Northwest Atlantic Fisheries Organization

Serial No. N1139 NAFO SCR Doc. 86/25

SCIENTIFIC COUNCIL MEETING - JUNE 1986

The Decline of Summer Subsurface Temperatures on the Grand Bank, at 47°N, 1978-1985

by

S. A. Akenhead
Department of Fisheries and Oceans, Fisheries Research Branch
P. O. Box 5667, St. John's, Newfoundland A1C 5X1

Introduction

The attempt to discern an interannual signal in ocean temperatures by occasional sampling is fraught with statistical hazards. Short time scale effects on temperature profiles, such as internal tides, subannual meanders of ocean currents, or mixing from storms, can lead to the appearance of differences between years that are not necessarily real (Mann and Needler, 1967). This effect is called aliasing, meaning that signals from unresolved short time scales are misinterpreted as being from longer time scales.

With this caveat in mind, the annual surveys of the Newfoundland continental shelf, in late July and early August each year, were examined for evidence of shifts in the ocean temperature climate. There were two reasons for this: first, there have recently been economically and politically important events in the fisheries ascribed to shifts in ocean climate, and some immediate address of the available data is required. Second, any more comprehensive analysis will benefit from noting the resolution of oceanic features (i.e. branches of the Labrador Current) and trends available from the historical transects. No address to the corresponding salinity data is attempted in this report.

Methods

Prior to 1982, Nansen bottles with reversing thermometers were used to collect temperatures at standard depths, following well known procedures. After 1982, a CTD probe ws used, with attendant increases in resolution. CTD thermometer calibration was checked against high quality reversing thermometer data collected on each cast. Table 1 lists the dates of the collections.

The data was contoured using an 'objective analysis' routine (Bretherton, et al 1975), using isotropic spatial correlation statistics of the raw data. A factor of 2000 was used to relate depth to horizontal distance. This technique assumes that the spatial correlation statistics are stationary throughout the field to be analyzed, in fact this is blatantly violated by the existence of sharp thermoclines and subsurface fronts.

Because depth is the predominant effect on temperature, all the data, from each occupation of the 47°N line involved, was lumped before fitting a smoothing spline to identify the trends with depth. The splines resulting were evaluated at specific depths to enable comparison between years, and to compare with the impression gained from looking over the temperature contour maps.

Results

The temperature contour maps, with bottom bathymetry, are presented as Figures 1 to 8. The correlation length scales emergent from this isotropic treatment of the data are in the neighborhood of 60 km horizontally or 30 m vertically.

The top of the Grand Bank (49°30'W) was 0.6 to 1.6 degrees in 1978-79, but below 0 degrees in 1982-85. The area of water below -1 degree on the eastern edge of the Grand Bank, corresponding to the 'cold core' of the Labrador Current, increases by about a factor of 5, steadily from 1978 to 1983, and does not noticeably recede after that. This is mirrored in the Avalon Channel, where the -1 degree water appears to spread over a much wider area from 1978 to 1984. The slow and consistent development of these temperature features over many years suggests that the patterns are real, however, there are important problems in the patterns generated and at this stage of analysis, details of the patterns presented are not reliable.

The compression of entire transects into mean temperature at depth profiles of entire transects reinforces the conclusion of substantially increased volumes of cold water on the Grand Bank. These results, in Table 2, demonstrate a trend to more intensive cooling in the 60-100 m layers, and more importantly, large-scale cooling in the 100-250 m range. The decline in temperatures can be traced easily on the computer maps, and involves a drop of about 3 degrees, from about 2 degrees in 140-180 m in 1978 to about -1 degree in 1982-85 at the same depth. The warm values at 60 to 160 in 1980 are due to restriction of cold water to shallower depths on the eastern Grand Bank; there is no change in station locations in this area.

Discussion

The trend of decreasing temperatures on the ocean floor of the Grand Banks is substantiated. In particular, areas which were refuges for fish avoiding sub-zero water in 1978-80 were inundated with cold water in the 1982-85 period. This is evident for those parts of the 47°N transect where the ocean bottom is less than 100 m deep. Presumably fish that were able to inhabit the shallows of the Grand Bank at 47°N, if they cannot tolerate the cold, have had to move south or move into water about 250 m deep on the slopes of the Grand Bank.

The contouring technique used to generate the temperature maps has the property of extrapolating sharp gradients in a non-conservative way, and will generate, for instance in the 1981 map, areas of water below -1.5 degrees when in fact no waters of this temperature were observed. The information that one seeks for fisheries oceanography and ocean climate studies is a time-series of anomalies from the long-term mean. In this case the mean temperature field is two-dimensional. The statistical properties of the anomaly fields are much better behaved than the fields used in the maps presented, and the errors of excessive smoothing of sharp features and generation of spurious features do not arise in contouring. The production of appropriate computer routines for creating climatological anomalies is in development at the Northwest Atlantic Fisheries Centre at this this time.

References

Mann, C. R. and G. T. Needler. 1967. Effects of aliasing on studies of long-term oceanic variability off Canada's coasts. J. Fish. Res. Board Can. 24(8): 1827-30

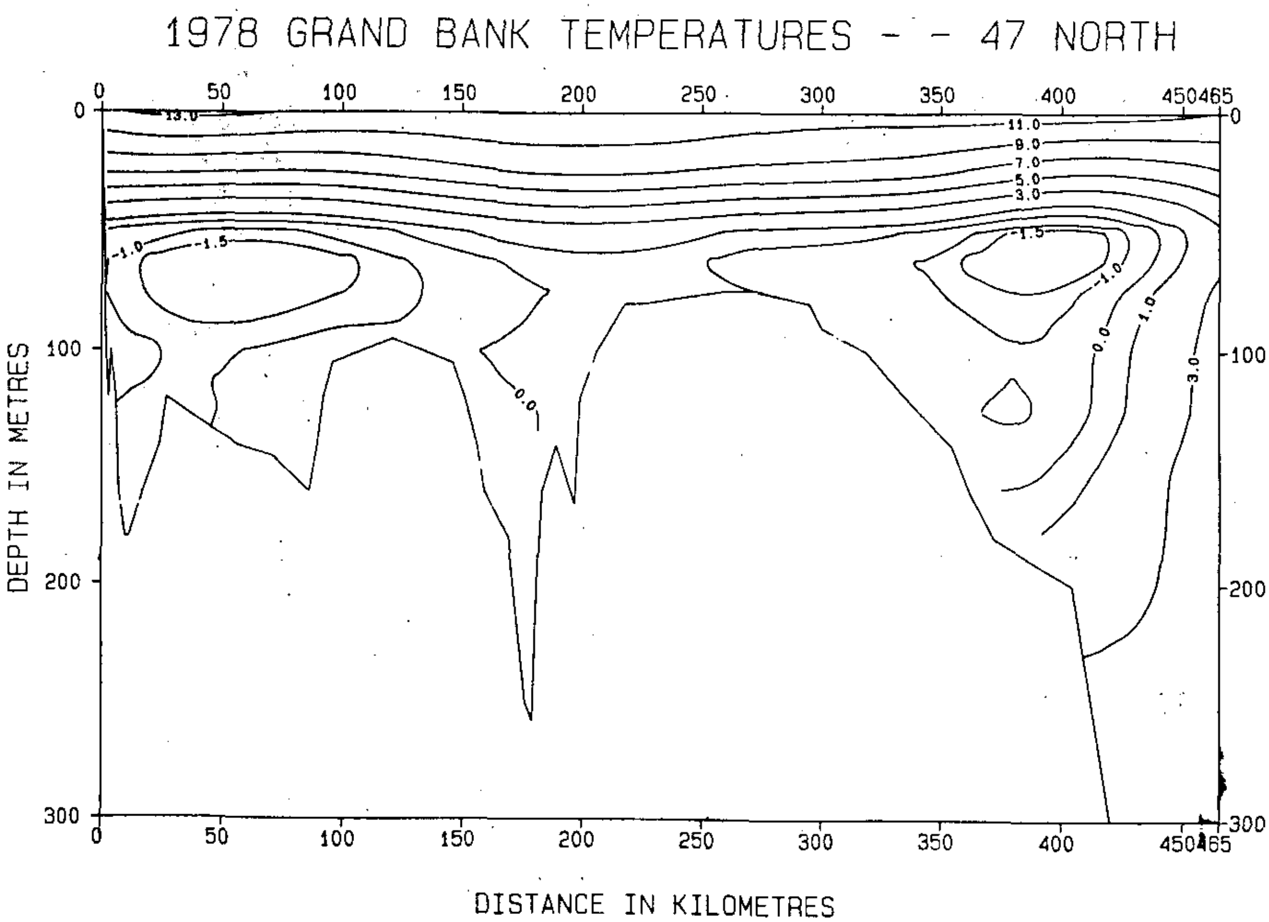
Bretherton, F. P., R. E. Davis and C. B. Fandry. 1975. A technique for objective analysis and design of oceanic experiments. Deep Sea Research 23: 559-582.

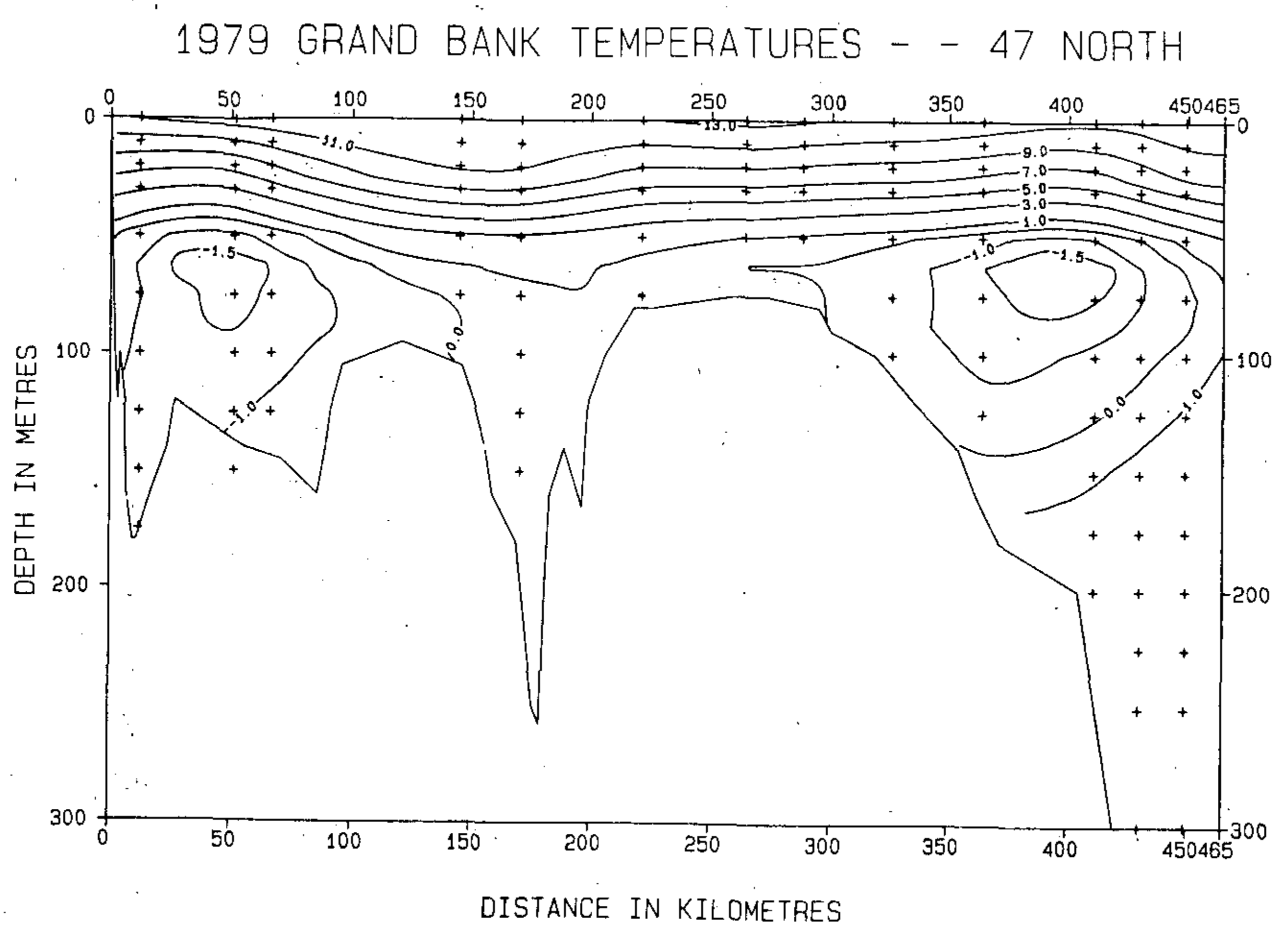
Table 1. Occupation dates of the transects.

Year	Month	Start day	End day
1978	7	28	29
1979	7	27	28
1980	7	20	20
1981	7	30	31
1982	7	27	28
1883	8	6	6
1984	8	5	6
1985	8	15	15

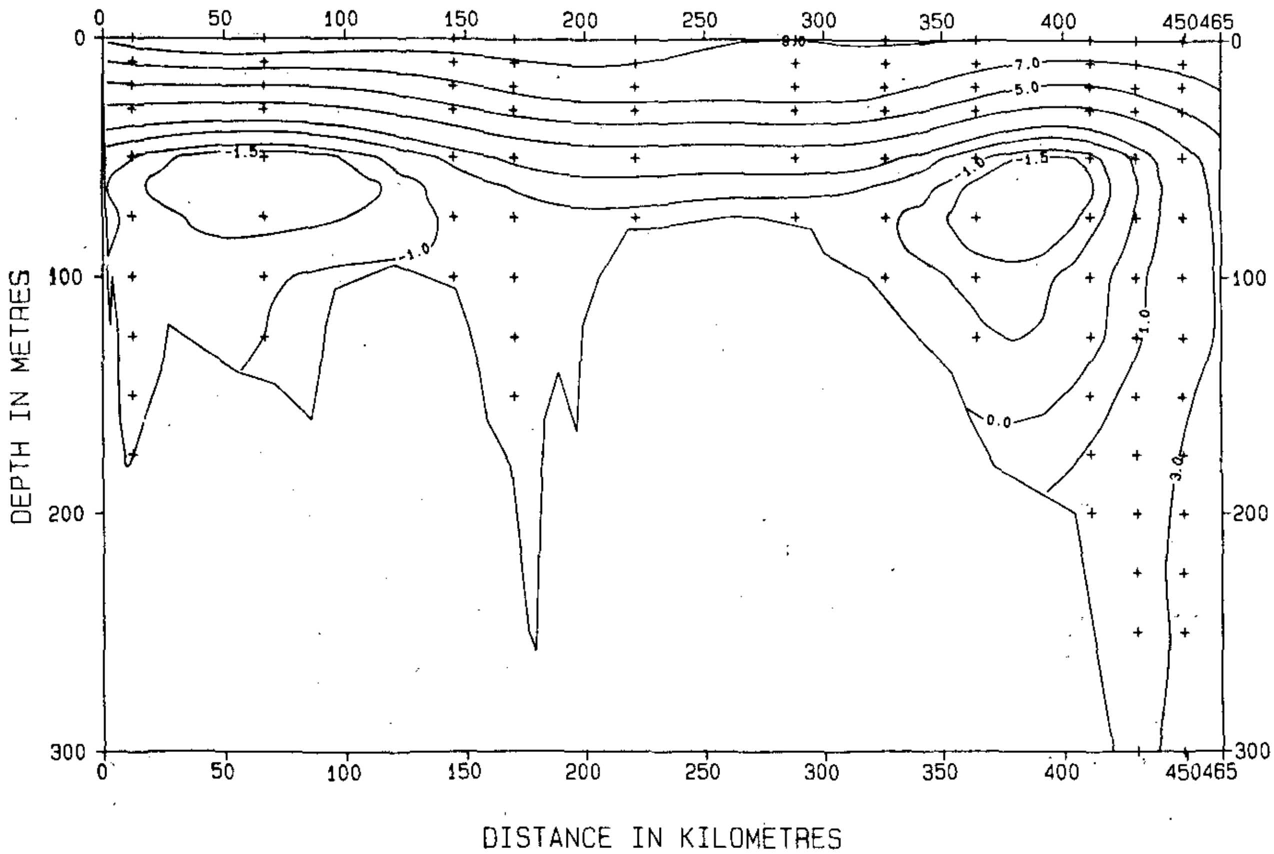
Table 2. Mean temperatures at depths on the Grand Bank, from splines fitted to all data from each annual ocean climate survey.

DEPTH	Year							
(m)	1978	1979	1980	1981	1982	1983	1984	1985
10	11.7	10.8	9.0	11.9	12.8	12.7	14.0	11.2
20	8.5	12.2	8.6	7.5	5.7	8.8	6.7	8.2
30	4.5	8.2	5.0	4.1	1.6	3.7	2.2	2.7
40	1.8	3.8	1.4	2.3	0.4	1.1	-0.2	1.3
50	0.3	1.2	0.4	0.9	-0.1	0.2	-0.8	0.3
60	-0.4	-0.1	0.3	0.0	-0.6	-0.2	-0.8	-0.3
70	-0.4	-0.5	0.1	-0.5	-0.9	-0.4	-0.8	-0.7
80	-0.1	-0.6	0.1	-0.7	-1.1	-0.7	-0.8	-0.9
90	0.2	-0.5	0.1	-0.8	-1.2	-0.8	-0.9	-1.0
100	0.4	-0.5	0.1	-0.7	-1.2	-1.0	-0.9	-1.0
120	1.0	-0.2	0.3	-0.4	-1.1	-1.1	-1.0	-1.1
140	1.4	0.2	0.6	0.0	-1.1	-1.2	-1.0	-1.0
160	1.9	0.6	0.9	0.4	-1.0	-1.1	-0.9	-0.9
180	2.2	1.1	1.4	1.0	-0.9	-0.9	-0.6	-0.6
200	2.5	1.6	1.8	1.5	-0.6	-0.7	0.0	0.0
220	2.8	2.0	2.3	2.1	-0.1	-0.3	0.7	0.8
240	3.0	2.4	2.7	2.6	0.9	0.1	1.5	1.6
260	3.1	2.7	2.9	3.0	1.9	0.7	2.3	2.4
280	3.2	2.9	3.1	3.4	2.2	1.6	3.0	2.7

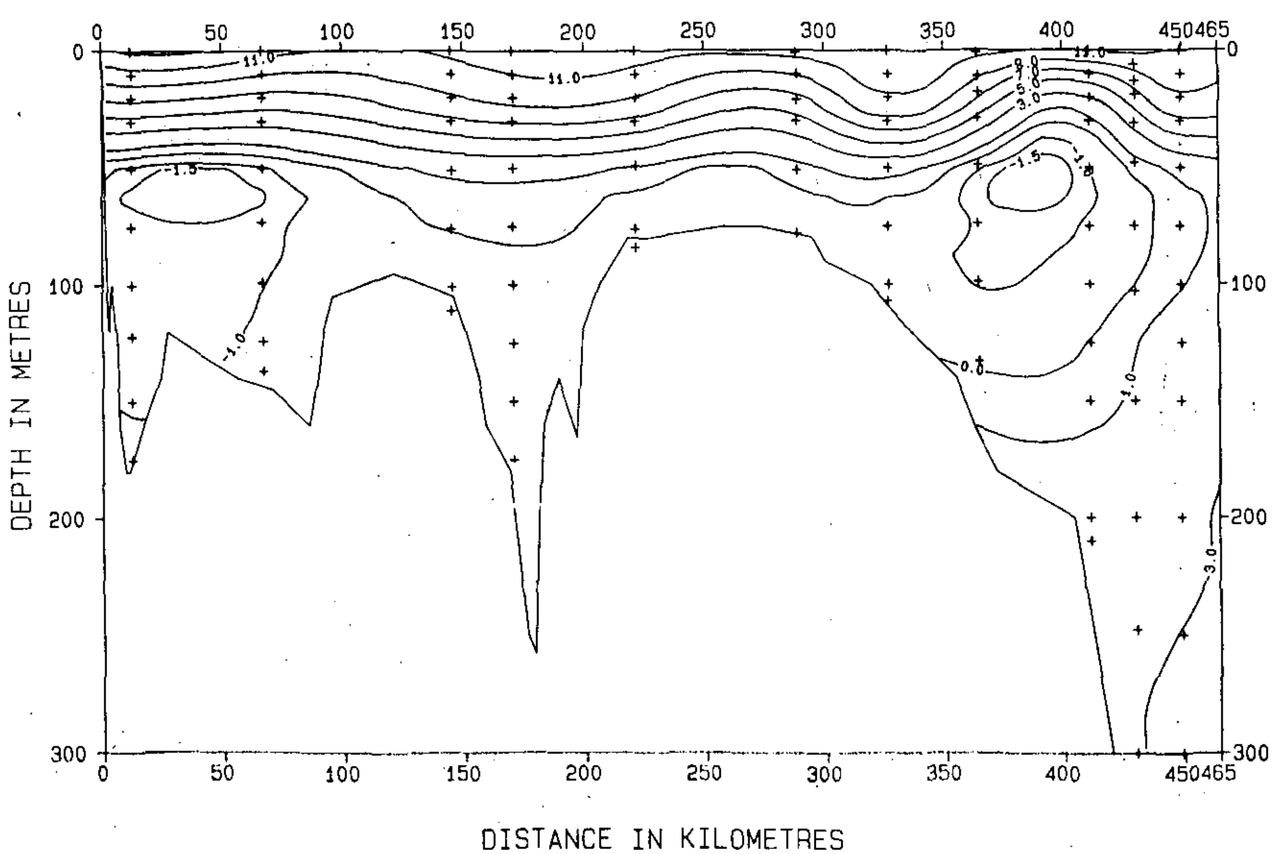

1978 GRAND BANK TEMPERATURES - - 47 NORTH
DEPTH IN METRES
DISTANCE IN KILOMETRES
0
50
100
150
200
250
300
350
400
450465
100
200
300
13.0
11.0
9.0
7.0
5.0
3.0
1.0
0.0
-1.0
-1.5
3.0


1979 GRAND BANK TEMPERATURES - - 47 NORTH
DEPTH IN METRES
DISTANCE IN KILOMETRES
0
50
100
150
200
250
300
350
400
450465
100
200
300
13.0
11.0
9.0
7.0
5.0
3.0
1.0
0.0
-1.0
-1.5

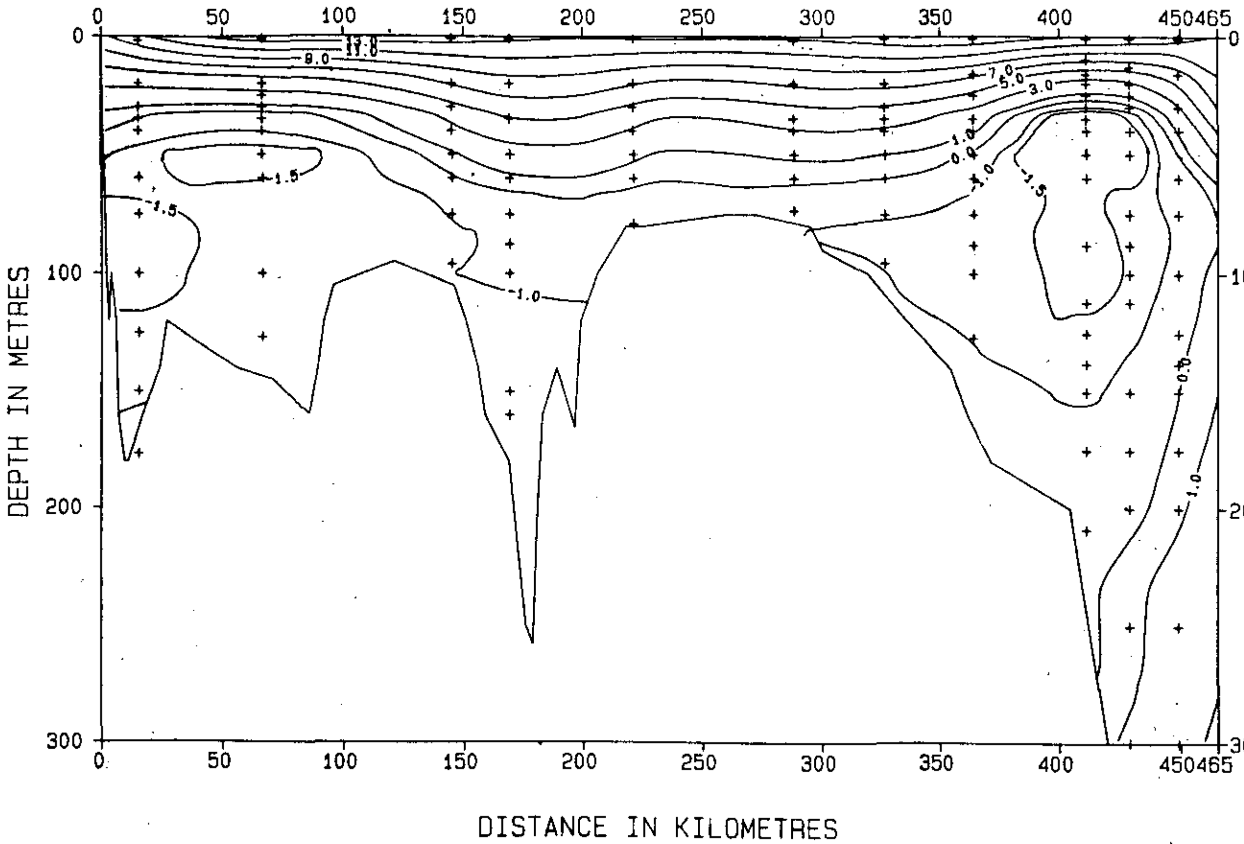
1980 GRAND BANK TEMPERATURES - - 47 NORTH



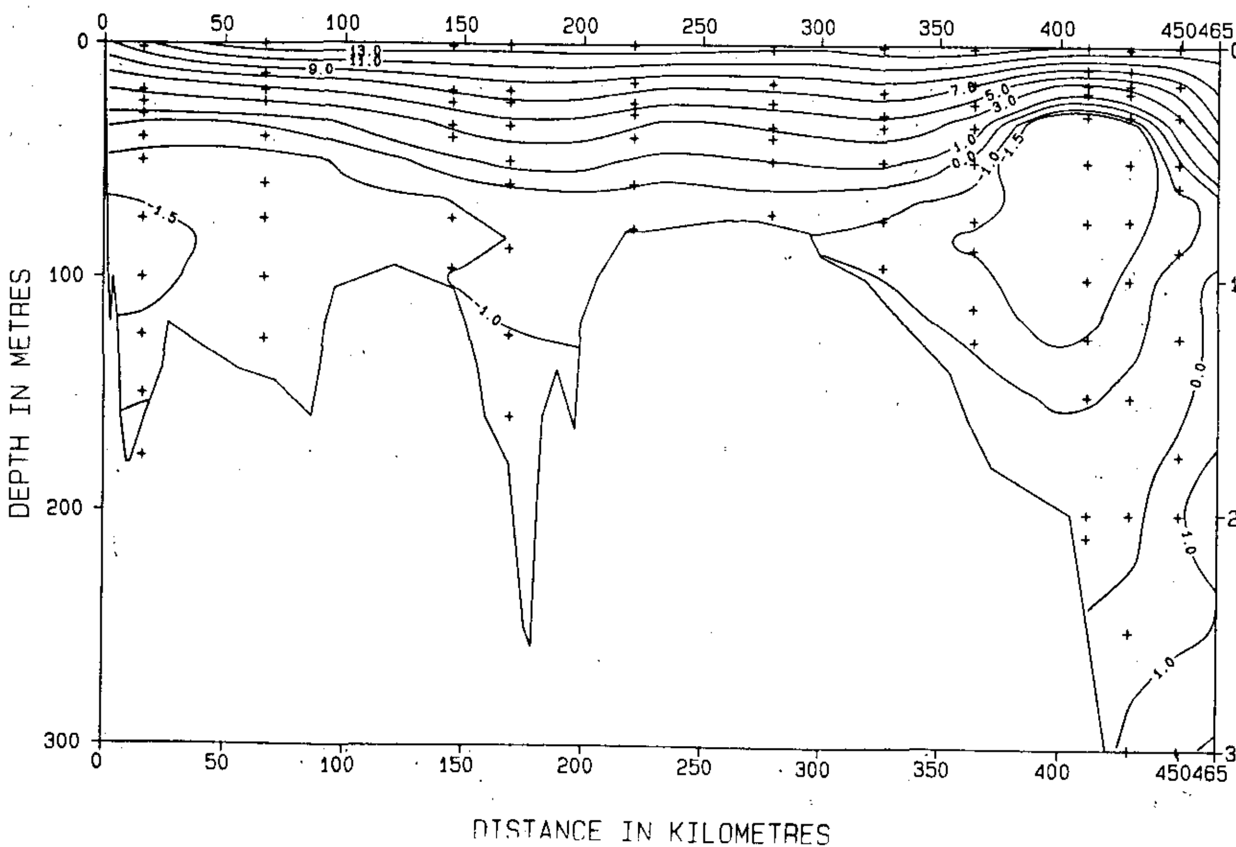
1981 GRAND BANK TEMPERATURES - - 47 NORTH



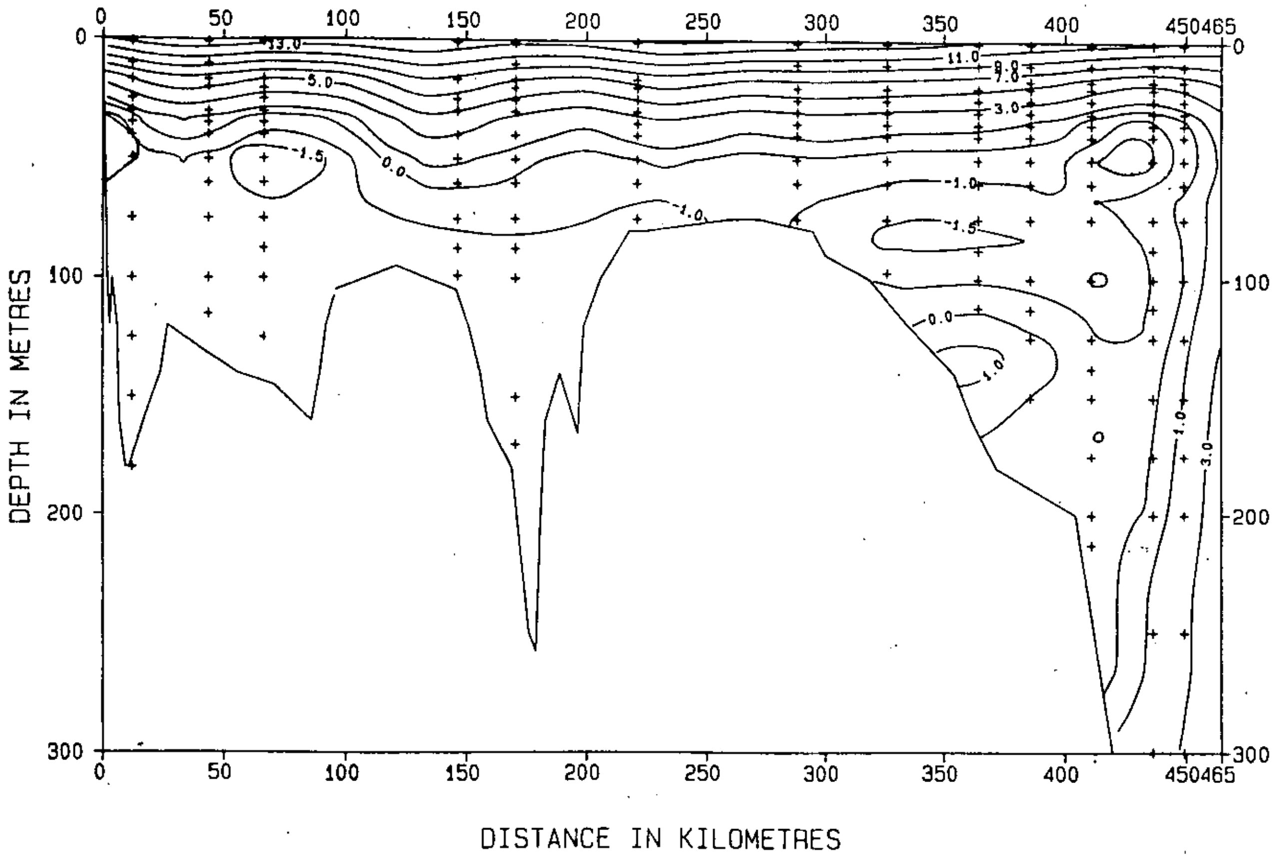
1982 GRAND BANK TEMPERATURES - - 47 NORTH



1983 GRAND BANK TEMPERATURES - - 47 NORTH



1984 GRAND BANK TEMPERATURES - - 47 NORTH



1985 GRAND BANK TEMPERATURES - - 47 NORTH