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Environment and distribution of herring larvae on Georges Bank and the Nova Scotia Shelf in September 1974

by

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I. Introduction

In accordance with ICNAF recommendations, the work on pre-recruitment of larval herring on Georges Bank and the areas bordering the Gulf of Maine and Nova Scotia were accomplished in 1974. On its part, France contributed its effort with the work of the R/V *Cryos* from 6-24 September 1974. The results obtained are denoted in this paper.

II. Materials and Methods

The standard station selection procedure for ICNAF was observed and at the termination of the cruise, 248 samples had been obtained (Fig. 1, Table 1).

As in the preceeding years, the same means were utilized and the same methods followed, briefly: the use of a double bongo with a 61 cm diameter with mesh openings of .555 and .303 mm. The flow-meters permit the calculation of the volume of water filtered and a bathyothermograph recorded the fishing depth. The bongos are towed to a maximum depth of 100 m or, for shallowed depths, they are towed 10 m from the bottom. They are set out at 50 m/min and retrieved at 10 m/min. The ship's speed is 3.5 knots. The samples obtained are preserved in 4% formalin.

In the laboratory, sorting was accomplished under binocular or microscope, on either the total sample or aliquot, for the separation of the ichthyoplankton. The zooplankton are then counted. To insure quantitative data, the volume of the sample or subsample is measured by the displacement of water. Finally, the larval herring are counted and measured with the help of a micrometer. (The length is from the snout to the base of the tail to the nearest mm.)

For the physical-chemical environment, an XBT thermal profile is made before each plankton tow. Two samples of water are taken, one at the surface and one at the bottom, which are used to determine the salinity titration.

[1] We wish to thank Mr T. Morris, J. Prezioso from NMFS, Mr A. Forest and J.C. Poulard from CRIP, St. Pierre for their participation during this cruise.

III. Results

As in 1971 (L'Herrou and Briand, 1972) and in 1973 (Minet, Paulmier, and Poulard, 1974) we provide some information on the general distribution of plankton by adding supplimentary data.

1. Quantitative distribution of plankton

The results are expressed in cm^3 of plankton for every 100 m^3 of water filtered. The observed anomalies in the geographic distribution of the volumes are introduced by the biases of the diurnal rhythm of many of the species and due to other causes of error from various origins: sampling error, instrument error, etc.

The areas of strong plankton density (>40 cm^3) are found to the west and southwest, the northern edge and southern part of Georges Bank and the littoral zone on the western coast of the Gulf of Maine.

The areas of moderate plankton density (10-40 cm^3) are found largely distributed over most of the study area: the Nova Soctia area, the entrance to the Bay of Fundy, the Gulf of Maine, the central shelf and the northeast part of Georges Bank, the northeast Peak and the southeast part.

The southern part of Georges Bank, the entrance of the Fundian Channel, as well as the central part of the Gulf of Maine and especially the slope waters are characterized by plankton quantitatively poor, (0-10 cm^3) but with a variety of species. In comparing our data with the results obtained by Minet, Paulmier and Poulard in 1973, it seems that the plankton production has the same momentum, although less elevated as compared to 1974, especially in the Nova Scotia area and in the central part of Georges Bank. Conversely, the distribution of plankton volumns seems more homogeneous (Fig. 2).

2. Distribution of principal taxa

Analysis shows that the geographic distribution of the different taxa, which are more or less dominant, is variable depending on existing conditions. The copepods are represented by numerous species, but 5 or 6 among them show a certain importance. Firstly, the *Centropages* of which *Centropages typicus* in one species exists more or less in the entire area surveyed and from this fact, has the largest distribution (Fig. 3). Its limits to the south and east of its area seem to correspond to the southern reaches of Georges Bank and to the west of Nova Scotia. The other important species of the genus, *Centropages hamatus*, is confined to the central shelf of Georges Bank (Fig. 3). At the southern limit of *Centropages typicus*, we encounter *Centropages bradyi* mixed with *Pleuromamma borealis*, *Acartia danae*, *Scolecithrix danae*, *Nannocalanus minor*, etc. The Calanidae are also well represented in this autumnal plankton population, principally *Calanus finmarchicus* which impinges slightly onto Georges Bank and the Nova Scotia Shelf, but is very abundant north of a line defined by the northern edge of Georges Bank and those of Nova Scotia. The copepod *Pseudocalanus* elongatus has a distribution which is more littoral. Its extension is from the Georges Bank and Nova Scotia Shelves and it expands its range up to the Great South Channel and the northern border of Georges Bank. A third species *Paracalanus parvus* is frequently encountered throughout the entire eastern part of the study area (Fig. 4).

The organisms rich in mesoglea, as the cnidarians and ctenophores, or having a gelatinous appearance similar to salps, are distributed by the ecological and functional

preferences of each group. The ctenophore *Pleurobrachia pileus* has a distribution which is somewhat restricted to the southern part of Nova Scotia (Fig. 5). The siphonophores are abundant to the south of Georges Bank where they are frequently associated with the caducicordesholoplanktonic tunicates *Thalia democratica* and *Sulfa fusiformia* (Fig. 5).

The euphausids have a well-defined diurnal rhythm and are always more numerous in the night tows. Two species, *Meganyctiphanes norvegica* and *Thysanoessa inermis* have a preference for relatively cold water and for this reason are found principally in the same area as the calanoids mentioned above. In addition, *Euphausia krohnii* is common in the southern area where they are often very abundant.

To summarize, we say that many planktonic types can coexist together or even partially overlap on Georges Bank and Gulf of Maine during September. *Centropages typicus* has the largest geographic distribution and is a component of practically all communities establishing itself as a characteristic autumn species (Sherman, 1966).

3. Distribution of larval herring

For the whole cruise, only 5 stations were positive, 4 were located on the Nova Scotia Shelf and one at the entrance to the Bay of Fundy. In all, 1,217 larvae were caught in the .505 net of which 94% were at station 113 and 116 (Fig. 6, Table 1).

The size of the larvae sampled varied from 4-22 mm. The mean diminishes with latitude: at the entrance of the Bay of Fundy (station 112) it is 13.56 mm, at the northern extremity of the Nova Scotian Penninsula (station 113), it is 8.21 mm and at the southern extremity (station 116, 117 and 120) it is 5.51-6.61 mm (Table 2). It appears that there are 3 generations each succeeding one another at short intervals (Fig. 6). At station 112, a very large range in lengths show a well developed population of larvae (8-22 mm). The small number of larvae caught do not permit us to distinguish a distinct mode (Fig. 7). The variability index $V = 100^5/\bar{x}$ is very high: 99.4%.

At station 113, the mode is 7-8 mm. Development is not as advanced. A few large larvae or post-larvae, perhaps belong to the same generation as those from station 112 (larvae >10 mm - 12.4%). The variability indes is 35.4%. The other stations from Nova Scotia are characterized by very small larvae, mode 5-6 mm, recently hatched and probably at the beginning of their developmental cycle, V = 9.3-24.7% (Monsueti and Hardy, 1967).

4. Hydrologic situation

The surface temperatures of Georges Bank were greater than 14°C and in the shallow water zones about 16°C; the salinities between 32 and 34 °/oo. South of Georges Bank, at the level of the continental slope, temperatures of 20°-25°C and salinities of 34-35°/oo characterized the origin of Atlantic waters which penetrate more or less the depths of the Gulf of Maine via the Fundian Channel (Fig. 8-9).

On the Nova Scotia Shelf, cold waters $\leq$12°C with salinities of 31-32°/oo of Laurentine origin which bathe the littoral zones, fall into the Gulf of Maine and enter into the Bay of Fundy, Beyond the 12°C isotherm, we find mixed waters (T° = 14°C, Sal. = 34°/oo).

On the bottom of the shallower areas of Georges Bank, the waters are relatively warm, >14°C, the salinities range between 32 and 33.5°/₀₀ . The slope waters are colder ≤7 -11°C and are rich in dissolved salts (35-36 °/₀₀). On the northern edge we find mixed waters (Sal: 34°/₀₀) cold temperatures (T°: 8°C). The bottom of the Nova Scotia Shelf and adjacent waters are covered with cold Laurentine waters, 5-10°C and are less salty, 32-33°/₀₀ (Fig. 10-11).

In the southern part of Georges Bank, at the level of 40°N and 69°W, exist a mass of water having temperatures and salinities which are less than the surrounding waters and perceptable from the bottom to the surface. Perhaps this is due to the mixing of water from Laurentine origin entrapped by Atlantic waters.

At the thermocline level, moderate temperatures fluctuate between 10° and 17°C on Georges Bank, 8° and 13°C to the south of Nova Scotia, and between 18° and 23°C at the slope level. The average penetration of the thermocline is located in 6 and 70 m. The temperature gradients ($\Delta T/\Delta Z$) vary from 0.1-0.9 for each meter. We can note the absence of a thermocline on the Nova Scotia Shelf and on the major part of the Georges Bank Shelf (Fig. 12).

IV. Discussion and Conclusion

Only a single center of egg laying was evident on the Nova Scotia Shelf during September 1974. The abundance of larvae is extremely variable at the subsequent stations (Fig. 6). Their dispersion had not yet occured even though the conditions were favourable: currents and an absence of a thermocline. Hatching of the larvae was recent, except at station 112. Application of the FISHER F test to the larvae population corresponding to station 112 to station 113, and to three other stations gave positive results, which are grouped to the south of Nova Scotia, show highly significant values for 99.9% confidence and confirm the presence of three distinct generations.

These observations are equally confirmed by the maturity stage analysis of spawning herring caught at the beginning of October. The majority were spawning or at maturity stages 5 and 6.

These results are very different than those obtained in 1973 during the same season (Minet, Paulmier, Poulard, 1974) where two spawning areas, one situated on the northeast part of Georges Bank and the other on the Nova Scotia Shelf, had been evident. Larval dispersion had been more extensive and their development more advanced, showing a greater precocity as reported in 1974.

It is possible to attribute these differences to hydrologic conditions, particularly at the bottom level and of the thermocline where the mean temperatures were generally higher in 1973 on Georges Bank while they were more stable on the Nova Scotia Shelf.

These differences have also been verified by the quantitative and qualitative distribution of the plankton production not as high, and dispersion of these preferential organisms to warm waters more northerly.

Table 1. Station data for R/V *Cryos* cruise, 6-24 September 1974.

Station number	Date	Position		Depth (m)	Sampling depth (m)	Volume of filtered water m^3 .333	Volume of filtered water m^3 .505	Number of larvae .333	Number of larvae .505	Number of larvae per 1 000 m^3 .505
		latitude	longitude							
12	22-9-74	40°15'	70°00'	78-92	84	430.45				
13	"	40°00'	70°01'	155	122	683.67				
14	23-9-74	40°16'	69°31'	78	62	493.78				
14.1	22-9-74	40°00'	70°00'	115	108	686.39				
14.3	"	39°59'	69°00'	1 450	107	705.14				
15	23-9-74	40°15'	69°00'	115	118	539.77				
16	18-9-74	40°30'	69°01'	70	64	373.46				
17	"	40°32	69°30'	55	48	285.68				
23	"	40°45'	69°29'	45	35	193.84				
24	"	40°45'	69°00'	70	64	362.45				
25	"	41°02'	69°01'	80	73	524.33				
26	15-9-74	41°01'	69°11'	47	40	259.26				
27	14-9-74	41°15'	69°25'	48	43	324.03				
28	18-9-74	41°15'	69°00'	113	92	727.35				
29	"	41°30'	69°00'	190	95	853.69				
30	14-9-74	41°30'	69°25'	64	64	366.74				
31	"	41°45'	69°31'	155	90	764.33				
32	"			162	92	859.42				
33	"	41°60'	69°01'	125	102	732.88				
34	12-9-74	42°30'	69°29'	205	101	748.18				
36	11-9-74	42°18'	70°00'	138	117	568.10				
37	"	48°31'	70°00'	145	104	606.75				
38	"	42°45'	70°01'	165	115	615.89				
39	"	42°45'	70°15'	126	101	746.04				

Table 1. (Continued)

40	"	43°00'	70°15'	165	106	698.56			
41	"	42°59'	69°56'	210	115	515.22			
42	"	43°15'	70°07'	115	100	734.61			
43	"	43°30'	70°00'	103	89	712.52			
44	"	43°30'	69°30'	145	116	702.39			
46	12-9-74	42°30'	69°30'	250	98	704.35			
46.1	"	42°31'	69°01'	212	98	717.69			
47	"	42°30'	68°30'	207	118	653.64			
48	18-9-74	42°15'	68°29'	163	92	705.73			
49	"	42°00'	68°31'	173	95	766.66			
50		41°45'	69°32'	160	101	866.82			
51	23-9-74	41°31'	68°31'	90	72	634.56			
52	"	41°15'	68°31'	55	41	265.29			
53	"	41°00'	68°30'	50	39	187.98			
54	"	40°45'	68°30'	59	59	364.63			
55	"	40°30'	68°30'	90	89	593.36			
56	"	40°15'	68°31'	157	103	719.77			
56.1	22-9-74	40°01'	68°30'	2 300	104	858.05			
56.2	"	40°00'	68°00'	2 400	98	646.98			
57	"	40°15'	68°00'	1 100	106	733.63			
58	"	40°30'	67°58'	115	119	667.86			
59	21-9-74	40°45'	68°00'	72	70	328.62			
60	"	41°00'	68°00'	50	50	247.96			
61	"	41°16'	67°54'	40	29	170.38			
62	"	41°26'	68°06'	47	43	217.68			
63	"	41°50'	68°00'	57	54	307.18			

Table 1. (Continued)

64	"	42°00'	68°01'	189	115	730.31		
65	14-9-74	42°15'	68°00'	190	95	745.16		
66	"	42°31'	67°59'	200	92	808.59		
67	12-9-74	42°45'	67°59'	170	98	764.33		
68	"	42°45'	67°30'	195	85	823.87		
69	"	42°30'	67°29'	270	116	545.49		
70	14-9-74	42°15'	67°30'	250	89	796.50		
71	18-9-74	42°00'	67°32'	43	43	201.08		
72	21-9-74	41°46'	67°30'	48	39	231.41		
73	"	41°30'	67°30'	48	47	267.79		
74	"	41°15'	67°30'	45	41	206.76		
75	"	41°00'	67°30'	65	63	372.00		
76	"	40°46'	67°30'	85	77	485.96		
77	"	40°29'	67°29'	225	107	717.76		
77.1	20-9-74	40°15'	67°30'	1 700	113	679.99		
77.2	"	40°15'	67°00'	2 450	107	725.03		
78	"	40°30'	67°00'	1 200	116	749.99		
79	"	40°45'	67°00'	104	89	736.13		
80	"	41°00'	67°00'	70	54	451.87		
81	"	41°15'	67°00'	68	58	416.89		
82	"	41°30'	67°00'	60	60	432.66		
83	"	41°45'	67°00'	64	55	369.45		
84	19-9-74	42°00'	67°00'	70	71	335.80		
85	13-9-74	42°16'	67°00'	347	102	774.69		
86	12-9-74	42°30'	67°00'	310	135	754.73		
87	13-9-74	42°30'	66°30'	241	116	904.39		
88	"	42°15'	66°31'	355	115	507.24		

Table 1. (Continued)

89	19-9-74	42°00'	66°30'	77	67	475.92				
90	20-9-74	41°44'	66°21'	75	63	465.58				
91	"			87	80	492.41				
92	"	41°15'	66°30'	87	79	526.02				
93	19-9-74	41°00'	66°30'	112	110	708.45				
93.1	"	40°45'	66°30'	1 950	112	766.41				
93.2	"	41°00'	66°00'	2 400	107	775.26				
94	"	41°15'	65°59'	360	116	635.90				
94.1	"	41°30'	65°30'	2 200	98	770.31				
95	"	41°30'	65°30'	185	107	670.25				
96	"	41°45'	66°00'	104	101	581.33				
97	"	42°00'	65°29'	1 000	104	803.31				
98	"	41°60'	65°59'	104	82	652.40				
99	13-9-74	42°17'	66°30'	213	115	574.23				
100	"	42°30'	65°30'	96	87	547.22				
101	"	42°30'	66°01'	175	92	772.53				
102	8-9-74	42°45'	66°00'	75	75	481.09				
103	"	42°45'	66°30'	88	77	737.58				
104	"	42°45'	67°00'	188	90	770.87				
105	"	43°03'	66°58'	185	125	495.59				
106	9-9-74	43°16	67°00'	186	100	841.65				
107	"	43°30'	66°60'	205	120	1 356.40				
108	"	43°45'	67°01'	165	102	722.10				
109	"	44°01'	67°00'	160	116	725.20				
111	10-9-74	44°20'	67°01'	121	115	737.50				
112	"	44°31'	66°30'	160	101	677.56	662.18	28	21	31.7

Table 1. (Continued)

113	"	43°60'	66°33'	85	85	518.07	504.69	748	55	1 093.7
114	9-9-74	43°46'	66°30'	80	83	400.99				
115	"	43°30'	66°30'	105	115	596.97				
116	"	43°30'	66°10'	58	49	328.48	323.29	862	592	1 831.2
117	"	43°15'	66°29'	85	77	549.07	547.88	20	36	65.7
118	"	43°00'	66°31'	125	106	715.55				
119	8-9-74	43°00'	66°00'	104	80	751.18				
120	"	43°10'	66°01'	75	74	540.24	525.62	24	16	30.4
121	"	43°10'	65°42'	64	55	150.83				
122	"	43°01'	65°30'	122	102	826.71				
123	7-9-74	43°10'	65°00'	175	95	751.65				
124	"	43°30'	65°01'	93	74	449.46				

Table 2. Length frequencies of larval herring caught in Nova Scotia areas.

Lt (mm)	Station 112		Station 113		Station 116-117-120	
	Number	%	Number	%	Number	%
4					29	4.86
5					273	45.73
6			23	4.86	233	39.03
7			142	30.02	47	7.87
8	2	6.25	182	38.48	9	0.02
9	1	3.12	67	14.16	1	0.001
10	6	18.75	18	3.81		
11	1	3.12	10	2.11	2	0.003
12	5	15.62	15	3.17	3	0.005
13	1	3.12	7	1.48		
14	5	15.62	5	1.06		
15	1	3.12	1	0.21		
16	3	9.37	2	0.42		
17	2	6.25				
18	2	6.25	1	0.21		
19						
20	2	6.25				
21						
22	1	3.12				

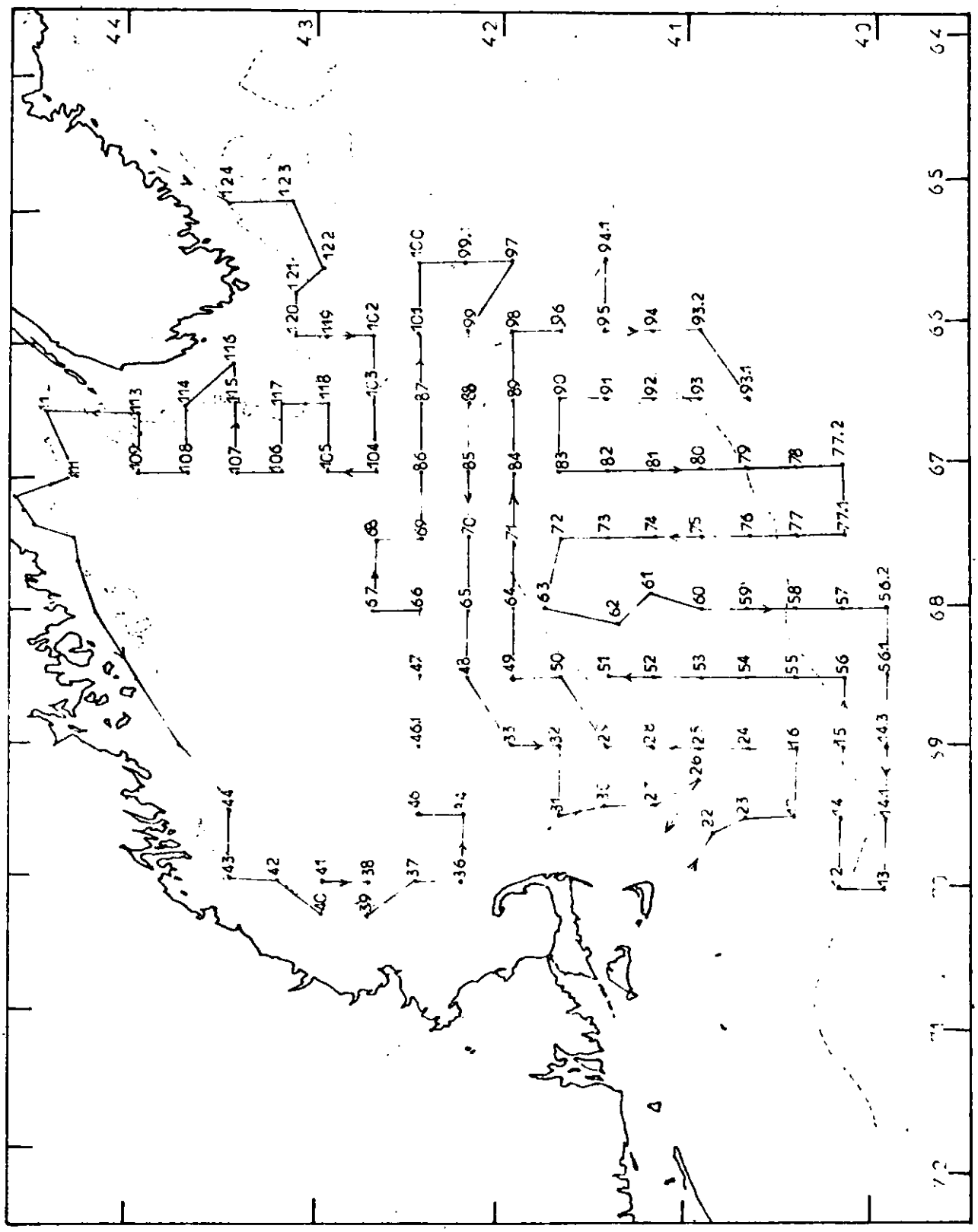

Fig. 1 - Cryos cruise track september 1974 04 - ICNAF Larval Herring survey.

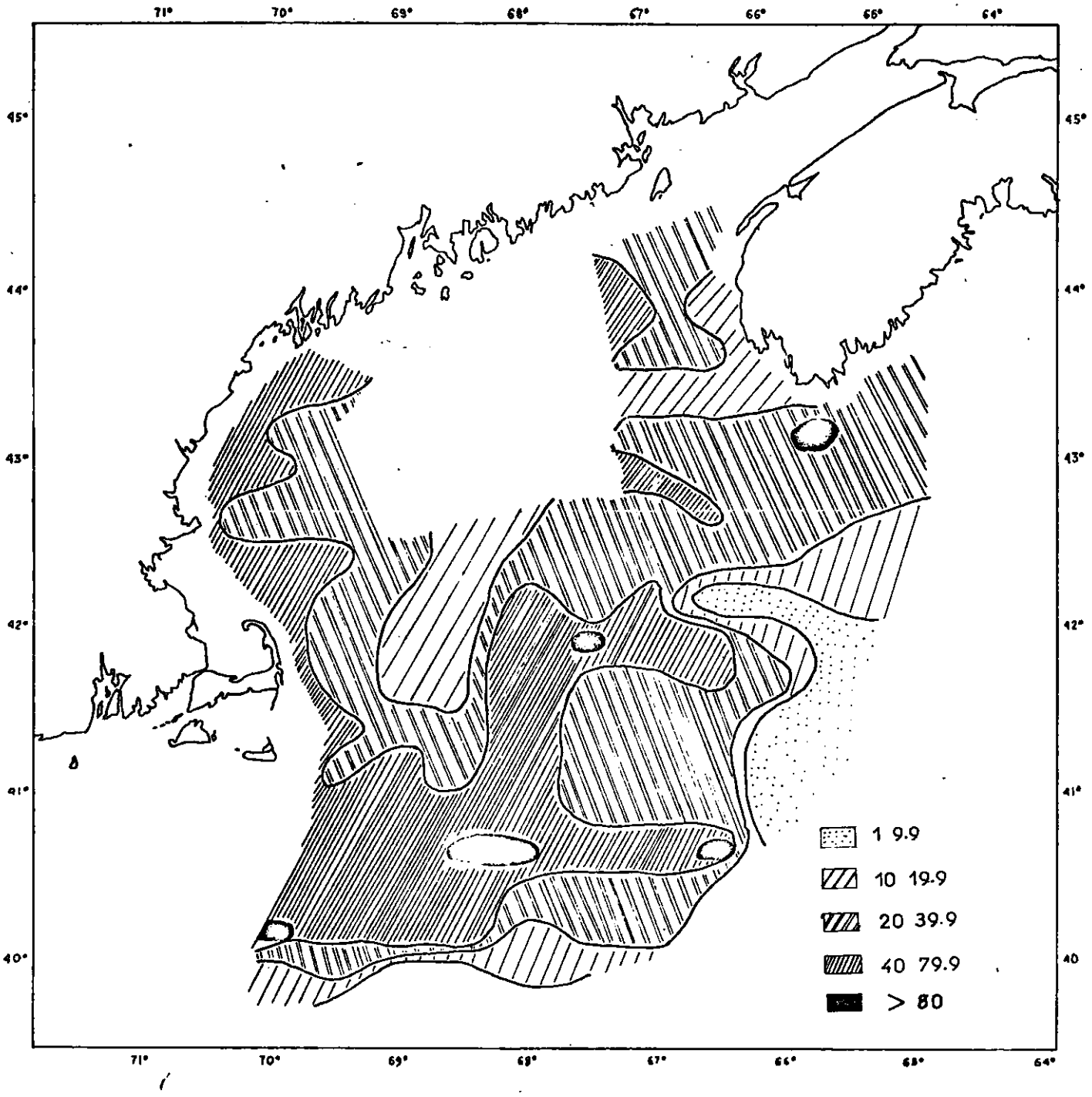

Fig. 2 - Quantitative distribution of plankton per 100 m^3 of filtered water.

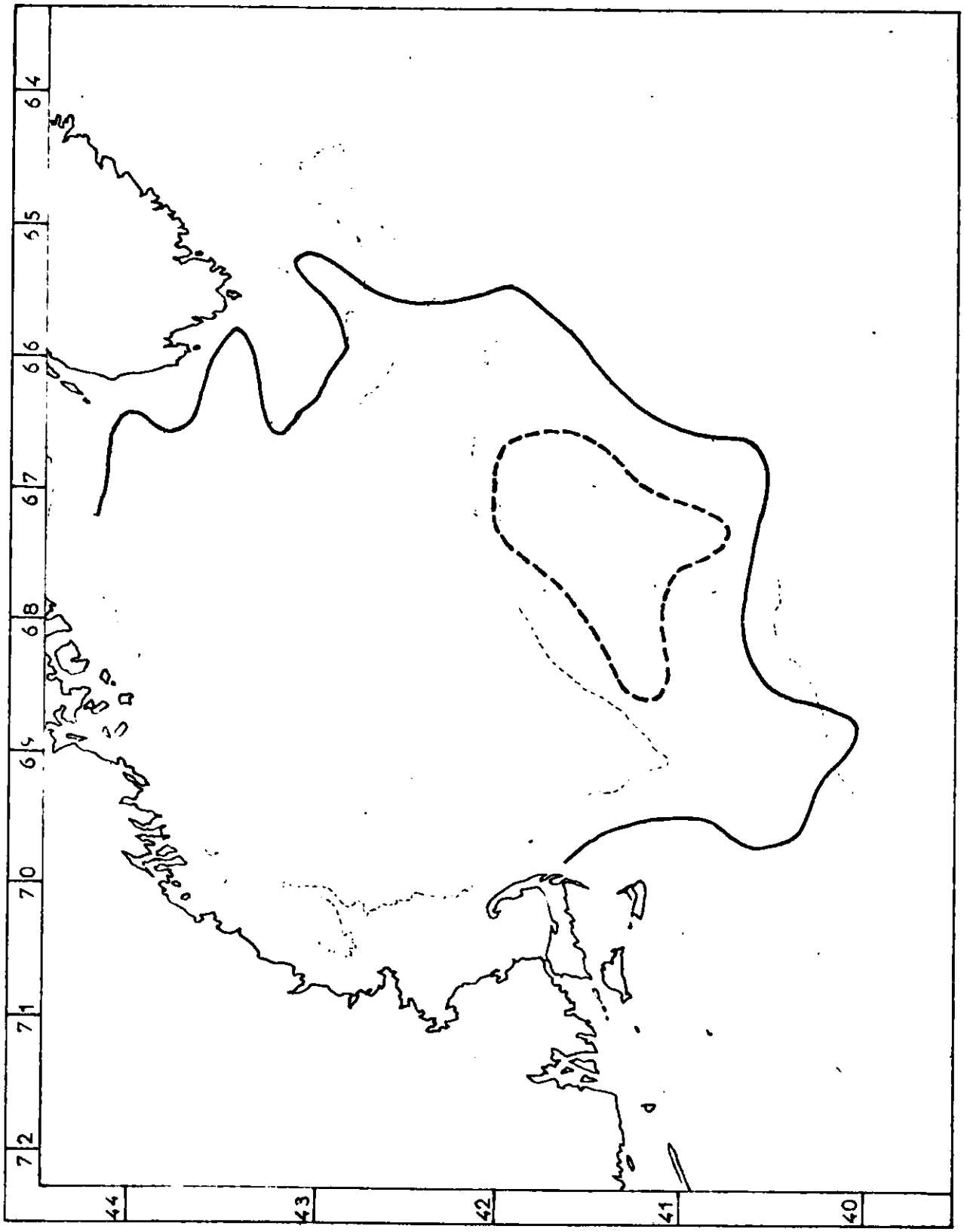

Fig. 3 - Distribution of Centropages typicus (full line) and Centropages hamatus (dash line).

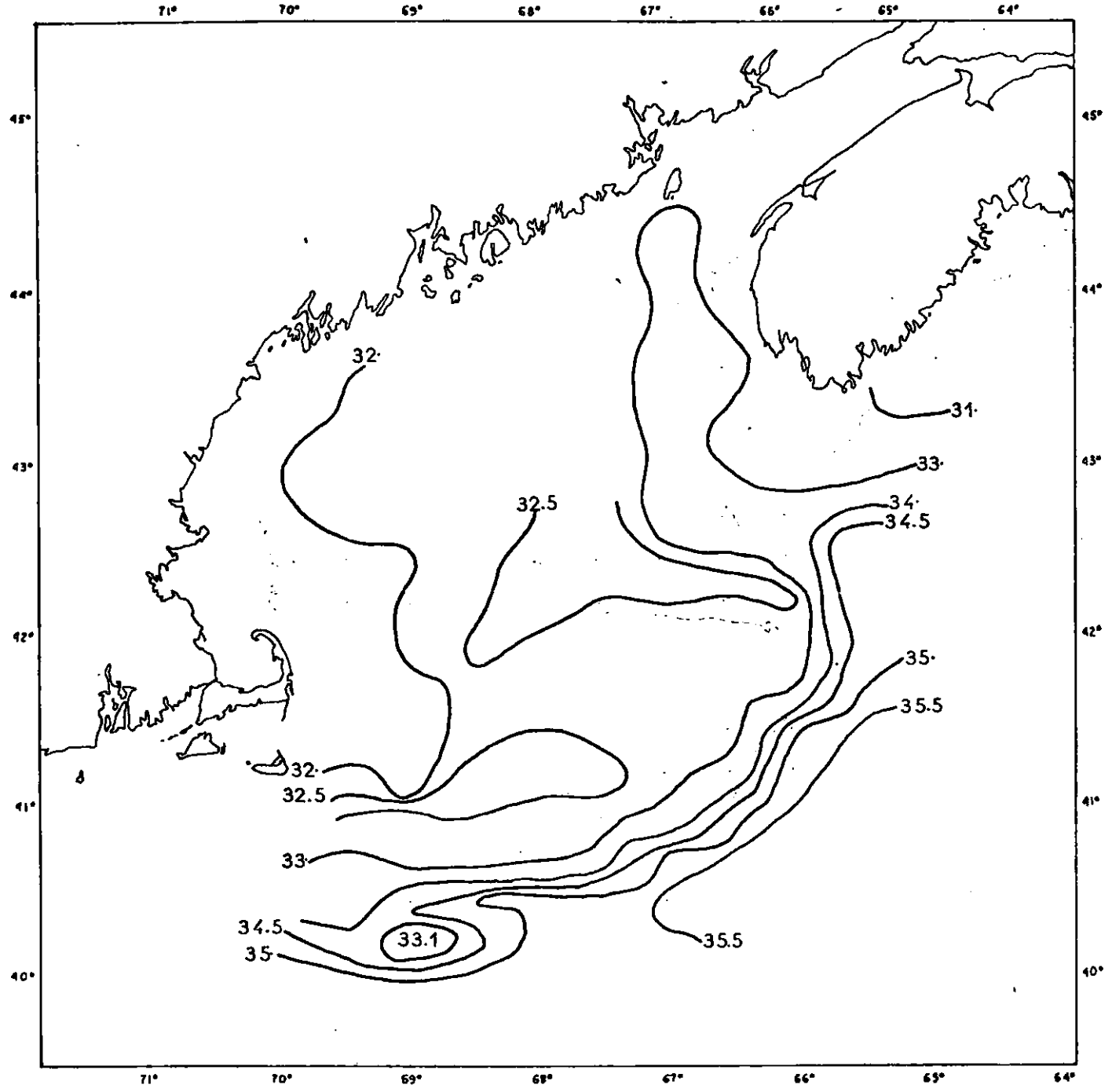

Fig. 4 - Distribution of Calanus finmarchicus (full line) and Pseudocalanus elongatus (dash line).

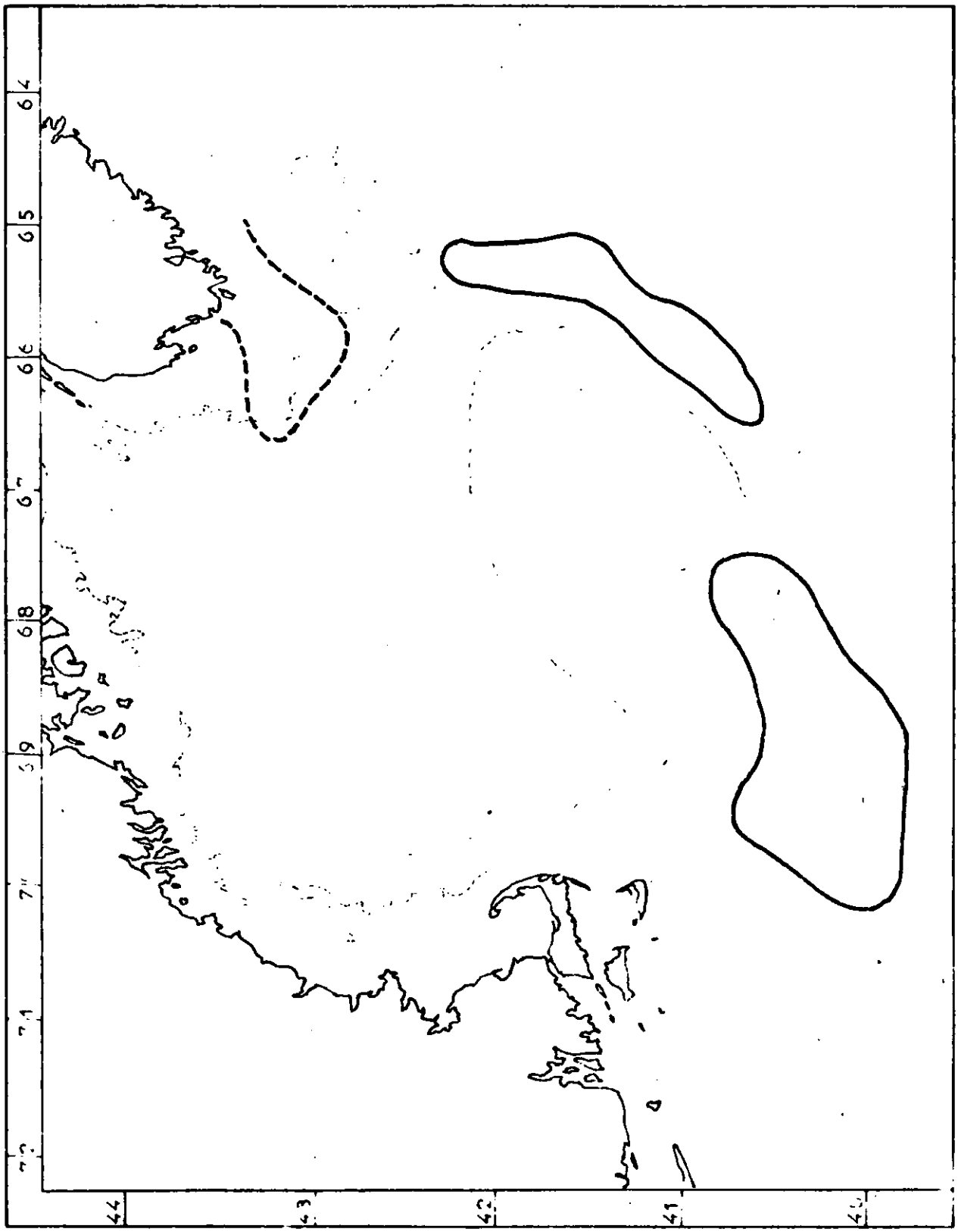

Fig. 5 - Distribution of geloplankton : Thalia democratica (full line), Pleurobrachia pileus (dash line).

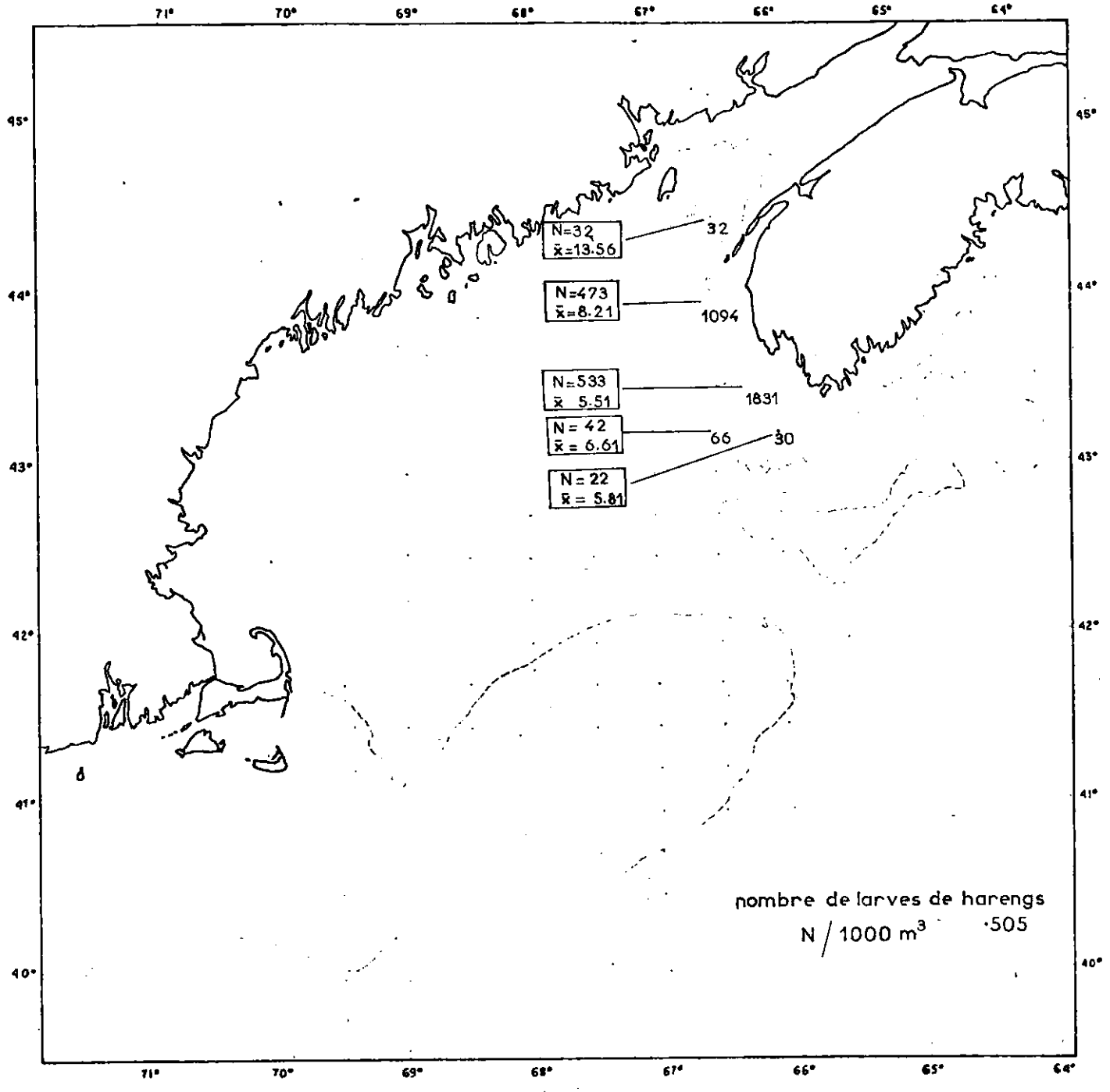

Fig. 6 - Distribution, abondance and mean length of larval herring.

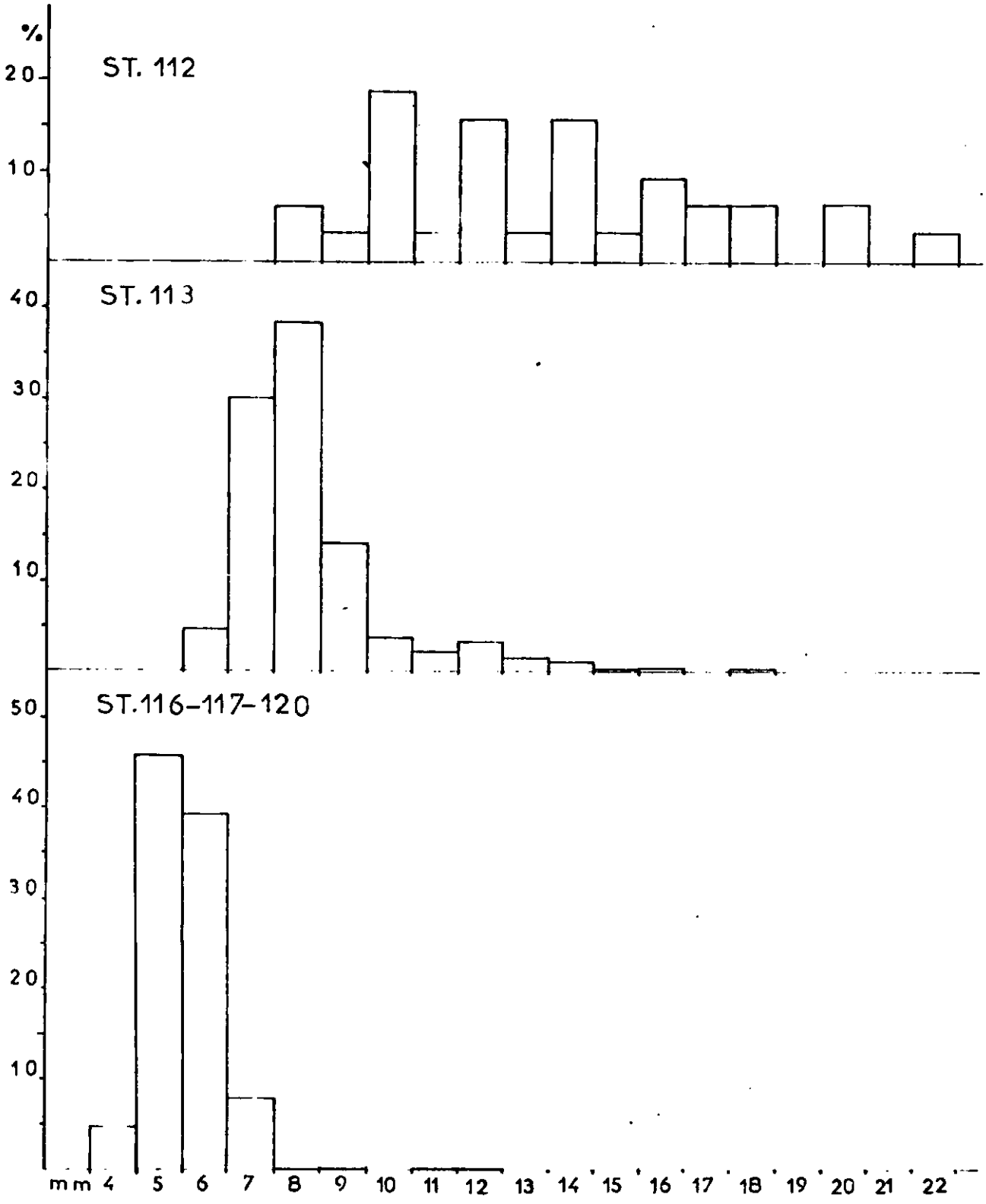

Fig. 7 - Length frequency of larval herring in the Nova Scotia areas.

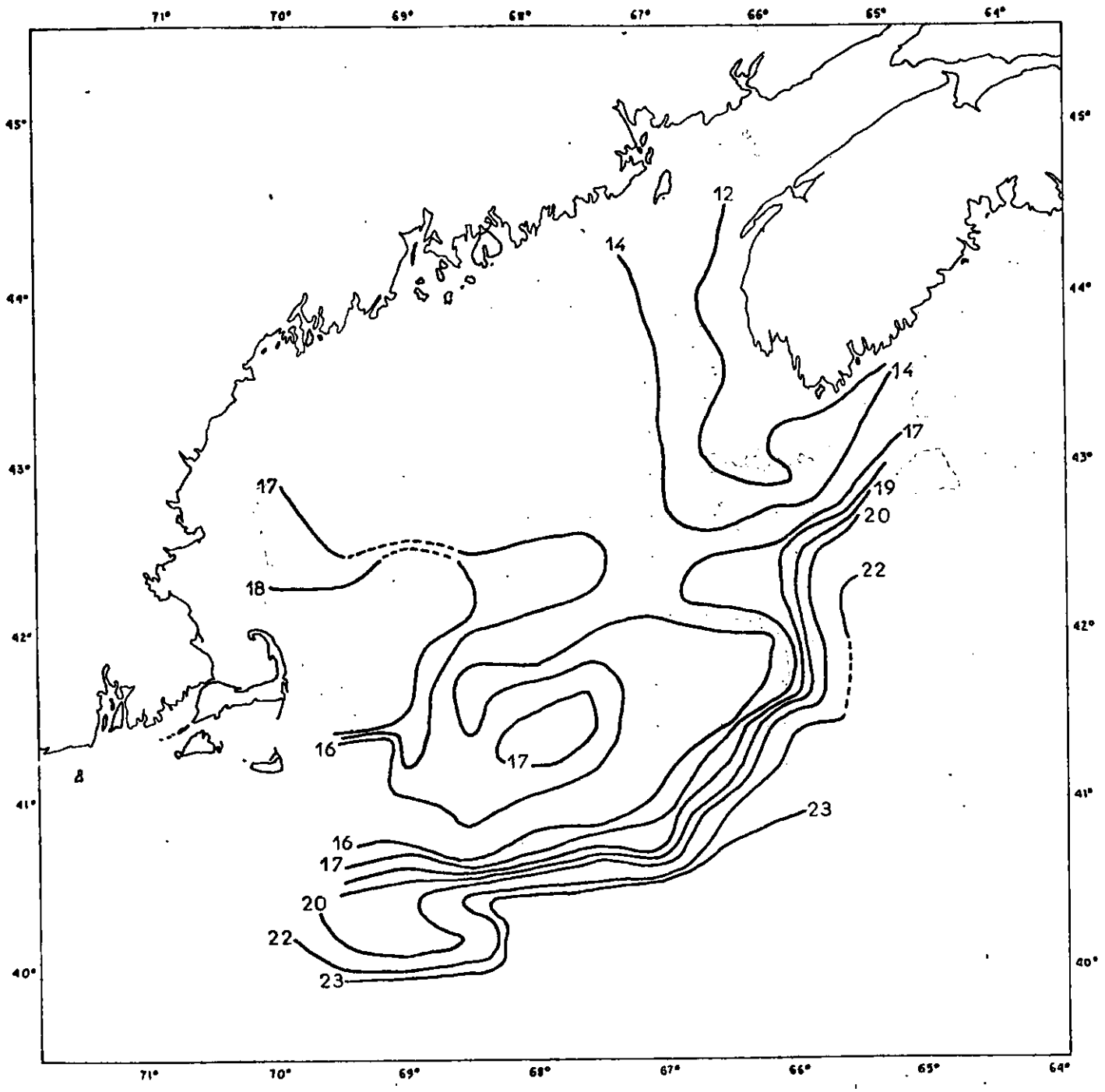

Fig. 8 - Distribution of surface temperatures.

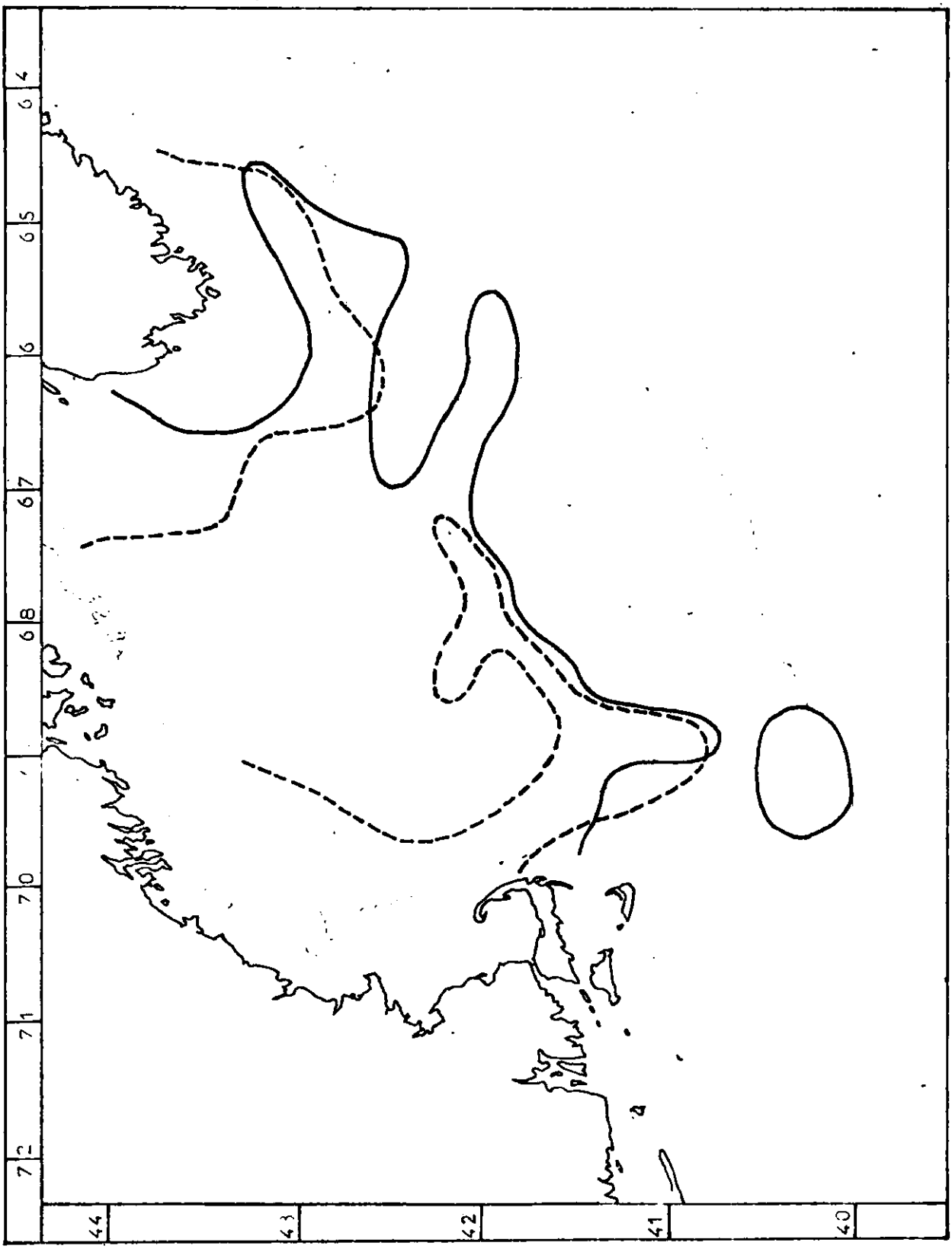

Fig. 9 - Distribution of surface salinities.

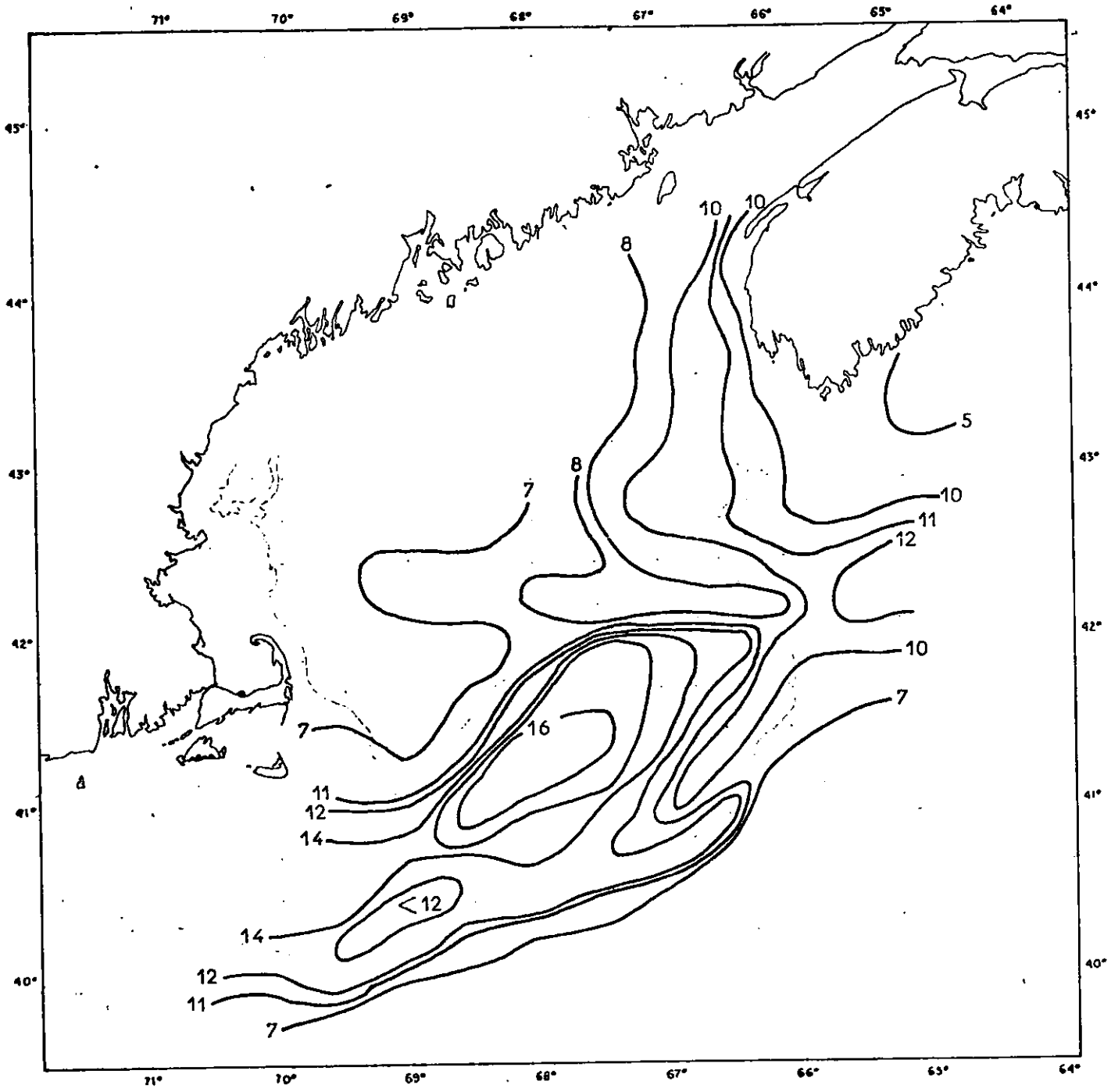

Fig. 10 - Distribution of bottom temperatures.

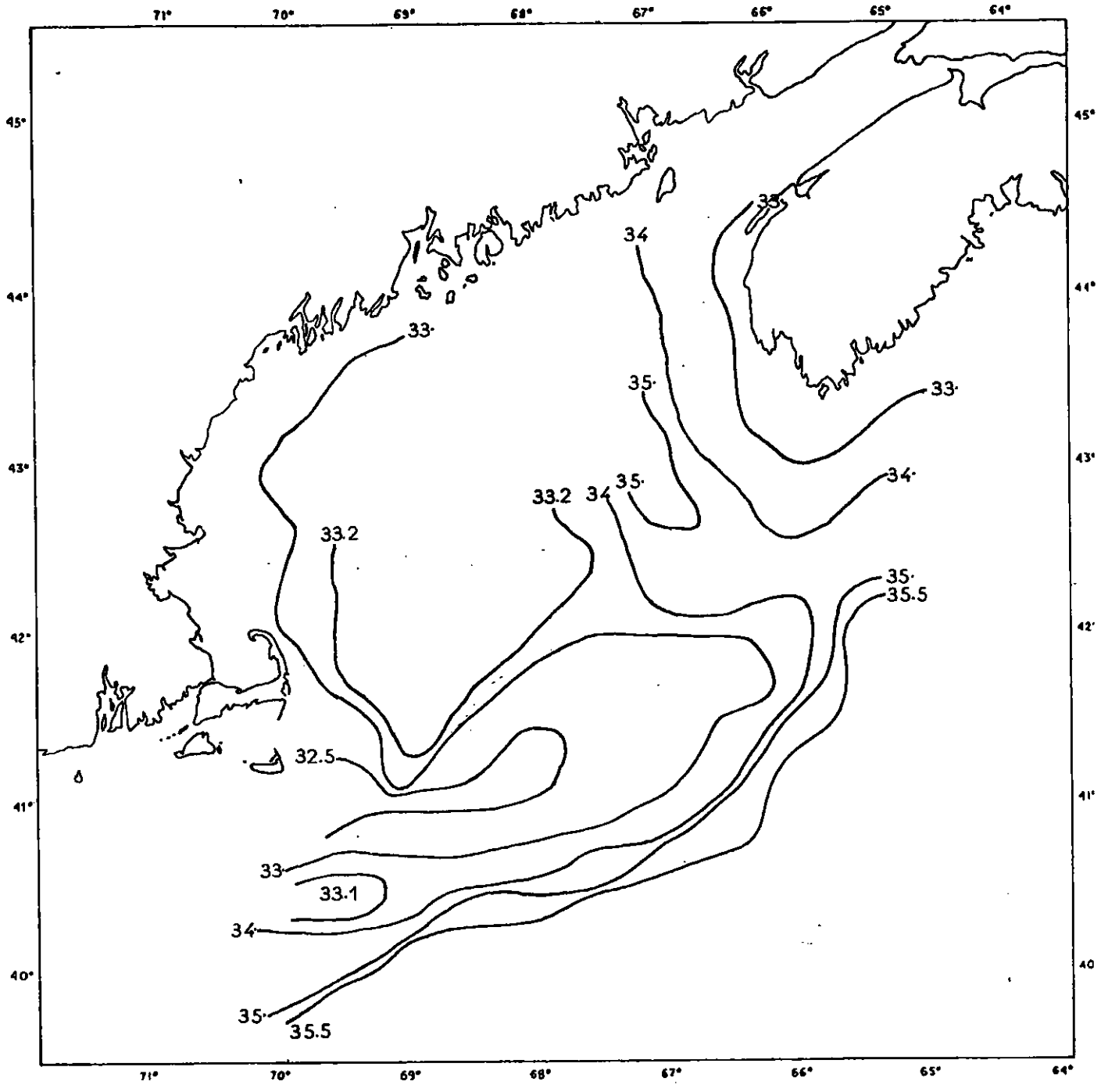

Fig. 11 - Distribution of bottom salinities.

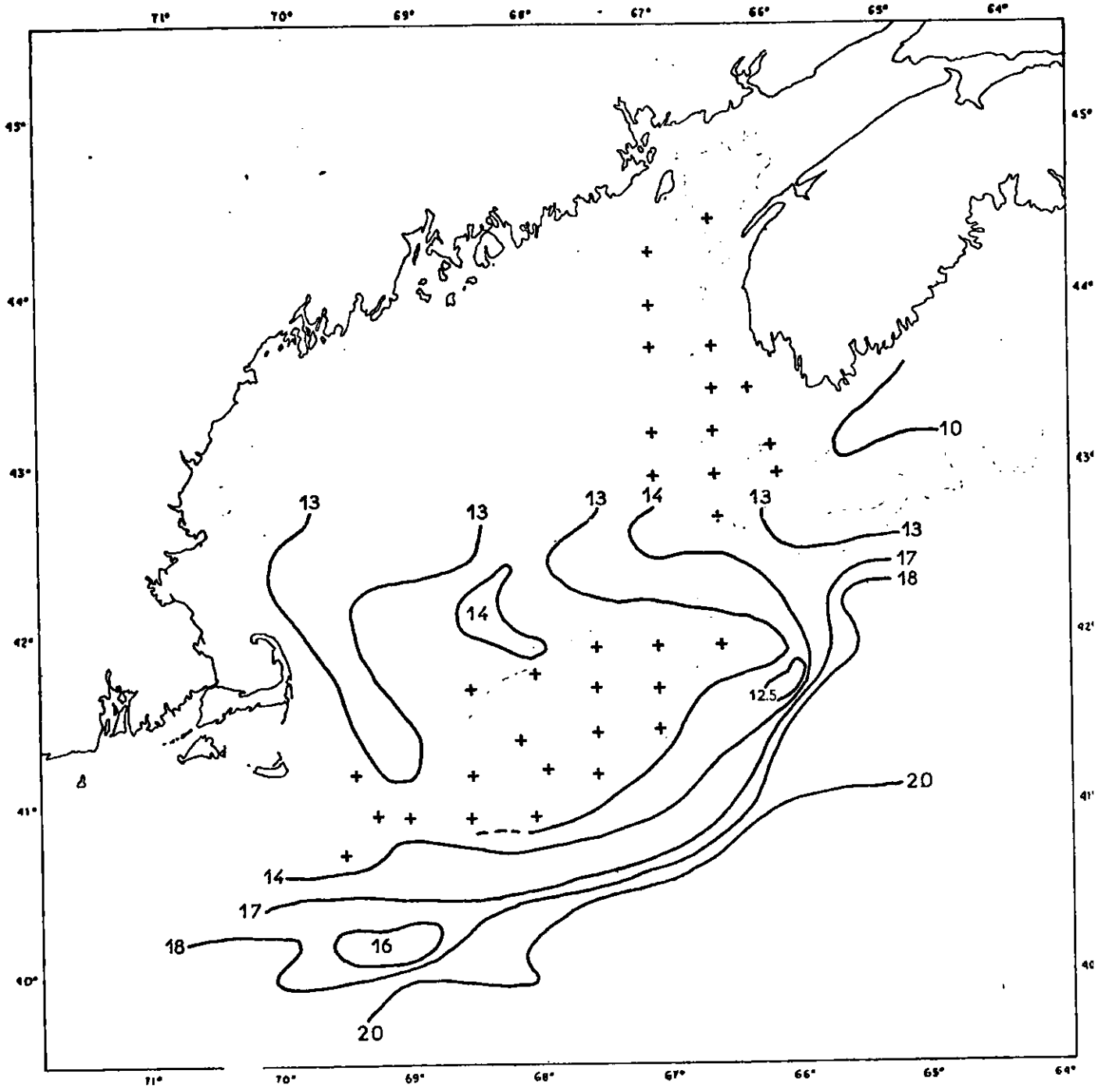

Fig. 12 - Distribution of temperatures at the thermocline level.

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St. Pierre et Miquelon

Page 3, line 1: Sentence "The ctenophore..... (Fig. 5)." should read:

"The ctenophore, *Pleurobrachia pileus*, has a distribution ..... (Fig.5)."

Page 3, line 5: Sentence "..... *Sulfa fusiformia* (Fig. 5)." should read:

"....."*Salpa fusiformis* (Fig.5)."

Page 3, 2nd para under "Distribution of larval herring", line 8: Sentence "The variability index V = ... 99.4%." should read:

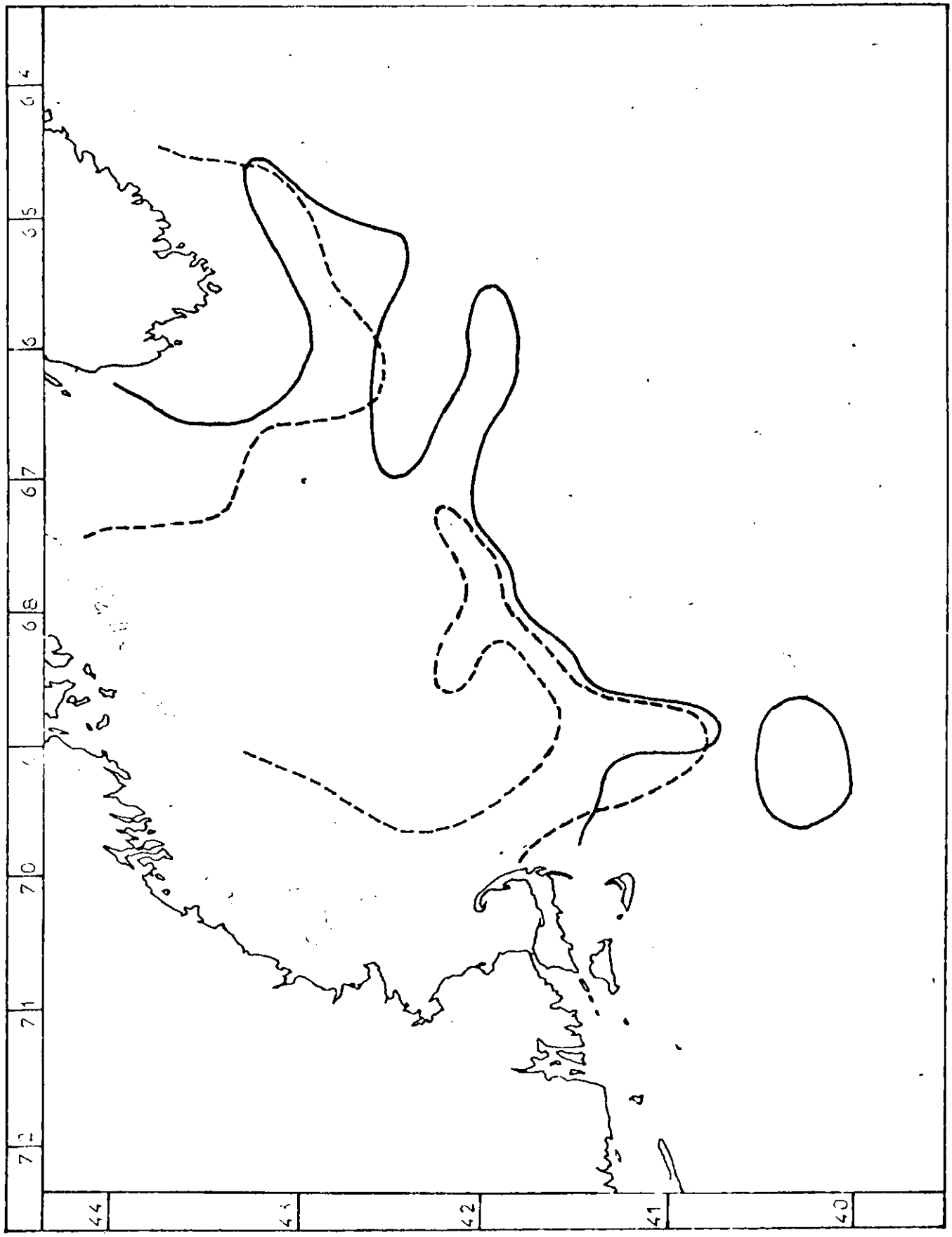
"The variability index $V = 100\ \sigma / \bar{X}$ is very high: 99.4%."

Page 3, 3rd para under "Distribution of larval herring", line 6: Sentence "..... V = 9.3-24.7% (Monsueti and Hardy, 1967)." should read:

"..... V = 9.3-24.7% (Mansueti and Hardy, 1967)."

Pages 14 and 19: Fig. 4 and Fig. 9, respectively.

Please substitute these pages with the attached corrected ones.



F 11

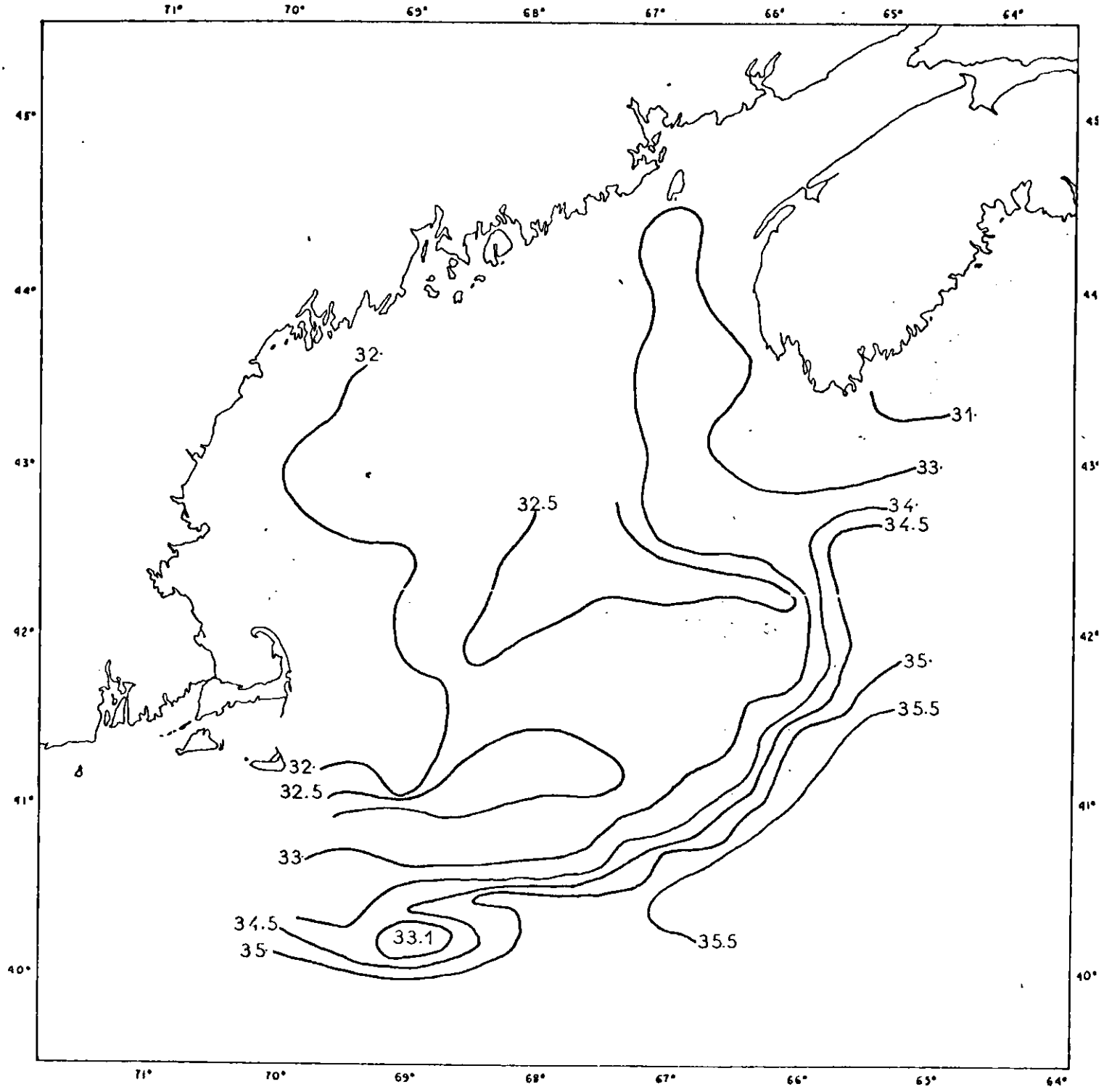


Fig. 9. Distribution of surface salinities.