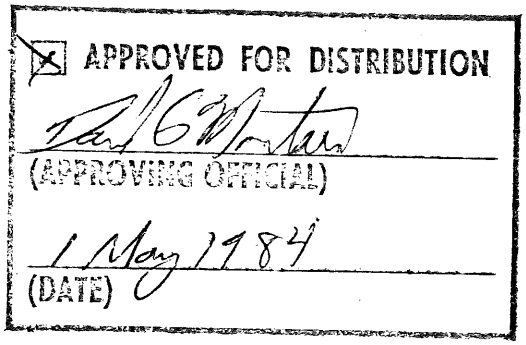
LABORATORY REFERENCE DOCUMENT NUMBER 83-21

PROCEDURES FOR PROCESSING SOOP XBT TRANSECTS FOR THE GULF OF MAINE

by

Catherine S. Jewell



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MARMAP Contribution MED/NEFC 83-27

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I. Introduction

This report describes the procedures used in processing data obtained by the Ship of Opportunity Program (SOOP). The program is operated jointly by the Northeast Fisheries Center (NEFC) and the Atlantic Environmental Group (AEG). It is designed to monitor the monthly changes in temperature and sea surface salinities in the Gulf of Maine. The ships most frequently involved in the study and their transect routes are as follows:

M.V.	CARIBOU REEFER II	Gloucester, Massachusetts to Cape Sable, Nova Scotia
M.V.	MARINE EVANGELINE	Portland, Maine to Yarmouth, Nova Scotia
M.V.	YANKEE CLIPPER	Boston, Massachusetts to Cape Sable, Nova Scotia
U.S.C.G.C.	ACTIVE	Along line 43° between 70°31' and 66°47'
U.S.C.G.C.	DECISIVE	Along line 42°25' between 70° and 67°34'
U.S.C.G.C.	DUANE	Along line 43°10' between 70° and 60°

Temperature versus depth profiles are obtained with Expendable Bathythermographs (XBT's) dropped on an hourly basis. Bucket temperatures and surface water samples are also taken at the time of drop. The water samples are analyzed for salinity determination with a conductive salinometer by AEG. Copies of MARMAP SOOP Logs (Figure 1) and XBT traces (Figure 2a) are sent to NEFC, where temperature cross sections for each cruise and seasonal sea surface temperatures and sea surface salinity distributions are plotted.

II. Data Quality

Since the contours depend upon the quality of the XBT traces, it is important to be able to distinguish between a usable trace and one that should be disregarded. Bad traces can be attributed to numerous malfunctions. To get aquainted with probe malfunctions and their causes, refer to "Examples of XBT Malfunctions" edited by S. Nickerson and to Technical Note 3700-75-77 "Guide to Common Shipboard Expendable Bathythermograph (SXBT) Recording Malfunctions," by S. Kroner and B. Blumenthal. Disagreement between the bucket temperature and XBT surface trace can be a good indication of a bad probe. Traces with temperatures exceptionally higher or lower then neighboring ones should be checked for signs of thermistor insulation damage (Figure 3). Some stations might be difficult to determine surface temperatures due to diurnal and seasonal thermoclines within the upper 25 or 50 meters (Figure 2b). For these stations

use the bucket temperature as a guide and set depths accordingly. It is extremely important that any and all doubtful features be checked for probe malfunctions.

Chart alignment is another problem that might arise. Most often the problem will be with the vertical or depth axis. Often the cause is simply due to the failure to position the stylus on the "SURFACE" line. When the cycle starts below the "SURFACE" line, adjust the depth scale upward accordingly (Figure 5). If the cycle started above the "SURFACE" line adjust the depth scale downward. Horizontal calibration errors seldom occur. This can just as easily be checked by looking at the location of the calibration mark (Figure 4). The check calibration mark should always be positioned at 16.7°C.

III. Bottom Depth

The next step is to find the bottom depths of the good traces. Where the bottom depth is within the operating limits of the probe, the bottom is often indicated by a spike on the trace (Figure 2c). These depths usually have been entered on the (SOOP) logsheet. At stations where no depth has been entered and no spike is evident, an estimate of bottom depth can be obtained by plotting the station position on a navigation chart. Conversion of fathoms to meters will then be required.

IV. Distance Between Stations

In order to plot XBT data, it is necessary to know the distance between the stations. To find this distance, use the Tektronix 4051 computer by inserting the tape cartridge with the "Distance Between Stations" program and proceeding with the following. Clear screen with the Home Page Key. Type FIND4, OLD, and RUN. Then follow the prompts. A copy of the results can be obtained through the Tektronix Hard Copy Unit. The distance, given in the first column in Nautical Miles, and in the second column in Kilometers.

If the Tektronix 4051 is not available, plot the station positions on a navigation chart for the area. The distance between stations may then be measured by a pair of dividers and the distance scale on the chart.

V. Reading A Trace

Proceed to fill out a worksheet listing for each XBT the surface temperature, bottom depth, and bottom temperature (Figure 6). Examine traces for the depth at which each isotherm is crossed. Record this depth on the worksheet across from the appropriate isotherm. It is important to note any unusual or redundant features, such as the trace recrossing (Figure 2d) or isostherm hugging (Figure 2e). When recrossing does occur, note at which depth the temperature was greater than or less than the isotherm. If the XBT did not reach bottom indicate the temperature at 200 meters or at the last readable depth.

VI. Plotting A Temperature Cross Section

SOOP runs are always plotted west to east. Plotting is done on K&E Standard Cross Section Paper, 10 x 10 to the half inch. The distance between stations are plotted on a horizontal scale of 20 km to the inch. A vertical scale of 40 m to the inch is used for depth.

Plot each station and its surface temperature. Draw in vertical lines for each station to use as a guide. Next plot bottom depth for the stations and join the depths by a smooth contour. At stations where the bottom depth exceeds the limits of the probes and no depth was indicated on the logsheet, join these to the neighboring stations with a broken line.

At stations where no bottom temperature was obtained, enter the deepest temperature obseved at its proper depth and draw two lines beneath it. At each station mark the depth of each isotherm crossing. With a smooth line connect the marks representing each temperature value to form the isotherm contours. To locate where isotherms intersect the surface and bottom, use a Gerber Rule to interpolate between neighboring surface and bottom temperature values. In cases where an isotherm encloses an area of water with a higher or lower temperature than the surrounding water, indicate the isotherm with a closed contour and put the appropriate greater than or less than sign inside of the contour. Record on the graph the ship name, cruise number, graph title, the latitude and longitude of the section end points, the date and a 10 kilometer horzontal scale.

VII. Inking a Cross Section (refer to Figure 7 and 8)

Pen and inking is done on a light table using K&E Crystalene tracing paper laid over the cross section plotted in section VI. K&E Leroy pens or Staedler Mars .700 pens are used for tracing. Pen head sizes 0-4 are the best for drawing. Black drawing ink is used to refill the cartridge. The Leroy lettering, set containing an Adjustable Scriber and lettering templates, or the Kroy Type 80 are used for lettering.

- Extend the cross section borders 1/4" beyond the first and last sections.

- The vertical scale should expand to 280 m or more if needed. Indicate the depths at 50 m intervals 3/16" horizontal lines should be drawn at these intervals on the left and far right of the plot.

- 3/16" lines should also be drawn down from each surface temperature and through the bottom depths using a #2 pen.

- Connect the bottom depths using a K&E Leroy Pen size 3. All other lines (i.e., isotherms, borders, and guides) are drawn using pen sizes 1 or 2.

- Ship, cruise number, date, heading (e.g., Boston to Cape Sable) and the depth intervals can either be drawn using an adjustable scriber and lettering plate (240 CL) with drawing pen size 2 or by using the Kroy Type 80 with Gothic Reel corresponding to 24 PT. ULNS.

- Surface temperature, bottom temperature, isotherm temperature, and the 10 km scale, should all be drawn with either an adjustable scriber with lettering plate (175 CL) and drawing pen size 2 or by using Kroy Type 80 with Gothic Reel corresponding to 18 PT. ULNS.

- Initial and final latitude and longitude can be drawn with either pen and lettering plate or by using the Gothic Reel corresponding to 14 PT. ULNS.

- When using Kroy Type 80, tape should be peeled off with forceps to prevent finger prints.

- Liquid paper can be used to cover up minor mistakes.

- When necessary variations on the location of the tittle and 10 km scale should be made to accommodate the contour.

- When finished file cruise material in a folder with its appropriate heading.

VIII. Plotting Sea Surface Temperature and Surface Salinity

Seasonal surface temperature and surface salinity transects are plotted to show monthly changes in the Gulf of Maine surface conditions. Both are drawn on K&E Standard Cross Section Paper, 10 x 10 to the half inch. Graphs are arranged according to season and transect routes. The seasons are defined as follows: Winter (January, February, March, April), Summer (May, June, July, August), and Autumn (September, October, November, December). In many cases the cruise dates will not be consistent enough to pattern the surface data as indicated above. If this happens, group together months with comparable temperatures. Two to five cruises should be plotted together.

After classifying cruises, use the Tektronix or Navigation Charts to determine the difference between the western most station for each cruise. Since all SOOP transects are plotted West to East, the station with the largest longitude will be the first plotted. Subsequent stations are plotted using the distance between station calculated for the cross sections.

Review the monthly data for surface temperature and salinity extreme values, (i.e., high and low). Use these extremes to set the range of values to be plotted. Questionable salinity values should be checked for possible errors in calculations. The length of the vertical scale should be conservative but not to the extent that lines appear cluttered. The vertical scale is 1/2" = 1°C for temperature and 1 1/2" = ppt for salinity.

Proceed to plot the cruise data for each station. When plotting surface temperature, use the same data that is on the

contour. Always use XBT data, except when there is a large variance between the bucket and the probe. Record on the graph paper the ship, graph title, year, heading and legend.

IX. Inking Sea Surface Temperature and Salinity (refer to Figures 9 and 10)

All surface plots are inked by the same method and with the same materials as the contours.

- Extend the borders 1/4" from the first and last station on the graph.

- Temperature and salinity are indicated for each (^{o}C) and (^{o}/oo).

- Horizontal lines, 1/5", are drawn at each salinity or temperature interval on the left and right side of the graph.

- The ship name, graph description, heading, depth intervals, year, and legend are done with either the Leroy Adjustable Scriber and lettering plate (size 3) with drawing pen size 2 or with Kroy Type 80 using Gothic Reel corresponding to 24 PT. ULNS.

- Some common legends used are ———, - - -, -.-., . . ., and ▬ .

- When necessary variations on the location of the title and legend should be made to accommodate the plot.

X. Procedure to Determine the Average Temperature of Water Below 100 Meters

An additional part of the SOOP run project is to determine the average temperature of water below 100 meters. Each transect route is divided into the following sub areas:

Boston or Gloucester to Cape Sable:	West of 69°, 69° to 68° and East of 68°
Portland to Yarmouth:	West of 68°30' and East of 68°30'.

Obtain the final draft of the cross section contours and draw a line across the 100 m depth. If not already done, label the longitude for each probe above the surface temperature. Use a Gerber variable scale to locate the area boundaries and draw them in.

Fill out an area worksheet (Figure 11) for each cruise. Indicate on the worksheet: ship name, date of cruise, cruise number, transect route and each region.

A one degree temperature class interval is used for the area. Indicate each temperature class interval that is in the region, across from the isotherm column.

The Zeiss planimeter is used to find the area between each temperature class interval. Before starting, clear the machine several times. Push the area button. Place a sheet of clear tracing paper over the contour and proceed to sketch around the area between the isotherms. Several readings should be taken for each area and an average obtained. Continued this for all the areas within the interval. Total the areas and record in the appropriate column on the worksheet.

If a probe did not extend to the bottom, and an estimate was made of the isotherm crossing below the final recording, note his on the area worksheet. Also note when the bottom exceeded the depth of the probe and was estimated. The Zeiss planimeter indicates area in mm^2, multiply the total area for each temperature class interval by the average temperature (e.g., for area between the $4^{\circ}C$ and $5^{\circ}C$ isotherm, multiply the total area by 4.5) to obtain a product. Sum up the areas and products of all the temperature class intervals. Divide the sum of the products by the sum of the areas to obtain the average temperature for the entire region.

S. DEPT. OF COMMERCE - N.O.A.A.
ATIONAL MARINE FISHERIES SERVICE
TLANTIC ENVIRONMENTAL GROUP

MARMAP SHIP OF OPPORTUNITY LOG (SOO)

COUNTRY: USA | OPERATIONAL UNIT: SOO NMFS/AEC | VESSEL: YANKEE CLIPPER | CRUISE: 8206

REMARKS: SHADED AREAS TO BE FILLED IN ASHORE

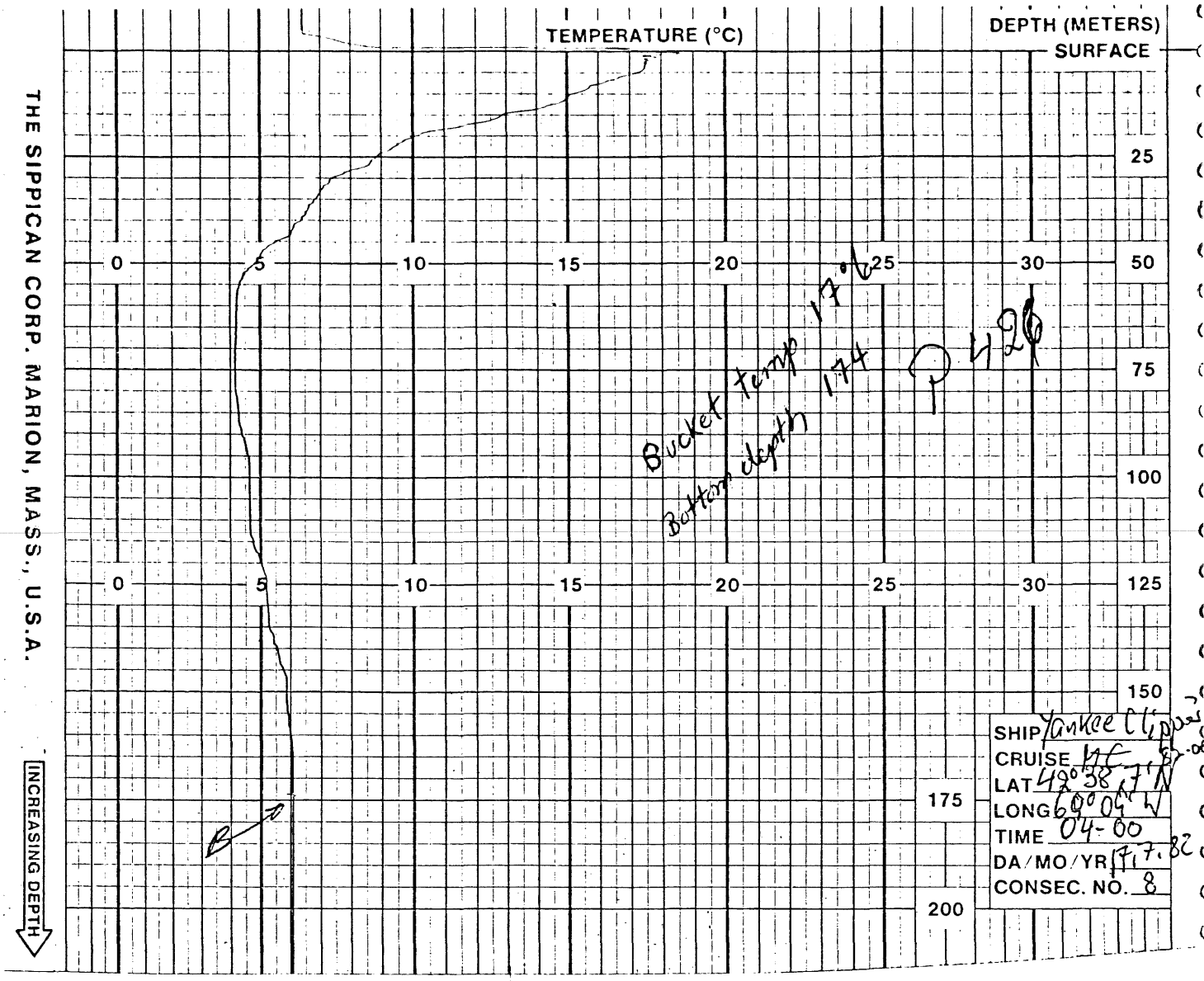
PSM TUNNEL READING	MARMAP STATION	CPR/UOR SHT ALT HAU -OR- BT. LAUNCH NO.	DATE DAY	DATE MONTH	DATE YEAR	TIME GMT HOUR	TIME GMT MIN.	LATITUDE DEG.	LATITUDE MIN.	LATITUDE NS	LONGITUDE DEG.	LONGITUDE MIN.	LONGITUDE EW	SURFACE TEMP (°C)	DEPTH TO BOTTOM (M)	SURFACE SALINITY BOTTLE NO.	SURFACE SALINITY ‰	WATER MASS CODE
60		~~Launch~~	~~16~~	~~07~~	~~82~~	~~20~~	~~30~~	~~42~~	~~24.0~~	~~N~~	~~070~~	~~49.3~~	~~W~~					
		001	16	07	82	21	00	42	25.1	N	070	43.0	W	173	0052	Q043	31381	
		2	16	07	82	22	00	42	27.6	N	070	30.4	W	177	0057	P934	31264	
		3	16	07	82	23	00	42	30.3	N	070	16.9	W	187	0157	P735	31171	
		4	16	07	82	24	00	42	32.3	N	070	03.6	W	187	0134	P309	31215	
		5	17	07	82	01	00	42	34.0	N	069	49.4	W	190	0211	P987	31237	
		6	17	07	82	02	00	42	35.9	N	069	35.8	W	183	—	P932	31822	
		~~7~~	~~17~~	~~07~~	~~82~~	~~03~~	~~00~~	~~42~~	~~37.1~~	~~N~~	~~069~~	~~22.0~~	~~W~~	~~181~~	~~0205~~	~~P147~~	~~32392~~	
		8	17	07	82	04	00	42	38.7	N	069	09.0	W	176	0174	P426	32390	
		09	17	07	82	05	00	42	41.1	N	068	56.0	W	157	0170	P938	32075	
		10	17	07	82	06	00	42	42.9	N	068	42.5	W	162	0191	P980	32005	
		11	17	07	82	07	00	42	45.3	N	068	29.7	W	165	0183	P863	32157	
		12	17	07	82	08	00	42	47.8	N	068	16.4	W	167	0200	P981	32473	
		13	17	07	82	09	00	42	50.5	N	068	04.3	W	158	0188	Q011	32432	
		14	17	07	82	10	00	42	54.0	N	067	52.2	W	158	0185	P996	32530	
		15	17	07	82	11	00	42	57.3	N	067	39.7	W	155	0204	B668	32509	
		16	17	07	82	12	00	42	58.2	N	067	27.9	W	157	—	P153	32429	
		17	17	07	82	13	00	43	00.3	N	067	14.7	W	141	0215	1	32375	
		18	17	07	82	14	00	43	02.6	N	067	02.2	W	106	0170	P855	32557	
		19	17	07	82	15	00	43	01.7	N	066	48.7	W	096	0155	P167	33022	

CPR/UOR TOW DATA: ROUTE ST MC
BODY NO. 605 PSM NO. 60571 DATA ACQUISITION SYST. NO. NA
IMPELLER SETTING 65°

MARMAP SHIP OF OPPORTUNITY LOG (SOO) FORM SOO (6/80)

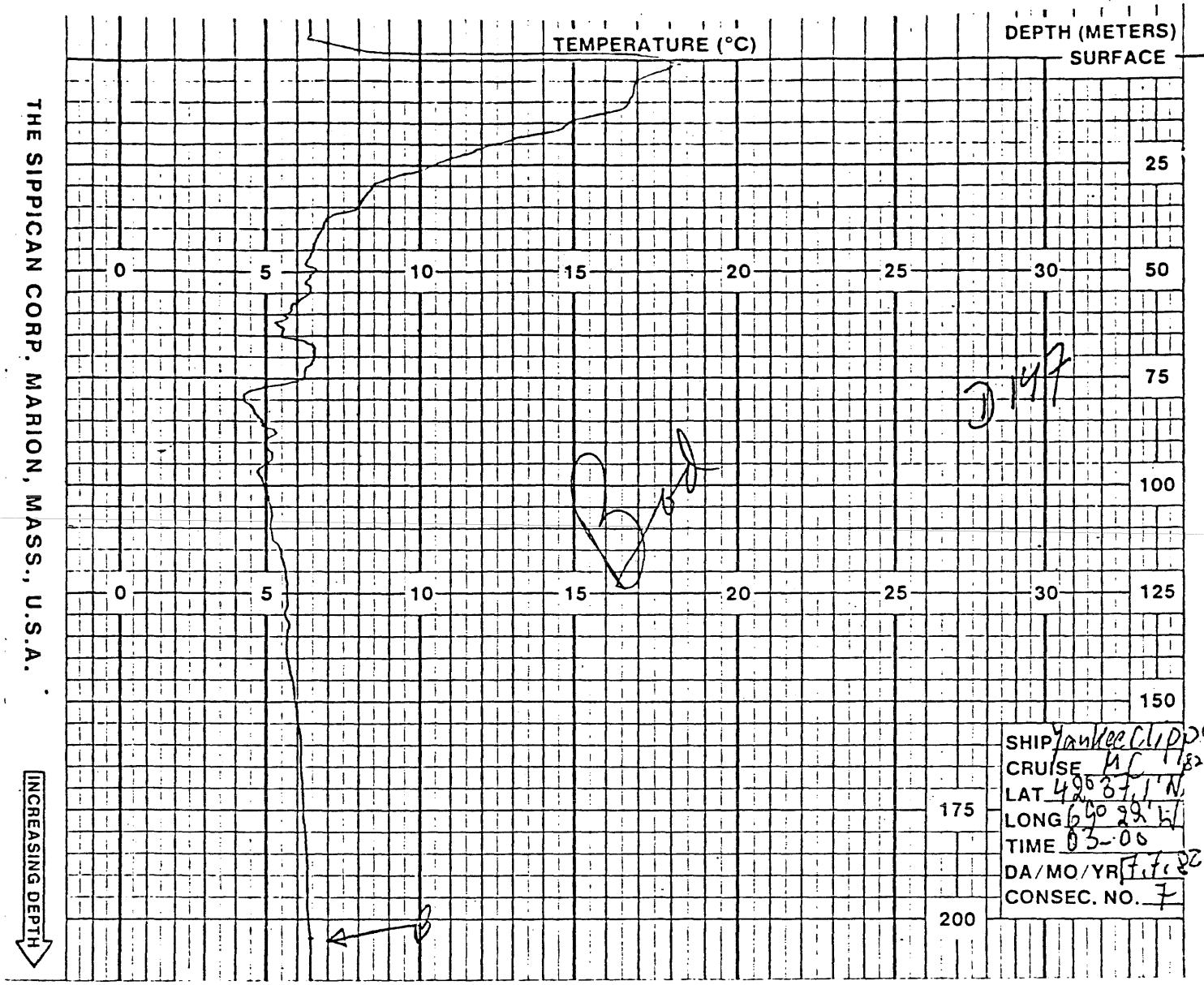
(fig. 1)

RECORDED BY: reviewed 22 Jul 82 OK DES 22 Jul 82



(fig.2)

a) XBT Trace
b) Thermocline in the top 50m
c) Splke at 174m
d) Weaving at 5°C isotherm
e) Hugging at 6°C isotherm



(fig.3) Wire leakage due to insulation disturbance.

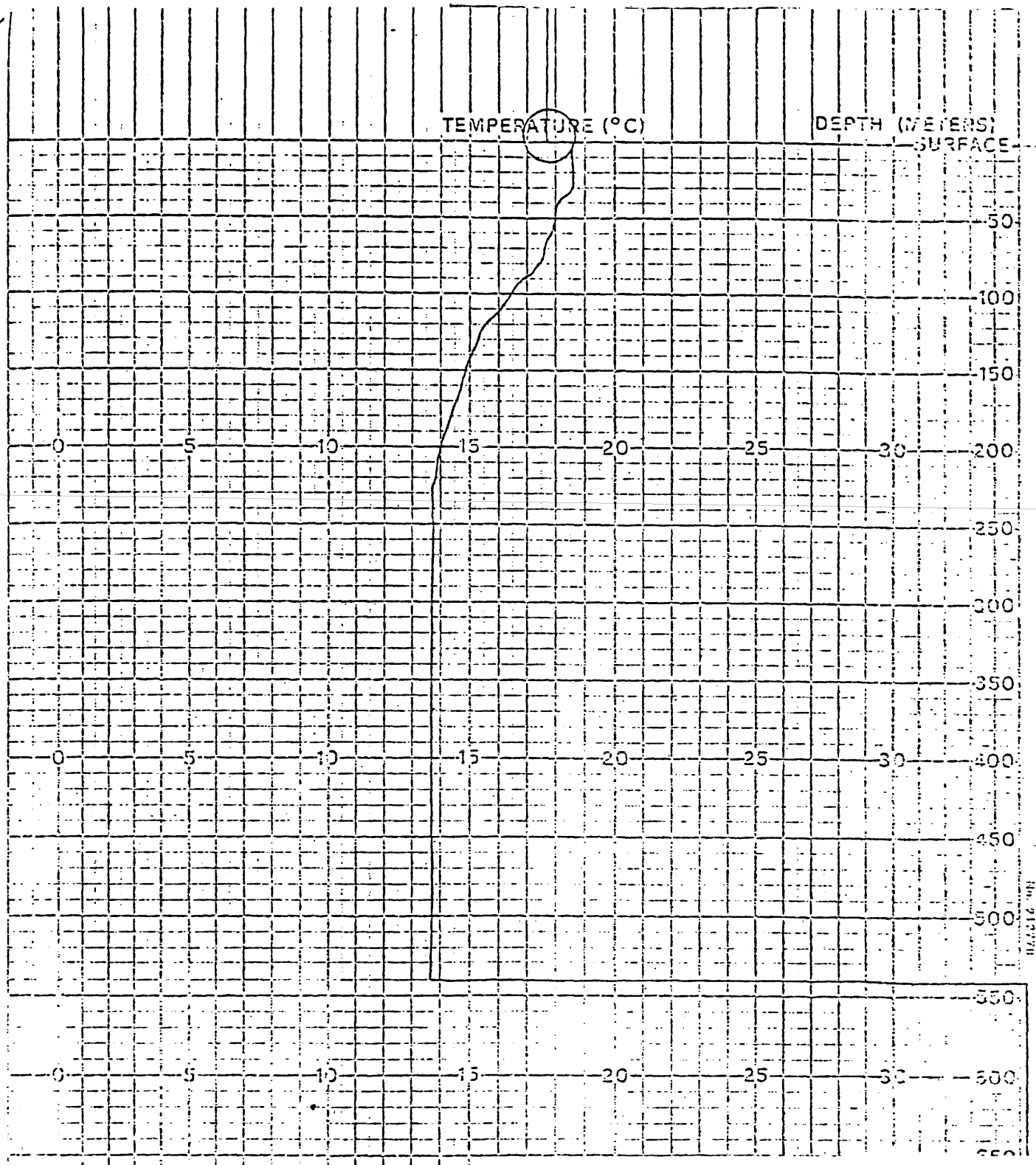
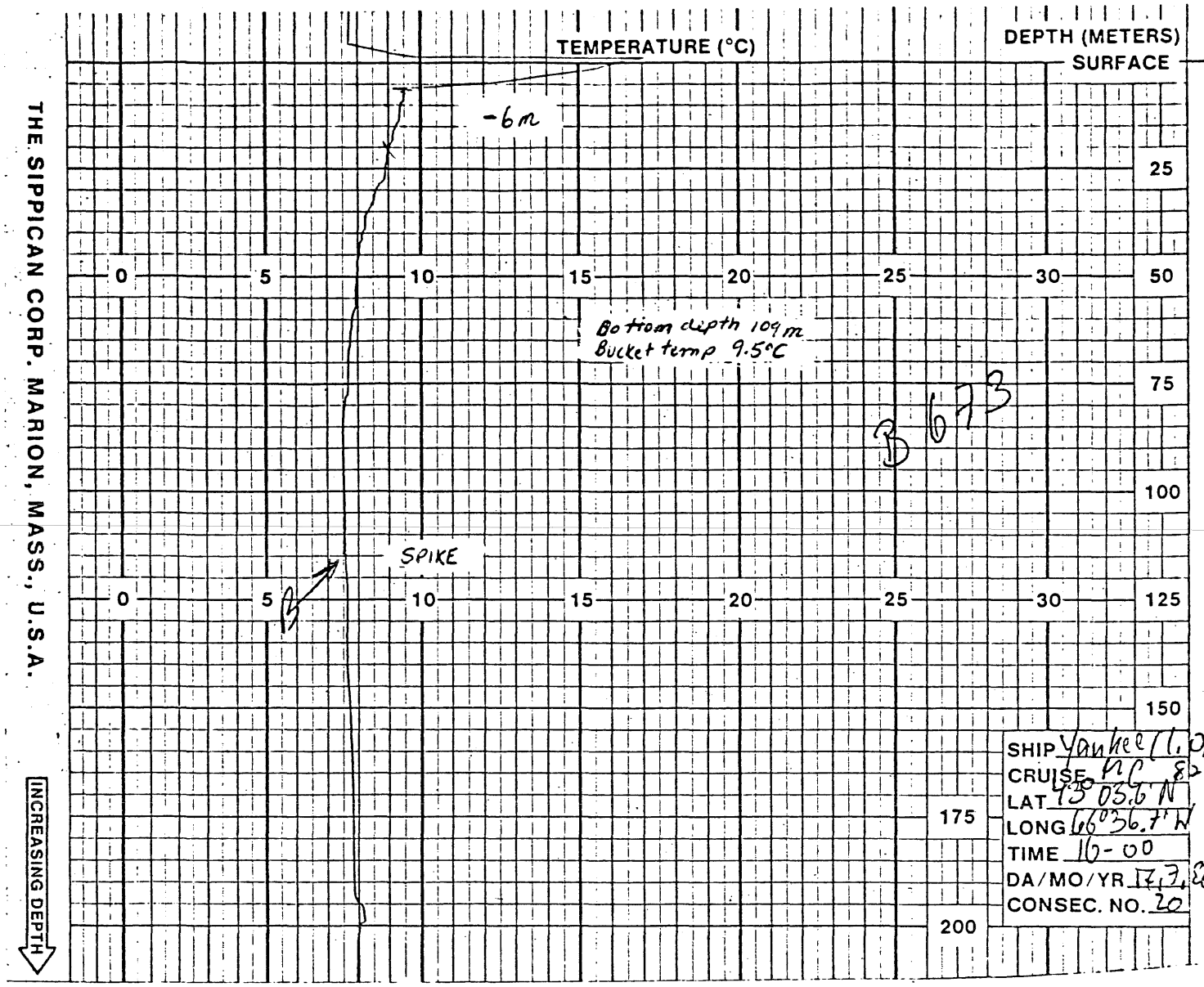


Figure 4 - Check mode calibration mark other than 16.7°C (appears at 17.7°C)

THE SIPPICAN CORP. MARION, MASS., U.S.A.

INCREASING DEPTH

THE SIPPICAN CORP. MARION, MASS., U.



(fig.5) Chart out of alignment.

Adjust all depths 6M up. Use 109M for the bottom depth not 115M.

FORM CD-26
(12-11-46)

U.S. DEPARTMENT OF COMMERCE

(SOO) WORKSHEET

YANKEE CLIPPER
82-06
7/16/82

XBT #	1	2	3	4	5	6	8	9	10
Long.	7043	7030	7017	7004	6949	6936	6909	6856	6843
Isotherms									
4									
5				97	97, 135		47, 120/>5		78, 110
6		41	46	62	45, 165	50, 173	44, 160	128	73, 135/<5
7	35	30	31	18	27	33	33	58	68
8	22	23	27	16	20	30	27	33	47
9	13	16	15	14	14	27	24	26	41
10	12	14	11	13.5	13	25	20	24	27
11	11	12	10	13	12	21	18	23	20
12	7	10	8.5	12	11	20	16	22	17
13	6	8	7.5	11	10	17	14	15	15
14	5	7	7	10	9	16	13	8	13
15	4.5	6	6.5	9	7	13	10	3	7
16	4	4	6	8	6	11	7		2
17	3	3	5.5	7	5	6	5		
18			5	5	4	1			
19					Surf				
20									
Surf Temp	17.5	17.7	18.7	18.7	19.0	18.3	17.6	15.7	16.2
Bottom Temp	6.3	5.9	5.6	4.8	6.5	6.4 At 200	6.1	5.9	6.7
Bottom Depth	52	57	157	134	211	≈225	174	170	191
XBT #	11	12	13	14	15	16	17	18	19
Long	6830	6816	6804	6752	6740	6728	6715	6702	6649
Isotherms									
4									
5									
6	71, 123				<7 140-204				
7	45	46-200/<7	75-188/<7	67-166/<7	67-83/83/140	<8 8			
8	33	37	40	37	43	44-100, 100-193		45	37
9	27	31	33	27	30	33, 130, 141	32, 61/<9	23	5
10	22	27	30	20	25	23	30, 75, <10, 150	10	
11	17	22	27	16	14	21	27		
12	14	16	21	13	11	15	13		
13	13	11	15	10	4	13	10		
14	8	7	6	7	3	8	2		
15	5	6	3	6	2	3			
16	3	3							
17									
Surf temp	16.5	16.7	15.8	15.8	15.5	15.7	14.1	10.6	9.6
Bottom Temp	6.8	7.0	7.0	7.3	7.0	7.7 At 210	9.5	7.9	7.7
B. depth	183	200	188	185	204	~225	215	170	155

(fig.6)

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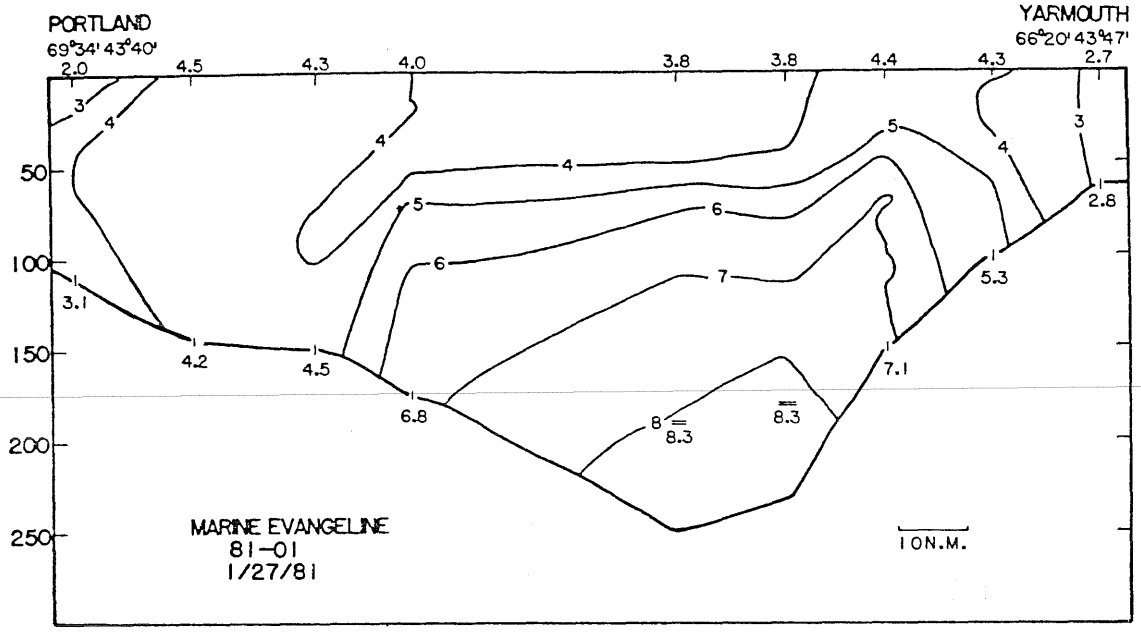


Figure 7

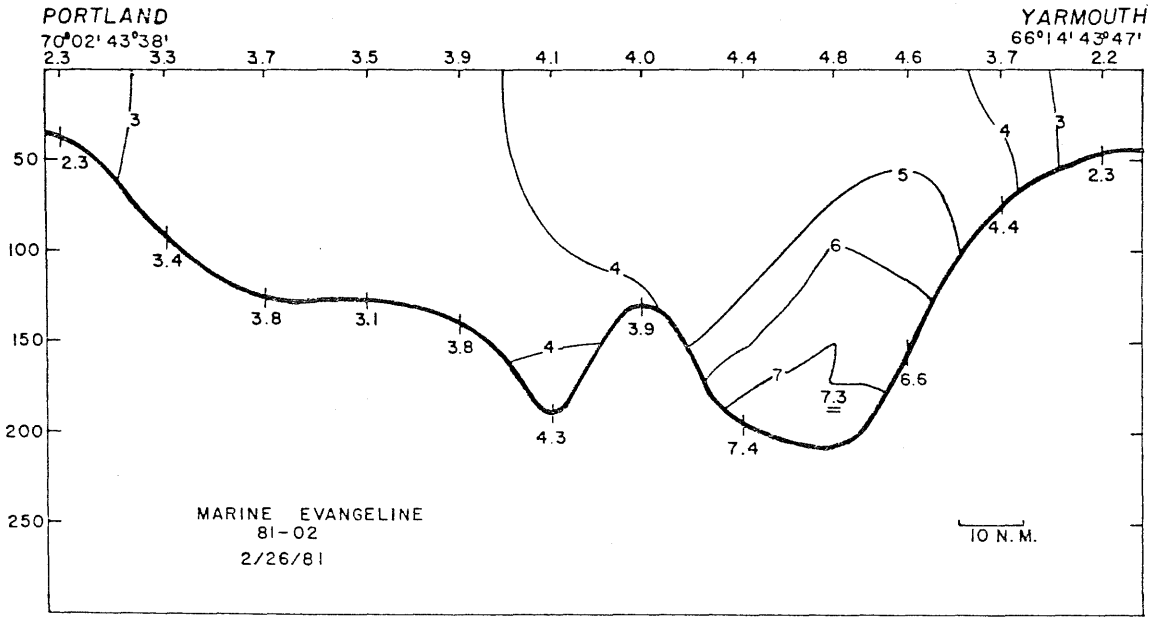
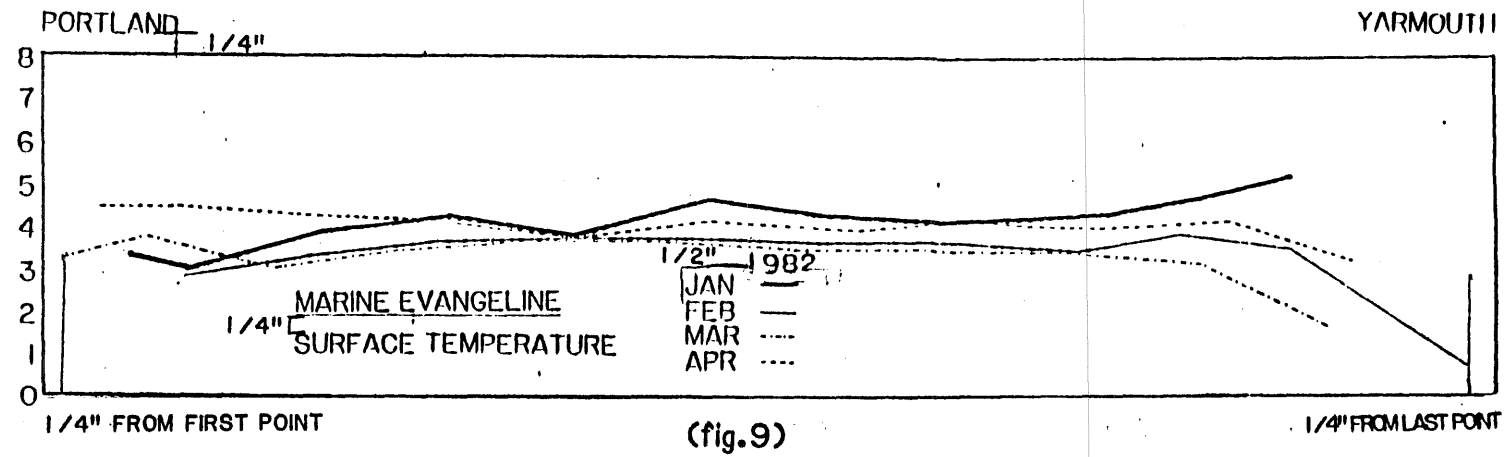
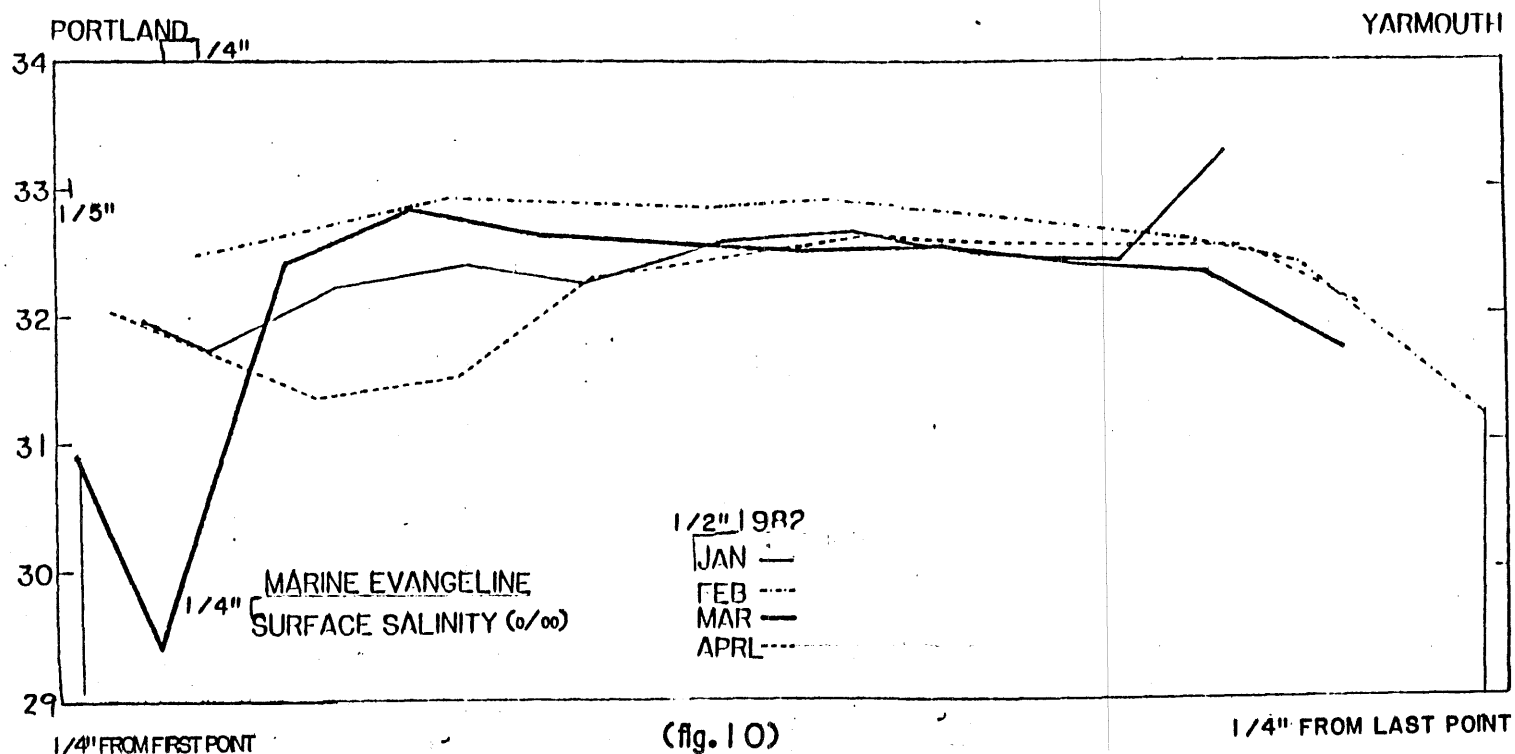


Figure 8


PORTLAND
1/4"
YARMOUTH
8
7
6
5
4
3
2
1
0
1/2" 1982
JAN
FEB
MAR
APR
MARINE EVANGELINE
1/4"
SURFACE TEMPERATURE
1/4" FROM FIRST POINT
1/4" FROM LAST POINT

(fig.9)


PORTLAND
1/4"
YARMOUTH
34
33
1/5"
32
31
30
29
1/2" 1982
JAN
FEB
MAR
APRL
MARINE EVANGELINE
1/4"
SURFACE SALINITY (o/oo)
1/4" FROM FIRST POINT
1/4" FROM LAST POINT

(fig. 10)

SHIP: CARIBOU REEFER DATE: Nov 14 '80

REGION: West of 69° TRANS: 80-14 Gloucester-Cape Sable

Isotherms	5-6	6-7	7-8	8-9	9-10						Total
Area(mm²)	82	2435	1265	1267	4880						9929
Area(m2)											
AreaxTemp	451	15828	9488	10770	46360						82897
SumArea (m2)											
SumArea x Temp											
Avg Temp				8·35							

NOTES:

SHIP: DATE:

REGION: 69°-68° TRANS:

Isotherms	6-7	7-8	8-9	9-10	10-11						Total
Area(mm²)	160	4670	1841	1558	298						85[illegible]
Area(m2)											
AreaxTemp	1040	35025	15649	14801	3129						6964[illegible]
SumArea (m2)											
SumArea x Temp											
Avg Temp				8·17							

NOTES:

SHIP: DATE:

REGION: 68°-EAST TRANS:

Isotherms	5-6	6-7	7-8	8-9	9-10	10-11	11-12				Total
Area(mm²)	193	590	1279	1401	1386	4591	2679				12119
Area(m2)											
AreaxTemp	1062	3835	9593	11904	13167	48206	30809				118891
SumArea (m2)											
SumArea Temp											
Avg Temp				9.78							

NOTES:

SHIP: DATE:

REGION: TRANS:

Isotherms											
Area( )											
Area(m2)											
AreaxTemp											
SumArea (m2)											
SumArea x Temp											
Avg Temp											

NOTES:

(fig. 11)