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Horizontal temperature sections from data collected on ICNAF larval herring surveys, fall-winter 1975[1]

by

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Introduction

Support from member nations of ICNAF for the cooperative larval herring survey in the Georges Bank area continued during fall 1975 with both improved standardization and increased sampling of various environmental parameters. In addition to the temperature, salinity, and meteorological data previously collected, nutrient and chlorophyll samples were obtained on each larval herring cruise. These latter samples are summarized in another Research Document (Cohen, 1976). A detailed analysis of all these data are planned for the future but was not possible for the present meeting because of time constraints. Horizontal temperature sections from each cruise are examined in this report to characterize persistent features of the Georges Bank area that may be examined in more detail during the sampling period of ICNAF larval herring survey.

Data

A summary of the first three years of oceanographic data collected on ICNAF larval herring surveys (Schlitz, 1975) indicated that standardization of procedures would improve the overall data quality and lead to better interpretations. This standardization was accomplished for the continuous temperature profiles obtained at every station during the cruises by the installation and use of a Sippican Expendable Bathythermograph System (XBT) on each participating research vessel. Overall system accuracy of $\pm$ 0.2°C and a depth range of 200 m was obtained using a type T-10 temperature probe. This depth capability was chosen because 90-95% of the stations were at positions where the water depth was <200 m.

The general area of standard station positions is indicated in Figure 1 although the number of stations varied between cruises because of the sampling strategy employed when herring larvae were caught (extra stations were placed midway between

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longitudinal sections). The cruise tracks were mostly limited to Georges Bank, Nantucket Shoals, and the continental shelf south of New England, except R/V ANTON DOHRN which sampled on Browns Bank and Jeffreys Ledge. The cruise information is given in Table 1.

Table 1.-- Stations completed during ICNAF Larval Herring Cruises, Fall-Winter 1975

Ship	Country	Dates	Number of stations
R/V BELOGORSK	USSR	25 Sep.-9 Oct.	90
R/V BELOGORSK	USSR	16-30 Oct.	94
R/V ANTON DOHRN	FRG	31 Oct.-16 Nov.	137
R/V ALBATROSS IV	USA	2-17 Dec.	95
R/V ALBATROSS IV	USA	10-25 Feb.	118

At each station a continuous vertical profile of temperature was obtained to 200 m or the bottom. The number of stations at which bad data were obtained is considered insignificant for the overall interpretation. These data were then digitized and horizontal charts were contoured at 1^{0}C intervals prepared for 0, 10, 20, 30, 40, 50, 75, 100, 150, and 200 m. This series of horizontal contour charts shows a much smoother distribution of temperatures than those of the previous years, and is probably caused by the use of the more reliable XBT system rather than a change in oceanic thermal conditions.

Results

1. Temperature sections

The patterns that emerged in an earlier report (Schlitz, 1975) were again present during the series of cruises for fall, 1975. The ANTON DOHRN cruise in November is an example (Figure 2). Not only are there isolated areas of relatively cool water on eastern Georges Bank that persisted until December but the mean temperatures there are generally lower than on the remainder of the bank. This has also been seen by Davis (1976) for bottom temperatures obtained on fall bottom trawl surveys. The most probable explanation is local upwelling at the eastern end of the bank, but direct measurements along with analysis of the nutrient data now collected will be needed to help determine this. Also the lower temperatures east of Nantucket Shoals persisted as in the previous report.

Table 2. Mean temperatures (^{o}C) from data obtained on ICNAF Larval Herring Cruises 1971-1973

Date	Depth	Nantucket Shoals	Georges Bank	Gulf of Maine	Northeast Channel
	0 m				
25 Sep- 9 Oct		16.8/30	14.9/44	15.6/9	14.0/6
17 Oct-30 Oct		14.5/33	13.5/47	13.1/9	12.8/6
31 Oct-16 Nov		13.3/40	12.6/56	11.2/16	11.2/12
2 Dec-17 Dec		11.0/33	9.7/43	9.1/14	9.2/10
10 Feb-25 Feb		5.3/46	5.5/51	5.0/13	5.0/8
	10 m				
25 Sep- 9 Oct		16.9/30	14.9/44	15.6/9	14.0/6
17 Oct-30 Oct		14.4/33	13.4/47	12.9/9	10.8/6
31 Oct-16 Nov		13.3/40	12.6/56	11.2/16	11.1/11
2 Dec-17 Dec		11.0/33	9.8/43	9.2/14	9.2/10
10 Feb-25 Feb		5.3/45	5.6/51	5.1/13	5.0/8
	20 m				
25 Sep- 9 Oct		15.7/30	14.7/44	14.0/9	13.7/6
17 Oct-30 Oct		14.2/33	13.7/47	12.7/9	12.6/6
31 Oct-16 Nov		13.4/40	12.6/56	10.9/16	11.0/11
2 Dec-17 Dec		11.3/33	9.9/43	9.3/14	9.5/10
10 Feb-25 Feb		5.3/45	5.6/51	5.1/13	5.0/8
	30 m				
25 Sep- 9 Oct		13.1/30	14.2/44	11.0/9	12.8/6
17 Oct-30 Oct		13.7/33	13.5/47	11.5/9	12.1/6
31 Oct-16 Nov		13.3/40	12.5/56	10.7/16	10.9/11
2 Dec-17 Dec		11.6/33	9.9/43	9.4/14	9.5/10
10 Feb-25 Feb		5.5/45	5.8/51	5.3/13	5.1/8
	40 m				
25 Sep- 9 Oct		11.4/27	13.8/43	7.6/9	11.0/6
17 Oct-30 Oct		12.7/30	12.7/46	9.2/9	10.5/6
31 Oct-16 Nov		13.2/38	12.3/54	10.0/16	10.3/11
2 Dec-17 Dec		12.0/31	10.0/42	9.4/14	9.5/10
10 Feb-25 Feb		6.2/39	5.9/50	5.2/13	5.1/8
	50 m				
25 Sep- 9 Oct		10.7/21	12.5/38	7.4/9	8.6/6
17 Oct-30 Oct		12.0/24	11.5/39	7.6/9	8.5/6
31 Oct-16 Nov		12.8/34	11.7/44	9.0/16	9.6/11
2 Dec-17 Dec		12.6/26	10.0/37	9.4/13	9.4/10
10 Feb-25 Feb		7.3/33	6.0/46	5.2/13	5.2/8
	75 m				
25 Sep- 9 Oct		10.3/14	10.5/26	6.8/9	7.4/6
17 Oct-30 Oct		11.6/13	10.1/26	6.3/9	6.9/6
31 Oct-16 Nov		11.4/19	9.8/29	7.4/15	7.6/11
2 Dec-17 Dec		14.3/16	9.9/24	8.2/12	8.7/10
10 Feb-25 Feb		10.2/16	7.6/27	5.4/12	5.8/8
	100 m				
25 Sep- 9 Oct		10.6/8	9.3/18	6.1/6	7.6/6
17 Oct-30 Oct		11.2/8	10.0/20	5.9/9	6.7/6
31 Oct-16 Nov		10.9/14	8.9/17	6.4/15	6.8/11
2 Dec-17 Dec		13.3/10	9.6/18	7.2/11	8.3/10
10 Feb-25 Feb		9.9/12	9.0/18	5.6/12	6.9/8

The large heat loss from the water column in the winter is illustrated by the temperature differences at 40 m obtained on the two cruises by R/V ALBATROSS IV. The data from the first cruise, 2-17 December 1975 (Figure 3), shows the cooling of the bank as a whole and the tendency for horizontal gradients to lessen as the fall progressed, while the second cruise, 10-25 February 1976 (Figure 4), indicates the cooling of $\sim 6^{\circ}$C on portions of Georges Bank that occurred in a period of two months and led to a nearly isothermal condition. Although 40 m was chosen as the example, temperatures were isothermal to 100 m in the Gulf of Maine and to 75 m in Northeast Channel, except for one station. Weather conditions were extremely severe in February with winds in excess of 30 knots common throughout the cruise period.

II. Shelf-slope front

The position of the slope water front, as defined by the center of the steep temperature gradient at all depths, was identical in overall characteristics to the data reported by Schlitz (1975). The "frontal corridor" (Figure 5) fluctuated between 80-2000 m on Georges Bank and 60-200 m south of New England. The excursions became less variable toward the east with the horizontal separation of the limits of the front at a minimum where the interface left Georges Bank. There were no cases during the series of larval herring cruises that showed penetration of the slope front into Northeast Channel.

In some cases the gradients turned offshore beyond the limits of data and then returned, but always to the west of $\sim 66^{\circ}15'$W. These may be areas where shelf water is being removed from the shallow areas but interpretation of these data is difficult. Analysis of satellite photography, however, indicates that the loss of shelf water into the slope water is fairly common at the surface. Each warm-cored ring that breaks off the Gulf Stream and approaches shallow water has entrained quantities of shelf water. This process is graphically seen in Figure 6 where shelf water is found along the eastern side of eddy G and meander F.

III. Mean temperatures

The mean temperatures were calculated for each cruise in the areas previously defined (Schlitz, 1975) as Nantucket Shoals, Georges Bank, Gulf of Maine, and Northeast Channel. There were insufficient data to calculate means for the Scotian Shelf, and coverage in the Gulf of Maine was marginal, limited mostly to the southwestern portion off Cape Cod. These data are presented in Table 2. No significant trends were apparent from the comparison of these data with the previous mean temperatures during the period September through December.

Comparison of the February data with the seasonal temperature patterns based on the period 1940-1959 (Colton and Stoddard, 1972) shows temperatures south of New England to be in the same range, <5-6°C, as their Area 6 ($40^{\circ}30'$N-$41^{\circ}00'$N, $71^{\circ}00'$-$72^{\circ}00'$W) except for 50 m. However the mean temperatures for the area defined as Nantucket Shoals are somewhat higher than their temperatures because of the larger area extending into the frontal region. Likewise Area 3 ($41^{\circ}30'$-$42^{\circ}00'$N, $66^{\circ}00'$-$67^{\circ}00'$W) on eastern Georges Bank and the data collected aboard ALBATROSS IV are not significantly different, both averaging about 5°C throughout the upper water column. The mean temperatures in February corresponding to Areas 3 and 6 are presented in Table 3.

Table 3. Mean temperatures (^{o}C) for February 1976 computed from XBT data collected during the ICNAF Larval Herring Cruises (areas correspond to those selected by Colton and Stoddard, 1972).

Depth	Georges Bank Area 3 $\bar{T}$/No. of Obs.	Southern New England Area 6 $\bar{T}$/No. of Obs.
0	5.0/11	5.1/9
10	5.0/11	5.1/9
20	5.1/11	5.1/9
30	5.1/11	*5.4/9
40	5.1/11	*5.9/9
50	5.1/11	*7.5/6

*One questionable observation included.

Conclusions

1. Because of the standardization of the temperature data implemented during the Fall-Winter 1975 ICNAF Larval Herring Cruises the contoured sections were smoother for each cruise. The procedure of using only one temperature profiling system, the Sippican XBT System, should be continued into the future.

2. The isolated areas of relatively cold water on eastern Georges Bank and east of Nantucket Shoals appear to be semi-permanent features throughout the fall season finally disappearing at the winter overturn. These phenomena deserve special attention to determine their causes and persistence.

3. Although satellite photographs indicate large movements of the shelf-slope water front, this interface was found between 80-2000 m on Georges Bank and 60-2000 m south of Nantucket Shoals at all depths for every ICNAF Larval Herring Cruise. However the movement of shelf water into the slope water region is not clearly seen from these data. Probably the large distance between sections ($\sim$25 nm) does not provide the resolution of these relatively narrow filaments.

4. Comparison of the February data collected in 1976 with the 1940-1959 mean temperatures (Colton and Stoddard, 1972) indicates no significant changes in upper water columns of two areas, eastern Georges Bank and the southern New England continental shelf.

References

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Davis, C. W. 1976. Spring and autumn bottom-water temperatures in the Gulf of Maine and Georges Bank, 1968-1975. Int. Comm. Northwest Atl. Fish. Res. Doc. 76/VI/ .

Schlitz, R. J. 1975. A preliminary summary of hydrographic data collected on ICNAF larval herring surveys 1971-1973. Int. Comm. Northwest Atl. Fish. Res. Doc. 75/111.

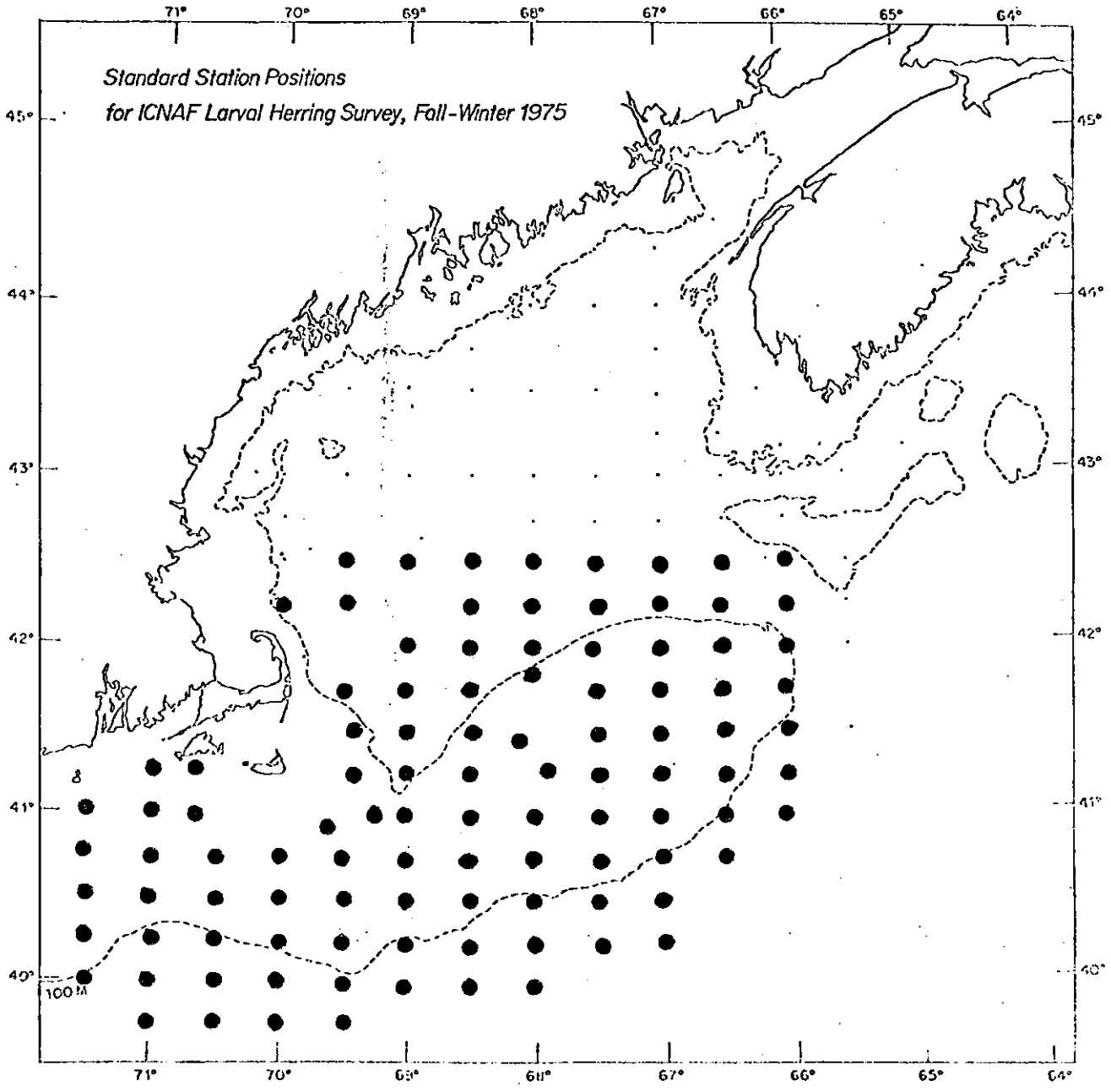
Standard Station Positions
for ICNAF Larval Herring Survey, Fall-Winter 1975
71°
70°
69°
68°
67°
66°
65°
64°
45°
44°
43°
42°
41°
40°
100 M

Figure 1.

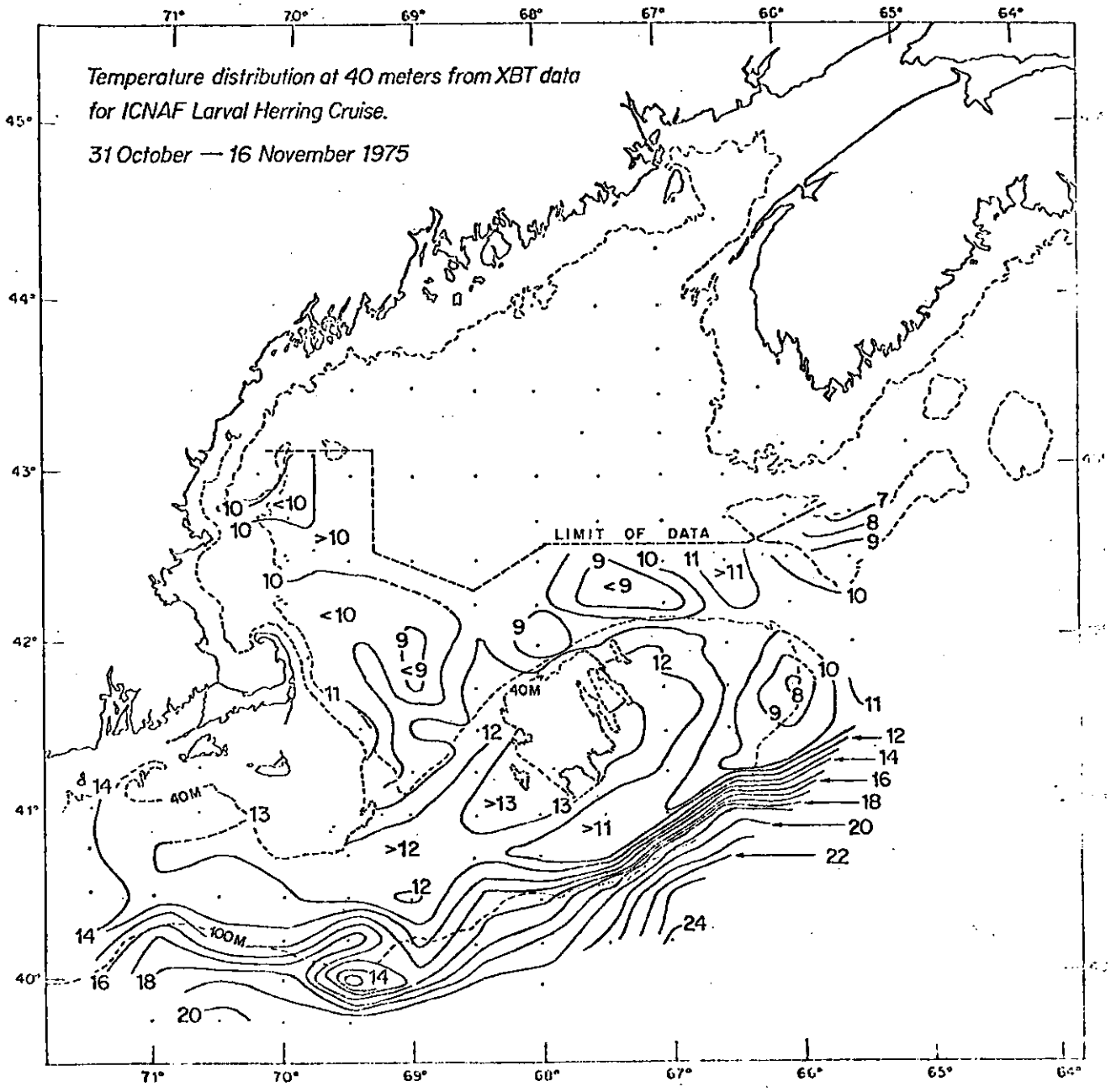
Temperature distribution at 40 meters from XBT data
for ICNAF Larval Herring Cruise.
31 October — 16 November 1975
71°
70°
69°
68°
67°
66°
65°
64°
45°
44°
43°
42°
41°
40°
LIMIT OF DATA
40M
100M
10
<10
>10
9
<9
11
>11
12
13
>13
14
16
18
20
22
24
7
8

Figure 2.

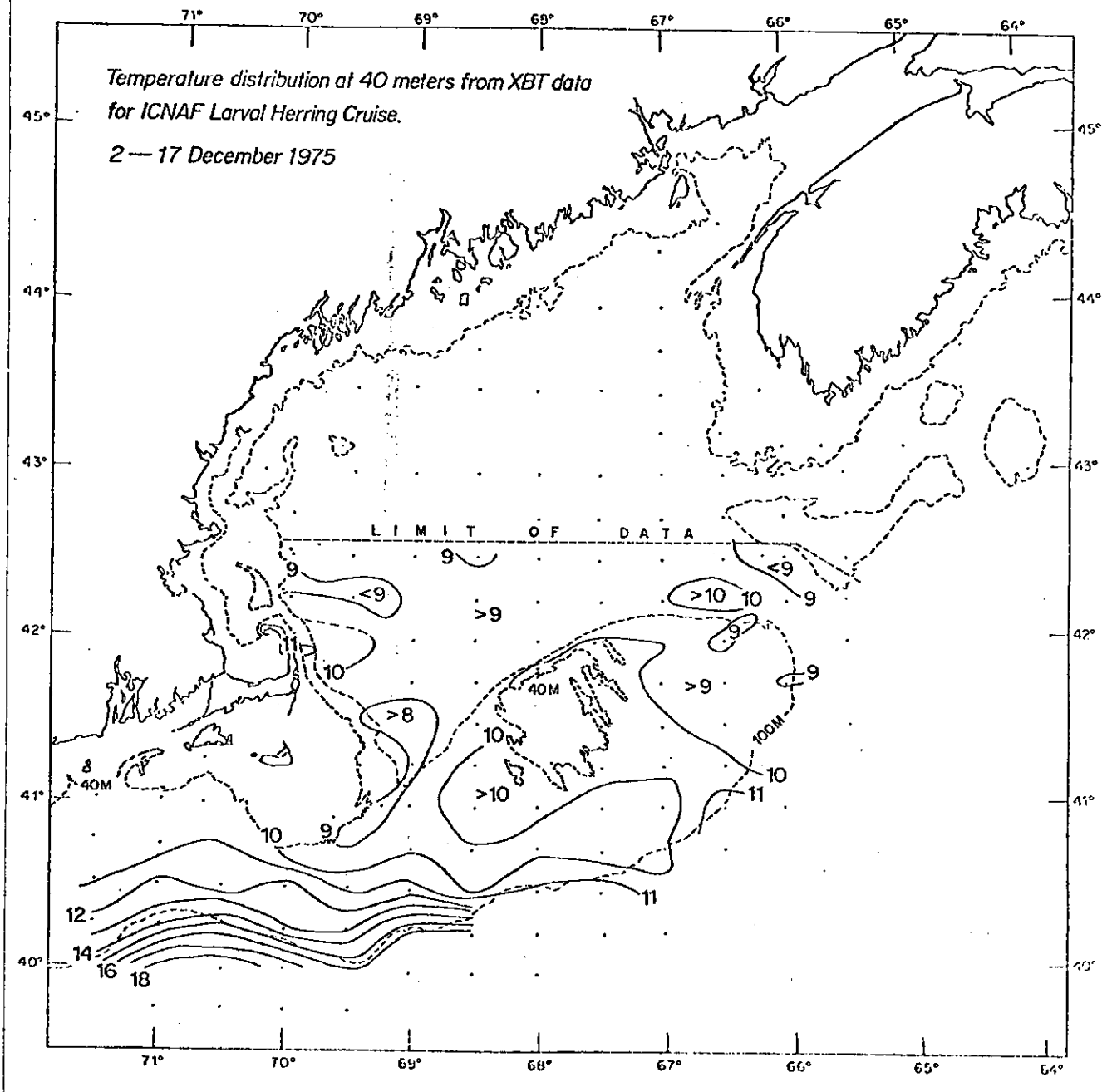
Temperature distribution at 40 meters from XBT data
for ICNAF Larval Herring Cruise.
2 — 17 December 1975
LIMIT OF DATA
40M
100M
71°
70°
69°
68°
67°
66°
65°
64°
45°
44°
43°
42°
41°
40°

Figure 3.

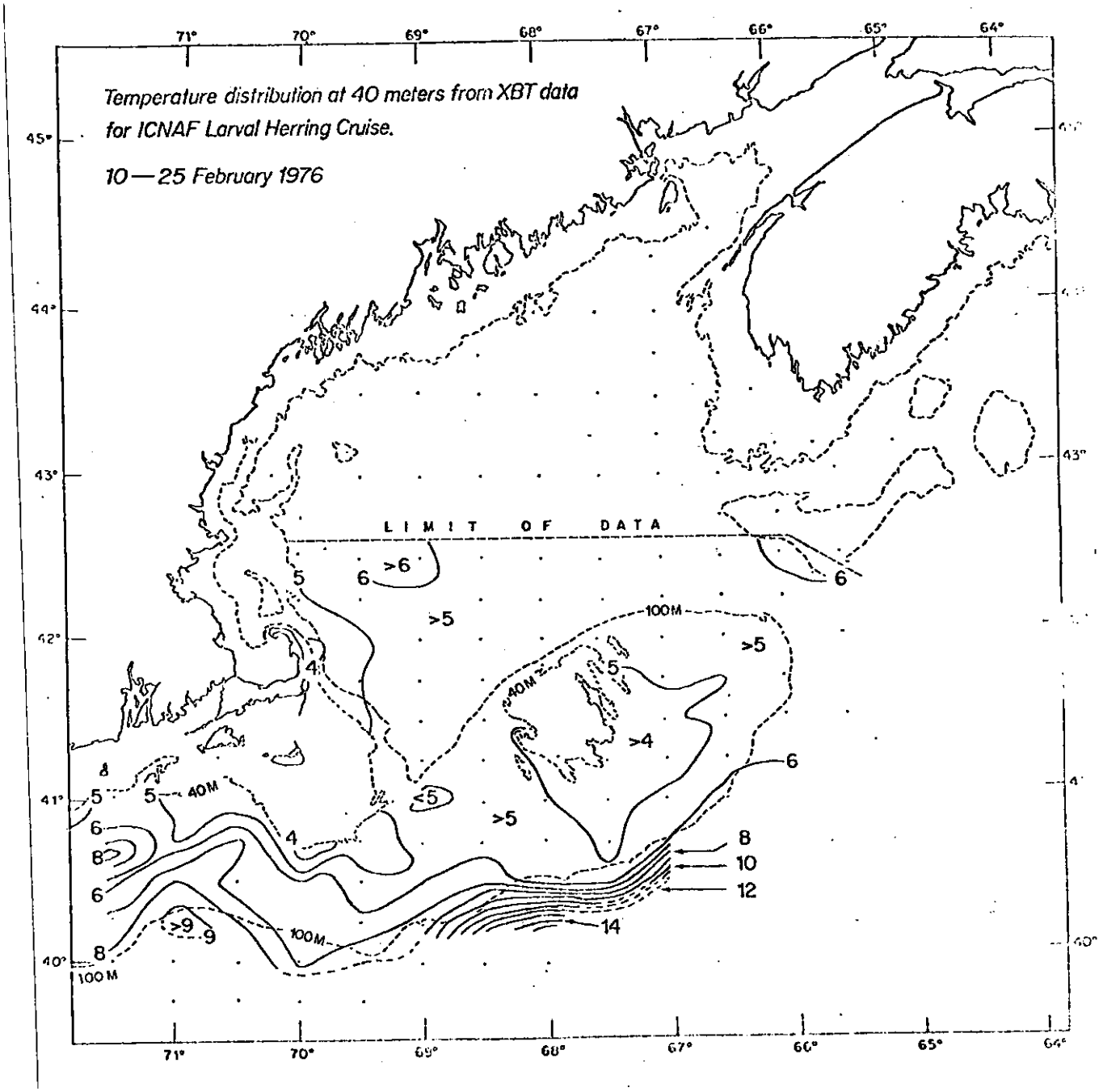
Temperature distribution at 40 meters from XBT data
for ICNAF Larval Herring Cruise.
10—25 February 1976
LIMIT OF DATA
100M
40M
71°
70°
69°
68°
67°
66°
65°
64°
45°
44°
43°
42°
41°
40°

Figure 4.

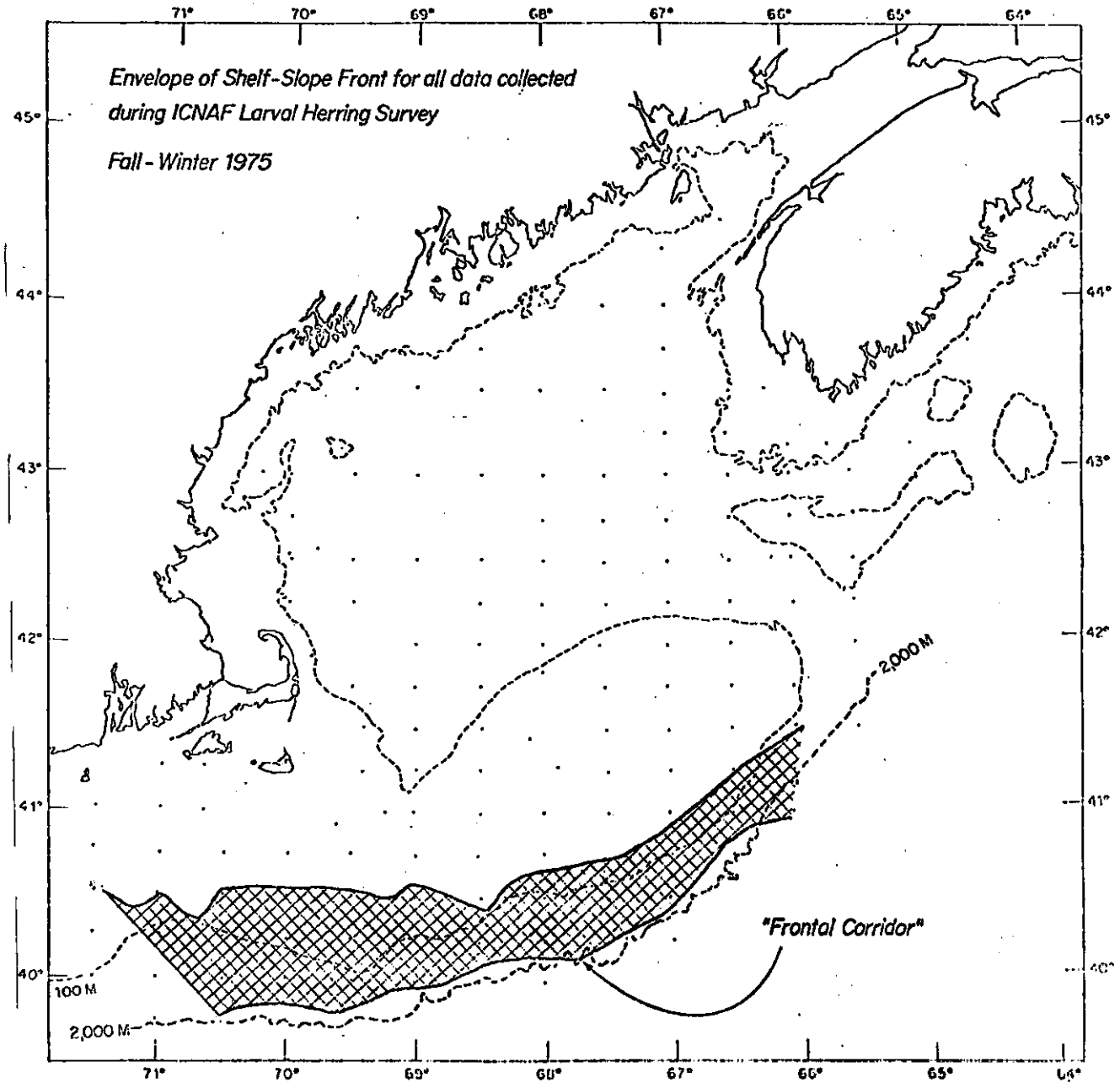
Envelope of Shelf-Slope Front for all data collected
during ICNAF Larval Herring Survey
Fall - Winter 1975
71°
70°
69°
68°
67°
66°
65°
64°
45°
44°
43°
42°
41°
40°
2000 M
"Frontal Corridor"
100 M
2,000 M

Figure 5.

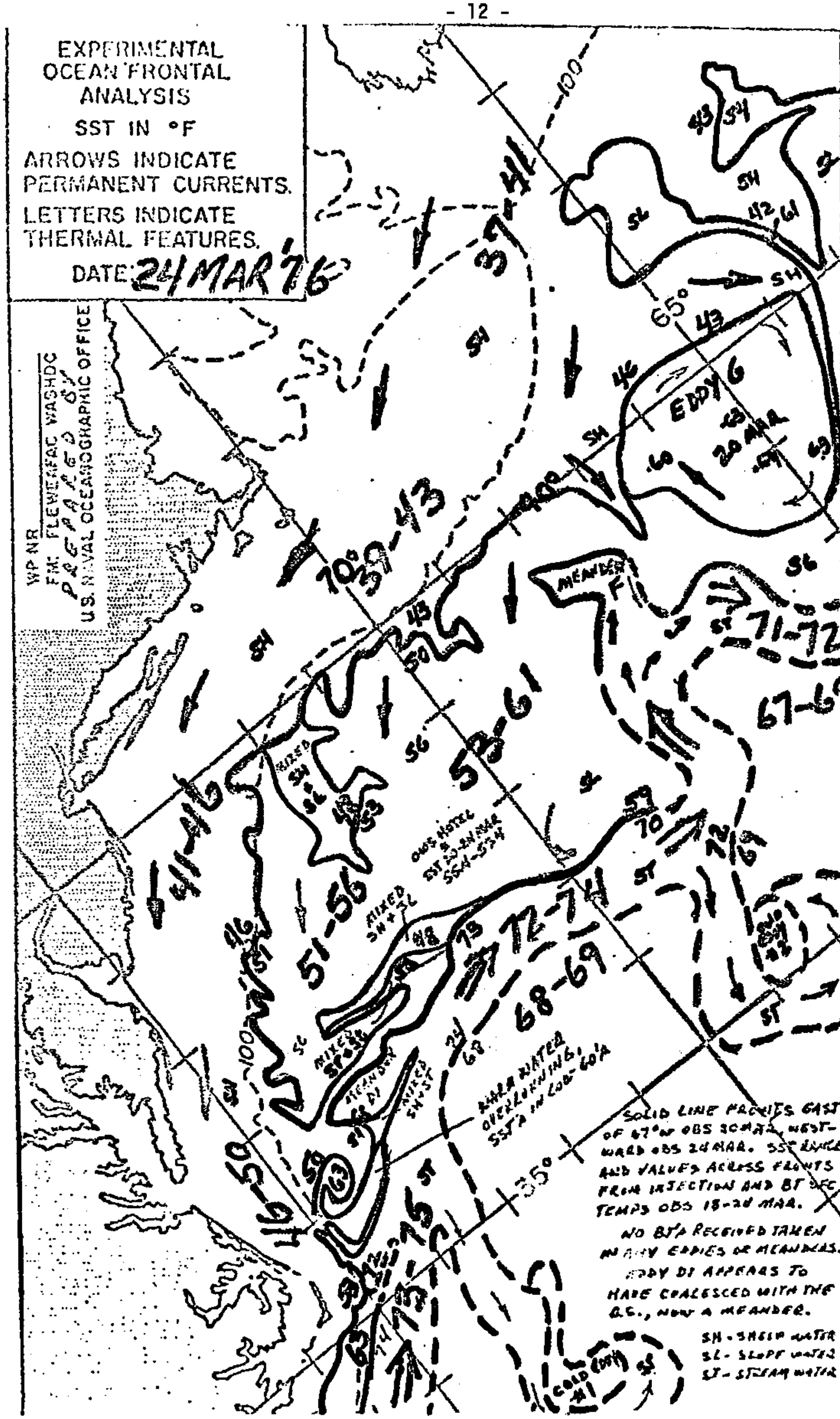
EXPERIMENTAL
OCEAN FRONTAL
ANALYSIS
SST IN °F
ARROWS INDICATE
PERMANENT CURRENTS.
LETTERS INDICATE
THERMAL FEATURES.
DATE: 24 MAR 76
U.S. NAVAL OCEANOGRAPHIC OFFICE
EDDY 6
MEANDER F
SOLID LINE FRONTS EAST OF 67°W OBS 20 MAR., WESTWARD OBS 24 MAR. SST RANGES AND VALUES ACROSS FRONTS FROM INJECTION AND BT SFC TEMPS OBS 18-24 MAR.
NO BT'S RECEIVED TAKEN IN ANY EDDIES OR MEANDERS.
EDDY DI APPEARS TO HAVE COALESCED WITH THE G.S., NOW A MEANDER.
SH - SHELF WATER
SL - SLOPE WATER
ST - STREAM WATER

Figure 6.