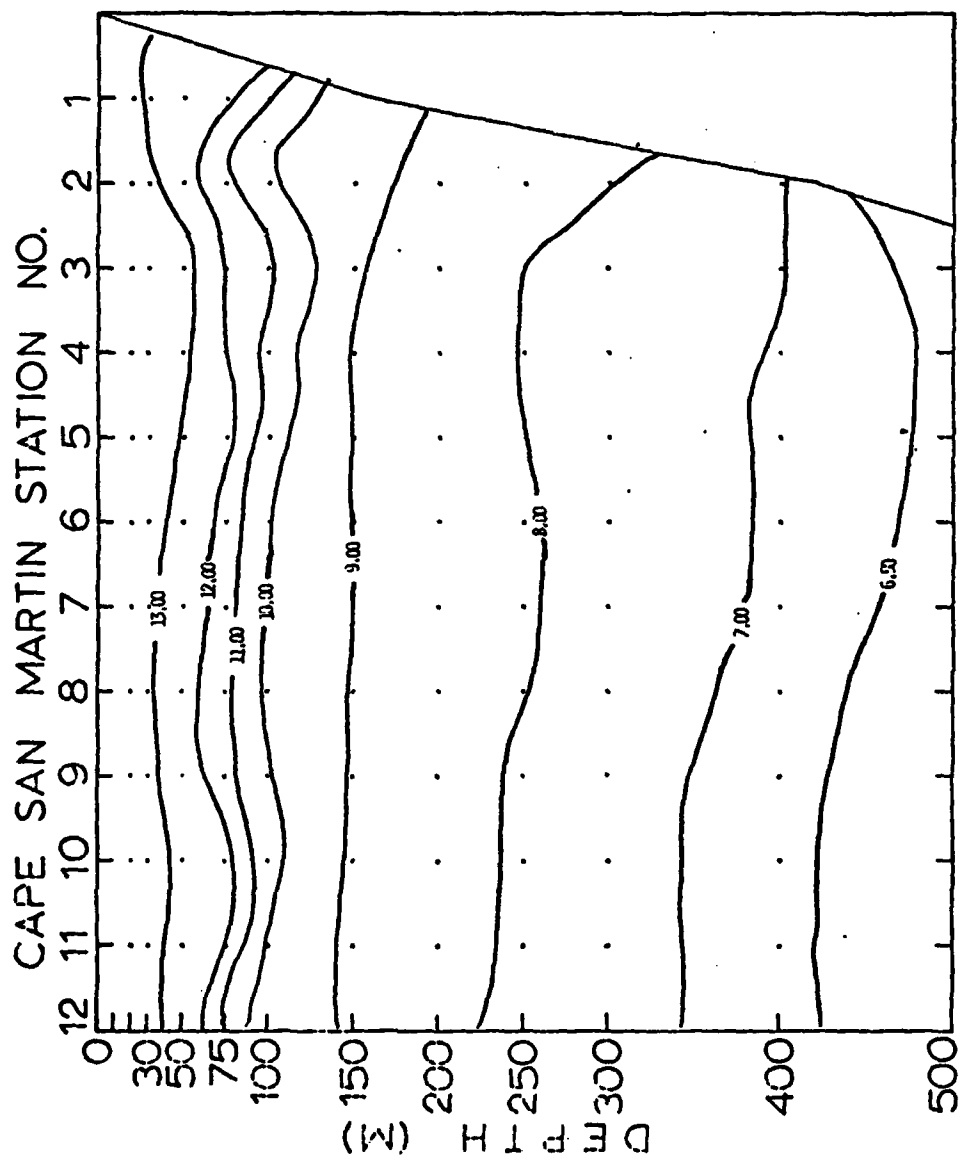


Figure 47. Temperature ($^{\circ}\text{C}$) on a vertical section for the Cape San Martin line on 22-23 January 1979.

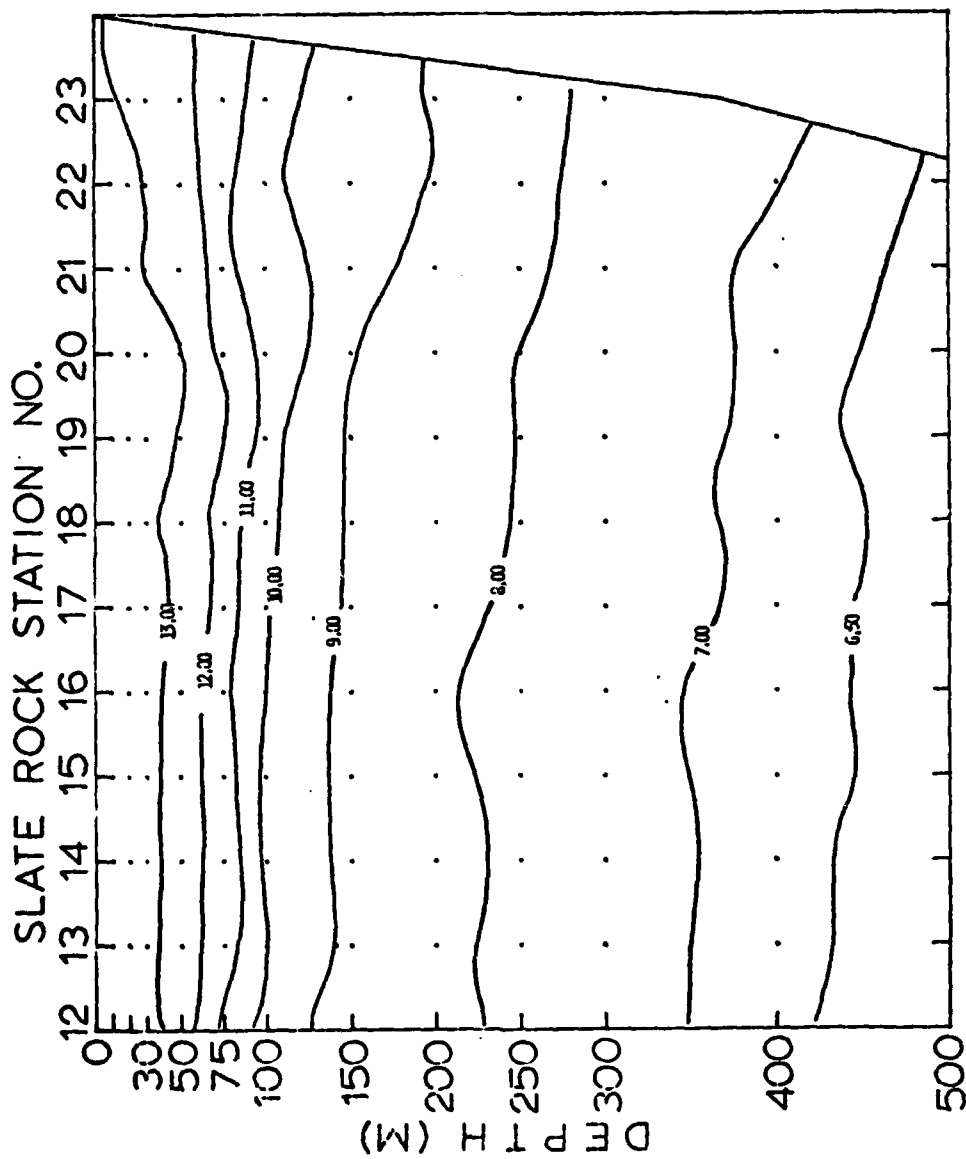


Figure 48. Temperature ($^{\circ}\text{C}$) on a vertical section for the Slate Rock line on 22-23 January 1979.

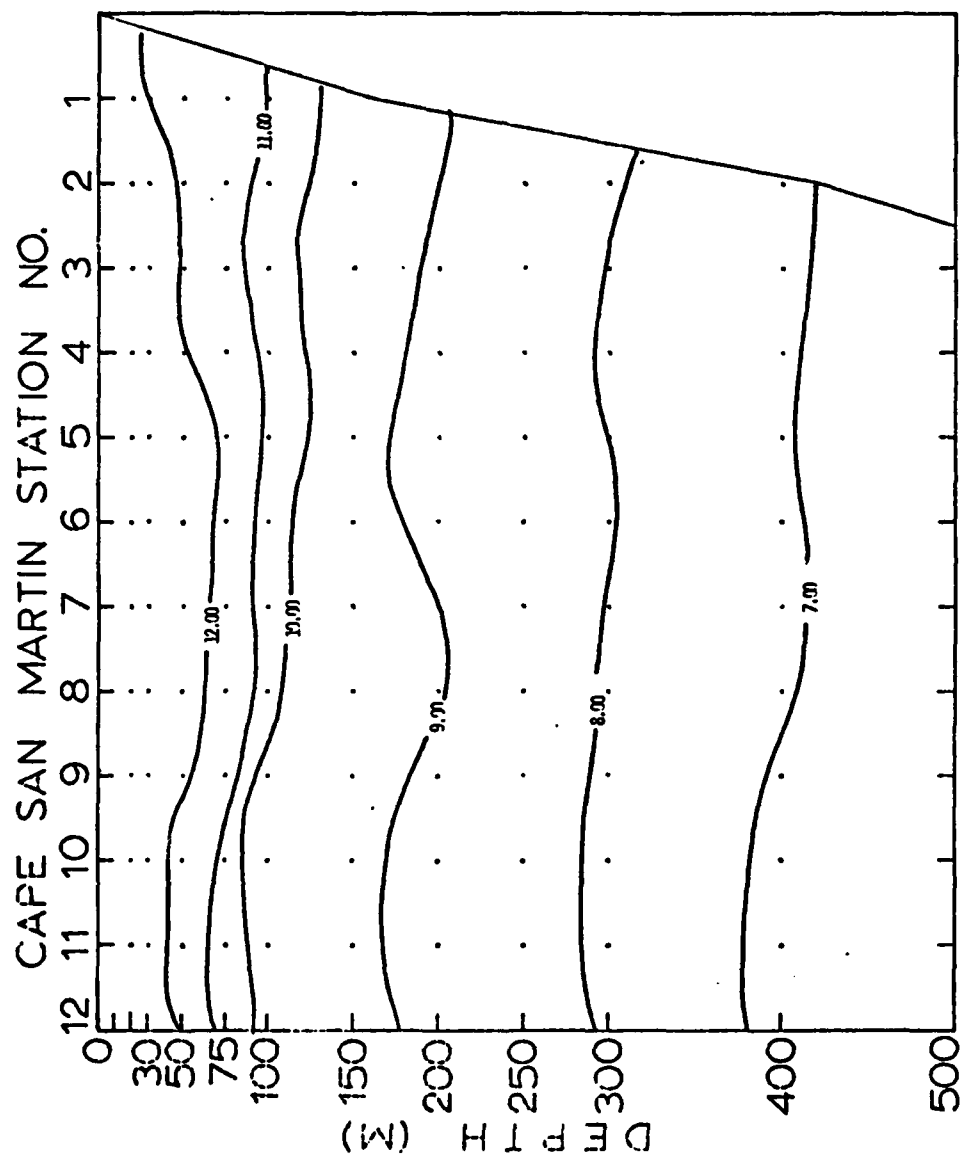


Figure 49. Temperature ($^{\circ}\text{C}$) on a vertical section for the Cape San Martin line on 21-22 February 1979.

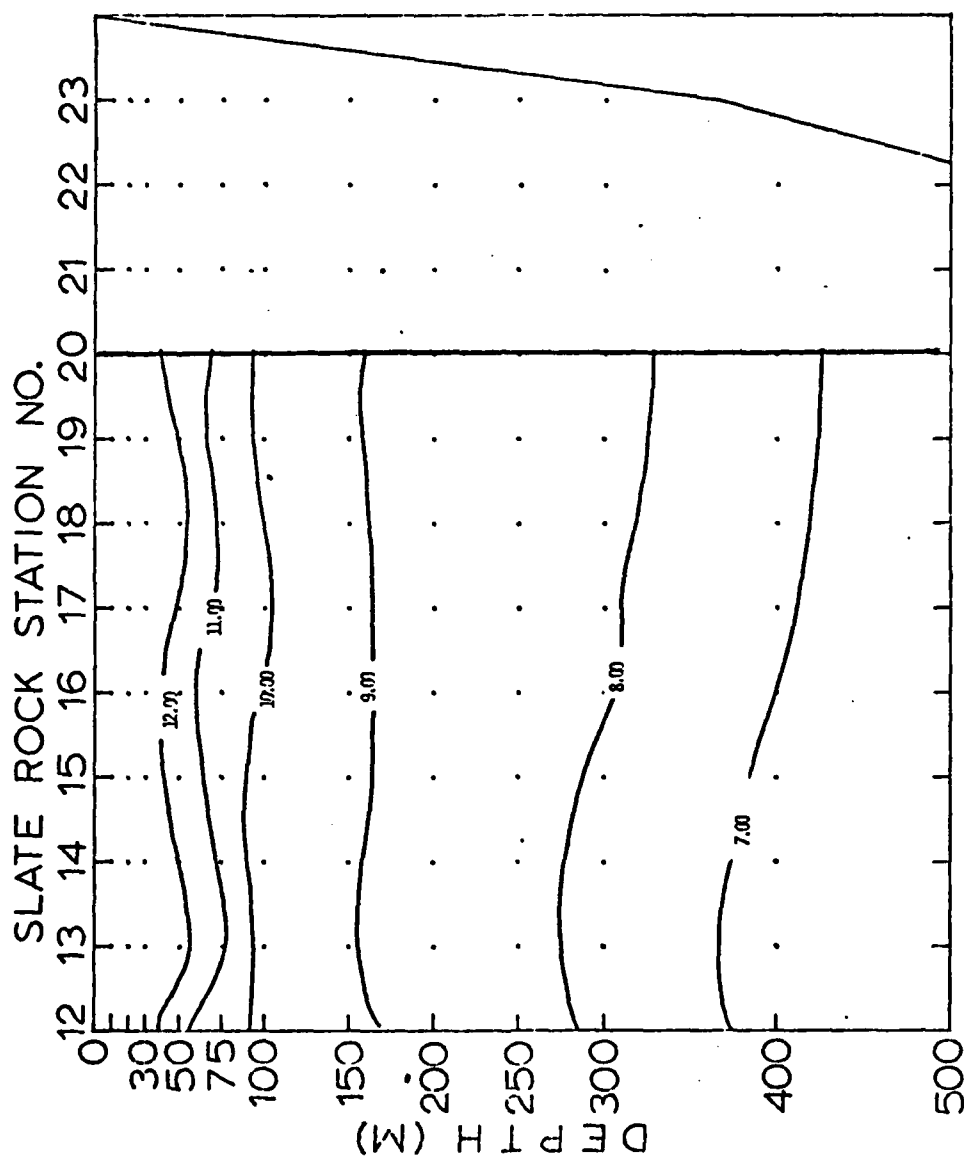


Figure 50. Temperature (°C) on a vertical section for the Slate Rock line on 21-22 February 1979.

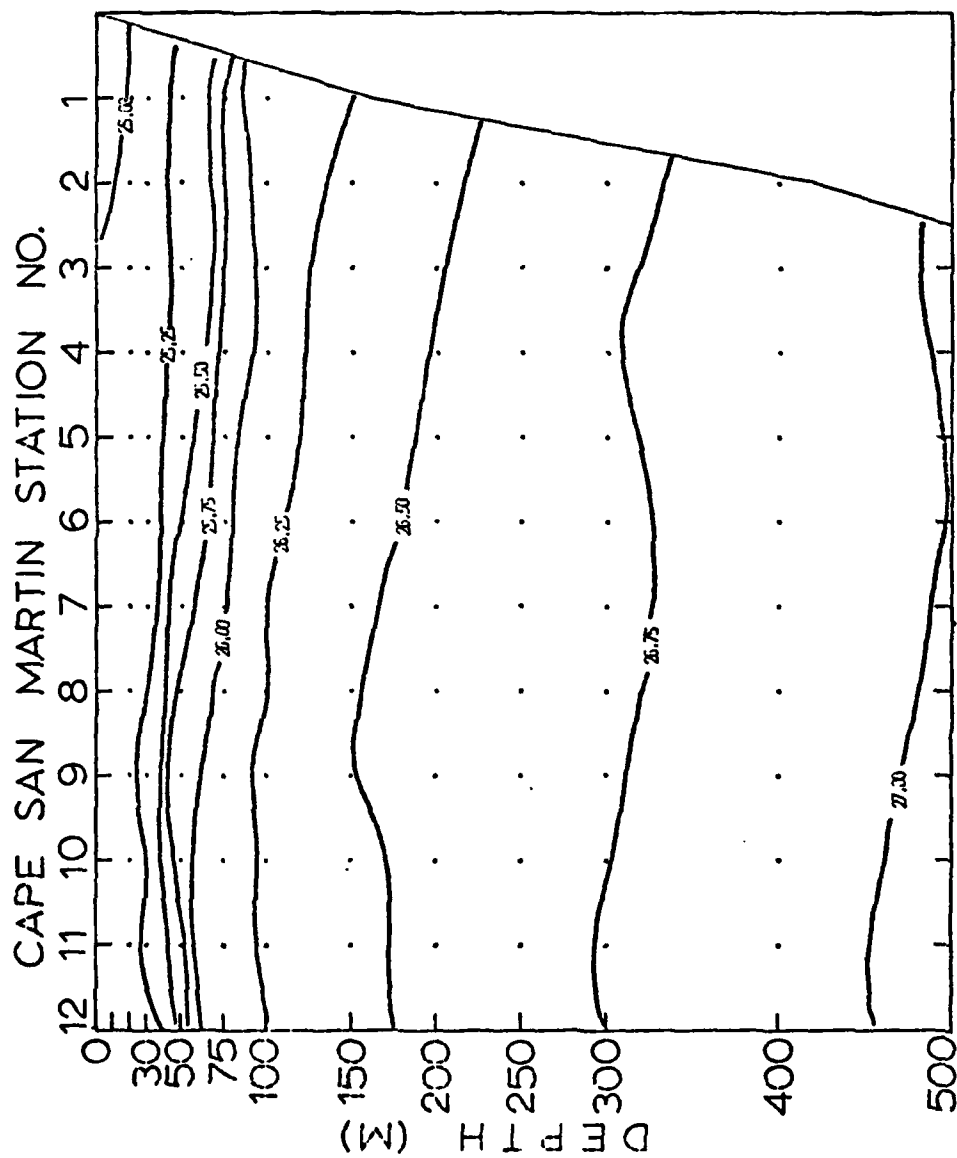


Figure 51. Sigma-t on a vertical section for the Cape San Martin line on 27-28 November 1978.

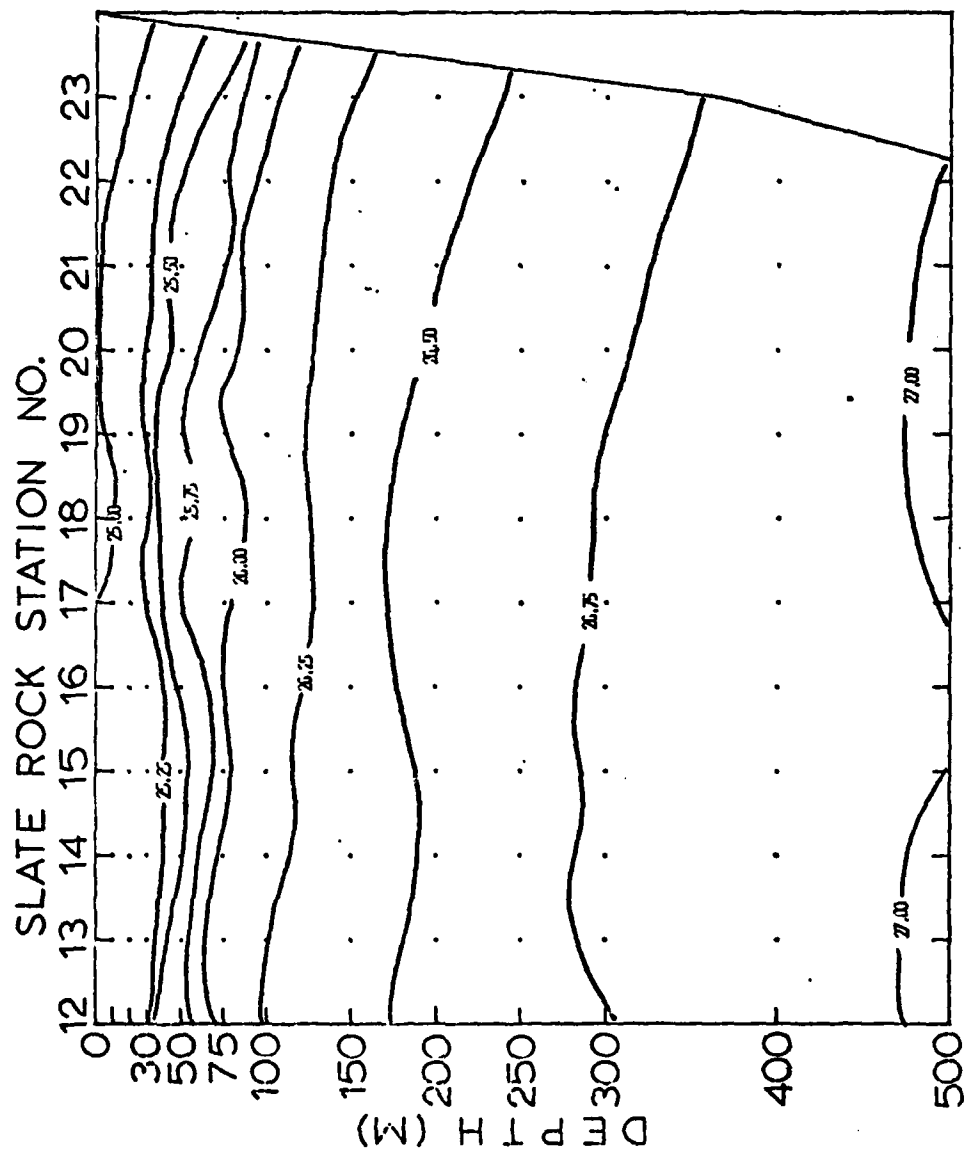


Figure 52, Sigma-t on a vertical section for the Slate Rock line on 27-28 November 1979.

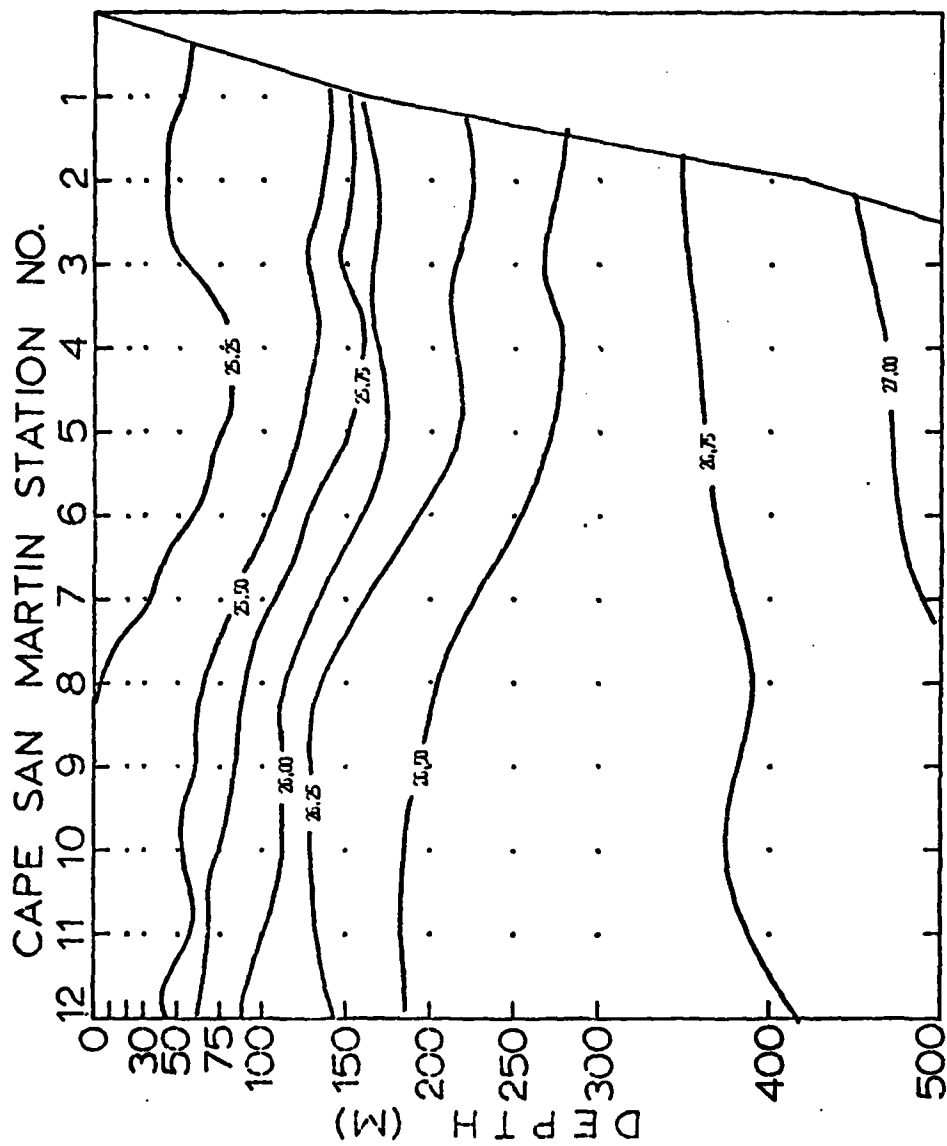


Figure 53. Sigma-t on a vertical section for the Cape San Martin line on 8-9 January 1979.

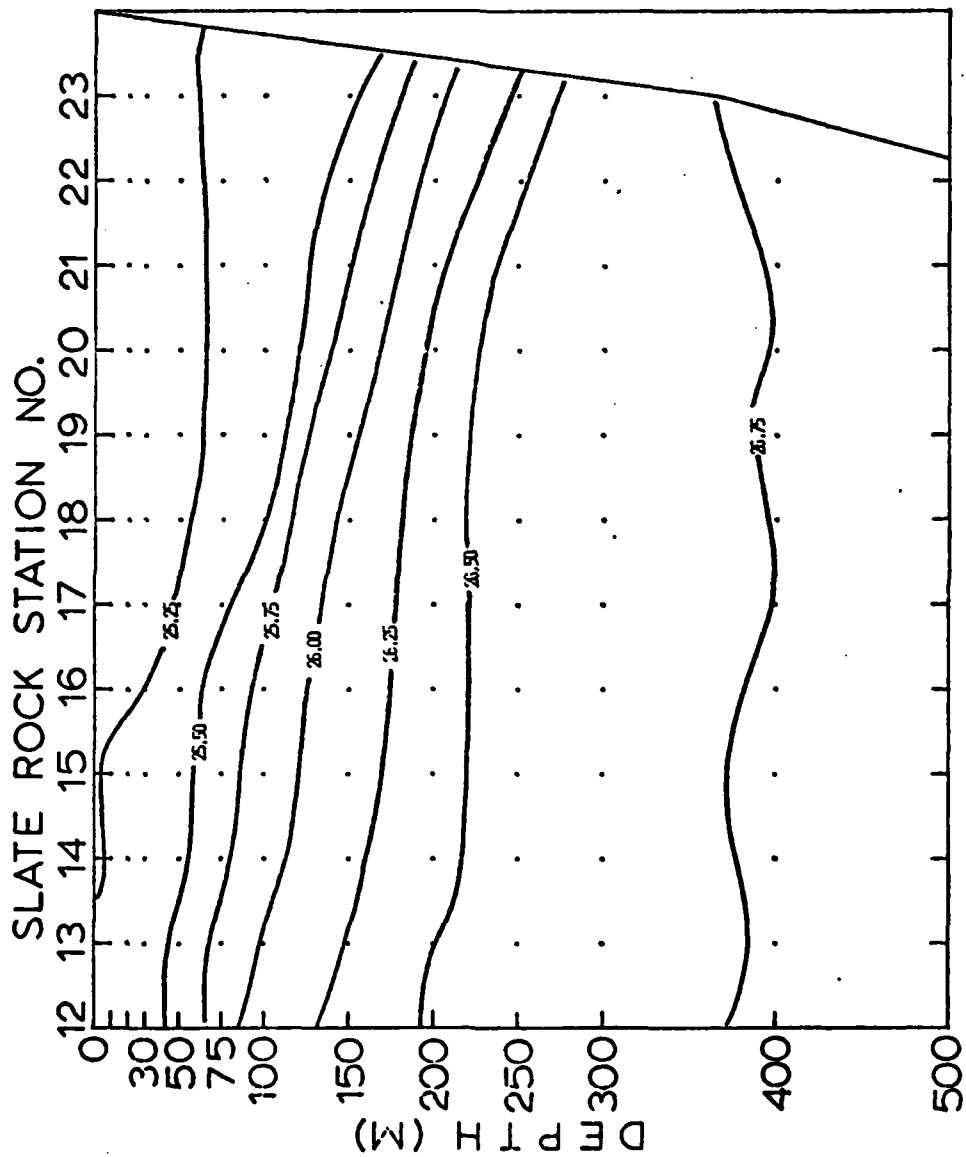


Figure 54. Sigma-t on a vertical section for the slate Rock line on 8-9 January 1979.

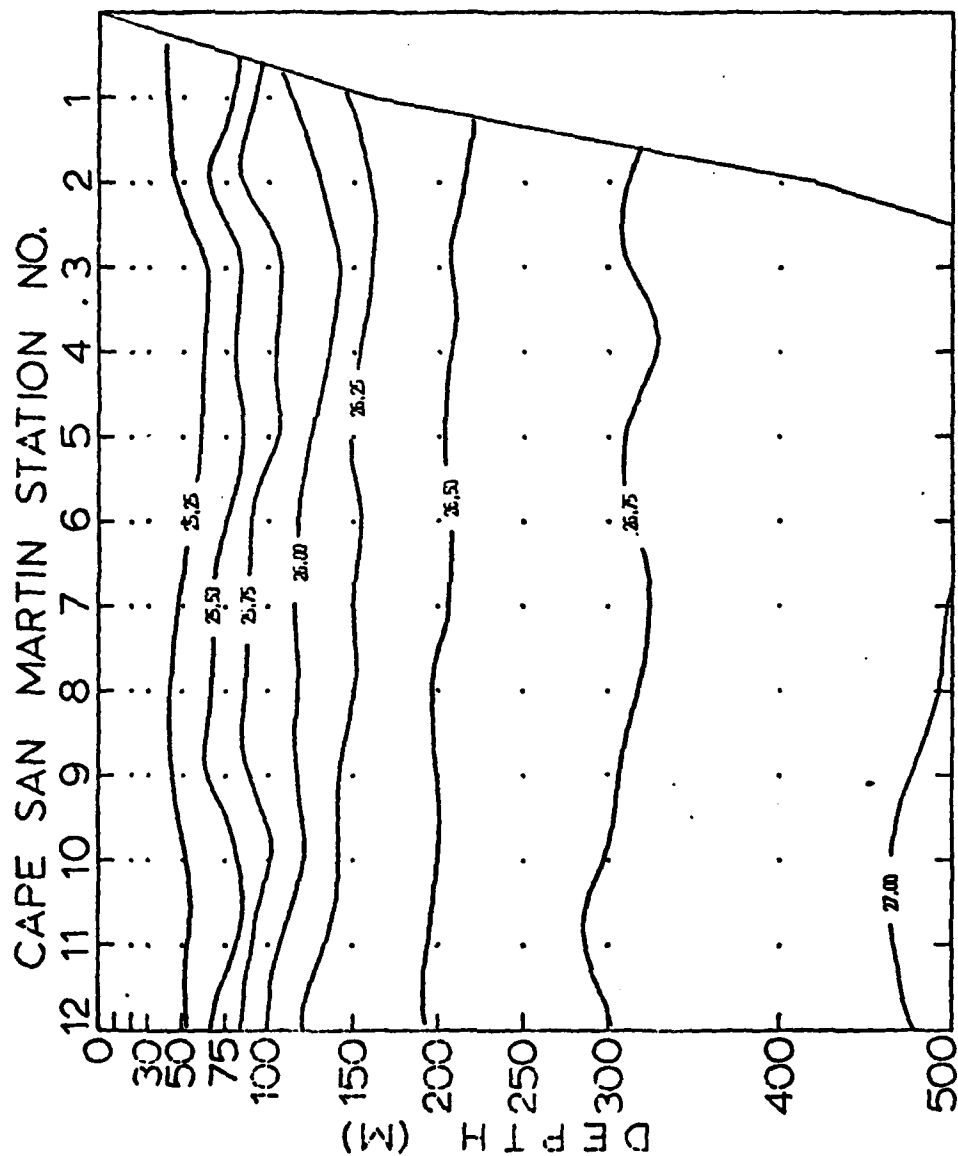


Figure 55. Sigma-t on a vertical section for the Cape San Martin line on 22-23 January 1979.

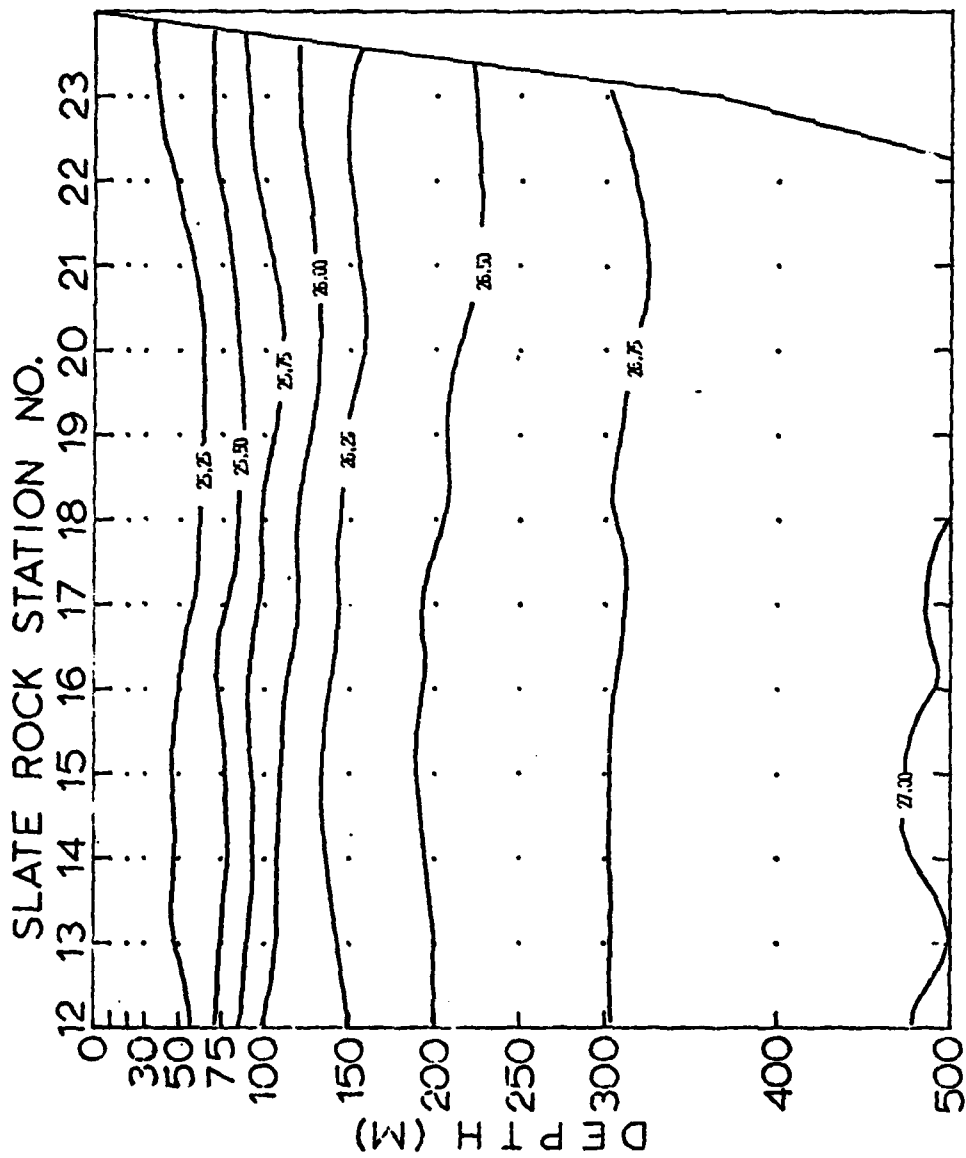


Figure 56. Sigma-t on a vertical section for the Slate Rock line on 22-23 January 1979.

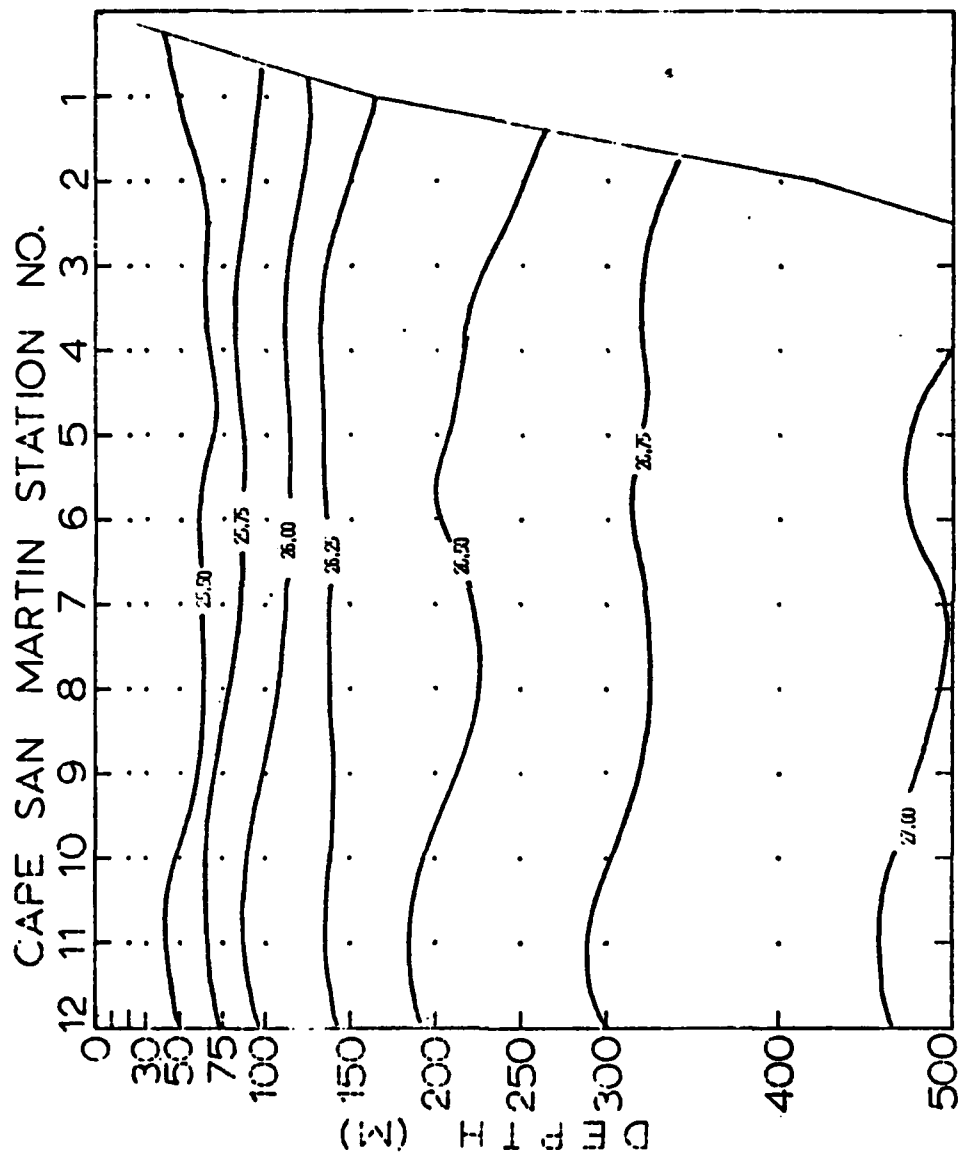


Figure 57. Sigma-t on a vertical section for the Cape San Martin line on 21-22 February 1979.

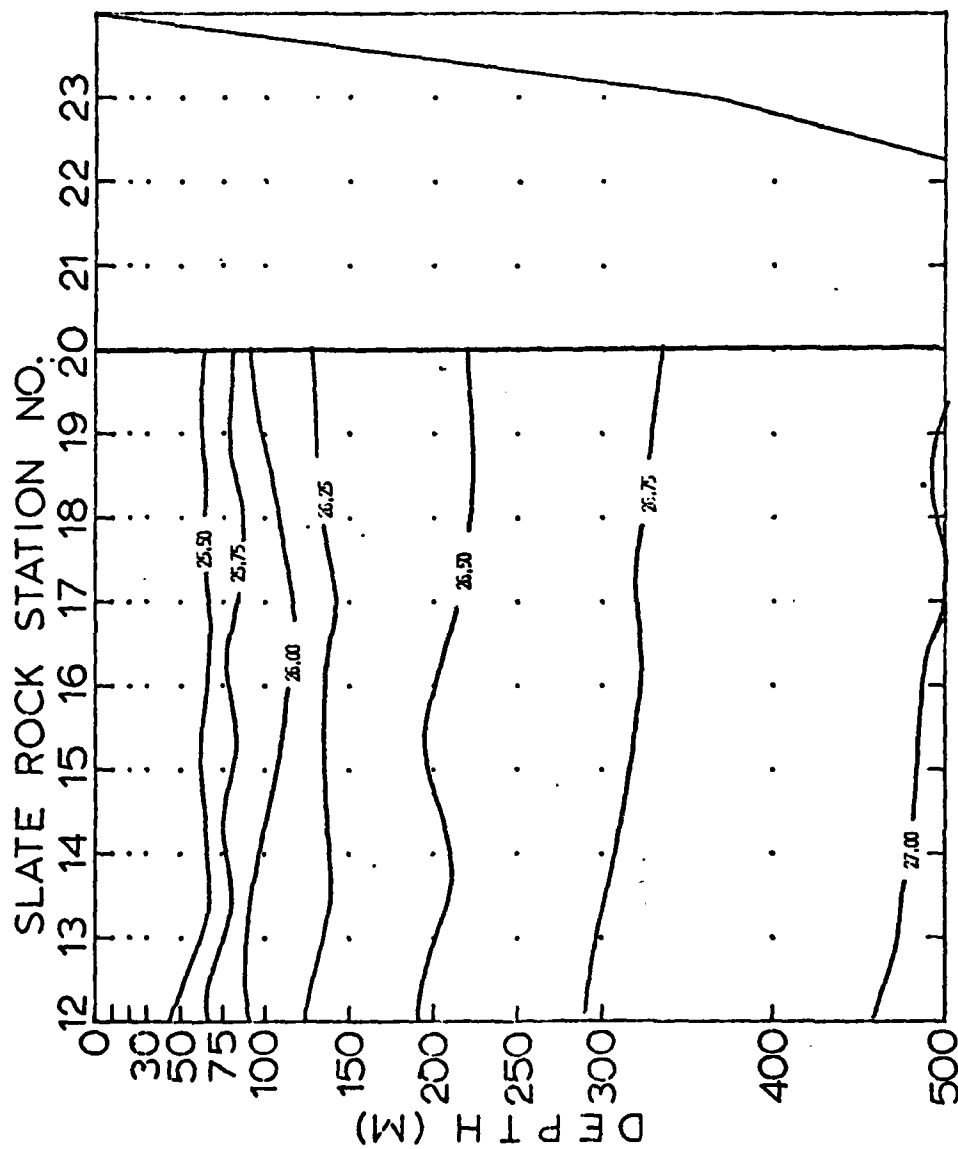
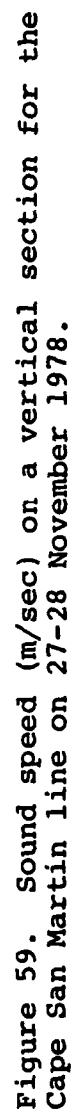


Figure 58. Sigma-t on a vertical section for the Slate Rock line on 21-22 February 1979.



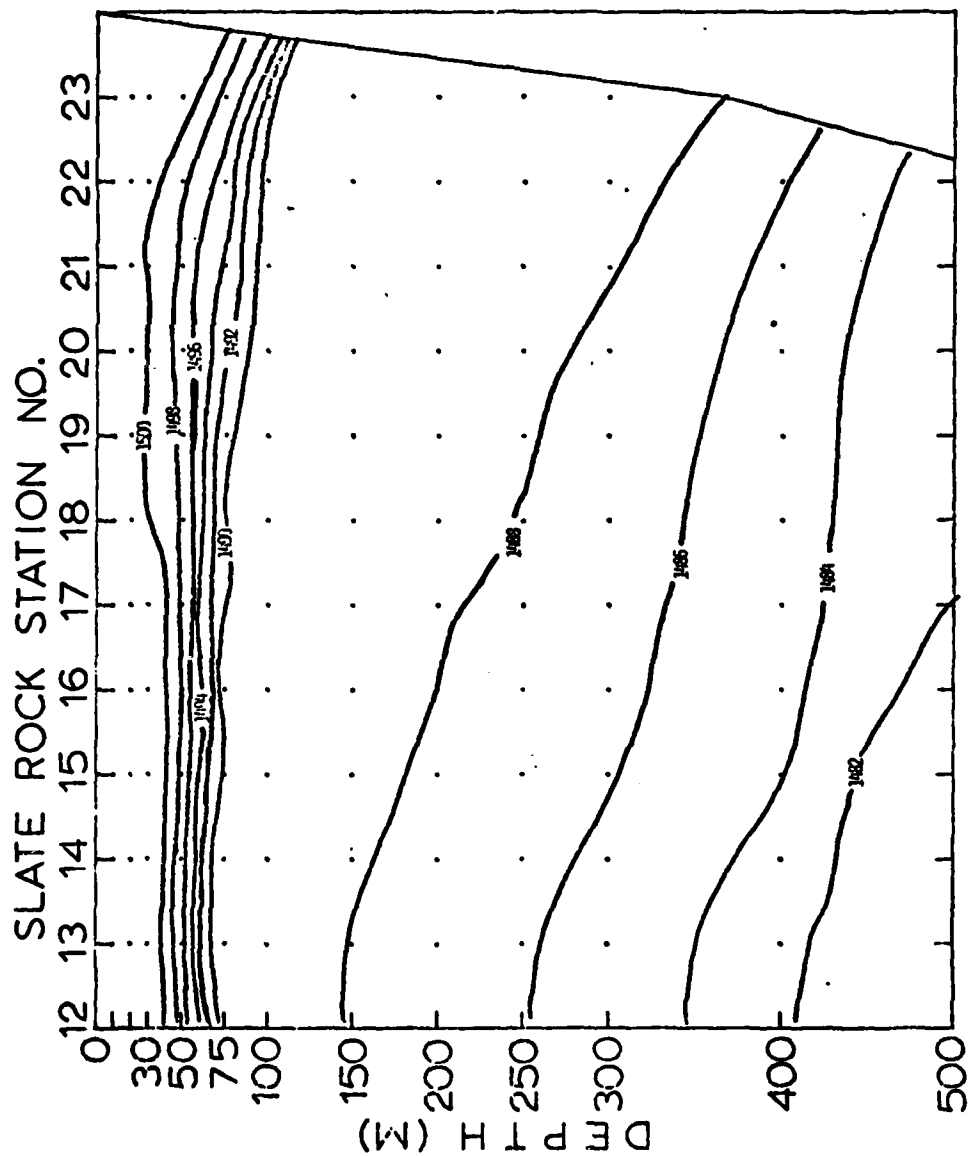


Figure 60. Sound speed (m/sec) on a vertical section for the Slate Rock line on 27-28 November 1978.

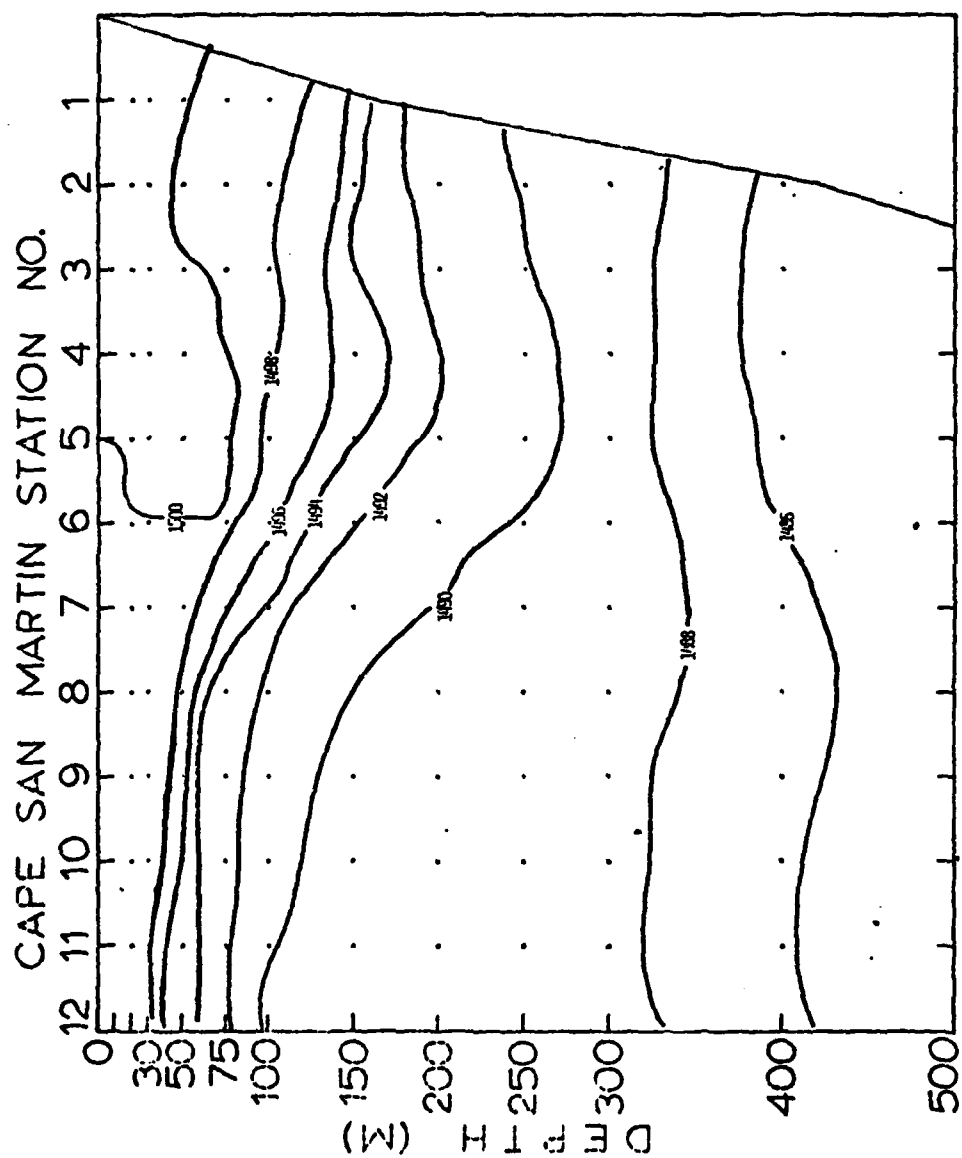


Figure 61. Sound speed (m/sec) on a vertical section for the Cape San Martin line on 8-9 January 1979.

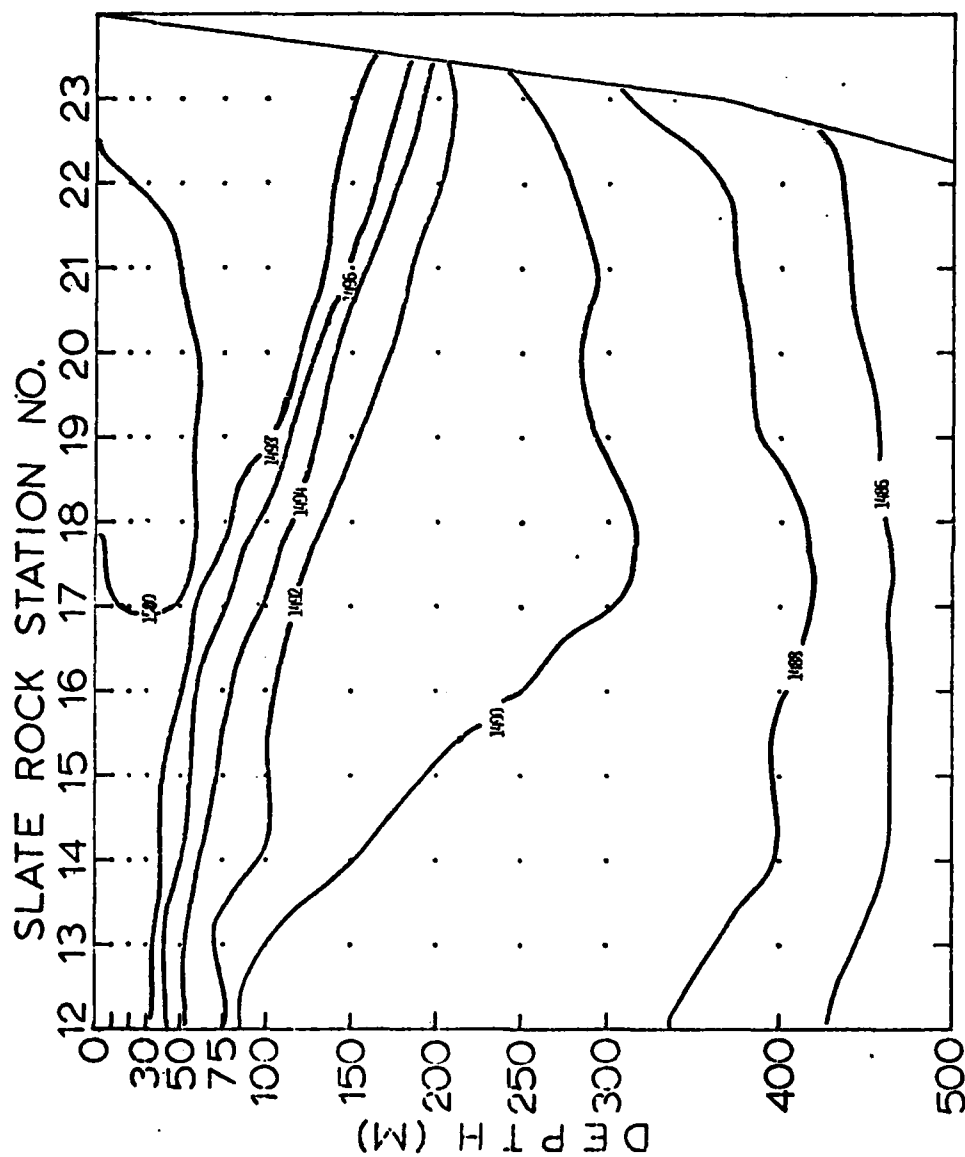


Figure 62. Sound speed (m/sec) on a vertical section for the Slate Rock line on 8-9 January 1979.

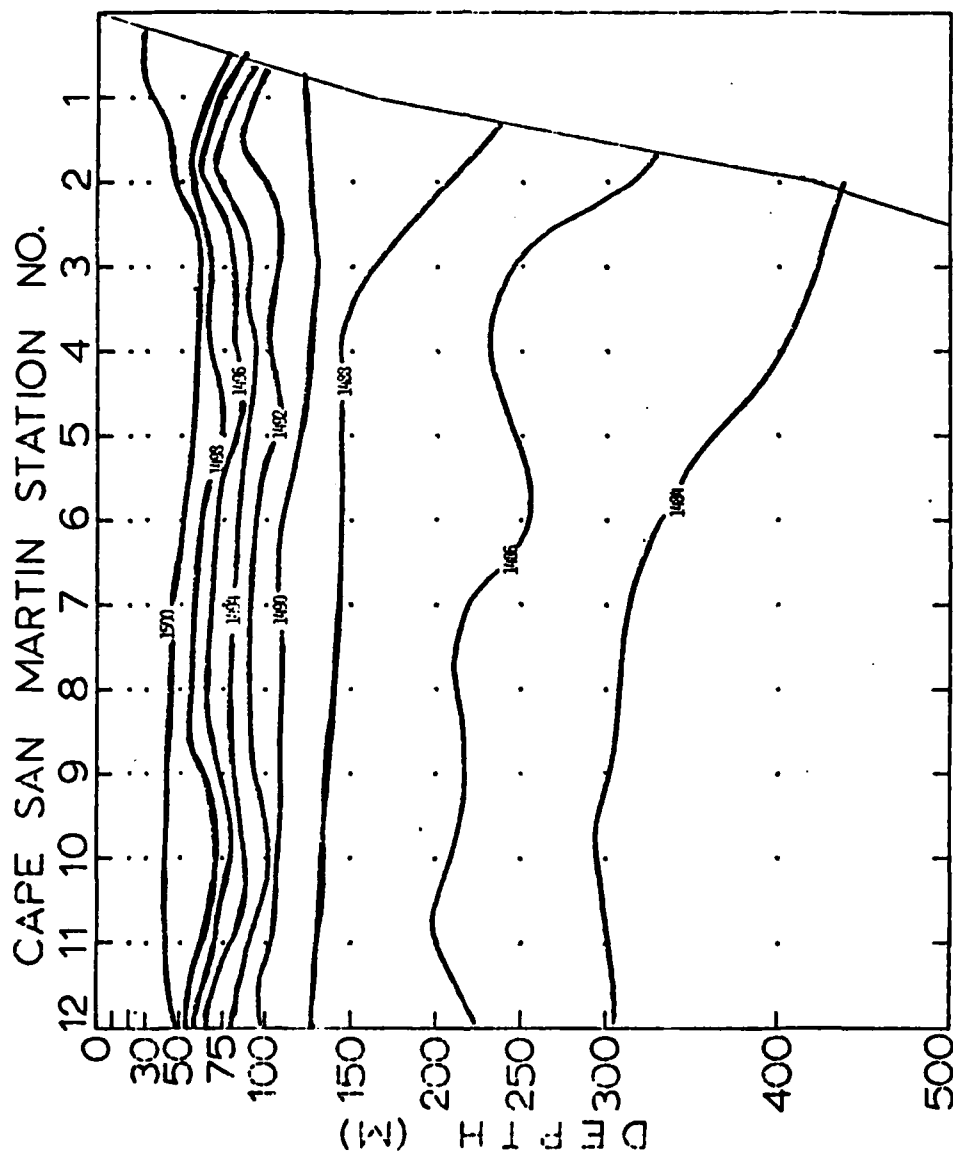
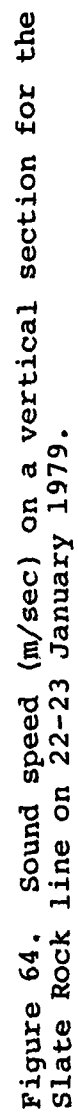


Figure 63. Sound speed (m/sec) on a vertical section for the Cape San Martin line on 22-23 January 1979.



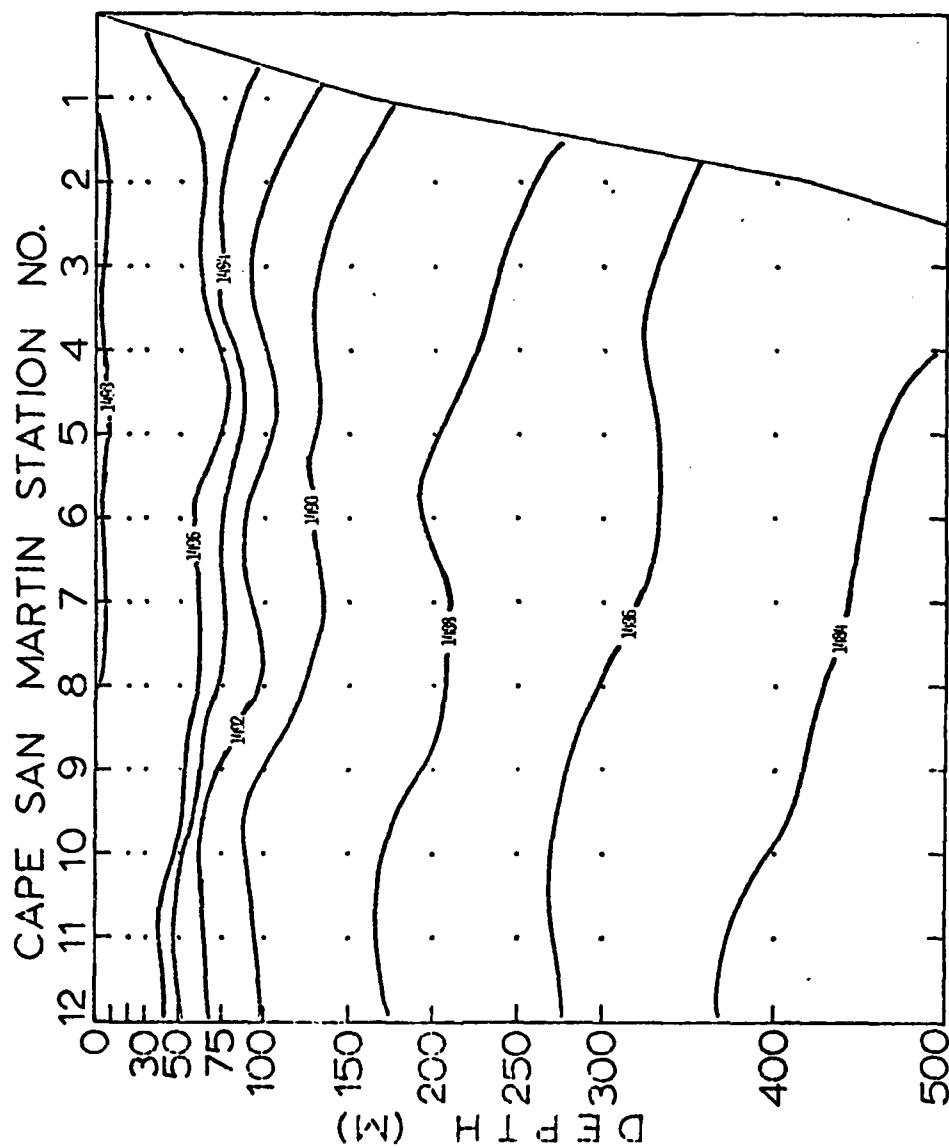


Figure 65. Sound speed (m/sec) on a vertical section for the Cape San Martin line on 21-22 February 1979.

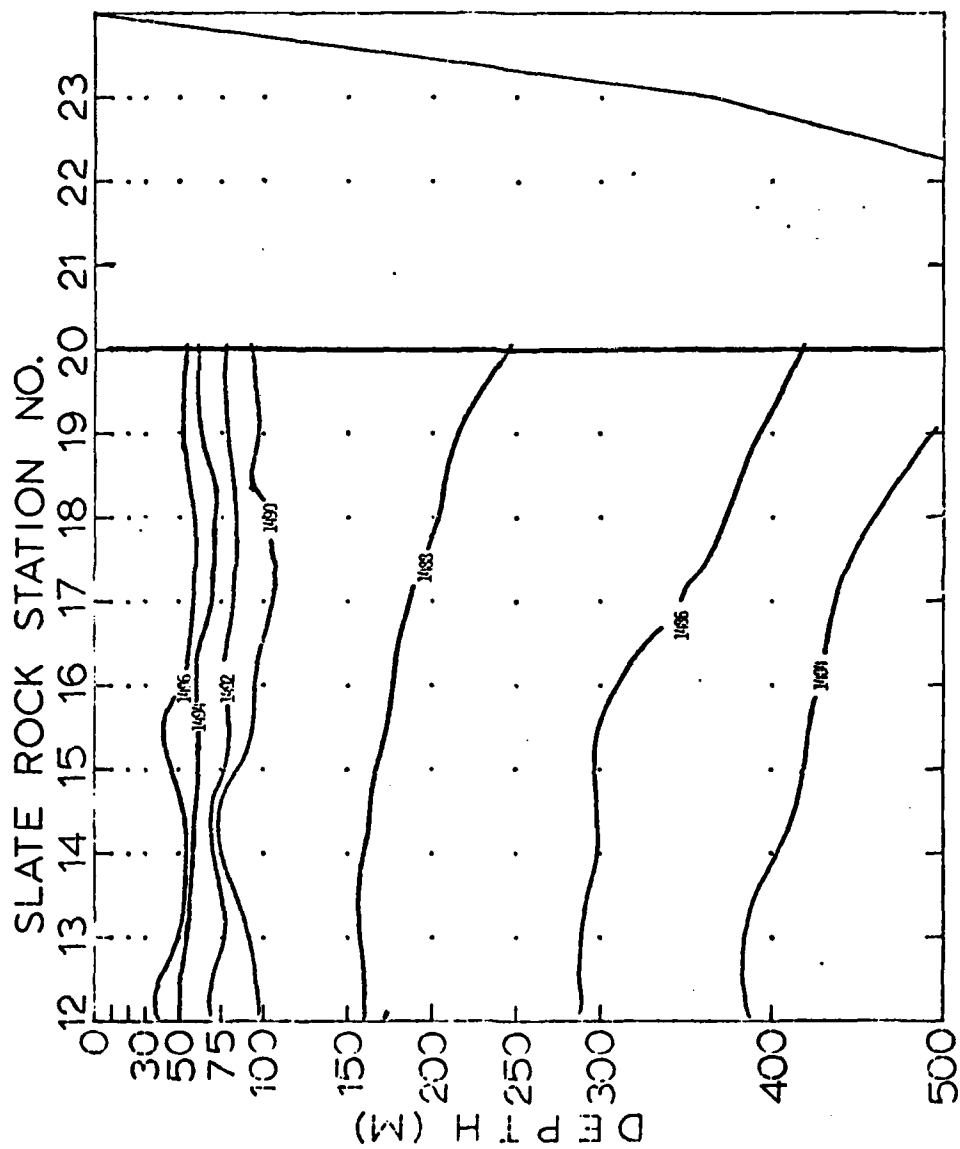


Figure 66. Sound speed (m/sec) on a vertical section for the Slate Rock line on 21-22 February 1979.

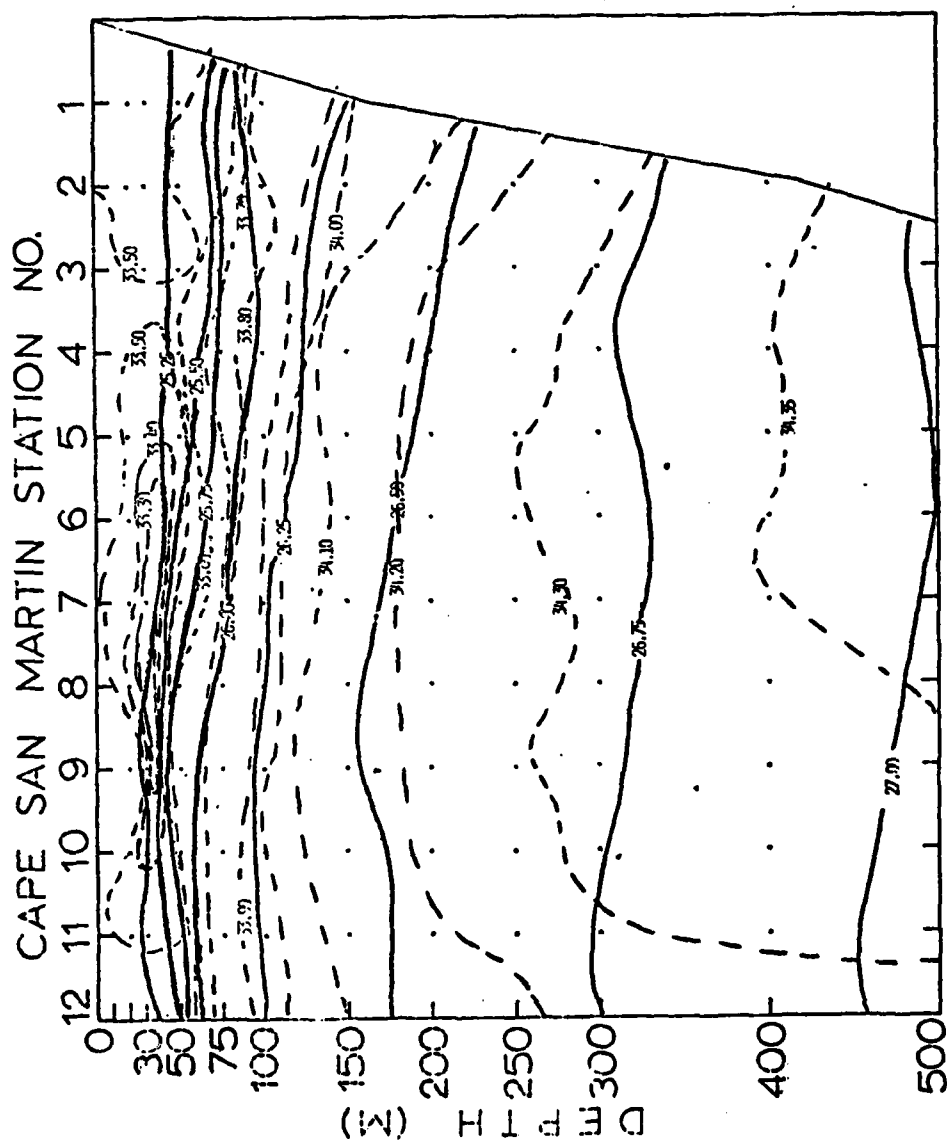


Figure 67. Sigma-t, solid line, and Salinity (‰), dashed line, superimposed on a vertical section for the Cape San Martin line on 27-28 November 1978.

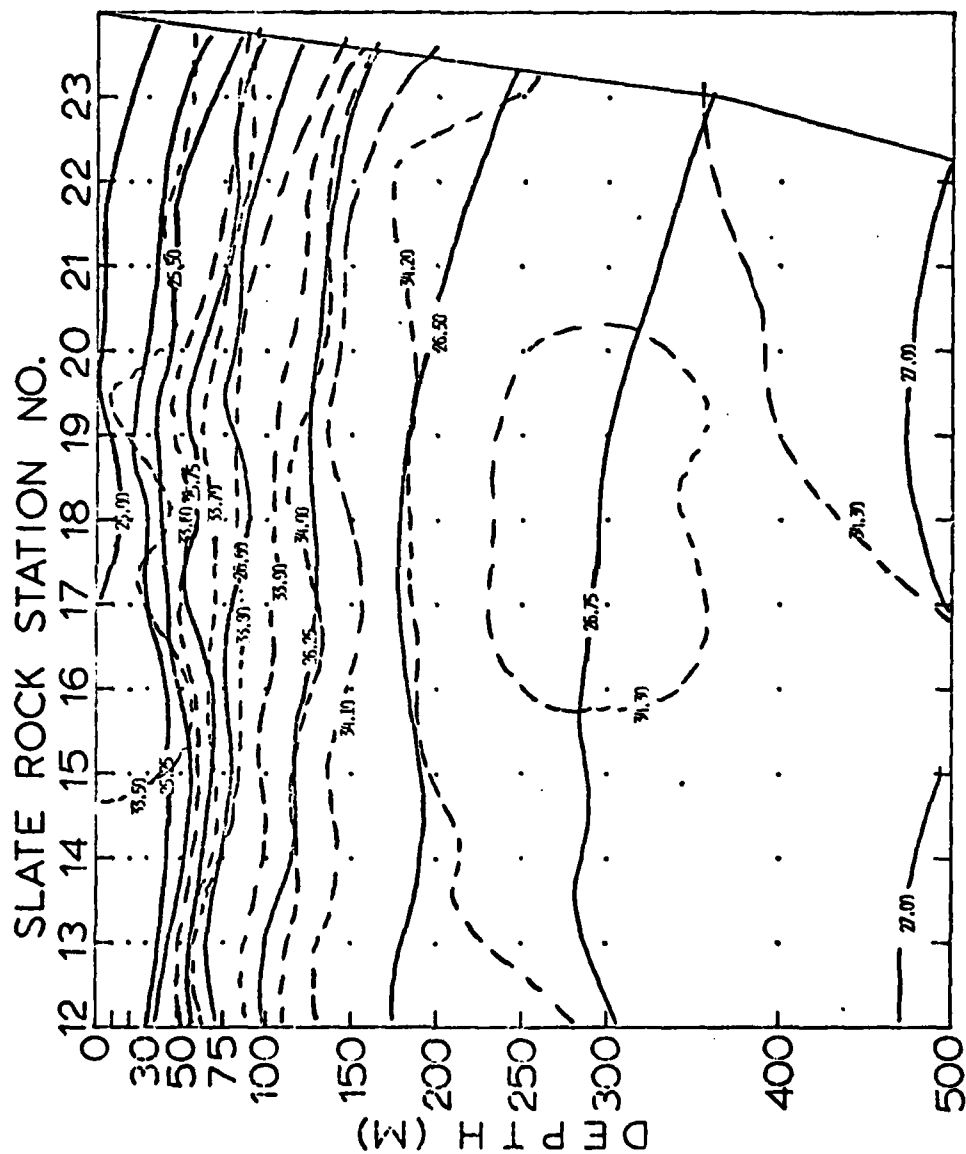
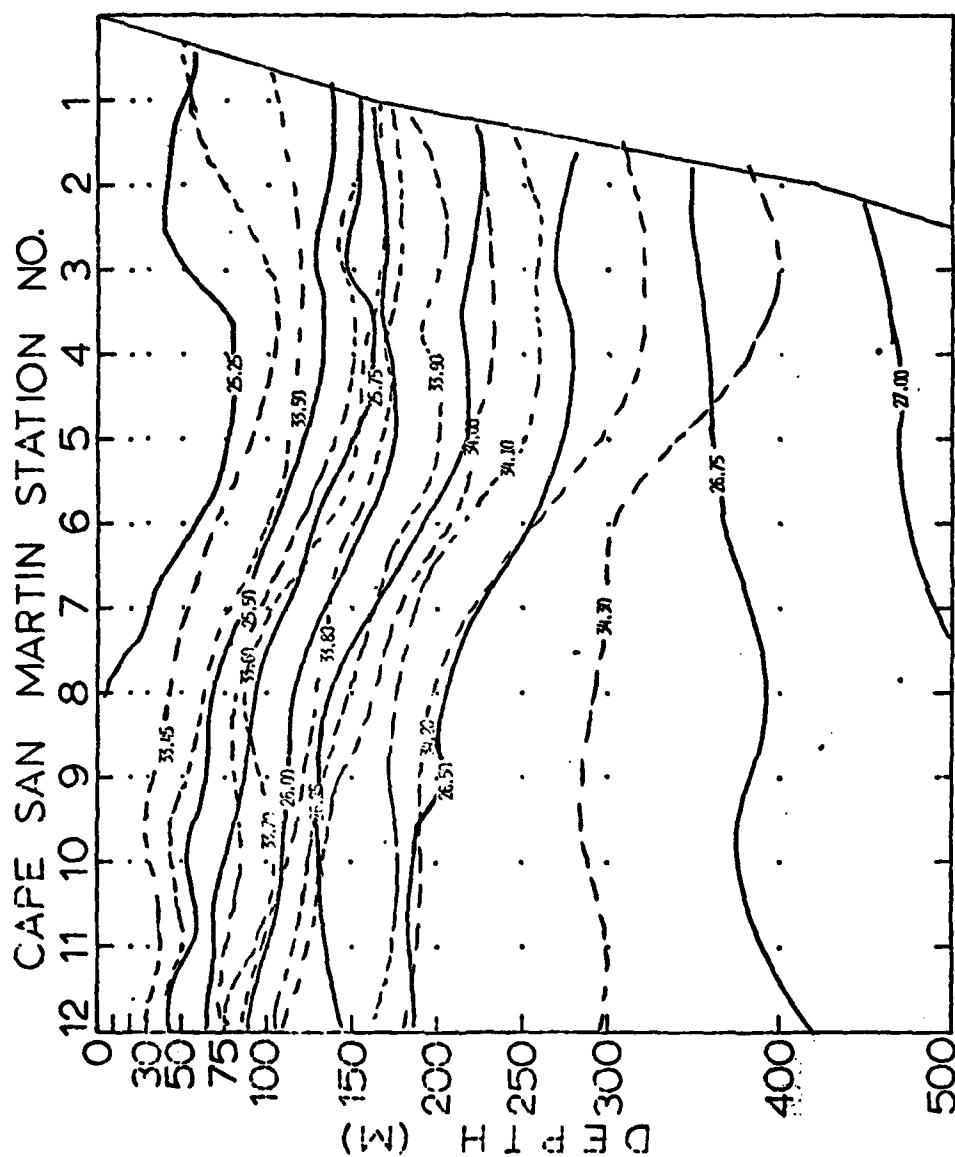


Figure 68. Sigma-t, solid line, and Salinity (‰), dashed line, superimposed on a vertical section for the Slate Rock line on 27-28 November 1978.



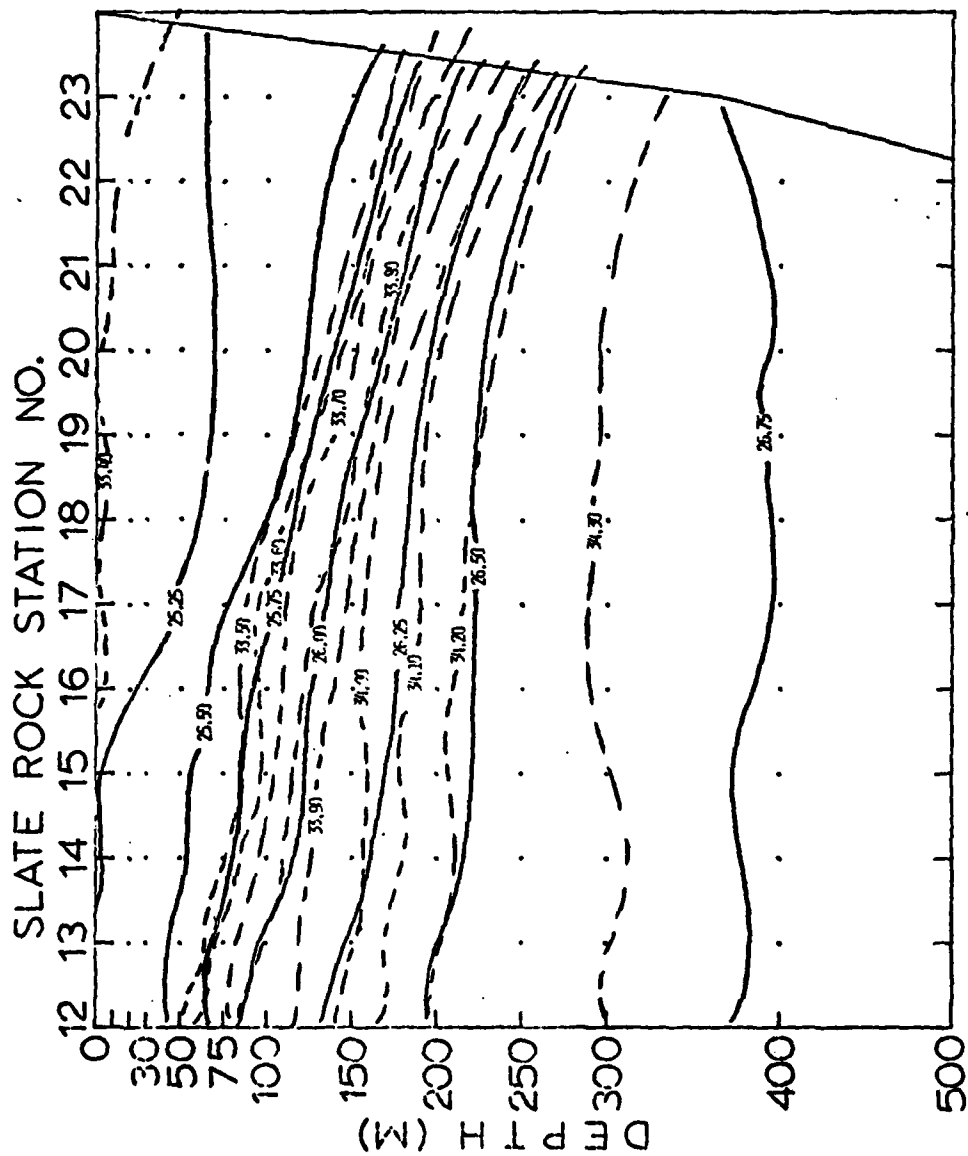


Figure 70. Sigma-t, solid line, and Salinity (‰), dashed line, superimposed on a vertical section for the Slate Rock line on 8-9 January 1979.

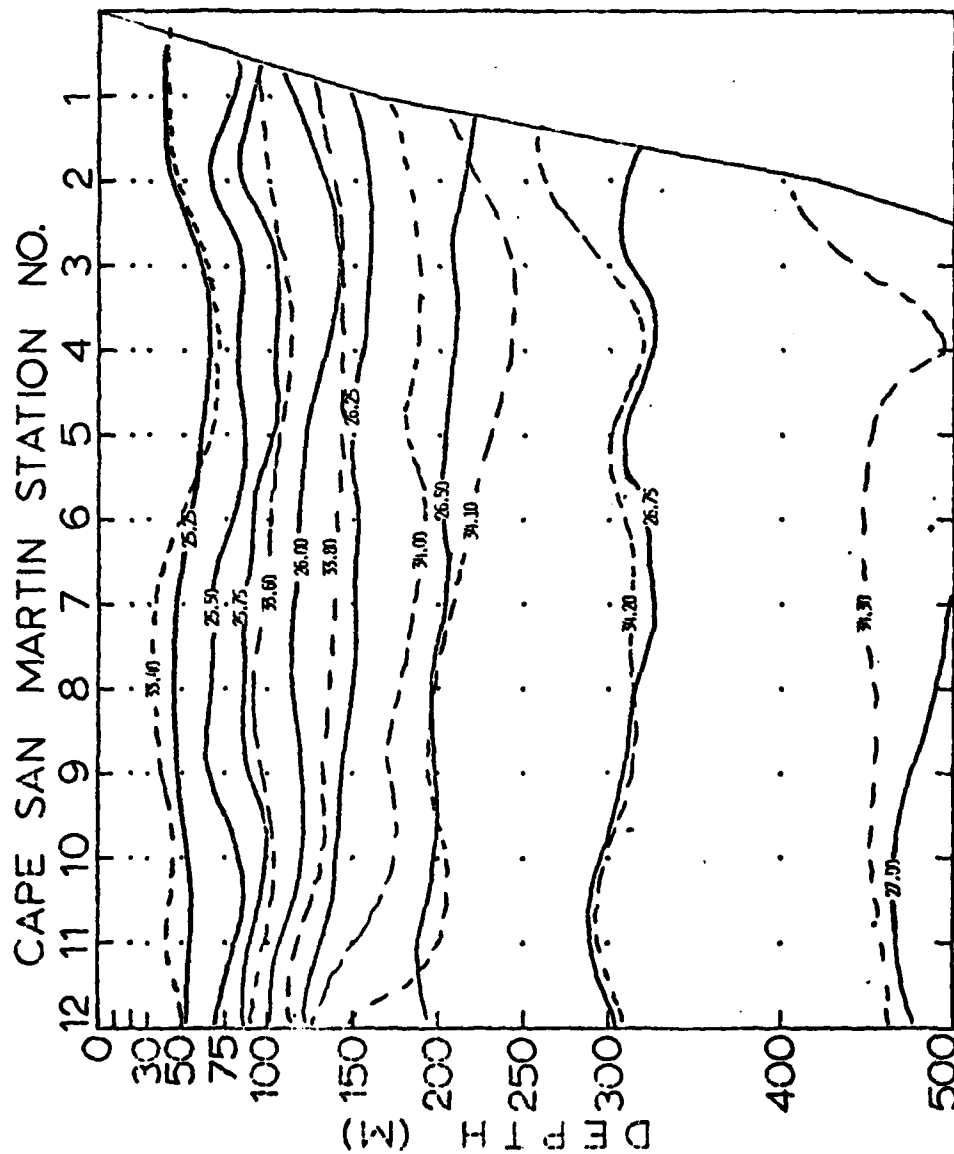


Figure 71. Sigma-t, solid line, and Salinity (‰), dashed line, superimposed on a vertical section for the Cape San Martin line on 22-23 January 1979.

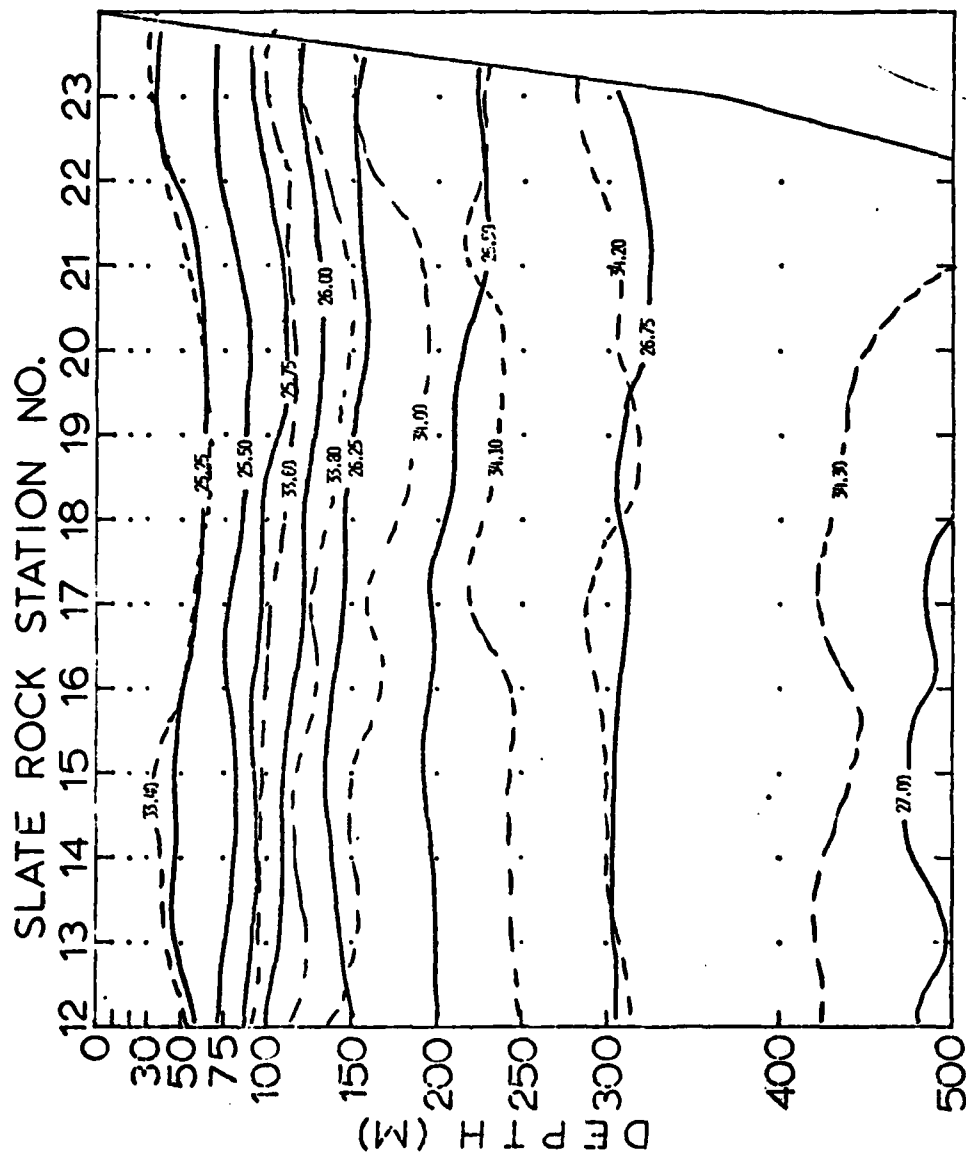


Figure 72. Sigma-t, solid line, and Salinity (%), dashed line, superimposed on a vertical section for the Slate Rock line on 22-23 January 1979.

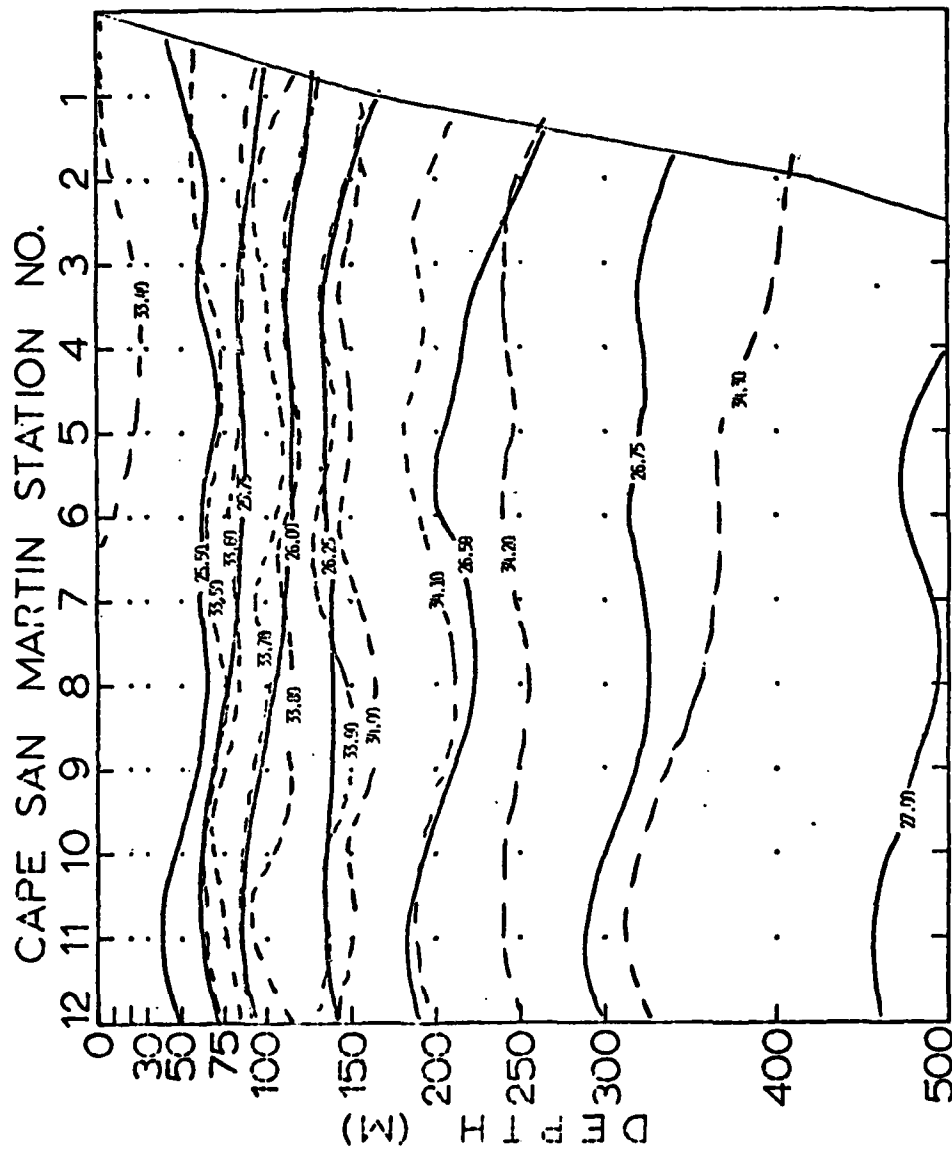


Figure 73. Sigma-t, solid line, and Salinity (‰), dashed line, superimposed on a vertical section for the Cape San Martin line on 21-22 February 1979.

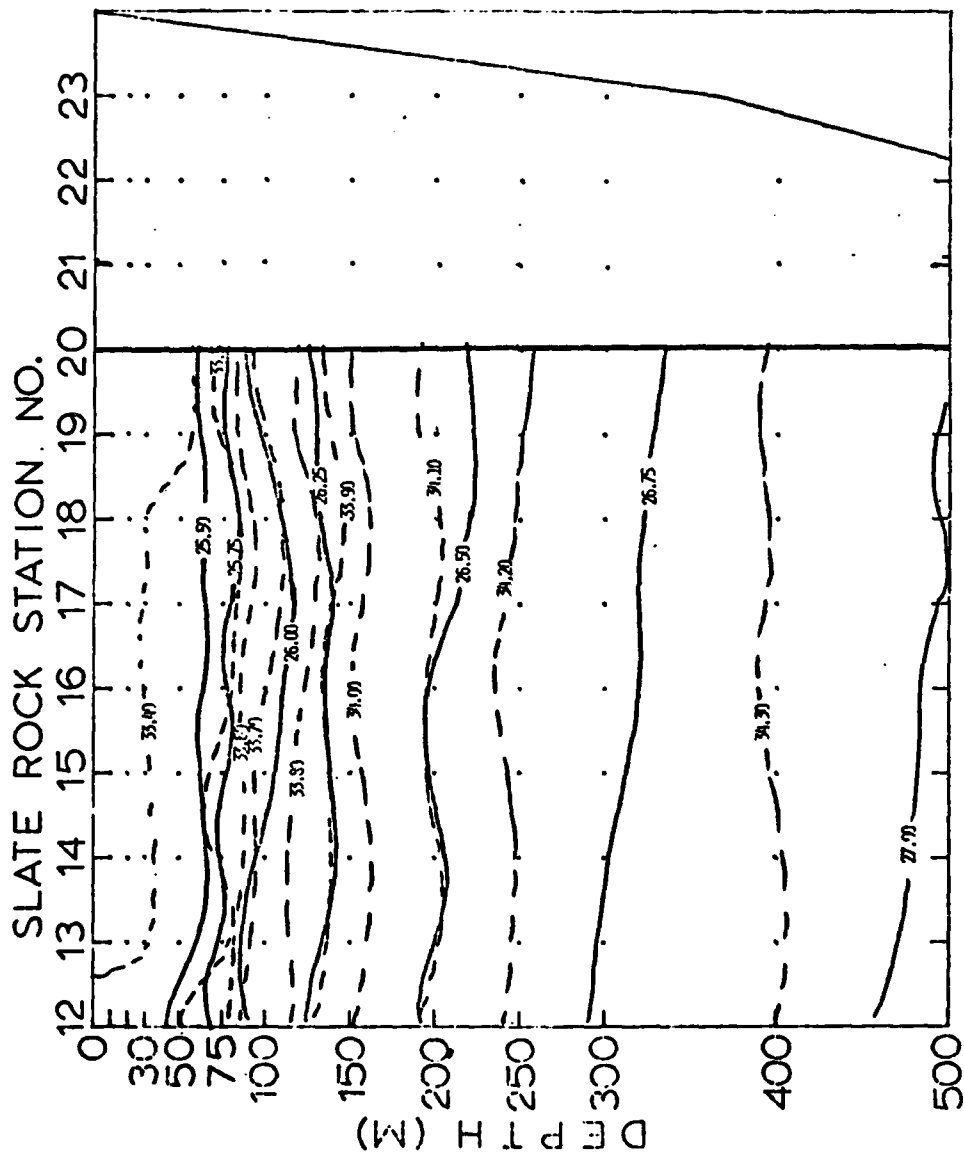


Figure 74. Sigma-t, solid line, and Salinity (‰), dashed line, superimposed on a vertical section for the Slate Rock line on 21-22 February 1979.

BIBLIOGRAPHY

1. Bernstein, R.L., Breaker L., and Whritner, R., "California Current Eddy Formation: Ship, Air, and Satellite Results," Science, v. 195, p. 353-359, 28 January 1977.
2. Greer, R.E., Mesoscale Components of the Geostrophic Flow and its Temporal and Spatial Variability in the California Current off Monterey Bay in 1973-74, Masters Thesis, Naval Postgraduate School, Monterey, California, 1975.
3. Ka pern, D., Smith, R.L., and Reed, R.K., "On the California Undercurrent Over the Continental Slope Off Oregon," Journal of Geophysical Research, v. 83, p. 1366-1372, 20 March 1978.
4. Hickey, B.M., "The California Current System - Hypothesis and Facts," Contribution Number 1038 of the Department of Oceanography, University of Washington, 24 April 1978.
5. Hughes, J.G., The Spatial and Temporal Variation of Sound Speed in the California Current System Off Monterey, California, Masters Thesis, Naval Postgraduate School, Monterey, California, 1975.
6. Huyer, A., "Seasonal Variation in Temperature, Salinity, and Density Over the Continental Shelf Off Oregon," Limnology and Oceanography, v. 22(3), p. 442-445, May 1977.
7. Huyer, A., Hickey, B.M., Smith, J.D., Smith, R.L., and Pillsbury, R.D., "Alongshore Coherence at Low Frequencies in Currents Observed Over the Continental Shelf Off Oregon and Washington," Journal of Geophysical Research, v. 80(24), p. 3495-3505, 20 August 1975.
8. Huyer, A. and Smith, R.L., "Physical Characteristics of Pacific Northwest Coastal Waters," The Marine Plant Biomass of the Pacific Northwest Coast, p. 37-47, 1978.
9. McCreary, J.P., Eastern Ocean Response to Changing Wind Systems, Ph.D Dissertation, University of California, San Diego, 1977.
10. Molnar, D.L., California Undercurrent Reconnaissance Between Monterey and Santa Barbara, Masters Thesis, Naval Postgraduate School, Monterey, California, 1972.

11. Mooers, C.N.K., Collins, C.A., and Smith, R.L., "The Dynamic Structure of the Frontal Zone in the Coastal Upwelling Region Off Oregon," Journal of Physical Oceanography, v. 6, p. 3-21, January 1976.
12. Mysak, L.A., "On the Stability of the California Undercurrent Off Vancouver Island," Journal of Physical Oceanography, v. 7, p. 904-917, November 1977.
13. NOAA Technical Report NMFS SSRF-718, Surface Currents as Determined by Drift Card Releases Over the Continental Shelf Off Central and Southern California, by J.L. Squire, Jr., p. 11, December 1977.
14. Pavlova, Yu. V., "Seasonal Variations of the California Current," Oceanology, v. 13, p. 806-814, August 1967.
15. Reid, J.L., Jr., "Measurements of the California Counter-current at a Depth of 250 Meters," Journal of Marine Research, v. 20, p. 134-137, 15 July 1962.
16. Reid, J.L., Jr., "Measurements of the California Counter-current Off Baja California," Journal of Geophysical Research, v. 68, p. 4819-4822, 15 August 1963.
17. Reid, J.L., Jr., Roden, G.I., and Wyllie, J.G., "Studies of the California Current System," California Cooperative Oceanic Fisheries Investigation Progress Report, p. 27-56, 1958.
18. Reid, J.L., Jr., and Schwatzlose, R.A., "Direct Measurements of the Davidson Current Off Central California," Journal of Geophysical Research, v. 67, p. 559-565, June 1962.
19. Smith, R.L., Pattullo, J.G., and Lane, R.K., "An Investigation of the Early Stage of Upwelling Along the Oregon Coast," Journal of Geophysical Research, v. 71(4), p. 1135-1140, 15 February 1966.
20. Sverdrup, H.U. and Fleming, R.H., "The Waters Off the Coast of Southern California," Scripps Institute of Oceanography Bulletin, v. 4, p. 261-375, 9 October 1941.
21. Sverdrup, H.U., Johnson, M.W., and Fleming, R.H., The Oceans: Their Physics, Chemistry, and General Biology, 23rd ed., Prentice-Hall, Inc., 1942.
22. Wickham, J.B., "Observations of the California Undercurrent," Journal of Marine Research, v. 33, p. 325-340, September 1975.

23. Wilson, W.D., "Speed of Sound in Sea Water as a Function of Temperature, Pressure, and Salinity," Journal of Acoustical Society of America, v. 32, p. 1357, 1960.
24. Woods Hole Oceanographic Institution Technical Report WHOI-73-71, Details of Woods Hole Moorings, by R.H. Heinmiller, and R.G. Walden, October 1973.
25. Woods Hole Oceanographic Institution Report WHOI-76-59, A Computer Program for the Design of a Single-Point Subsurface Mooring Systems: NOYFB, by D.A. Moller, June 1976.
26. Wooster, W.S. and Jones, J.H., "California Undercurrent Off Northern Baja California," Journal of Marine Research, v. 28, p. 235-250, 15 May 1970.
27. Wyllie, J.G., "Geostrophic Flow of the California Current at the Surface and at 200 Meters," California Cooperative Oceanic Fisheries Investigation, Atlas No. 4, December, 1966.

INITIAL DISTRIBUTION LIST

	No. Copies
1. Chairman Code 68 Department of Oceanography Naval Postgraduate School Monterey, CA 93940	3
2. Director Naval Oceanography Division (OP952) Navy Department Washington, DC 20350	1
3. Office of Naval Research Code 480 Naval Ocean Research and Development Activity NSTL Station, MS 39529	1
4. Dr. Robert E. Stevenson Scientific Liaison Office, ONR Scripps Institution of Oceanography La Jolla, CA 92037	1
5. SIO Library University of California, San Diego P.O. Box 2367 La Jolla, CA 92037	1
6. Department of Oceanography Library University of Washington Seattle, WA 98105	1
7. Department of Oceanography Library Oregon State University Corvallis, OR 97331	1
8. Commanding Officer Fleet Numerical Weather Central Monterey, CA 93940	1
9. Commanding Officer Naval Environmental Prediction Research Facility Monterey, CA 93940	1
10. Commander Oceanographic Systems Pacific Box 1390 Pearl Harbor, Hawaii 96860	1

- | | | |
|-----|---|---|
| 11. | Defense Documentation Center
Cameron Station
Alexandria, VA 22314 | 2 |
| 12. | Library Code 0142
Naval Postgraduate School
Monterey, CA 93940 | 2 |
| 13. | Commanding Officer
Naval Ocean Research and Development Activity
NSTL Station, MS 39529 | 1 |
| 14. | Commander
Naval Oceanography Command
NSTL Station, MS 39529 | 1 |
| 15. | Commanding Officer
Naval Oceanographic Office
NSTL Station, MS 39529 | 1 |
| 16. | Dr. S.P. Tucker Code 68Tx
Department of Oceanography
Naval Postgraduate School
Monterey, CA 93940 | 4 |
| 17. | Professor J.B. Wickham Code 68Wk
Department of Oceanography
Naval Postgraduate School
Monterey, CA 93940 | 4 |
| 18. | Commandant (G-PTE-1/72)
U.S. Coast Guard
400 7th Street S.W.
Washington, DC 20590 | 2 |
| 19. | Lt. K. Coddington
Department of Ocean Sciences
U.S. Coast Guard Academy
New London, CT 06320 | 5 |