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A preliminary summary of hydrographic data collected on ICNAF larval herring surveys, 1971-1973

by

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Introduction

Since 1971, member nations of ICNAF have been engaged in a cooperative larval herring survey each fall in the Georges Bank-Gulf of Maine area. The main objective has been a description of the distribution and abundance of the larvae throughout the spawning season (Schnack 1974). In addition, various physical parameters, including temperature, salinity, and meteorological conditions, have been sampled as logistic constraints have allowed. Instrumentation ranged from surface bucket thermometers to the highly sophisticated continuous environmental profiling systems (STD). The objective of this report is to summarize the present state of three years (1971-1973) of hydrographic data, document anomalous conditions, infer water flow where possible, and suggest improvements to future sampling and data exchange and reduction. This paper was written specifically with reference to the ICNAF Environmental Working Group Recommendations (Summ. Doc. 75/7) and for the special discussions on larval herring studies at the 1975 annual meeting (Circular Letters 75/5, 75/13).

Data collection and reporting

Sampling stations were assigned on a gridded scheme by latitude and longitude within the Georges Bank-Gulf of Maine area. Typically, stations were separated by 15' of latitude and 30' of longitude (Circular Letter 74/29). The grid has expanded somewhat through the years around the periphery of the original area, but spacing has remained nearly constant (Figure 1). The original plan was to complete a plankton tow and vertical profiles of temperature and salinity at every station. The temperature data nearly conformed to the operational procedure, and each of the 15 ICNAF larval herring surveys sampled subsurface temperatures either continuously with bathythermographs (BT), expendable bathythermographs (XBT), STD systems, or discreetly with reversing thermometers. However, salinity observations were incomplete on most cruises. In most cases, inadequate cruise time was allotted to permit all the biological and the hydrographic sampling (first priority is given to larval sampling), taking into account the normal incidence of severe weather, mechanical breakdowns, etc. Consequently, the salinity data are extremely sparse throughout the years, with subsurface samples collected on only five of the 10 cruises in 1972 and 1973 and presently available for three cruises. The determinations were made by titration methods, inductive laboratory salinometers, or *in situ* salinometers on STD systems.

The recommended reporting procedure requires that standard hydrographic data summary sheets with temperatures and salinities at specific depths (0, 10, 20, 30, 40, 50, 75, 100, 150 m, and bottom), and temperature and salinity countour charts at three levels (0, 30, 100 m) be submitted to the ICNAF Secretariat by 1 February of the following year. The three levels were selected by the biologists in an attempt to relate larval distribution primarily to temperature characteristics of the water. In reality, the hydrographic data collected during the fall are usually summarized on charts by individual countries in research documents at the following annual meeting. In many cases, the Secretariat has not received the standard summary sheets. However, because of individual data exchange between scientists involved in the larval herring surveys, the Northeast Fisheries Center has acquired all hydrographic summary sheets with the exception of the 1973 USSR data. These data are presented in Tables 1a and 1b for the years 1971-1973 as of 20 April 1975.

A number of discrepancies existed between the requested and reported data. These did not prevent use of the data, but point out the need for a more comprehensive data reporting procedure. The temperature data from FRG (29 October-12 November 1971) were not in a form readily usable at standard depths. Although original logs were available, temperature readings were at nonstandard depths. These data were added to the data set, assuming that inflection points were noted on the logs and linear interpolation was appropriate between readings. Also the USA (4-20 December 1973) subsurface salinity data has not yet been reported in final form, although the preliminary values are available. The delay is caused by necessary calibration and quality control of the STD data, and these will be finalized as soon as the processing is completed. Finally, minor differences from the requested reporting level of 75 m are reported for four cruises. The data are presented for 70 m and/or 80 m, but this is not a serious discrepancy.

Various countries collect additional data on the ICNAF larval herring cruises, but these are not routinely reported to the ICNAF Secretariat. For example, Furtak (1973) mentions that oxygen and phosphate data were collected in 1972. In addition, there are further data collected at the same time in the area, including oxygen, phosphates, nitrates, and silicon (Karavlovsky 1975). Since oxygen and nutrients are valuable tracers of water masses, these additional data, especially if taken on the larval herring surveys, should be reported.

Areal distribution of data

Table 1a indicates the extent of temperature data collected. Twelve of the 15 cruises sampled temperature in the entire region. Figure 1 shows all the planned stations for 1973, including the suggested stations in the central Gulf of Maine. A few stations were more consistently excluded on the Scotian Shelf than in any other area, but may not greatly affect interpretation. However, three cruises did not sample large areas and may limit interpretation of the data. Since the cruise tracks are presented in the original research documents, they will not be reproduced but an overview given.

In 1971 all ships essentially covered the planned area, and in addition the USSR (9-25 October) and USA (2-17 December) occupied extra stations in the central Gulf of Maine not in the original scheme. Most stations not sampled were near the coasts of the USA and Canada.

In 1972 the USSR (22-30 September) covered only Georges Bank and a portion of the Nova Scotian Shelf, and FRG (31 October-11 November) did not sample a portion of the Nova Scotian Shelf. Poland (2-28 October) and USA (28 November-15 December) added extra stations within the Gulf of Maine. Again, other stations appear to be left out because of proximity to land.

In the sampling for 1973, France (16-28 September) sampled Georges Bank, the Scotian Shelf, and eight stations in the eastern Nantucket Shoal-Southern New England region. The USA (4-20 December) did not sample the northern Gulf of Maine and the Nova Scotian Shelf, while Poland added stations within the Gulf of Maine. Although the data from the USSR have not yet been received, Balkovoy, Sushin, and Sigaev (1974) indicate that coverage was completed except for territorial water exclusions (119 stations).

The salinity data in Table 1b were not distributed as widely as the temperature data for the cruises that vertically sampled the water column. The first data to be eliminated for higher priorities were vertical salinity distributions. Table 1c indicates the distribution within each area.

Treatment of data

Since the data on the standard summary sheets are only at certain specific levels, with no means of reconstructing the distribution throughout the water column, horizontal sections for each cruise and standard level were prepared. The temperature and salinity plots used data from the summary sheets (no results from research documents were used) to insure a consistent procedure in contouring. In addition, temperature means were determined at each depth for every cruise in the four general areas--Nantucket Shoals, Georges Bank, Scotian Shelf, and Gulf of Maine--and an additional area, the Northeast (Fundian) Channel, for depths greater than 200 m near this entrance to the Gulf of Maine. Also, grand weighted means for the fall season were calculated and the data are presented in Table 2. Salinity means were calculated only for the surface, as data from subsurface samples were too sparse. The horizontal sections and the mean temperatures will be discussed in detail after looking at data accuracy.

For this paper, every data point was included, although there were some highly probable errors. Some of these errors are discussed below as an indication of the quality control procedures needed. However, discrimination between transcription or other human errors, instrument failures, and shifts in the distribution of properties, was nearly impossible in many cases because the data are in summary form.

Quality of data

A very difficult portion of any cooperative research program is the comparability of data collected by many different sources using varied instrumentation. While the plankton portion of the larval herring survey has developed standardized procedures, the hydrographic data collection has not. An attempt was made to find data suitable for possible quality control checks during the three available years. Identical stations sampled within three days of each other were sought to compare hydrographic data among vessels. This time was chosen because it corresponds to the average duration of weather systems, and no better criteria were available. For the 15 cruises, only six stations were found to have such an overlap and have data available: Poland (2-28 October 1972) and USSR (12-28 October 1972), stations 106, 107, 108, 109, 114, and 115. These data are presented in Table 3.

Deviations from a total of 46 temperature pairs (temperatures at corresponding stations and depths) are plotted in Figure 2. Although the results are tenuous because of small sample sizes and the short-term variability of a shallow-water ocean, a mean temperature deviation is present at .3-5° C. Such differences in temperature do not affect interpretation of data in terms of the broadest scale features found on the continental shelf in the area (*e.g.* the shelf-slope interface, intrusions of slope water into the Northeast Channel, distinction between Scotian Shelf water and surrounding waters). However, smaller-scale processes may be masked (*e.g.* heat content of the water column as the season progresses, reaction to storm passage, and analyses using dynamic heights). The deviations of the 24 salinity pairs (Figure 2) have a mode at 0 °/oo which suggests there were no major differences in analytical techniques. However, the level of accuracy represented by the reported data is only .1 °/oo, even though accuracies by the titration method should be ± .02 °/oo, and ± .003 °/oo for inductive salinometers. Thus the agreement represented by the reported salinity data could still mask consistent differences which could be significant for studying smaller scale processes away from fronts. For example, the understanding of mixing processes that transform the slope water as it moves into the interior of the Gulf of Maine and the stability of a water column may depend on salinity differences of ± .02 °/oo. The need for such salinity data in one case is presented later.

Other possible comparisons in 1973 involving Poland, USSR, and FRG must be postponed until the USSR data arrive. Controlled comparisons between participating countries would help the interpretation of data at other than the broadest scales.

A number of obvious erroneous data values have been found on the horizontal sections. Examples are presented to show the nature of the errors, without any attempt to determine the causes. The FRG cruise, 31 October-11 November 1972, has salinity values that range from 37.4-38.1 °/oo and temperatures about 19° C, at two stations taken at the edge of the continental shelf. These values are higher than any salinities encountered at that temperature in the North Atlantic Ocean (Wright and Worthington 1970). Temperature data from the USA, 21 September-4 October 1971, show many cells within the area with very large gradients between the centers of the cells. These conditions are usually found only in small-scale extreme mixing at frontal zones, and not in the interiors of regions like the Gulf of Maine.

These examples of errors show that more attention must be given to the initial quality control of the hydrographic data, and that original records should be made available to help correct errors and evaluate anomalous conditions so that investigators will not resort to arbitrary decisions on data acceptability.

Results

Since these data are limited to temperature in most cases, and water masses cannot be identified or densities determined, a qualitative description of major features in the horizontal sections is given. Two major areas of low temperatures persisted below the surface throughout the period September-November for the three years: the first at the eastern edge of Georges Bank, and the second in an area east of Nantucket Shoals in the northern portion of Great South Channel. Representative contour charts at 40 m are presented, although these features generally extended vertically from 20 m to 75 m. Below 75 m the data are more sparse and do not allow definite interpretations.

An isolated pocket of colder water at the eastern edge of Georges Bank was found on succeeding cruises in 1971 (Figures 3 and 4). The center of this area shifted toward the south as the season progressed, and temperature at 40 m decreased from 7.9° C to 5.1° C. (Isolation must be assumed in the second case; the temperature value is at the boundary of data). The temperature of 7.9° C is lower than any temperature in the eastern area during the September cruise. Thus this area of cool water is probably a local phenomenon and not introduced by horizontal advection from another area. In 1973 evidence for a similar pattern was observed in the surface salinity as well as the 40 m temperatures (Figures 5 and 6). At approximately the same position as the low temperatures shown in Figures 3 and

4, the surface salinity in 1973 was 31.0 $^{o}/oo$ surrounded by much higher values (Figure 5). The low values could be from the Scotian Shelf where values below 29 $^{o}/oo$ were recorded, or they could be caused by local rainfall. However, the sky was only 50% cloudy during this period and the former seems more likely. The 1973 temperature pattern at 40 m is elongated along the eastern edge of the bank at the 100 m contour (Figure 6). In 1972 this temperature pattern appears as a tongue at times (Figures 7 and 8) from the Scotian Shelf across the Northeast Channel.

At present a number of possibilities can explain the 40 m temperature distributions: 1. Local upwelling could produce zones of cold water. Evidence from bottom drifter recoveries indicates that Northeast Channel is an upwelling zone (Lauzier 1967). 2. Intermittent intrusions of Scotian Shelf water across Northeast Channel, either as a continuous tongue or isolated bubbles, also would produce these distributions. 3. Complex but yet unexplained interactions at the shelf-slope water boundary, caused by currents flowing at the unstable interface.

Even though an explanation of the cold temperatures is not possible at present, the eastern end of Georges Bank was cooler than the remainder of the Bank throughout the fall, with the temperatures becoming more uniform in December. Future investigations of this area should include at least salinity, oxygen, and nutrients to permit definite identification of water masses.

A second area of low temperatures persisted in northern Great South Channel. Figure 6 illustrates the very low temperatures compared to the temperatures at 40 m throughout the entire region. The largest volume of cold water was found in 1972 (Figure 8) when a value of 5.8° C was recorded off Cape Cod. The striking feature is the large temperature gradient present above the sill depth in Great South Channel. The available salinity data do not show a corresponding salinity gradient in this area. The average monthly temperatures from 1940-1959 computed from existing BT and hydrographic data (Colton and Stoddard 1972) show a gradual warming throughout the fall (September-November) in this area at 40 m, with the lowest temperature about 9° C. A mean vertical section through Great South Channel has showed water less than 6° C only below 70 m in September and disappearing in November. The source of this cold water and the mechanism for its retention above the sill in Great South Channel are not known at present but appear to be local phenomena.

Most of the results presented above relied heavily on the horizontal distribution of temperatures alone. However, during December 1972 an intrusion of water from the Scotian Shelf onto eastern Georges Bank can be seen at the surface in both temperature and salinity contour charts, probably extending to a depth between 10 and 20 m. Figures 9 and 10 show the tongue of relatively fresh, cool water across the eastern edge of the Bank. This temperature pattern is repeated at 10 m. However, beginning at 20 and continuing to 100 m, water greater than 9° C penetrates into Northeast Channel. This temperature distribution is best illustrated by the 30 m contour chart (Figure 11). The interesting aspects of these two flows are the shear that must exist between 10 and 20 m with intense mixing resulting, and the erroneous conclusions which may be drawn by using surface drifts to indicate circulation throughout the water column.

Shelf-slope front

An interface between the coastal and oceanic waters exists along the east coast of the United States and Canada, beginning at Cape Hatteras where the Gulf Stream leaves the coast. Steep gradients of temperature, salinity, oxygen, and nutrients characterize this zone. Definition of the front, from data collected on the ICNAF larval herring cruises, was carried out mostly with temperature data, thus leaving ambiguous areas where the gradients flattened. The center of a steep gradient was defined as the frontal position at each depth. Using this criterion, a "frontal corridor" was found along the southern edge of Georges Bank west of about 41° 15' N, 66° W. The "corridor" was bounded generally by the 80 and 2,000 m isobaths. The approximate location of the front is represented in Figure 12 for all cruises in 1973. Excursions of the order of 30-40 NM were normal. East of the above point, the interface left shallow water on many occasions, while at other times the front followed the topography and penetrated into Northeast Channel. Again, we are at the bounds of the data and interpretations become difficult.

West of Georges Bank, the front was found further onto the Nantucket Shoals area, often at the 60 m isobath, showing greater penetration of oceanic waters in this region. Although the front was found in Great South Channel, there is no evidence to support inflow to the Gulf of Maine through this area. This supports the conclusions from the horizontal salinity sections where no gradients were found.

Although the schematic view of the front is a salt wedge, the area is so dynamic that vigorous mixing and meandering can completely distort this in a large number of cases. Since large amounts of shelf water can be lost through the frontal zone, further investigation in relation to survival of the planktonic communities seems necessary.

Mean temperature trends

The mean temperatures for each month (defined by the major portion of any cruise) were plotted for the areas defined in Figure 1 and are presented in Table 2 and Figures 13-17. The most striking features are the sharp rises in temperatures at 100 m through the fall and the generally higher temperatures at depth in all areas in 1973. The seasonal temperature pattern at 100 m based on the period 1940-1959 (Colton and Stoddard 1972) shows a rise of about 1° C for much of the Gulf of Maine from October to November, but then nearly constant conditions into December in the range 6°-9° C. On the edge of the continental shelf, the temperatures show a small cooling trend through the season. The magnitude of the temperature increase in the Gulf of Maine from the 1971-1973 data is greater than the long-term mean rise (1° C), and the observed temperature rise on the seaward edge of Georges Bank is opposite to the long-term trend. Reasons for an increase in temperature of the area are not apparent from the data, but there is building evidence for a rise in the temperatures throughout the continental shelf area during the last few years. In the New England area, Konstantinov and Noskov (1975) in the USSR research report indicate warming from 1966; and Davis *et al.* (1975) shows a progressi intrusion of bottom waters, probably slope water, with temperatures greater than 8° C, into the Gulf of Maine in the spring, particularly since 1971.

Recommendations for future work

In light of the previous discussions on the data and results obtained from the larval herring surveys in 1971-1973, a number of suggestions are made for improving the quality and exchange of hydrographic data.

1. Methods should be adopted for inter-vessel comparisons of hydrographic equipment and procedures during the cruise period. Even if comparisons could only be carried out between each succeeding pair of ships in the sequence, the possibility exists to intercalibrate techniques and permit more accurate analyses.

2. Original data should be submitted instead of hydrographic summary sheets. Although the exact form of reporting is open, serious consideration should be given to immediate implementation of the MEDS data-handling proposal (Summ. Doc. 75/7). The original data would allow important types of analyses (*e.g.* thermocline breakdown, frontal analysis), which are not possible with the present form of the data, and the original data would permit better quality control. These data should be submitted as quickly as possible, so that a synthesis of the data collected during the fall would be available at the subsequent annual meeting.

3. In order to be able to infer medium-scale water movements with reasonable assurance (based on sampling intervals on the order of three weeks), hydrographic or STD casts should be completed at each station and include nutrients and oxygen. This level of effort would add about five days of station time to each cruise. Given a complete series of these observations, frontal positions could be determined with reasonable precision, water-mass analysis could be carried out, and causes for events like the rise in deep-water temperatures (*e.g.* catastrophic overturn, slope-water intrusion) could be investigated. The additional salinity data, if based on determinations made by inductive salinometers (accuracy ± .003 °/oo) would permit the sense of residual currents to be determined through geostrophic analysis even in shallow water where these are second-order flows. Geostrophic calculations could be done with temperature and salinity data alone but no additional time would be required to collect the oxygen and nutrient samples; and these latter parameters would be invaluable for water-mass analysis and other biological studies. It is felt that a level of investigation much below that indicated would permit only detection of gross changes in water masses. Ultimately the ability to link the field of motion to driving forces in a way leading to a predictive capability will require the direct measurement of currents by both Eulerian and Lagrangian methods, over and above the standard hydrographic surveys.

The USSR research report (Konstantinov and Noskov 1975) provides an example of geostrophic analysi to describe the summer-autumn circulation in the Georges Bank area. In addition, areas of convergence an divergence are delineated. Unfortunately, the procedures by which the upwelling and downwelling were cal culated are not mentioned, and clarification of the methods would be useful for future research in the ar

If expanded hydrographic sampling unduly restricts the scope of the biological program, then perhaps additional ships dedicated solely to hydrographic sampling should be considered. The area could thus be covered more synoptically and perhaps improve quality control in hydrographic studies; and the ships formerly performing both tasks could add specialized biological experiments or fill in gaps in larval distribution.

4. An atlas should be prepared from the existing hydrographic data, to provide background information for the first years. The number of contoured levels prepared were too numerous to present here. However, a consistent method of contouring would allow investigators to compare various months and years without bias from different interpretations and procedures. In order to insure adequate quality control and permit construction of vertical sections of temperature and salinity, the atlas should be based on original rather than summary data.

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Table 1a

Temperature Data Available at NEFC from ICNAF Larval Herring Surveys, 1971-1973

Country	Date	# of Sta.	0 M	10 M	20 M	30 M	40 M	50 M	75 M	100 M	150 M	Other
1973												
France	16-28 Sept	83	x	x	x	x	x	x	x	x	x	
Poland	29 Sept-21 Oct	132	x	x	x	x	x	x	x	x	x	
USSR	15 Oct-1 Nov	119										
FRG	28 Oct-8 Nov	126	x	x	x	x	x	x	x	x	-	
USA	4-20 Dec	114	x	x	x	x	x	x	-	x	-	70
1972												
USSR	22-30 Sept	64	x	x	x	x	x	x	x	x	-	
Poland	2-28 Oct	128	x	x	x	x	x	x	x	x	-	
USSR	12-28 Oct	105	x	x	x	x	x	x	x	x	-	
FRG	31 Oct-11 Nov	119	x	x	x	x	x	x	x	x	-	
USA	28 Nov-15 Dec	127	x	x	x	x	x	x	x	x	-	
1971												
France	9-24 Sept	125	x	x	x	x	x	x	x	x	x	
USA	21 Sept-4 Oct	115	x	x	x	x	x	x	-	x	x	80
USSR	9-25 Oct	100	x	x	x	x	x	x	-	-	-	60 70 80
FRG	29 Oct-12 Nov	105	x	x	x	x	x	x	x	x	x	
USA	2-17 Dec	143	x	x	x	x	x	x	-	x	x	80

Table 1b

Salinity Data Available at NEFC from ICNAF Larval Herring Surveys, 1971-1973

Country	Date	# of Sta.	0 M	10 M	20 M	30 M	40 M	50 M	75 M	100 M	150 M	Other
1973												
France	16-28 Sept	83	x	-	-	-	-	-	-	-	-	
Poland	29 Sept-21 Oct	132	x	-	-	-	-	-	-	-	-	
USSR	15 Oct-1 Nov	119										
FRG	28 Oct-8 Nov	126	x	x	x	x	x	x	x	-	-	
USA	4-20 Dec	114	x	x	x	x	x	x	-	x	x	70
1972												
USSR	22-30 Sept		-	-	-	-	-	-	-	-	-	
Poland	2-28 Oct	128	x	-	-	-	-	-	-	-	-	
USSR	12-28 Oct	105	x	x	x	x	-	x	x	x	-	
FRG	31 Oct-11 Nov	119	x	x	x	x	x	x	x	-	-	
USA	28 Nov-15 Dec	127	x	-	-	-	-	-	-	-	-	
1971												
France	9-24 Sept	125	x	-	-	-	-	-	-	-	-	
USA	21 Sept-4 Oct		-	-	-	-	-	-	-	-	-	
USSR	9-25 Oct		-	-	-	-	-	-	-	-	-	
FRG	29 Oct-12 Nov		-	-	-	-	-	-	-	-	-	
USA	2-17 Oct		-	-	-	-	-	-	-	-	-	

Table 1c

Areal Distribution of Salinity Profiles from Data on 1971-1973 ICNAF Larval Herring Surveys

Year	Country	Dates	Total # of vert. sta.	Number of Profiles in Each Subsection: Nantucket Shoals	Georges Bank	Scotian Shelf	Gulf of Maine	Northeast Channel
1973	France	16-28 Sep	0					
	Poland	29 Sep-21 Oct	0					
	USSR	15 Oct-1 Nov	-	-	-	-	-	-
	FRG	28 Oct-8 Nov	85	34	24	0	22	8
	USA	4-20 Dec	0+					
1972	USSR	22-30 Sep	0					
	Poland	2-28 Oct	0					
	USSR	12-28 Oct	105	23	42	15	20	15
	FRG	31 Oct-11 Nov	57	16	23	0	17	5
	USA	28 Nov-15 Dec	0					
1971	No vertical salinity profiles taken.							

+ Reported as zero because data is not yet in final form, preliminary results available.

Table 2

Mean Temperatures (°C) From Data Obtained On ICNAF Larval Herring Cruises 1971-1973

Date	Depth	Nantucket Shoals	Georges Bank	Scotian Shelf	Gulf of Maine	Northeast Channel
	0 m					
9/24 Sep 1971		19.2/26+	18.0/40	13.3/18	16.9/26	16.9/12
21 Sep-4 Oct 1971		18.6/23	16.9/44	12.1/18	15.8/25	15.7/17
9-25 Oct 1971		16.6/19	14.6/41	11.9/12	12.3/24	13.4/13
29 Oct-12 Nov '71		13.7/24	14.0/36	12.1/17	11.7/24	13.5/14
2-17 Dec 1971		9.5/18	9.7/42	7.7/20	7.9/49	8.2/15
22-30 Sep 1972		----	16.0/42	11.9/14	15.2/8	14.5/16
2-28 Oct 1972		16.8/29	13.8/42	10.0/21	12.7/33	12.3/16
12-28 Oct 1972		15.5/23	12.5/42	9.8/15	11.8/20	11.4/16
31 Oct-11 Nov '72		13.2/28	11.7/41	9.4/7	10.2/24	10.8/16
28 Nov-15 Dec '72		10.1/29	9.5/42	7.4/21	8.0/29	8.1/16
29 Sep-21 Oct '73		17.0/30	15.3/42	11.6/21	13.3/30	13.3/16
28 Oct-8 Nov 1973		14.3/30	13.0/42	9.8/21	10.9/26	10.5/16
4-20 Dec 1973		10.7/32	10.1/42	8.4/2	7.4/25	8.4/15
16-28 Sep 1973		15.4/8	16.9/35	15.6/22	15.2/7	15.8/15
	10 m					
9-24 Sep 1971		18.7/26	17.3/40	13.0/18	16.2/26	16.1/12
21-Sep-4 Oct '71		18.3/23	16.6/44	11.9/18	15.5/25	15.5/16
9-25 Oct 1971		16.6/19	14.6/41	11.5/12	12.3/24	13.0/13
29 Oct-12 Nov '71		13.5/23	13.8/38	11.5/17	11.5/27	13.1/11
2-17 Dec 1971		9.6/18	9.8/42	7.9/20	7.9/49	8.2/15
22-30 Sep 1972		----	16.0/42	11.7/14	15.3/8	14.5/16
2-28 Oct 1972		16.7/29	13.8/42	9.9/21	12.6/33	12.2/16
12-28 Oct 1972		15.5/23	12.5/42	9.8/15	11.8/20	11.4/16
31 Oct-11 Nov '72		13.2/28	11.7/41	9.4/7	10.2/24	10.8/16
28 Nov-15 Dec '72		10.2/29	9.6/42	7.5/21	8.3/29	8.3/16
16-28 Sep 1973		14.8/8	16.7/35	12.3/22	14.9/7	15.6/15
29 Sep-21 Oct '73		17.0/30	15.3/42	11.6/21	13.3/30	13.3/16
28 Oct-8 Nov 1973		14.2/30	13.0/42	9.8/21	10.9/26	10.5/16
4-20 Dec 1973		11.0/32	10.3/42	8.6/2	8.3/25	8.5/15
	20 m					
9-24 Sep 1971		16.4/26	16.3/40	12.3/18	12.8/26	14.6/12
21 Sep-4 Oct '71		18.2/22	16.2/43	11.4/18	12.9/25	14.7/16
9-25 Oct 1971		16.6/19	14.1/41	11.2/18	12.2/24	12.7/13
29 Oct-12 Nov '71		13.6/23	13.6/38	11.1/17	11.4/27	12.9/11
2-17 Dec 1971		9.7/17	9.9/42	7.9/20	8.0/48	8.3/15
22-30 Sep 1972		----	15.5/42	11.1/14	15.0/8	13.9/16
2-28 Oct 1972		16.5/29	13.8/42	9.8/21	12.4/33	12.1/16
12-28 Oct 1972		15.6/23	12.4/42	9.7/15	11.7/20	11.2/16
31 Oct-11 Nov '72		13.2/28	11.7/41	9.4/7	10.2/24	11.1/16
28 Nov-15 Dec '72		10.5/29	9.9/42	7.7/21	8.5/29	8.5/16
16-28 Sep 1973		13.5/8	16.4/35	12.0/22	13.9/7	15.2/15
29 Sep-21 Oct 1973		16.9/30	15.3/42	11.5/21	12.9/30	13.2/16
28 Oct-8 Nov 1973		14.2/30	13.0/42	9.8/21	10.9/26	10.6/16
4-20 Dec 1973		11.3/32	10.6/42	8.8/2	8.5/25	8.8/15

+ Number of observations

---- Data absent

(Mean Temperatures cont'd.)

Date	Depth	Nantucket Shoals	Georges Bank	Scotian Shelf	Gulf of Maine	Northeast Channel
	30 m					
9-24 Sep 1971		13.7/26	15.0/40	11.6/18	10.7/26	12.5/12
21 Sep-4 Oct '71		15.8/23	15.2/43	10.0/19	10.8/25	12.9/16
9-25 Oct 1971		16.5/19	13.8/41	10.6/11	11.8/24	12.4/12
29 Oct-12 Nov '71		13.7/23	12.9/38	10.8/17	11.1/27	11.9/11
2-17 Dec 1971		9.8/17	9.9/42	7.9/20	8.1/48	8.3/15
22-30 Sep 1972		----	15.0/42	10.3/14	13.8/8	12.9/16
2-28 Oct 1972		15.5/29	13.6/42	9.6/21	11.4/33	11.6/16
12-28 Oct 1972		13.0/27	11.6/41	9.3/7	10.1/24	10.8/16
28 Nov-15 Dec '72		10.6/28	10.1/42	7.9/21	8.6/29	8.6/16
16-28 Sep 1973		12.5/8	15.3/35	11.5/22	11.5/7	13.3/15
29 Sep-21 Oct '73		16.0/30	15.2/42	11.0/21	12.1/30	13.0/16
28 Oct-8 Nov '73		13.8/30	13.0/42	9.9/21	10.8/26	10.6/16
4-20 Dec 1973		11.6/31	10.8/42	8.8/2	8.6/25	9.0/15
	40 m					
9-24 Sep 1971		11.01/23	13.8/40	11.0/18	8.9/26	10.6/12
21 Sep-4 Oct '71		13.2/21	13.8/43	9.8/18	9.1/25	10.9/16
9-25 Oct 1971		16.2/18	13.6/38	10.4/7	10.7/24	11.5/11
29 Oct-12 Nov '71		13.8/21	12.0/37	10.4/17	10.6/27	10.7/11
2-17 Dec 1971		10.2/15	10.0/39	8.0/19	8.2/46	8.5/15
22-30 Sep 1972		----	13.6/41	9.6/14	10.2/8	10.5/16
2-28 Oct 1972		13.9/25	13.2/38	9.4/21	10.0/32	10.6/16
12-28 Oct 1972		14.0/22	11.9/34	9.4/15	9.4/20	9.6/15
31 Oct-11 Nov '72		13.0/27	11.2/35	9.2/7	9.8/24	10.6/16
28 Nov-15 Dec '72		11.2/26	10.2/42	8.0/21	8.7/29	8.6/16
16-28 Sep 1973		10.9/5	14.0/21	10.7/14	10.4/3	13.2/6
29 Sep-21 Oct '73		13.7/30	14.7/41	10.5/21	10.6/30	12.2/16
28 Oct-8 Nov 1973		13.6/29	13.0/40	9.8/21	10.2/26	10.5/16
4-20 Dec 1973		11.8/31	10.7/40	8.9/2	8.3/24	9.2/15
	50 m					
9-24 Sep 1971		9.8/19	12.6/37	10.7/17	7.8/26	9.5/12
21 Sep-4 Oct 1971		12.1/16	12.5/40	9.5/17	8.0/25	9.3/16
9-25 Oct 1971		14.9/16	13.4/26	9.7/8	9.7/23	10.1/11
29 Oct-12 Nov '71		14.2/15	11.3/33	9.9/16	9.8/27	9.1/11
2-17 Dec 1971		10.4/13	10.1/31	8.1/19	8.2/45	8.4/15
22-30 Sep 1972		----	12.0/35	9.1/14	7.6/8	9.1/16
2-28 Oct 1972		12.3/21	12.0/31	9.2/20	8.9/33	9.8/16
12-28 Oct 1972		12.7/19	11.3/31	9.1/15	8.0/19	9.2/16
31 Oct-11 Nov '72		13.0/19	10.4/29	9.1/7	9.1/24	10.0/16
28 Nov-15 Dec '72		11.8/21	10.5/34	8.1/20	8.8/29	8.7/16
16-28 Sep 1973		12.2/6	12.1/28	10.2/21	8.9/7	9.8/15
29 Sep-21 Oct 1973		12.2/25	13.6/36	10.2/21	9.3/30	11.1/16
28 Oct-8 Nov 1973		13.2/23	13.1/35	9.7/21	9.1/26	10.0/16
4-20 Dec 1973		12.9/23	11.1/36	9.0/21	8.9/23	9.3/15

(Mean Temperatures cont'd.)

Date	Depth	Nantucket Shoals	Georges Bank	Scotian Shelf	Gulf of Maine	Northeast Channel
	100 m					
9-24 Sep 1971		8.9/7	9.2/13	9.7/10	6.5/25	8.0/12
21 Sep-4 Oct '71		10.4/6	8.4/15	8.8/10	6.4/24	7.0/15
29 Oct-12 Nov '71		8.8/3	7.9/9	8.8/12	7.9/25	6.7/11
2-17 Dec 1971		12.2/4	9.7/12	8.2/12	8.3/36	7.8/15
22-30 Sep 1972		----	9.5/17	8.1/11	5.5/8	7.2/16
2-28 Oct 1972		10.5/6	10.2/13	8.0/13	6.5/31	7.4/16
12-28 Oct 1972		11.2/8	9.5/15	8.2/12	6.1/20	7.6/16
31 Oct-11 Nov '72		11.8/6	8.0/15	8.8/6	6.4/22	7.0/16
28 Nov-15 Dec '72		12.0/5	11.3/14	8.3/13	8.4/24	8.6/15
16-28 Sep 1973		5.3/1	9.9/14	9.9/13	7.0/7	8.6/15
29 Sep-21 Oct '73		12.0/9	10.9/17	9.8/17	6.8/30	8.0/16
28 Oct-8 Nov 1973		11.7/7	12.0/14	9.4/15	7.1/23	9.2/15
4-20 Dec 1973		13.4/8	12.3/16	9.4/2	8.7/17	9.1/14

Table 3

Temperature and Salinity Differences From Data Separated By Three Days or Less On ICNAF Larval Herring Surveys, 1971-1973

Poland 2-28 October 1972
USSR 12-28 October 1972

	Poland	USSR	Diff.	Poland	USSR	Diff.	Poland	USSR	Diff.
	Station		Pol.-	Station		Pol.-	Station		Pol.-
Temp.	106	106	USSR	107	107	USSR	108	108	USSR
0 m	10.2	10.2	0.0	10.0	10.2	-0.2	10.0	9.9	0.1
10	10.2	10.2	0.0	10.0	10.2	-0.2	10.0	9.9	0.1
20	10.3	10.0	0.3	9.8	10.3	-0.5	10.0	9.9	0.1
30	10.1	10.0	0.1	9.6	10.2	-0.6	10.0	9.9	0.1
40	10.0	9.5	0.5	9.5	9.5	0.0	10.0	9.4	0.6
50	9.6	9.1	0.4	9.4	9.2	0.2	9.7	9.2	0.5
75	8.2	8.6	-0.4	8.9	8.3	0.6	—	8.8	
100	8.0	8.0	0.0	8.5	8.1	0.4	8.6	8.6	0.0
	Average	=	+0.1	Average	=	+0.0	Average	=	+0.2
S°/oo									
0 m	32.7	32.68	0.02	32.8	32.75	0.05	32.8	32.77	0.03
10	32.8	32.68	0.02	32.8	32.75	0.05			
20	32.8	32.75	0.05	32.8	32.79	0.01			
30	32.8	32.77	0.03	33.0	32.97	0.08			
40	32.8	—		33.0	—				
50	32.9	32.81	0.09	33.1	33.15	-0.05			
75	33.0	33.17	0.17	33.5	33.52	-0.02			
100	33.	33.36		33.9	33.82	0.08			
	Average	=	+0.00	Average	=	+0.02			

Temp.	109	109		114	114		115	115	
0 m	10.1	9.6	0.5	9.9	9.6	0.3	9.8	9.3	0.5
10	10.1	9.6	0.5	9.9	9.6	0.3	9.8	9.3	0.5
20	10.1	9.5	0.6	9.8	9.5	0.3	9.7	9.2	0.5
30	10.1	9.5	0.6	9.8	9.5	0.3	9.5	9.2	0.3
40	10.1	9.5	0.6	9.8	9.4	0.4	9.5	9.2	0.3
50	9.7	9.5	0.2	9.8	9.2	0.6	9.5	9.2	0.3
75	8.8	8.8	0.0	9.6	8.9	0.7	9.4	8.7	0.7
100	8.8	8.8	0.0	—	—		9.3	8.7	0.5
	Average	=	+0.4	Average	=	+0.4	Average	=	+0.4
S°/oo									
0 m	32.8	32.96	-0.16	32.7	32.87	-0.17	32.7	32.96	-0.26
10	32.6	32.99	-0.39	—	32.87		—		
20	32.8	32.99	-0.19	—	32.82		—		
30	32.6	33.15	0.45	—	32.90		—		
40	32.6	—		—	—		—		
50	33.0	33.17	-0.17	—	—		—		
75	33.6	33.52	0.08	32.9	33.38	-0.48	—		
100	35.9	33.54	0.36				33.72		
	Average	=	-0.00						

Table 3

Temperature and Salinity Differences From Data Separated By Three Days or Less On ICNAF Larval Herring Surveys, 1971-1973

Poland 2-28 October 1972
USSR 12-28 October 1972

	Poland Station 106	USSR Station 106	Diff. Pol.-USSR	Poland Station 107	USSR Station 107	Diff. Pol.-USSR	Poland Station 108	USSR Station 108	Diff. Pol.-USSR
Temp.									
0 m	10.2	10.2	0.0	10.0	10.2	-0.2	10.0	9.9	0.1
10	10.2	10.2	0.0	10.0	10.2	-0.2	10.0	9.9	0.1
20	10.3	10.0	0.3	9.8	10.3	-0.5	10.0	9.9	0.1
30	10.1	10.0	0.1	9.6	10.2	-0.6	10.0	9.9	0.1
40	10.0	9.5	0.5	9.5	9.5	0.0	10.0	9.4	0.6
50	9.6	9.1	0.4	9.4	9.2	0.2	9.7	9.2	0.5
75	8.2	8.6	-0.4	8.9	8.3	0.6	—	8.8	
100	8.0	8.0	0.0	8.5	8.1	0.4	8.6	8.6	0.0
	Average	=	+0.1	Average	=	+0.0	Average	=	+0.2
S°/oo									
0 m	32.7	32.68	0.02	32.8	32.75	0.05	32.8	32.77	0.03
10	32.8	32.68	0.02	32.8	32.75	0.05			
20	32.8	32.75	0.05	32.8	32.79	0.01			
30	32.8	32.77	0.03	33.0	32.97	0.08			
40	32.8	—		33.0	—				
50	32.9	32.81	0.09	33.1	33.15	-0.05			
75	33.0	33.17	0.17	33.5	33.52	-0.02			
100	33.	33.36		33.9	33.82	0.08			
	Average	=	+0.00	Average	=	+0.02			

	Poland 109	USSR 109	Diff.	Poland 114	USSR 114	Diff.	Poland 115	USSR 115	Diff.
Temp.									
0 m	10.1	9.6	0.5	9.9	9.6	0.3	9.8	9.3	0.5
10	10.1	9.6	0.5	9.9	9.6	0.3	9.8	9.3	0.5
20	10.1	9.5	0.6	9.8	9.5	0.3	9.7	9.2	0.5
30	10.1	9.5	0.6	9.8	9.5	0.3	9.5	9.2	0.3
40	10.1	9.5	0.6	9.8	9.4	0.4	9.5	9.2	0.3
50	9.7	9.5	0.2	9.8	9.2	0.6	9.5	9.2	0.3
75	8.8	8.8	0.0	9.6	8.9	0.7	9.4	8.7	0.7
100	8.8	8.8	0.0	---	---		9.3	8.7	0.5
	Average	=	+0.4	Average	=	+0.4	Average	=	+0.4
S°/oo									
0 m	32.8	32.96	-0.16	32.7	32.87	-0.17	32.7	32.96	-0.26
10	32.6	32.99	-0.39	—	32.87		—		
20	32.8	32.99	-0.19	—	32.82		—		
30	32.6	33.15	0.45	—	32.90		—		
40	32.6	---		—	—		—		
50	33.0	33.17	-0.17	—	—		—		
75	33.6	33.52	0.08	32.9	33.38	-0.48	—		
100	35.9	33.54	0.36				33.72		
	Average	=	-0.00						

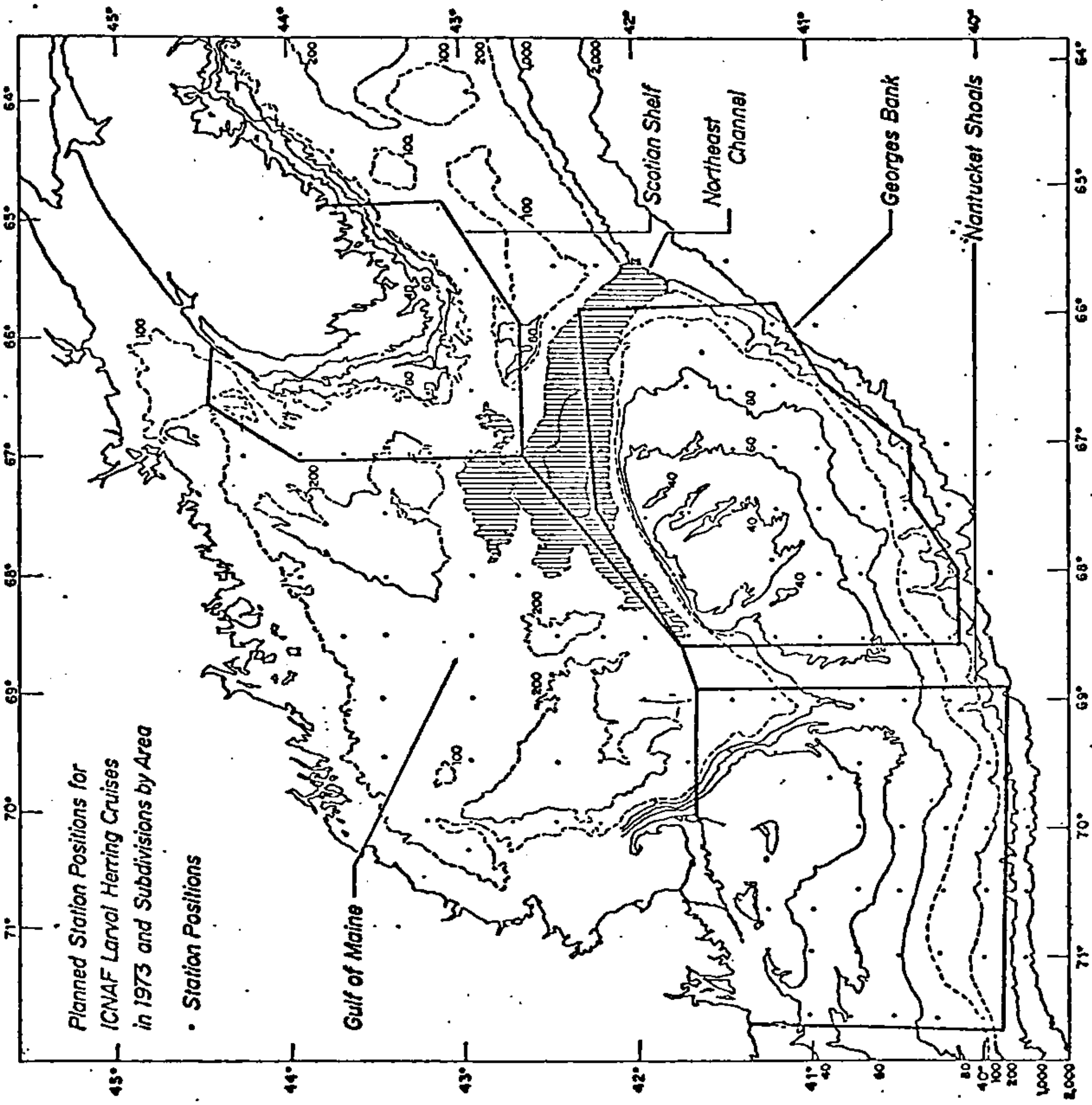
Planned Station Positions for
ICNAF Larval Herring Cruises
in 1973 and Subdivisions by Area
• Station Positions
Gulf of Maine
Scotian Shelf
Northeast
Channel
Georges Bank
Nantucket Shoals

Figure 1

Histograms of Differences
Between Polish and USSR Temperature and Salinity Data

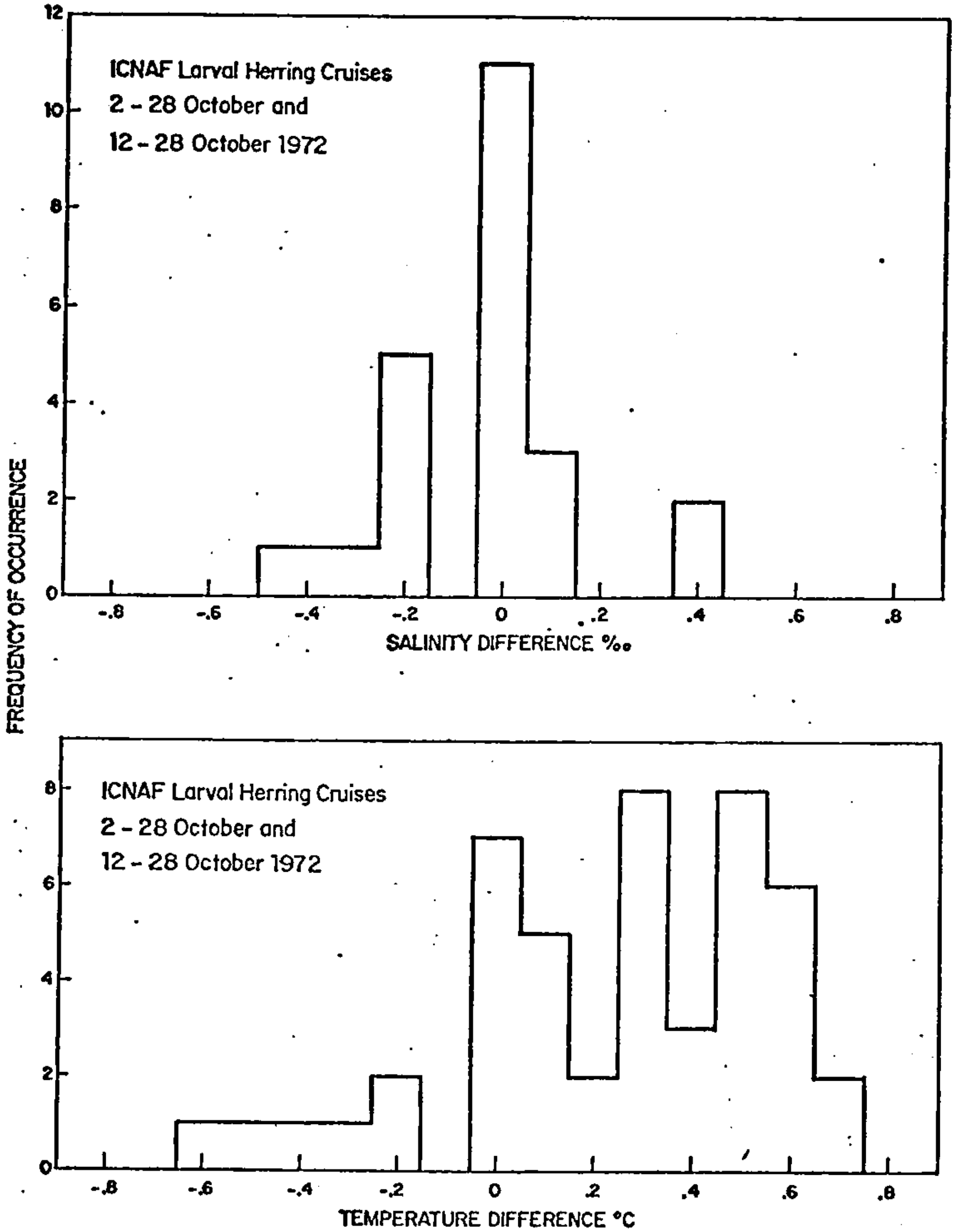

Figure 2

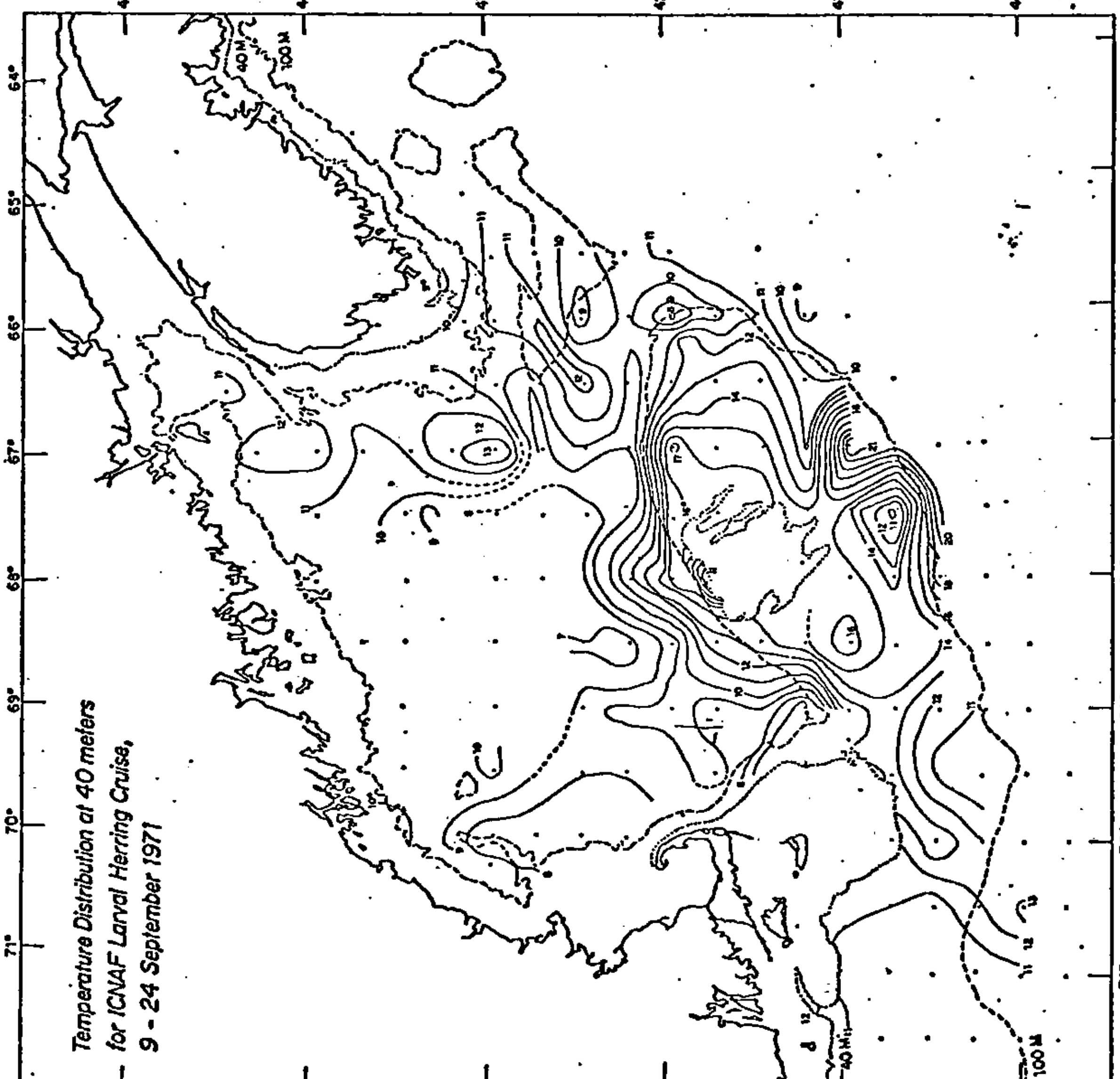
Temperature Distribution at 40 meters
for ICNAF Larval Herring Cruise,
9 - 24 September 1971
40 M
100 M

Figure 3

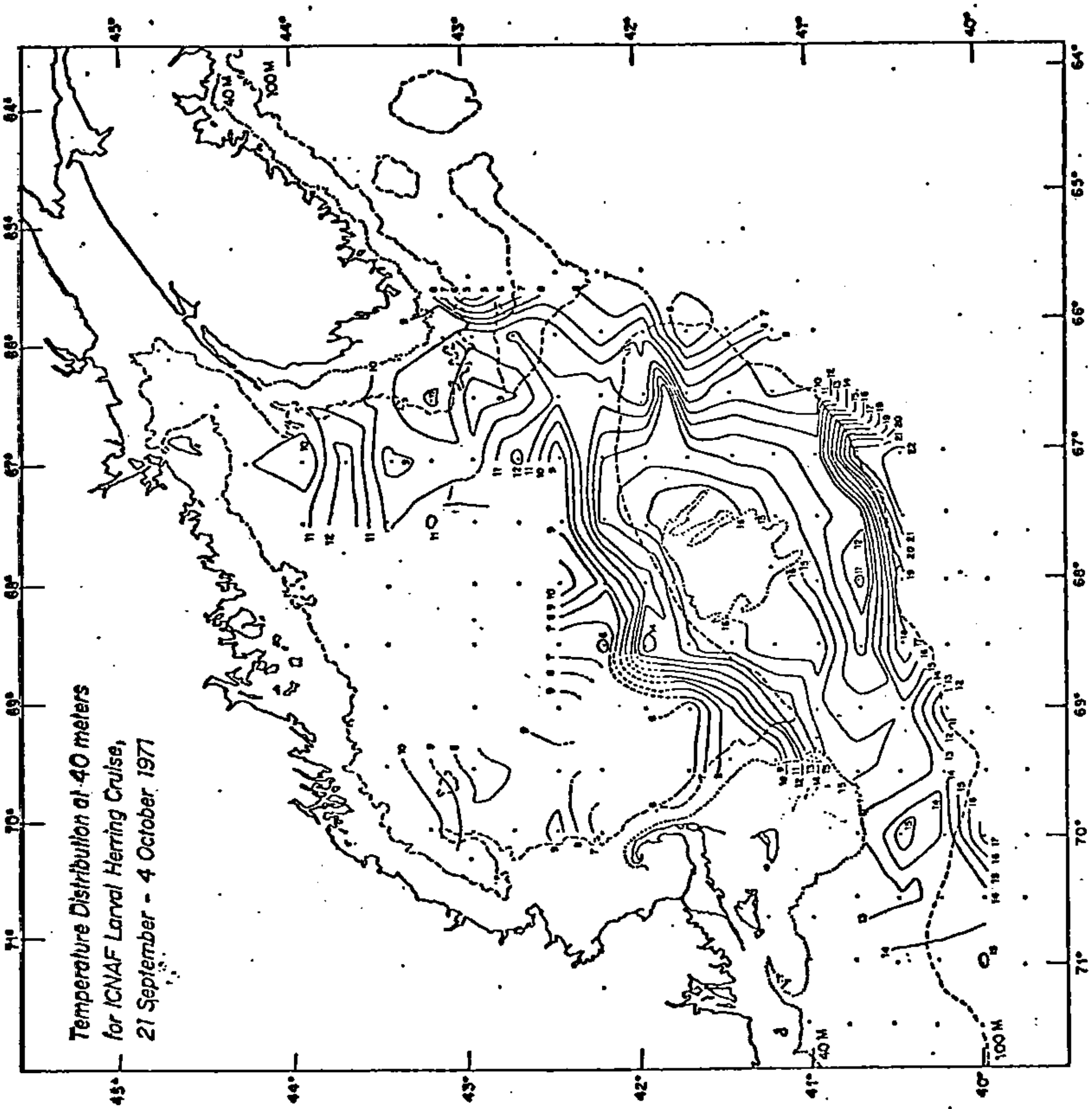
Temperature Distribution at 40 meters
for ICNAF Larval Herring Cruise,
21 September - 4 October 1971
40 M
100 M

Figure 4

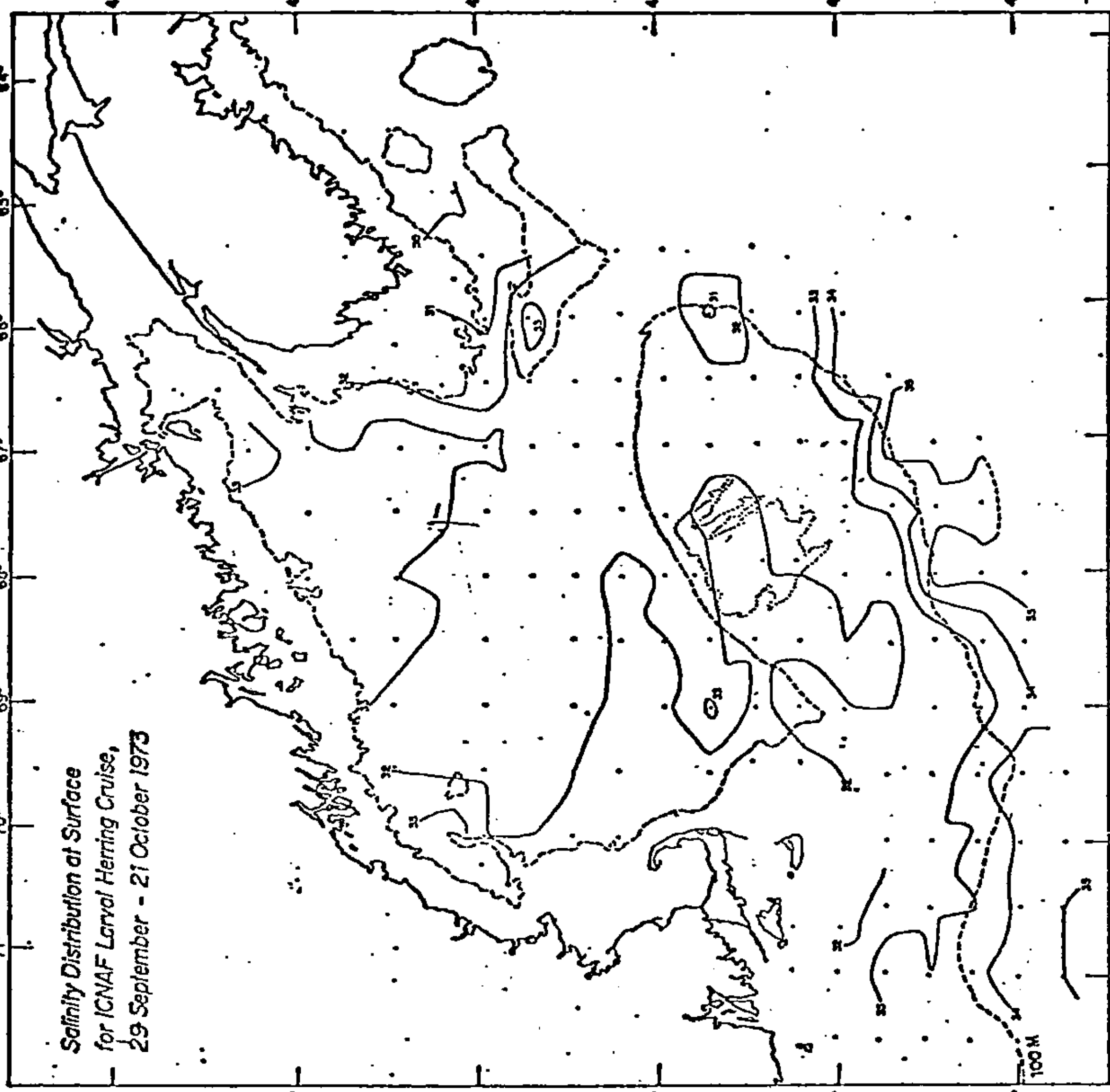
Salinity Distribution at Surface
for ICNAF Larval Herring Cruise,
29 September - 21 October 1973
100 M

Figure 5

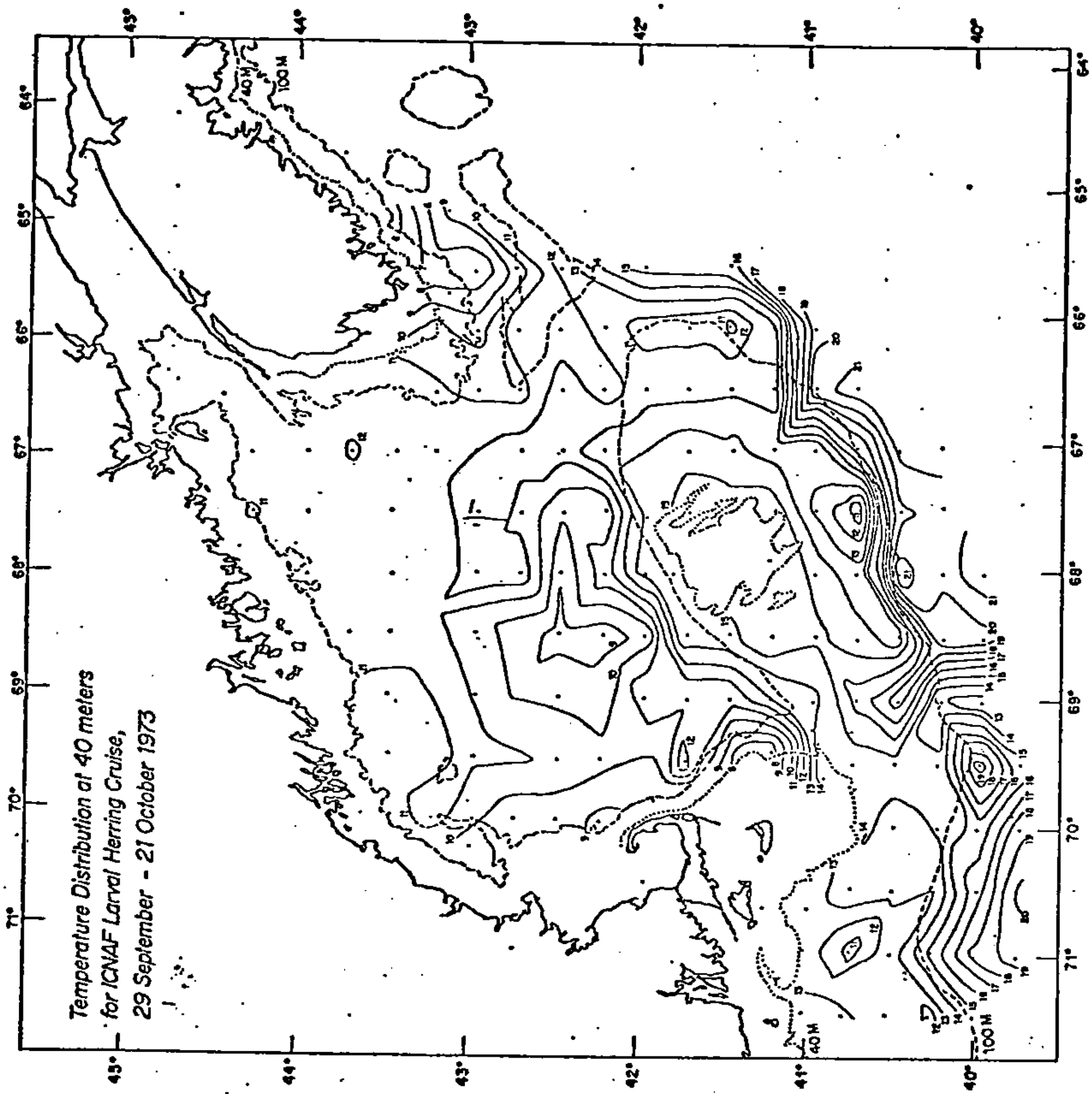
Temperature Distribution at 40 meters
for ICNAF Larval Herring Cruise,
29 September - 21 October 1973
40 M
100 M

Figure 6

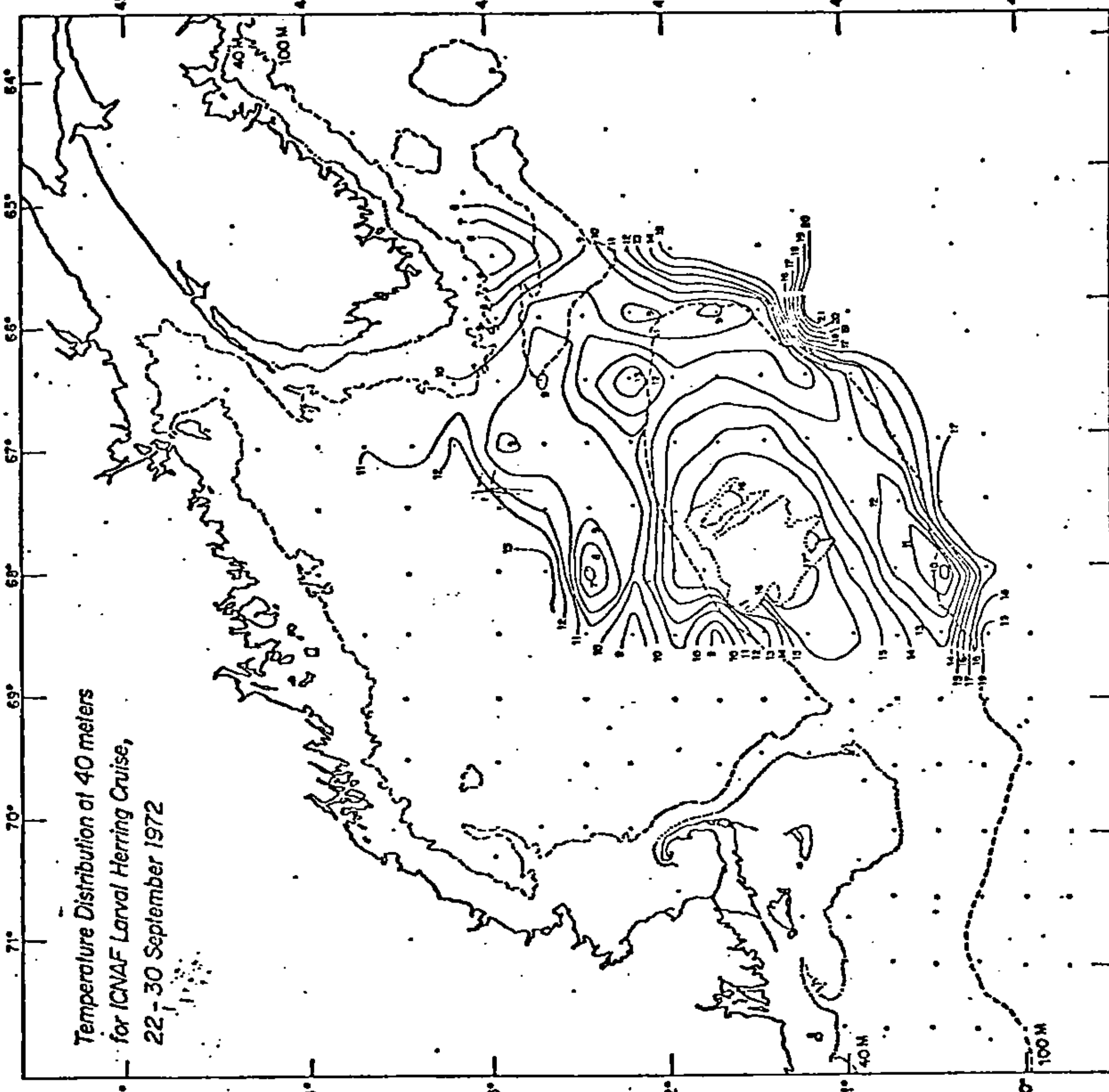
Temperature Distribution at 40 meters
for ICNAF Larval Herring Cruise,
22 - 30 September 1972
40 M
100 M

Figure 7

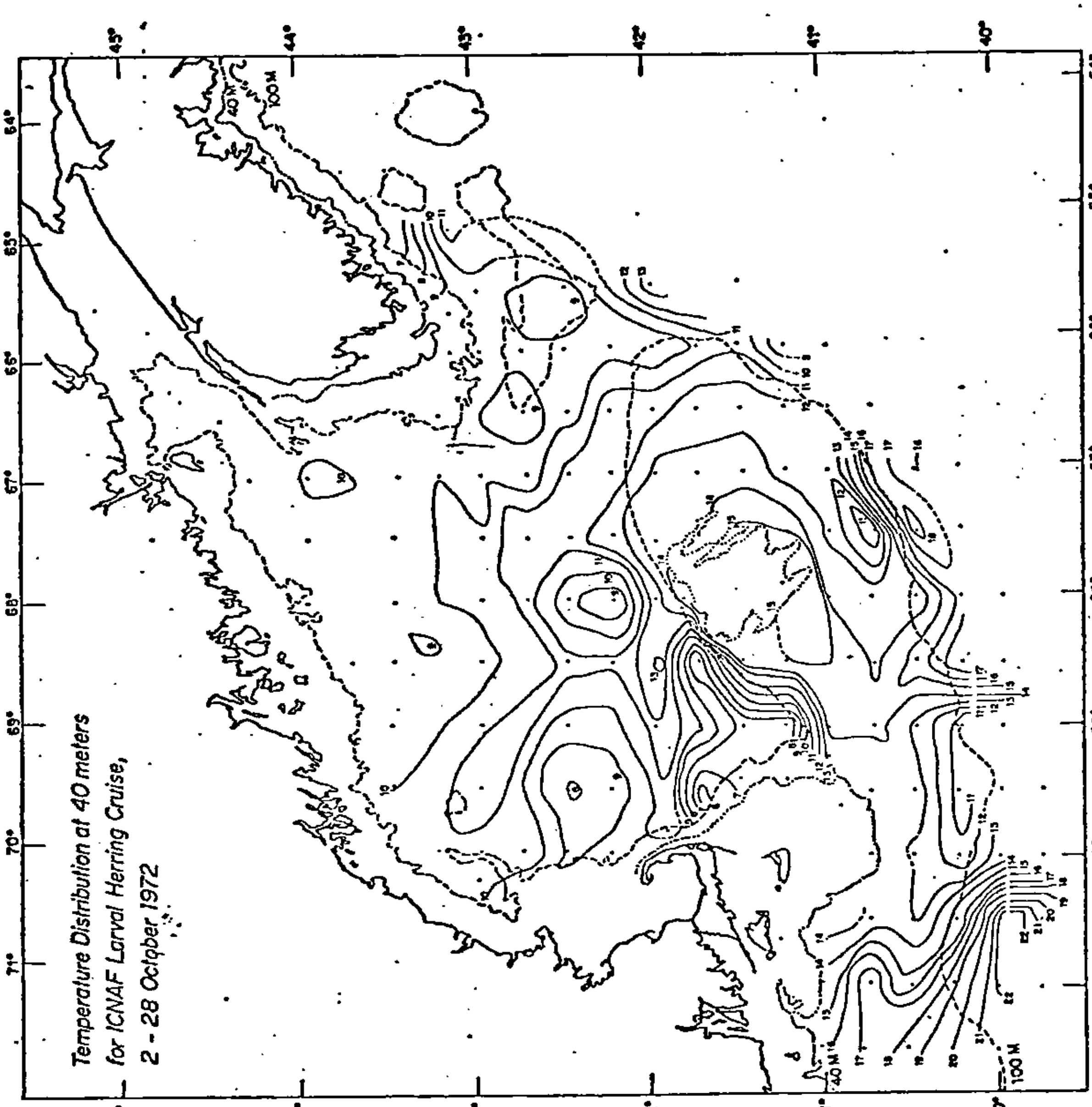
Temperature Distribution at 40 meters
for ICNAF Larval Herring Cruise,
2 - 28 October 1972
40 M
100 M

Figure 8

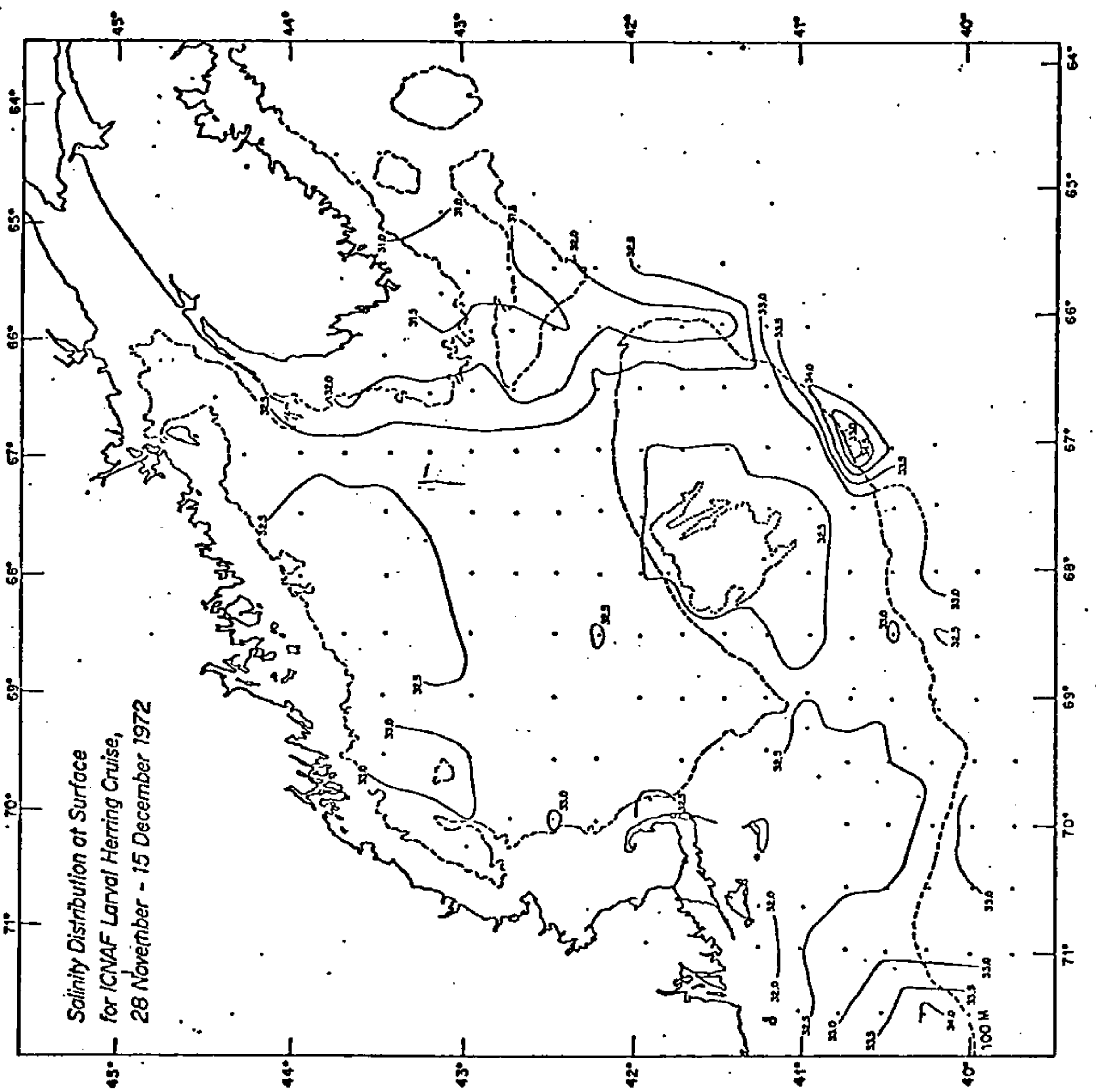
Salinity Distribution at Surface
for ICNAF Larval Herring Cruise,
28 November - 15 December 1972
100 M

Figure 9

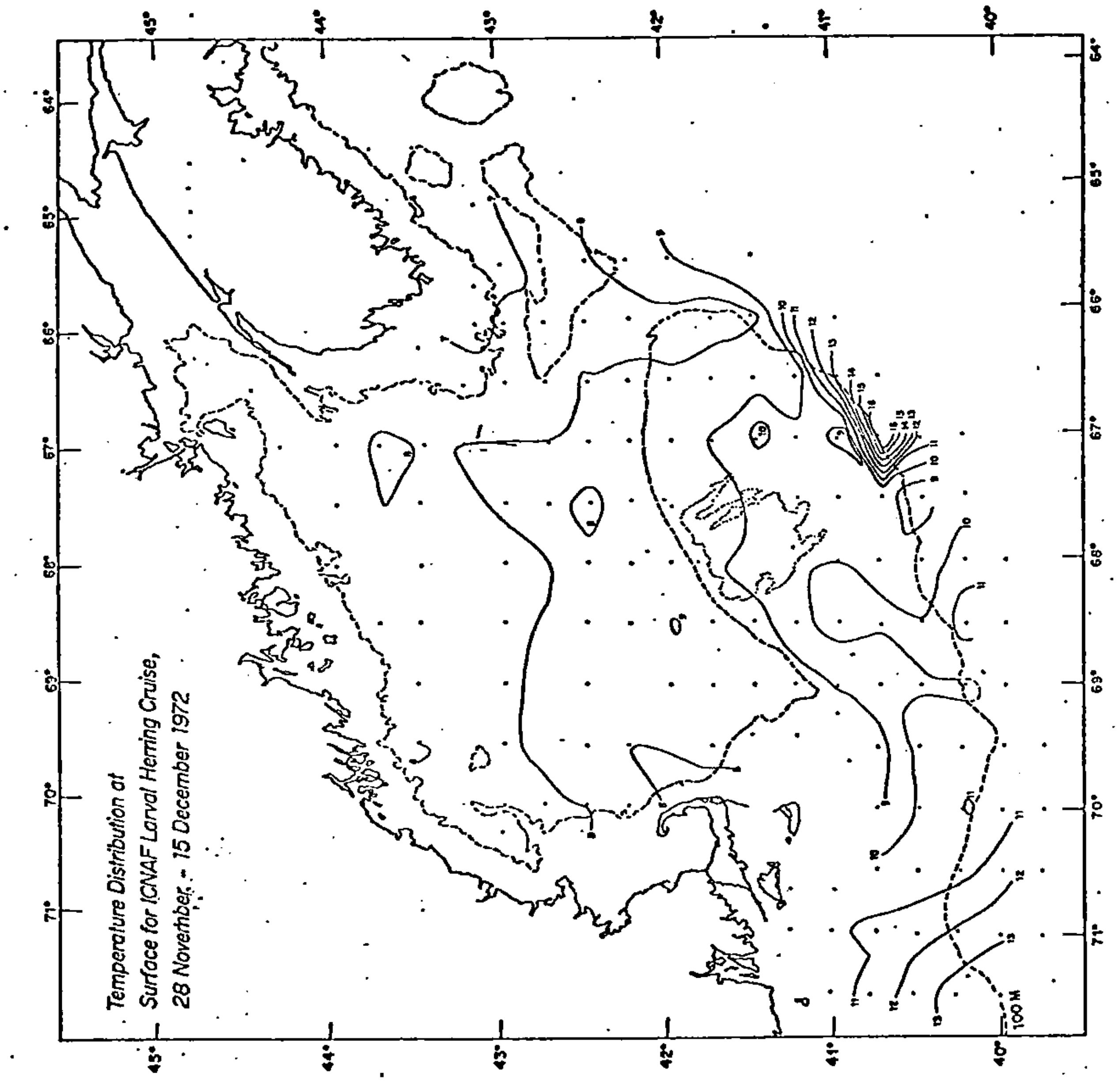
Temperature Distribution at
Surface for ICNAF Larval Herring Cruise,
28 November - 15 December 1972
100 M

Figure 10

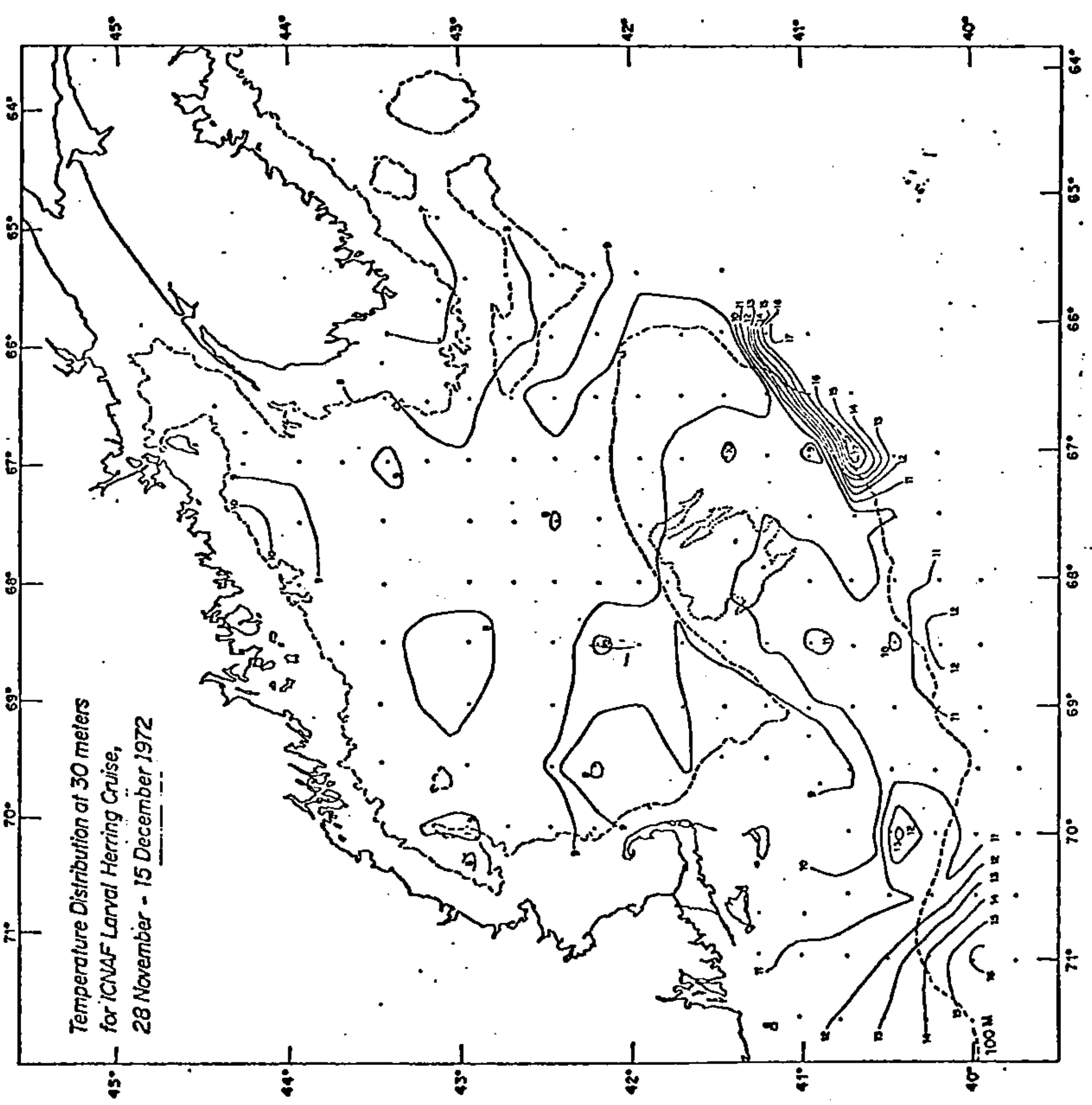
Temperature Distribution at 30 meters
for ICNAF Larval Herring Cruise,
28 November - 15 December 1972
100 M

Figure 11

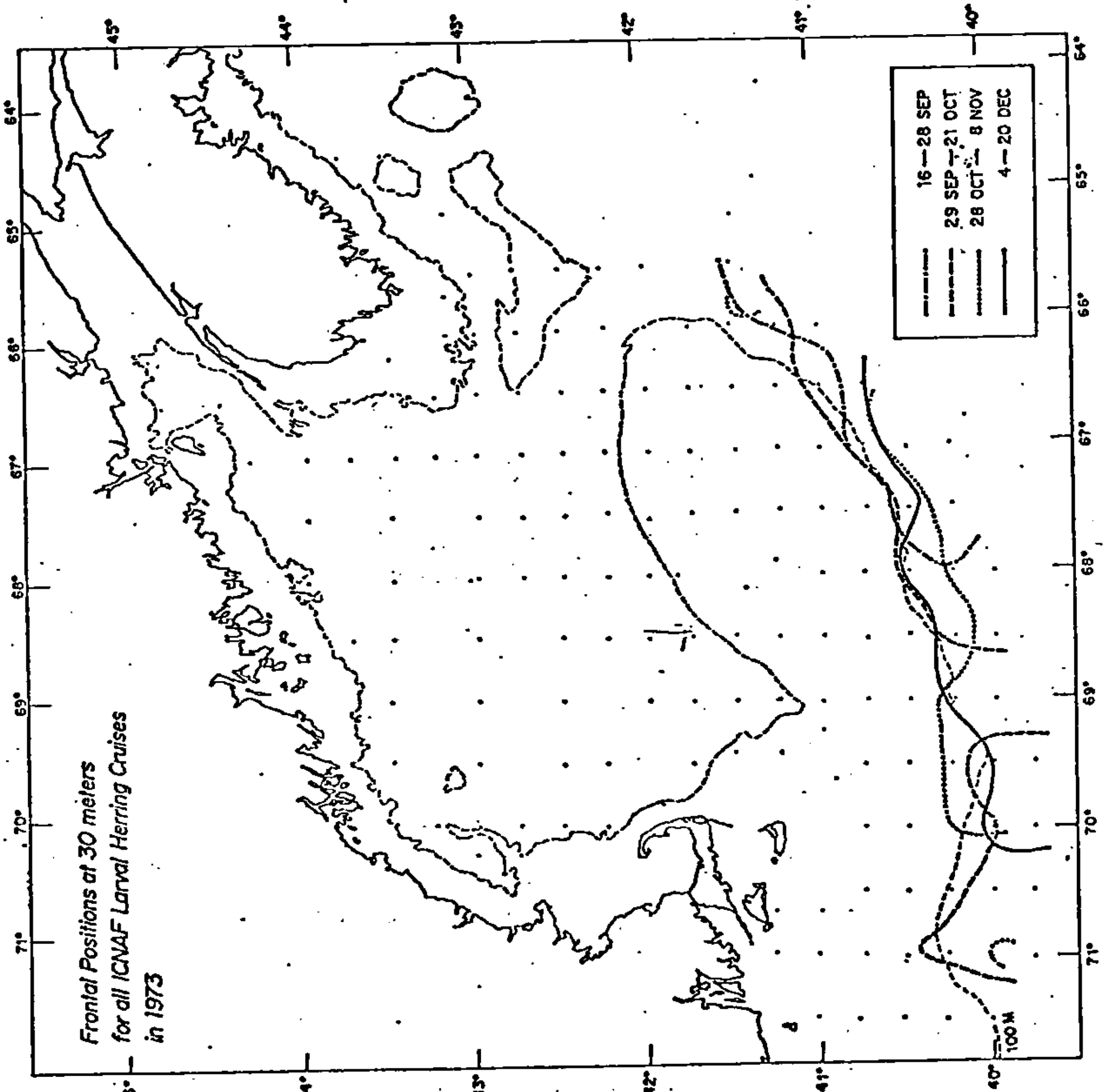
Frontal Positions at 30 meters
for all ICNAF Larval Herring Cruises
in 1973
16—28 SEP
29 SEP—21 OCT
28 OCT—8 NOV
4—20 DEC
100 M

Figure 12

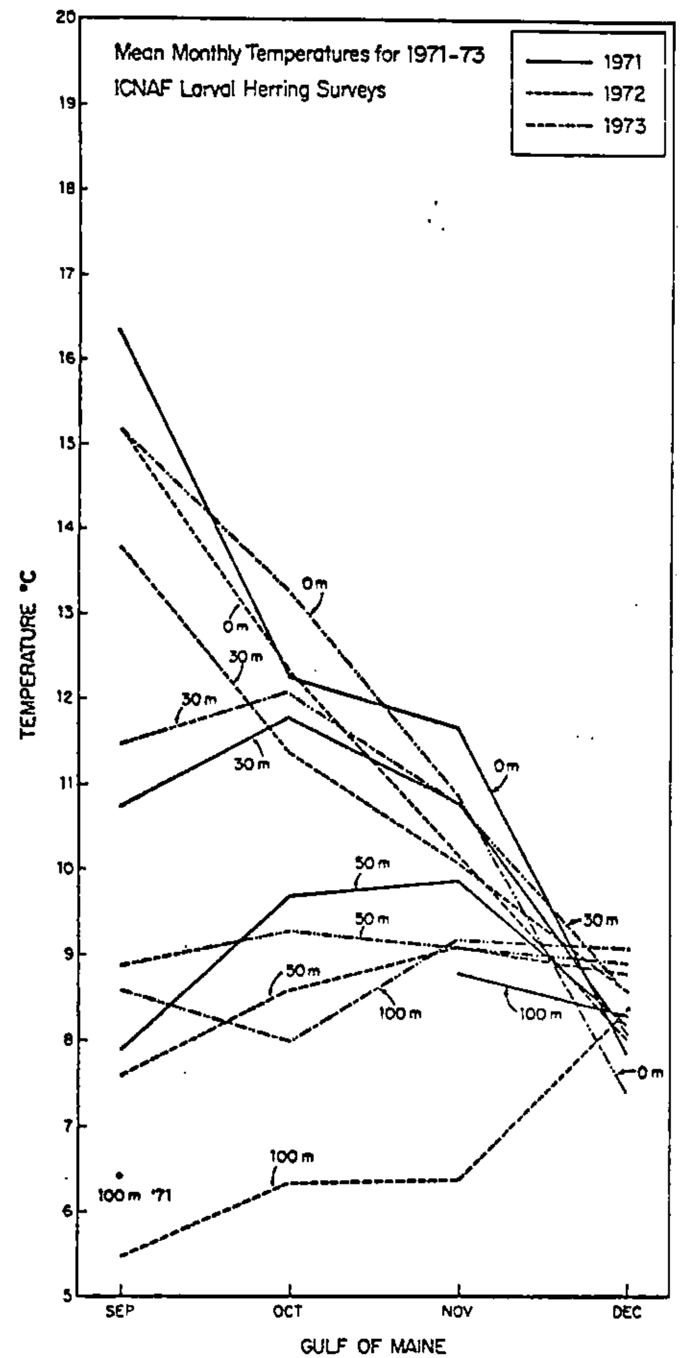

Figure 13

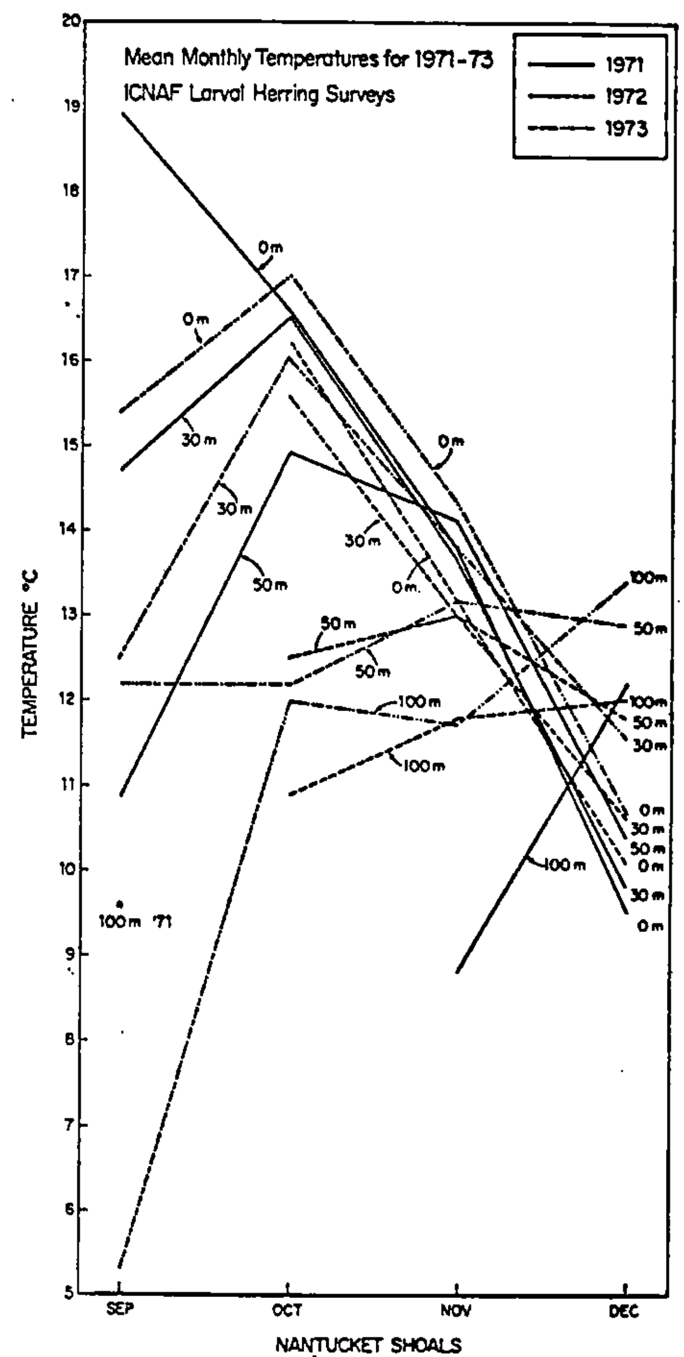

Figure 14

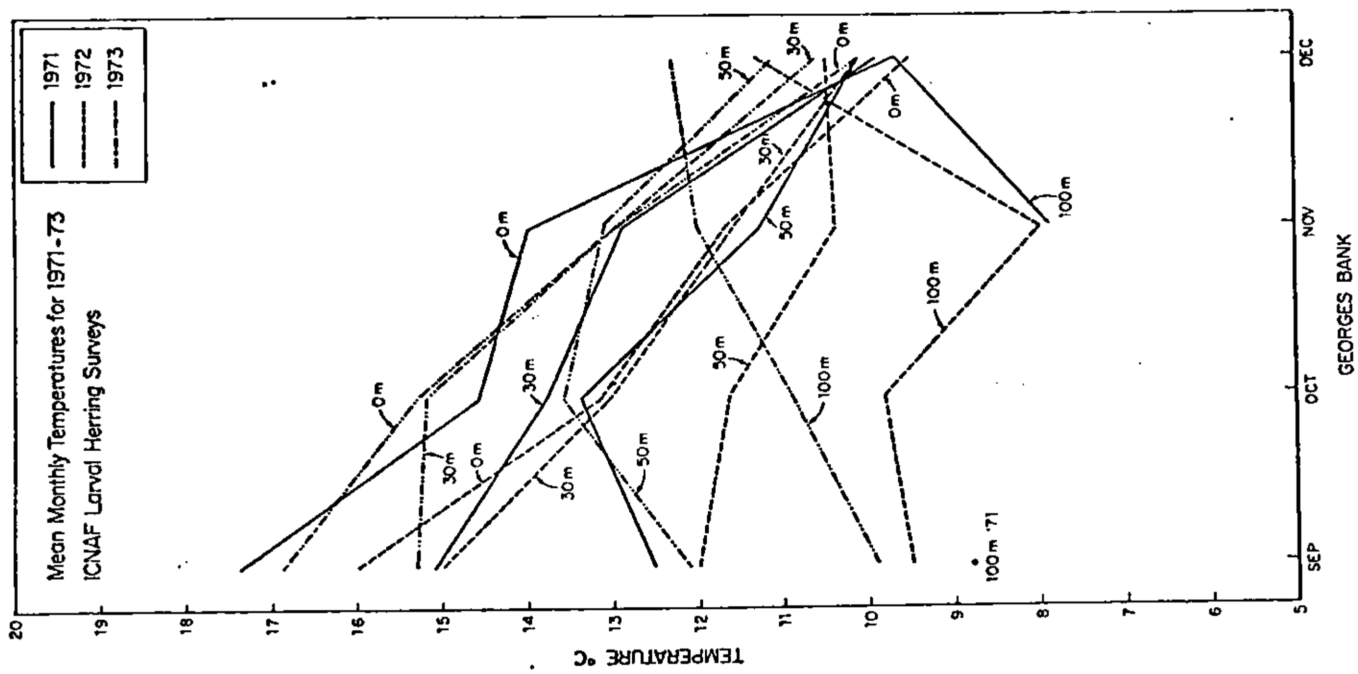
Mean Monthly Temperatures for 1971-73
ICNAF Larval Herring Surveys
1971
1972
1973
TEMPERATURE °C
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
SEP
OCT
NOV
DEC
GEORGES BANK
0m
30m
50m
100m
100m '71

Figure 15

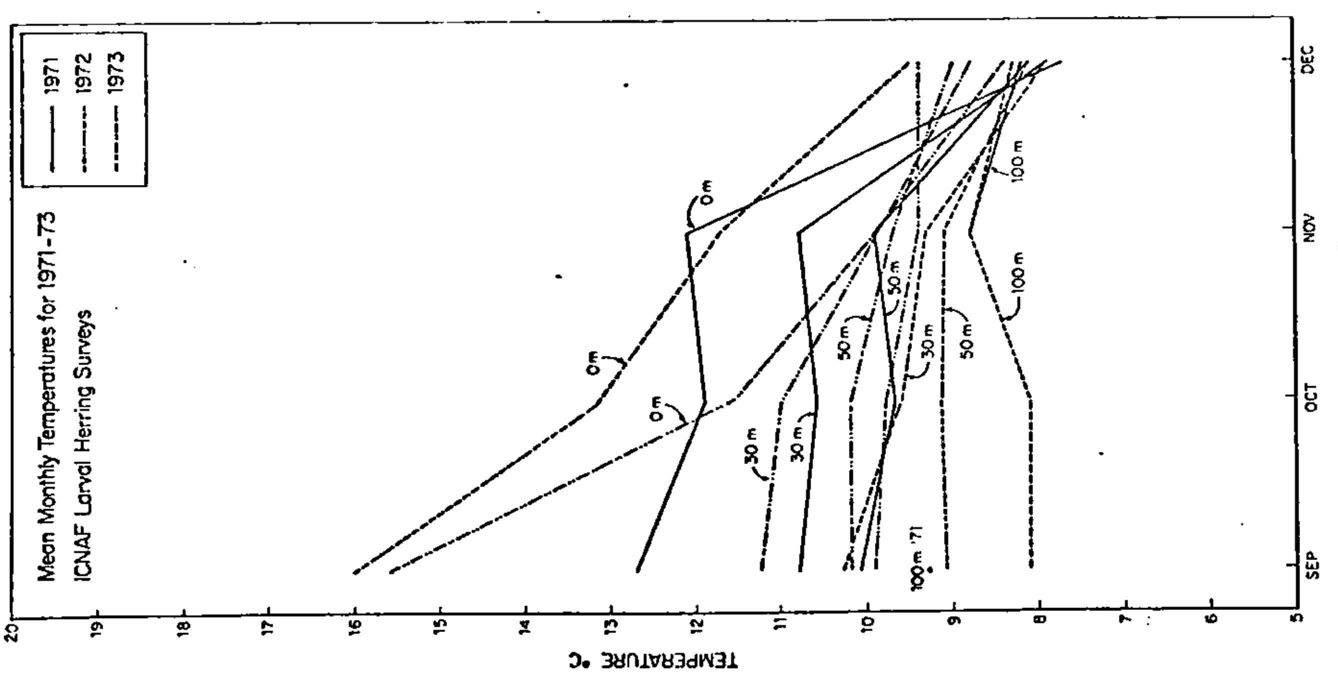

Figure 16

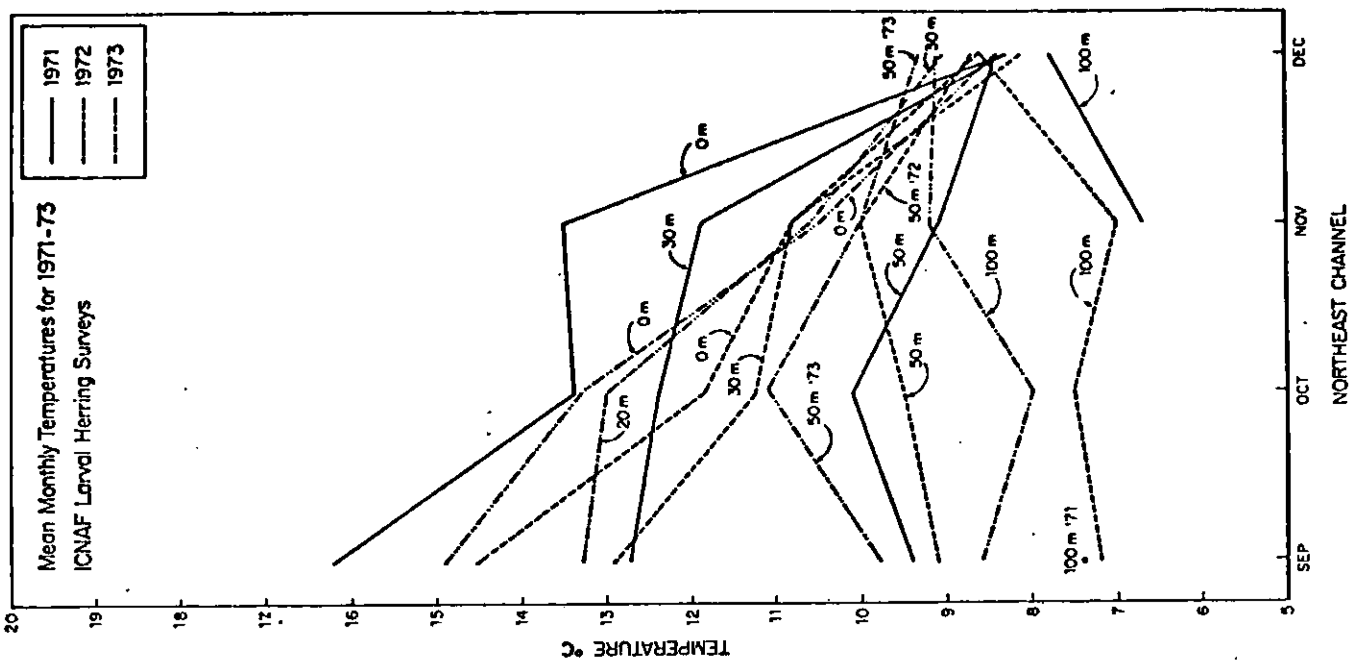

Figure 17