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Distribution of larval herring on Georges Bank and off southern Nova Scotia, September 1973

by

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INTRODUCTION

In 1973 ICNAF recommended increased international cooperative study of the distribution, abundance and dispersion of herring larvae on Georges Bank and the Gulf of Maine.

The Federal Republic of Germany, USA, Poland and USSR have collaborated in this international effort. French participation was by the R/V *Cryos* from 16-28 September 1973.

Preliminary results are presented here.

MATERIAL AND METHODS

Sampling was carried out at 76 standard ICNAF stations (Fig. 1). These stations were made with the Bongo nets composed of 2 nets of 61 cm in diameter with meshes of 0.505 and 0.333 mm, respectively, to which were attached a depth gauge and 2 current meters.

At each station the Bongo net was lowered to a maximum depth of 100 m or to 10 m off the bottom at lesser depths. Boat speed was about 3.5 knots. The Bongo net was paid out at 50 m/min and hauled back at 10 m/min.

Samples were preserved in 4% formalin solution.

In the laboratory, after sub-sampling, the volume of plankton was, first, measured by displacement of water. Second, the ichthyoplankton was separated out under a binocular scope. For this study, we only used the data on herring larvae. The larvae were counted and measured (total length to the nearest millimeter) using a micrometer.

Concerning the environment, a temperature profile was obtained by using XBT before each plankton set. Also, sea water samples were taken at the surface and at the average depth of the thermocline for salinity determinations.

RESULTS

Although the ICNAF program bears mainly on the distribution of herring larvae, it seemed useful to add the data on plankton distribution.

Quantitative distribution of plankton

Results (Fig. 2) are expressed in cm^3 of plankton per 100 m^3 of water filtered. The quantitative analysis does not take into account here the diurnal rythm of many of the plankton species, which explains certain anomalies seen in the distribution of plankton volumes.

The richest zones (volumes of 40-80 cm^3 and greater) were on Georges Bank and along the shore of Nova Scotia. On Georges Bank the greatest plankton densities were distributed over the central part and projected toward the west-southwest between the 40 and 70 m isobaths. They also bordered the southern extremity of Nova Scotia and the entrance to the Bay of Fundy. The average plankton density (10-40 cm^3) generally encircled regions of strong density. They covered the rest of Georges Bank and the southern part of the Nova Scotia

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shelf as far as Browns Bank.

Georges Bank and Nova Scotia are separated by a zone of low plankton density occupying approximately the north slope of the Fundian Channel and part of the Jordan Basin. The south slope of Georges Bank and the adjacent open ocean stations are also very poor in plankton.

We cannot appreciate the degree of development of the plankton from data collected in two weeks. However, after referring to the data of Sherman (1970) and of Sherman and Honey (1970), we estimate that we are in the second yearly peak characterized by a strong abundance of the copepod, *Centropages typicus*.

Distribution of herring larvae

About 4,700 larvae were taken in the areas covered by the R/V *Cryos*. The raw results are in Table 1. Larvae were observed on Georges Bank, off Nova Scotia and at the entrance of the Bay of Fundy (Fig. 3). For the period concerned, the general area of larval herring distribution is divided into two main regions. This difference in spawning areas has already been verified by Tibbo and Legare (1960), Tibbo and Lauzier (1970), Boyar, Marak, *et al.* (1971), Honey and Chenoweth (1972), and l'Herrou and Briand (1972).

a) Georges Bank

More than 1,800 larvae were taken on Georges Bank. Only seven stations gave larvae. The greatest concentration was of 1,715 larvae. Their lengths varied from 4-11 mm, with a mode length of 7 mm (Fig. 4, Table 2). The small length of the whole of the larvae sampled (83.5% were less than or equal to 8 mm in length) suggests recent hatching. This agrees with the observations of Graham and Chenoweth (1971) who show that the larvae can measure from 6-7 mm at birth. It seems that the spawning on this bank was delayed from reports of 1971 and 1972 (l'Herrou and Briand, 1972; Balkovoi, 1973); on the other hand, it is probable that spawning began for the whole Bank. The dispersal of larvae from their point of maximum concentration does not show an increase in average length of larvae as would be expected (Fig. 5).

b) Nova Scotia

Nearly 2,800 larvae were taken on the Nova Scotia shelf. In fact, using the single criteria of larval length, this region can be divided into two main sub-regions: the first being west-southwest of Yarmouth and into the Bay of Fundy (N.S. I), and the second more to the east and south of the peninsula of Nova Scotia (N.S. II) (Fig. 3 and 5).

Larval length in N.S. I varied from 6-23 mm, with a modal length of 12 mm (Fig. 4). Here, spawning began earlier than on Georges Bank. Larvae of 6-14 mm (mode of 12 mm) are most abundant at this time. One or two important hatchings seem to have taken place, since there is another mode at 16 mm (Table 2). The development and dispersal of the larvae from a very localized spawning area seems clearer here. Dispersion is generally north-northwest, average lengths being 17.4, 15.0 and 19.0 mm at stations 110, 111 and 112, respectively. Certain larvae should have a tendency to enter the Bay of Fundy, carried by the currents predominating at this time (Bumpus, 1960; Tibbo and Lauzier, 1970).

In N.S. II larval length varies from 6-20 mm (Fig. 4), but 95% are between 6 and 11 mm, with a mode of 8 mm. The 12 and 13 mm classes are practically non-existent and the second mode is at 16 mm (Table 2). As in N.S. I, two distinct generations are superimposed but here the youngest is from a more recent hatching, since the average length is 8.0 mm against 12.0 mm (Fig. 4). It would seem that there are two generations of larvae rather than a general development from a single spawning. The larvae being younger than in N.S. I, their dispersion is not yet evident.

Hydrography

At the surface (Fig. 6 and 7), water temperatures over Georges Bank were between 15 and 16°C and salinity near 32‰, while on the slopes water of Atlantic origin is 16 to 23°C and salinity, 33 to 35.5‰.

The southern Nova Scotia shelf has, by contrast, colder (11-13°C) and more saline (31-33‰) water of Laurentian origin.

Near bottom (Fig. 8), Georges Bank temperatures are between 7 and 17°C, depending on the depth. The north-northeast part of the Bank has 8-12°C water bathing the slopes and penetrating partly the Fundian Channel in slope water of 11-12°C. On the southern shelf of Nova Scotia, in the eastern part, is water of pure Laurentian origin (3-8°C), while the rest of the shelf is covered by a mixture of more temperate water (9-11°C).

One should, therefore, note the similarity between the temperature of the waters covering the two main spawning areas.

The average temperature at the thermocline (Fig. 9) varied from 9 to 14°C on the Nova Scotia shelf and

on Georges Bank. Average depths of the thermocline varied from 15 to 55 m. Temperature gradients ($\Delta t/\Delta z$) were between 0.1 and 1.2°C per meter (Table 3). It should be noted that the thermocline is absent on the western part of the Nova Scotia shelf and over Georges Bank.

At the average depth of the thermocline, salinities were 32 to 33‰ on the Nova Scotia shelf and on Georges Bank (Fig. 10).

DISCUSSION AND CONCLUSIONS

Over and above the confirmation, by distribution, of the existence of two main spawning areas, one in the northeastern part of Georges Bank and the other on the southern Nova Scotia shelf, our observations make it possible to compare the general development of the herring larvae in each of the two areas.

1. Abundance. At this time of year, herring larvae are slightly more numerous off Nova Scotia than on Georges Bank: 3,290 against 2,746 larvae, from the data gathered from 1,000 m^3 of filtered water (Table 3).

2. Dispersion. On Georges Bank, the larvae are still all well bunched, average lengths being from 5.6 to 8.3 mm (Table 3). By contrast, on the Nova Scotia shelf, the larvae are more dispersed and average lengths vary greatly from 7.5 to 19.0 mm (Table 3).

3. On the Nova Scotia shelf, average lengths in N.S. I and N.S. II are significantly different (student's "t" test), due to the presence in N.S. I of larvae of 12.0 mm average length and in N.S. II, 8.1 mm. By contrast, for larvae greater than 14 mm, averages in the neighbourhood of 16.6 mm are found in N.S. I and 16.4 mm in N.S. II.

Finally, it is probable that it is a matter of successive hatchings spread out in time and space, the larvae greater than 14 mm from N.S. I and N.S. II can well belong to the same generation.

4. The prime requirements sought by the herring for spawning, followed by hatching of its eggs, are well defined granular beds bathed by currents for oxygenation of the eggs. These conditions are realized in the northeastern part of Georges Bank (Drapeau, 1973; Wigley, 1961; Bumpus, 1960). Also, favourable temperatures assure good development of the larvae. On Georges Bank, most larvae have been found between 9.3 and 16.4°C, while off Nova Scotia temperatures were from 8.9 to 13.4°C (Table 3). Furthermore, in the light of our results, it seems that the thermocline influences the distribution and dispersion of larvae. In fact, in places of greatest concentrations, the thermocline is absent (Fig. 9 and Table 3). Without the thermal barrier provided by a thermocline, larvae seem to have a greater dispersion.

5. By the abundance and length of herring larvae, it would appear that the spawning period in 1973 was later than reported in the two preceding years. This is confirmed by adult herring taken in bottom trawls on northeastern Georges Bank: only 16% were spawning (Gonad/Somatic relationship greater than 20.0); the remainder were maturing (Gonad/Somatic relationship of 15.0). In 1971, at the same time, all herring taken were spawning (l'Herrou and Briand, 1972).

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Table 1. Station data for R/V *Cryos* cruise, 16-28 September 1973.

Station number	Date	Position		Depth (m)	Sampling depth	Number of larvae 0.505 + 0.333	Volume of filtered water (m^3)	Number of larvae per 1 000 m^3
		latitude	longitude					
16	16-9-73	40°32'	69°00'	77	66	0	891.75	
17	"	40°32'	69°30'	66	52	0	893.29	
23	"	40°44'	69°30'	50	34	0	508.39	
24	"	40°45'	68°59'	72	60	0	705.68	
25	"	40°59'	69°00'	85	64	0	952.86	
26	"	41°00'	69°15'	64	50	0	935.59	
27	"	41°15'	69°24'	49	28	0	482.03	
28	"	41°14'	68°59'	139	123	0	1 491.46	
57	17-9-73	40°15'	68°00'	1 100	95	0	1 414.90	
58	"	40°30'	68°00'	124	89	0	1 354.96	
59	"	40°45'	68°00'	77	62	0	935.10	
60	"	41°00'	68°00'	52	44	0	795.36	
61	"	41°15'	67°53'	39	34	0	447.02	
62	"	41°25'	68°05'	41	36	0	407.91	
63	"	41°49'	68°00'	60	54	0	768.31	
64	18-9-73	42°00'	68°00'	196	103	0	1 416.93	
65	"	42°15'	68°00'	198	94	0	1 186.45	
66	"	42°29'	67°59'	192	106	0	1 278.69	
67	"	42°44'	68°00'	189	91	0	1 425.51	
68	"	42°45'	67°30'	177	100	0	1 418.75	
69	"	42°29'	67°30'	274	90	0	1 567.60	
70	"	42°14'	67°30'	268	105	0	1 663.63	
71	"	42°00'	67°32'	48	40	0	562.63	
72	"	41°49'	67°24'	55	52	0	699.63	
73	19-9-73	41°30'	67°29'	50	48	0	575.37	
74	"	41°15'	67°30'	47	36	0	572.04	

..continued

Table 1. Continued.

Station Number	Date	Position		Depth (m)	Sampling depth	Number of larvae 0.505 + 0.333	Volume of filtered water (m^3)	Number of larvae per 1 000 m^3
		latitude	longitude					
75	"	41°00'	67°30'	65	58	0	799.84	
76	"	40°45'	67°29'	86	78	0	1 095.30	
77	"	40°30'	67°29'	132	114	0	1 203.43	
78	"	40°29'	67°00'	>1000	88	0	1 [illegible]	
79	"	40°44'	67°00'	99	74	0	1 466.29	
80	"	41°00'	67°00'	70	60	0	[illegible].82	
81	20-9-73	41°14'	67°00'	65	55	0	775.19	
82	"	41°29'	66°59'	65	56	0	[illegible].49	
83	"	41°45'	67°00'	55	38	972	566.84	1 715
84	20-9-73	42°00'	67°00'	65	55	496	739.42	671
85	"	42°14'	66°58'	220	91	12	1 651.13	7
86	"	42°30'	67°01'	330	75	0	412.53	
87	"	42°28'	66°30'	265	80	0	1 561.92	
88	"	42°15'	66°30'	225	84	0	1 515.11	
89	"	42°00'	66°30'	80	71	44	1 009.32	44
90	24-9-73	41°45'	66°30'	80	58	156	1 020.57	153
91	"	41°29'	66°30'	91	91	148	965.60	153
92	"	41°14'	66°30'	93	84	0	1 026.74	
93	"	40°59'	66°30'	112	95	0	1 428.32	
94	"	41°14'	66°00'	>1000	100	0	1 493.87	
95	"	41°29'	65°59'	135	70	0	1 672.32	
96	25-9-73	41°44'	65°59'	100	91	4	1 225.51	3
97	"	41°59'	65°31'	875	93	0	1 483.74	
98	"	42°00'	66°00'	102	75	0	1 436.72	
124	"	43°30'	65°00'	100	78	12	1 065.25	11
112	26-9-73	44°30'	66°30'	175	99	8	1 450.05	6
113	"	44°00'	66°30'	84	69	586	1 013.18	578
114	"	43°44'	66°29'	85	79	1 240	894.46	1 386
115	"	43°29'	66°29'	105	88	4	1 374.83	3
116	"	43°29'	66°09'	48	44	220	576.69	381
117	"	43°14'	66°30'	65	57	219	778.68	281
118	"	43°00'	66°30'	110	77	0	1 626.62	
119	"	43°00'	66°00'	111	104	56	1 589.76	35
120	"	43°10'	66°00'	73	67	442	760.42	581
121	"	43°09'	65°42'	68	59	0	743.25	
122	"	43°01'	65°30'	125	116	0	1 340.31	
123	"	43°10'	65°00'	161	88	0	1 553.37	
103	27-9-73	42°45'	66°30'	100	88	0	1 209.68	
104	"	42°45'	66°59'	165	88	0	1 658.01	
105	"	43°00'	67°00'	170	110	0	1 720.60	
106	"	43°15'	66°59'	185	95	0	1 696.39	
107	"	43°30'	66°59'	210	106	0	1 476.20	
108	"	43°45'	66°59'	158	88	2	1 615.32	1
109	"	44°00'	67°00'	164	125	2	895.52	2

Table 1. Continued.

Station number	Date	Position		Depth (m)	Sampling depth	Number of larvae 0.505 + 0.333	Volume of filtered water (m3)	Number of larvae per 1 000 m³
		latitude	longitude					
110	27-9-73	44°19'	67°29'	95	82	30	1 308.79	23
111	"	44°19'	66°59'	115	85	4	1 662.80	2
99	28-9-73	42°14'	66°18'	240	81	0	1 984.84	
100	"	42°30'	65°29'	101	71	0	1 366.88	
101	"	42°30'	66°00'	162	102	0	1 339.17	
102	"	42°44'	66°00'	80	74	0	877.23	

Table 2. Length frequencies of larval herring caught on Georges Bank and in Nova Scotia areas.

L* (mm)	Georges Bank		Nova Scotia I		Nova Scotia II	
	Number	%	Number	%	Number	%
4	1	0,21				
5	17	3,59				
6	68	14,37	2	0,22	43	10,59
7	173	36,57	8	0,90	130	32,01
8	136	28,75	32	3,60	164	40,39
9	63	13,31	57	6,41	37	9,11
10	12	2,53	100	11,26	9	2,21
11	3	0,63	207	23,31	2	0,49
12			254	28,60		
13			75	8,44		
14			24	2,70	1	0,24
15			30	3,37	5	1,23
16			35	3,94	8	1,97
17			16	1,80	3	0,73
18			21	2,36	1	0,24
19			11	1,23	1	0,24
20			8	0,90	2	0,49
21			6	0,67		
22			1	0,11		
23			1	0,11		

Table 3. Catch of larval herring in relation to temperature.

Station number	Catch per 1 000 m3	mean length (mm)	Thermocline		t° sampling depth /t° 0 m
			+ or -	gradient $\Delta t/\Delta z$	
16	0		+	0.1	
17	0		+	0.2	
23	0		-		
24	0		+	0.1	
25	0		-		
26	0		-		
27	0		+	0.7	
28	0		+	0.3	
57	0		+	0.3	
58	0		+	0.4	
59	0		+	0.2	
60	0		+	0.3	
61	0		-		
62	0		-		
63	0		+	0.2	
64	0		+	0.2	
65	0		+	0.3	
66	0		+	0.2	
67	0		+	0.1	
68	0		+	0.3	
69	0		+	0.2	
70	0		+	0.2	
71	0		+	0.2	
72	0		-		
73	0		-		
74	0		-		
75	0		+	0.2	
76	0		+	0.3	
77	0		+	0.6	
78	0		+	0.3	
79	0		+	1.2	
80	0		+	0.2	
81	0		+	0.2	
82	0		-		
83	1715	7.6	-		15.0/15.3

.. continued

Table 3. Continued.

Station number	Catch per 1 000 m^3	mean length (mm)	Thermocline		t° sampling depth /t° 0 m
			+ or -	gradient $\Delta t/\Delta z$	
84	671	6.5	-		14.9/15.3
85	7	6.7	+	0.2	5.5/16.0
86	0		+	0.2	
87	0		+	0.2	
88	0		+	0.2	
89	44	5.6	+	0.3	10.4/16.4
90	153	8.3	+	0.3	12.0/15.5
91	153	8.3	-		9.3/15.8
92	0		+	0.3	
93	0		+	0.5	
94	0		+	0.4	
95	0		+	0.4	
96	3	8.0	+	0.2	8.5/15.3
97	0		+	0.5	
98	0		+	0.2	
99	0		+	0.2	
100	0		+	0.1	
101	0		+	0.2	
102	0		-		
103	0		-		
104	0		+	0.1	
105	0		+	0.1	
106	0		+	0.1	
107	0		+	0.1	
108	1	12.0	+	0.1	10.2/13.4
109	2	12.0	+	0.2	8.9/12.8
110	23	17.4	-		10.3/11.0
111	2	15.0	+	0.2	9.7/12.0
112	6	19.0	-		10.1/11.2
113	578	12.3	-		11.1/11.6
114	1386	11.9	-		10.8/11.6
115	3	12.0	-		10.7/12.3
116	381	7.5	-		11.0/11.4
117	281	7.7	-		9.8/11.4

Table 3. Continued.

Station Number	Catch per 1 000 m^3	mean length (mm)	Thermocline + or −	Thermocline gradient $\Delta t/\Delta z$	t° sampling depth /t° 0 m
118	0		−		
119	35	8.1	−		11.0/11.0
120	581	8.6	−		10.3/10.5
121	0		+	0.2	
122	0		+	0.4	
123	0		+	0.5	
124	11	7.5	+	0.4	2.8/13.7

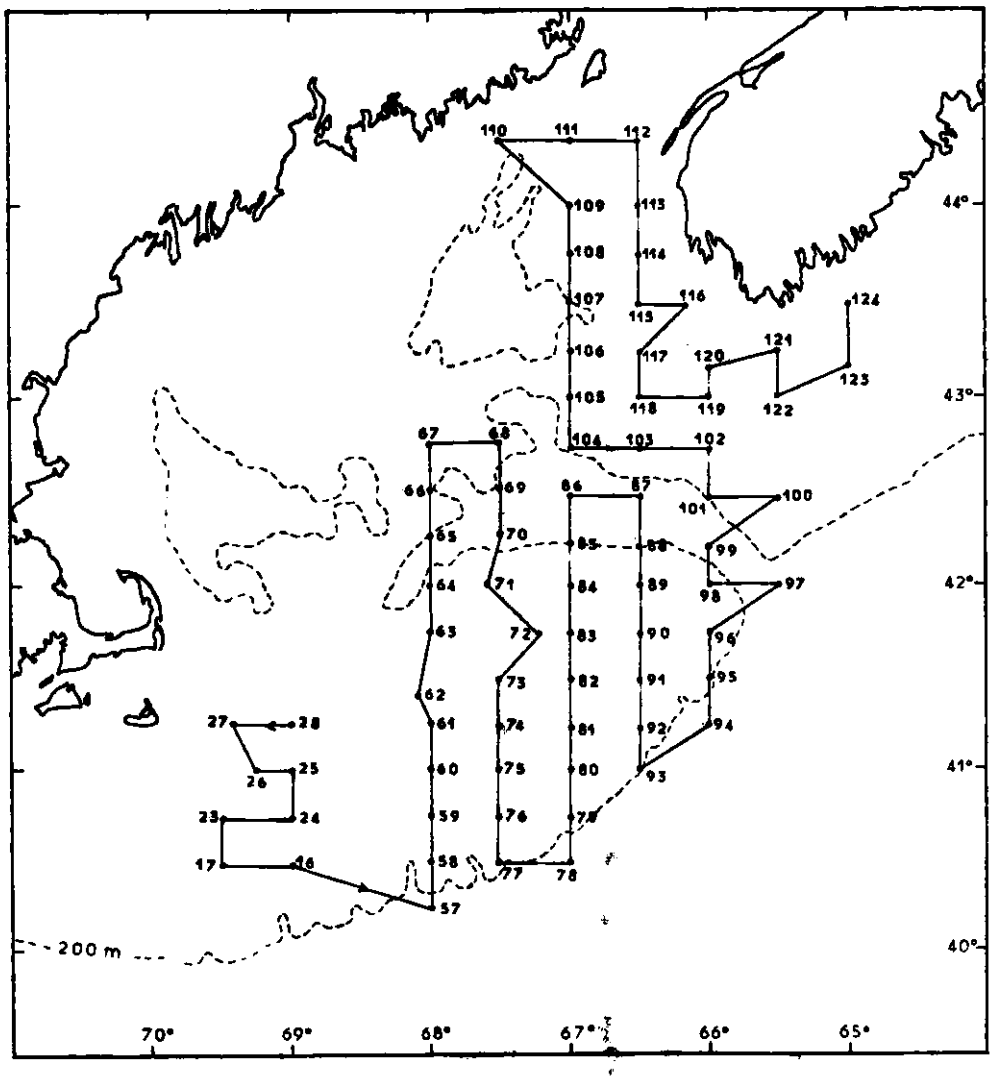

Fig. 1. Cruise track of R/V *Cryos*, 16-28 September 1973.

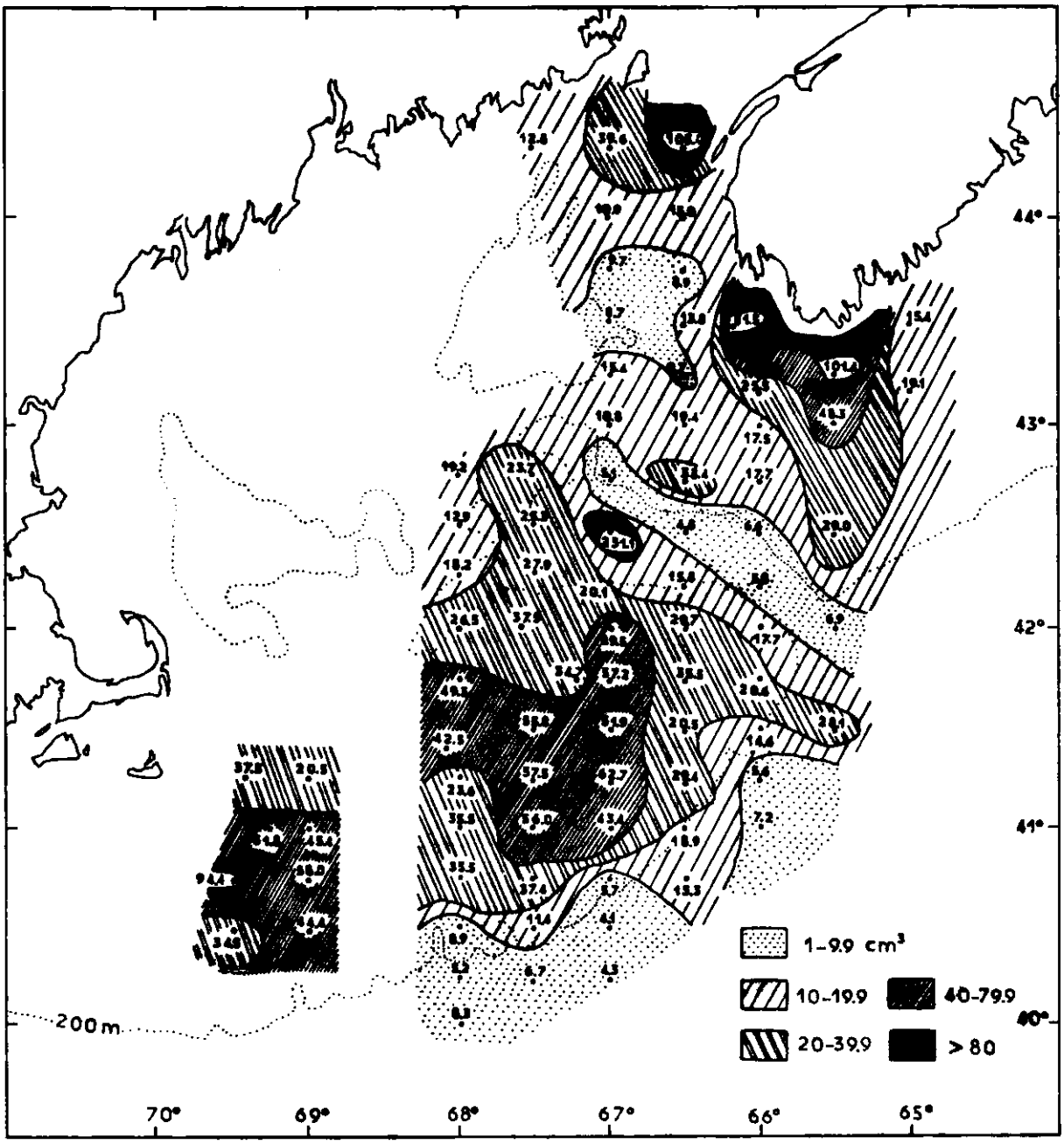

Fig. 2. Quantitative distribution of plankton per 100 m³ of filtered water.

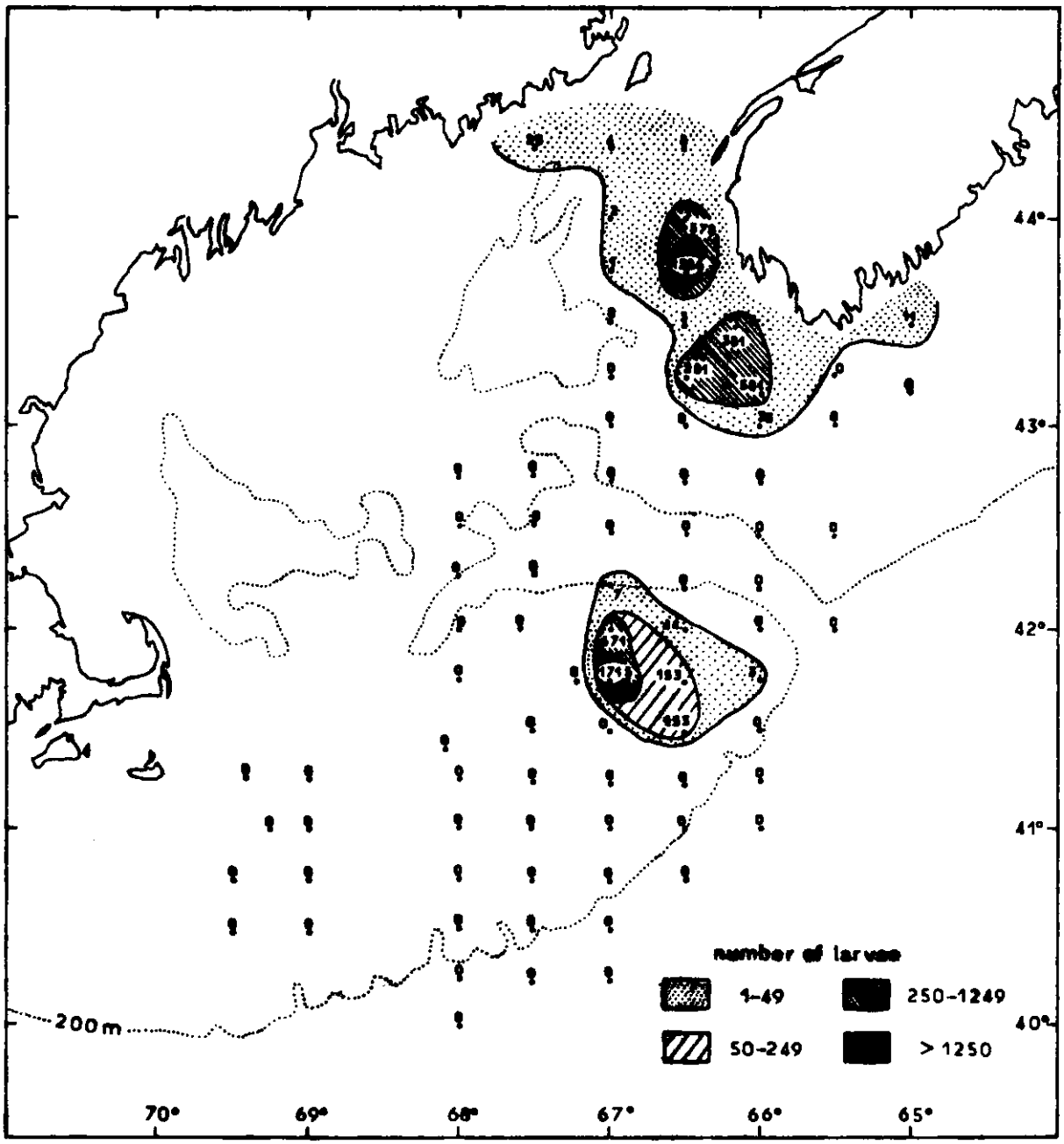

Fig. 3. Distribution and abundance of larval herring (number per 1,000 m^3 of filtered water).

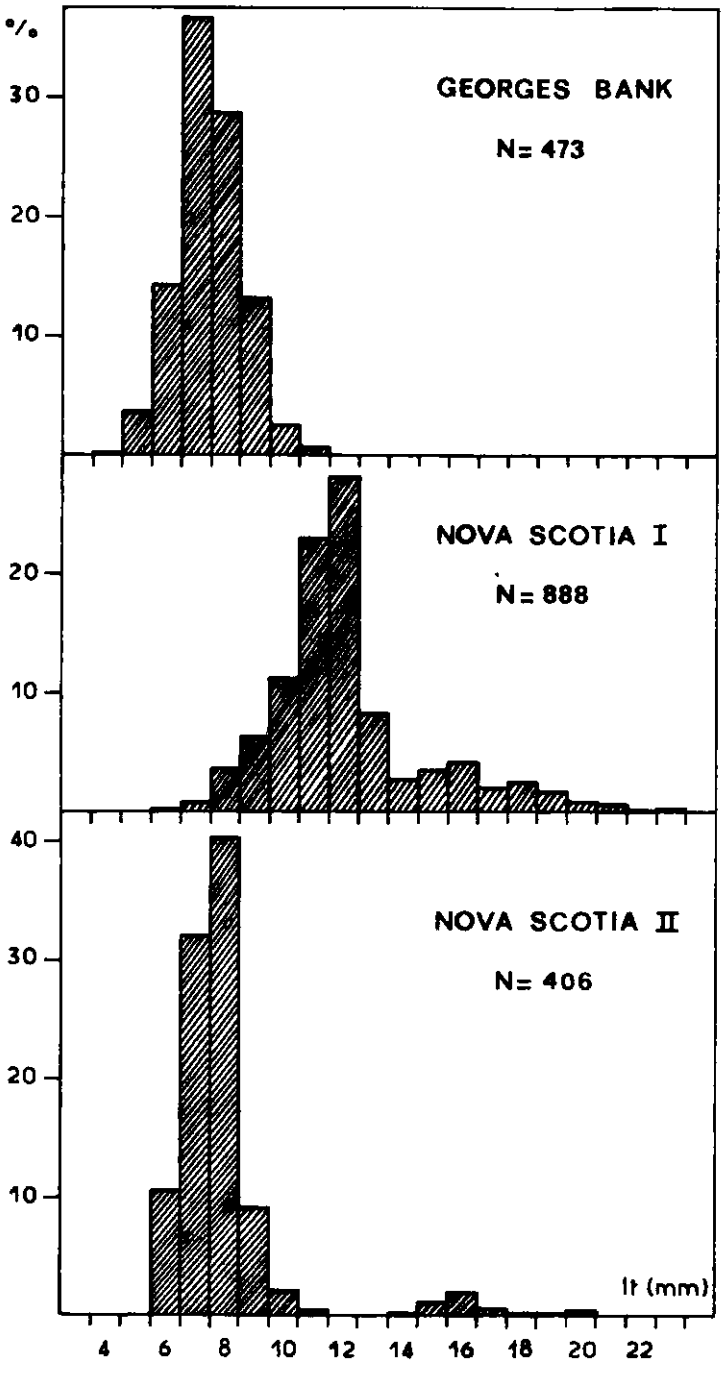

Fig. 4. Length frequency of larval herring in the different areas.

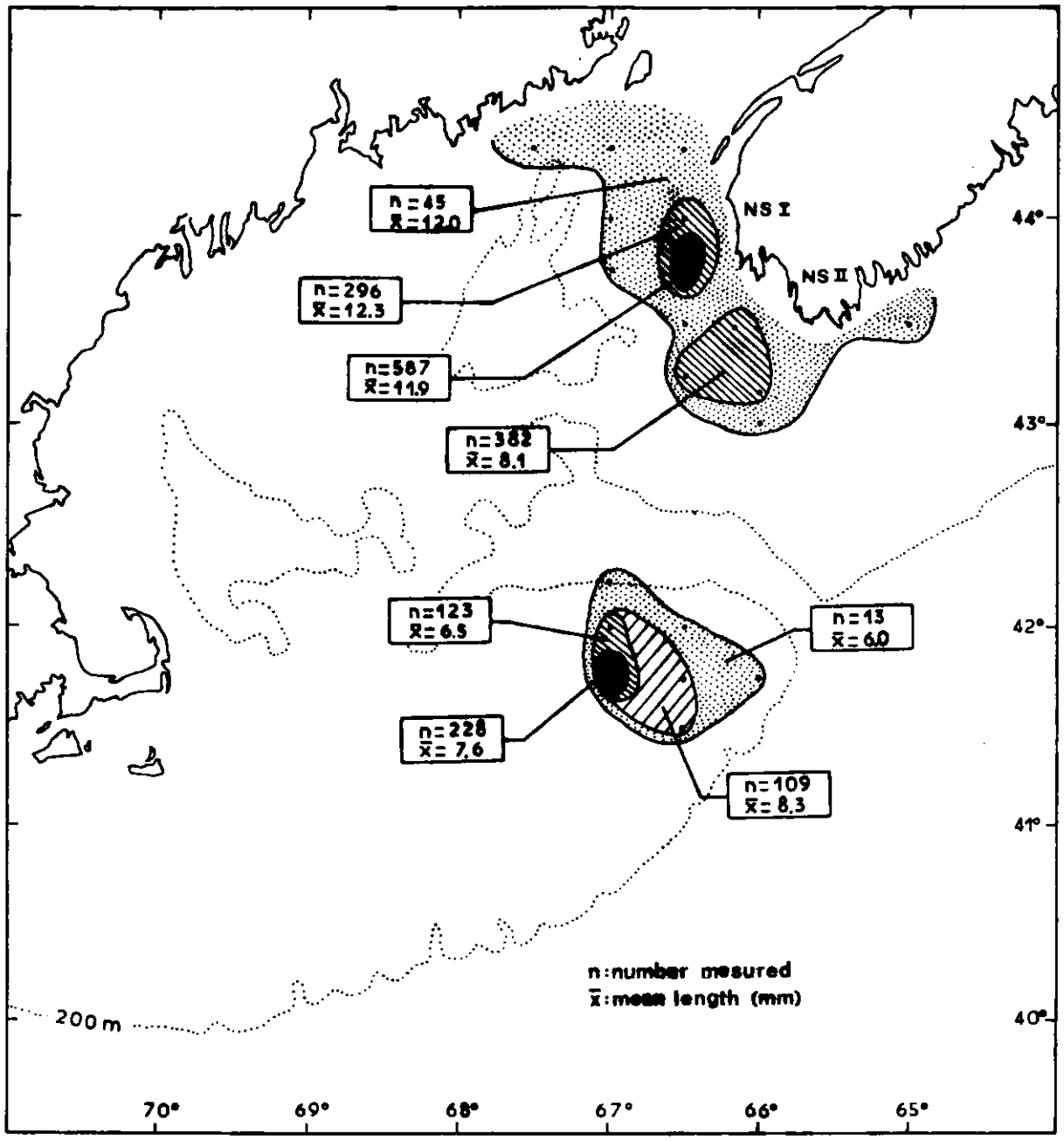

Fig. 5. Mean length of larval herring in relation to distribution.

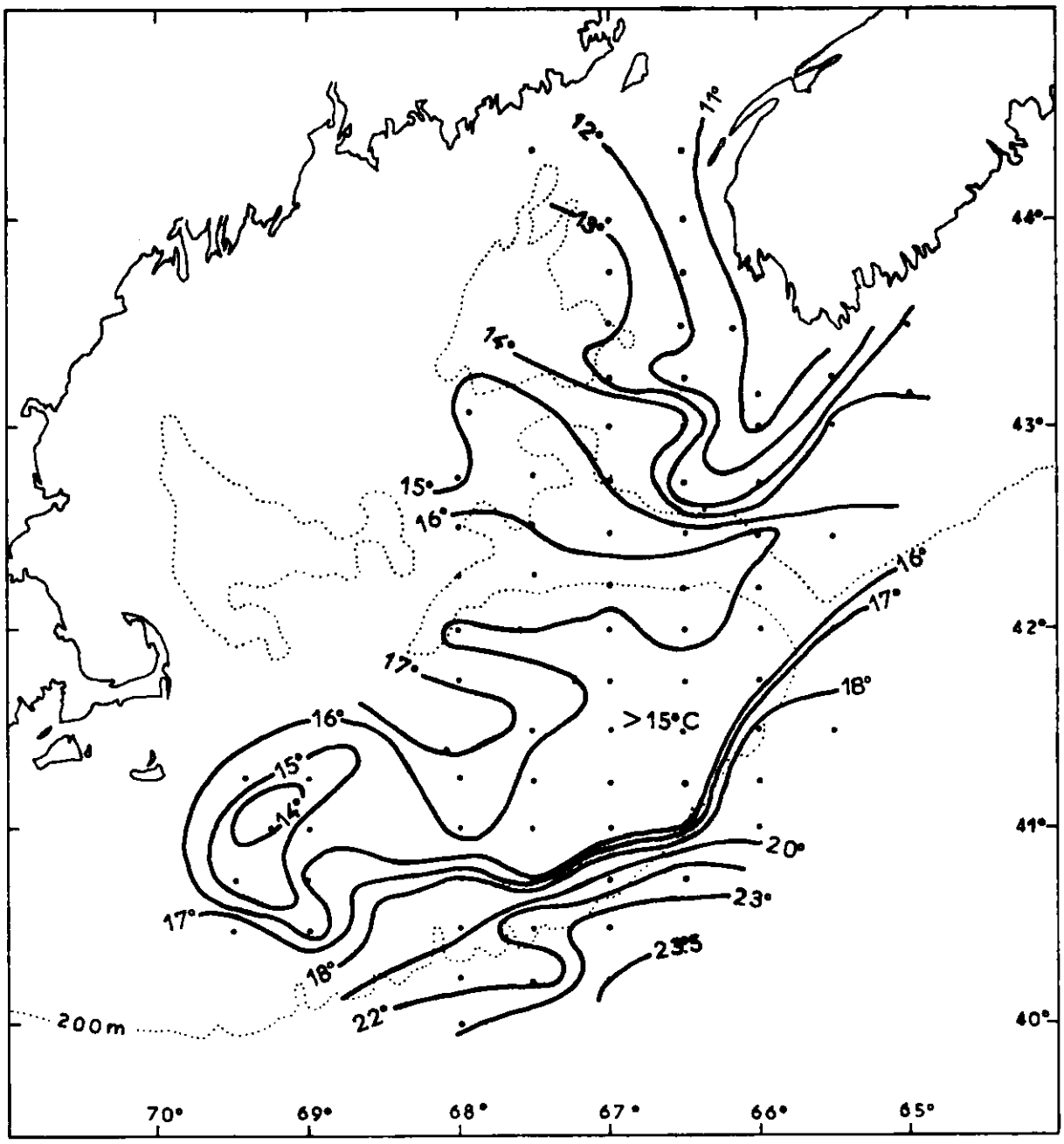

Fig. 6. Distribution of surface temperatures.

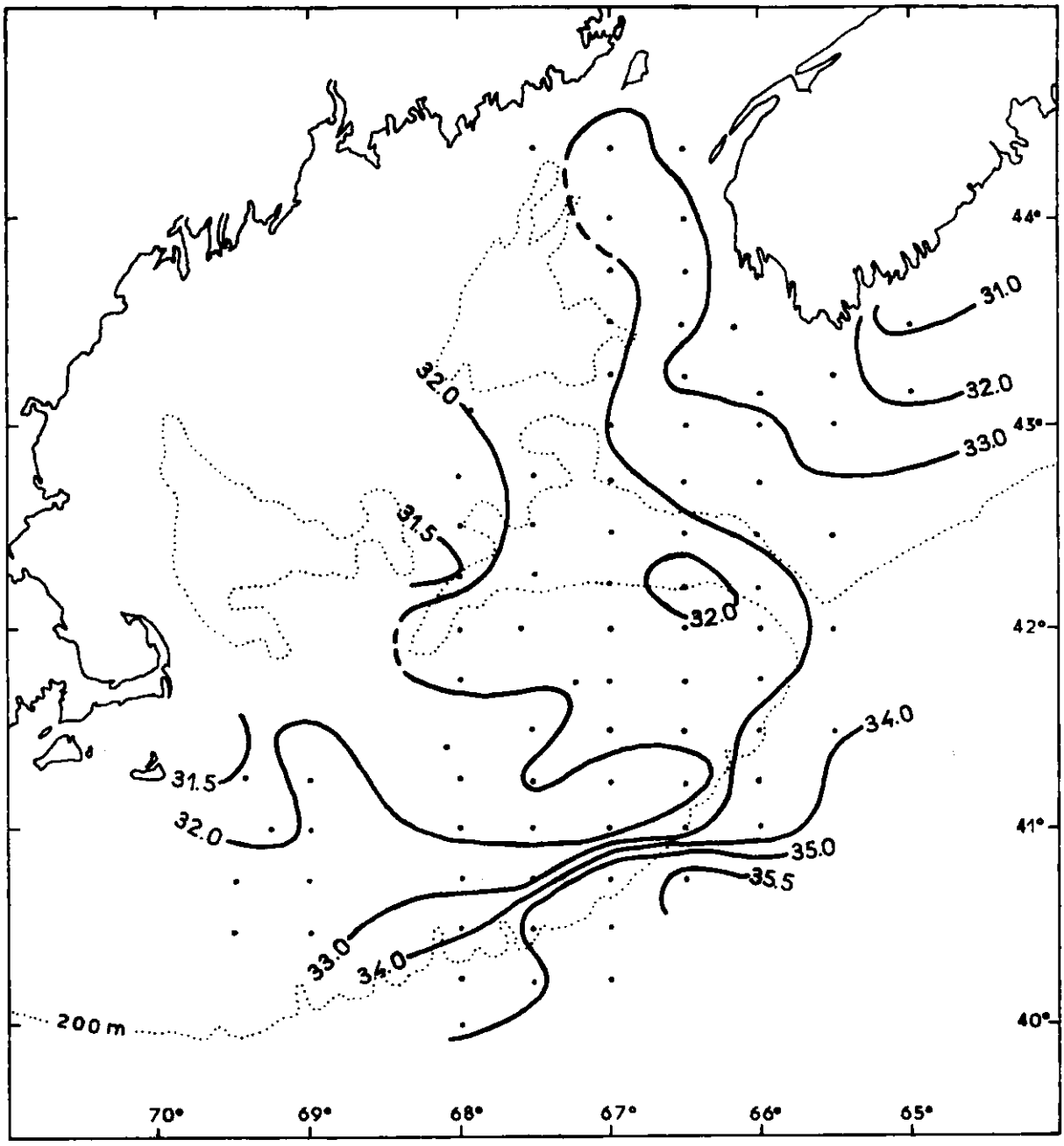

Fig. 7. Distribution of surface salinities.

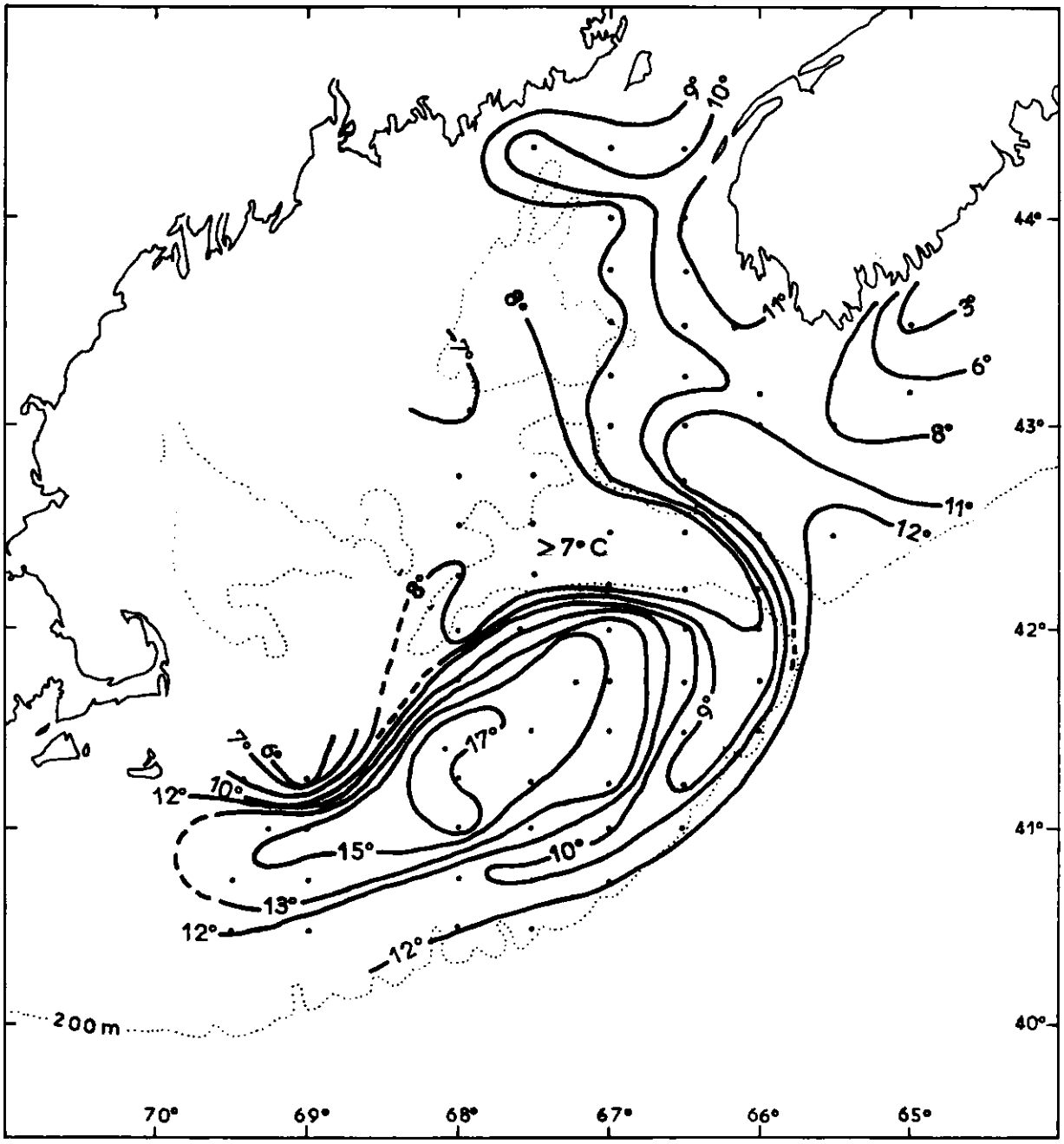

Fig. 8. Distribution of bottom temperatures.

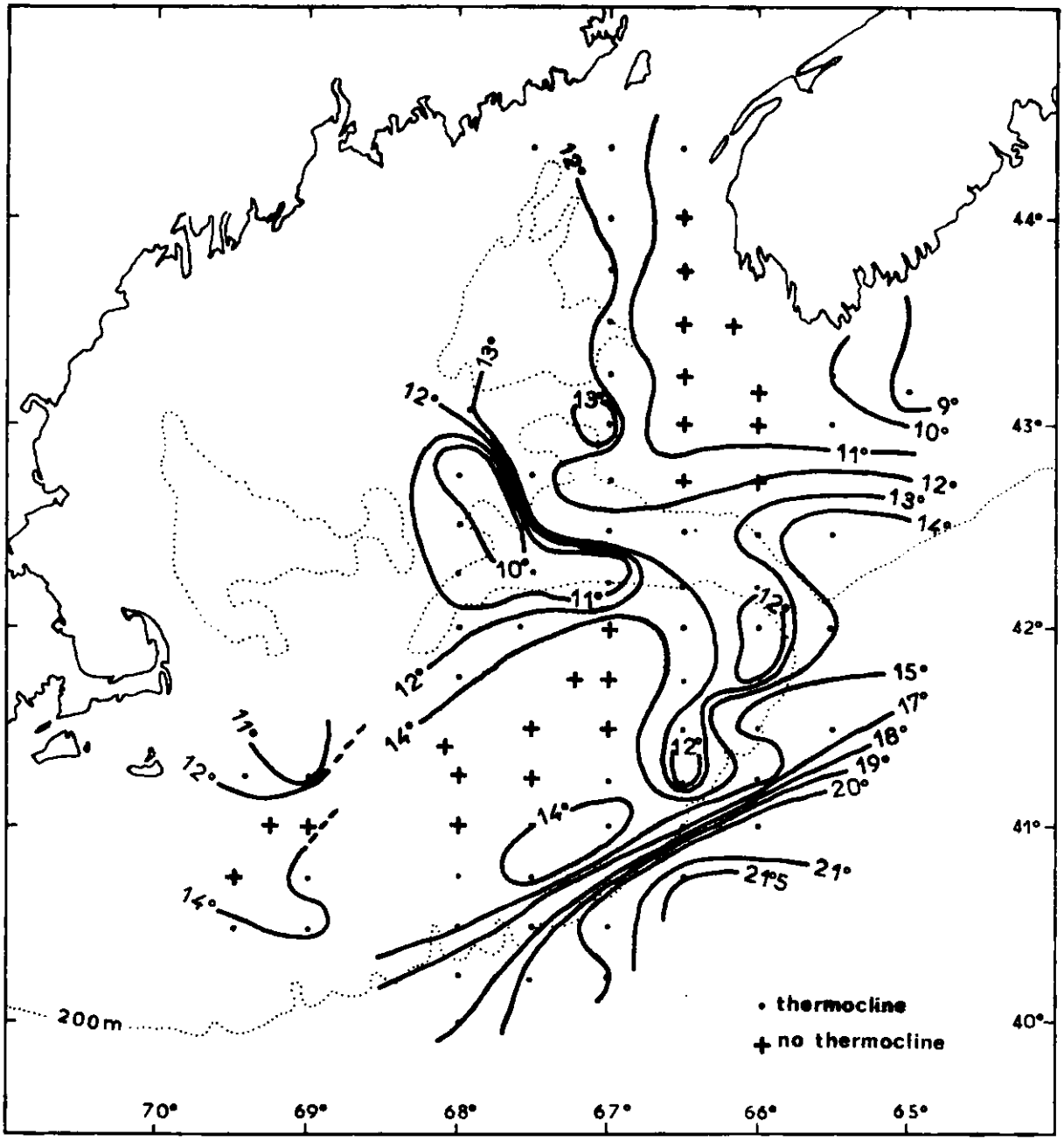

Fig. 9. Distribution of temperatures at the thermocline level.

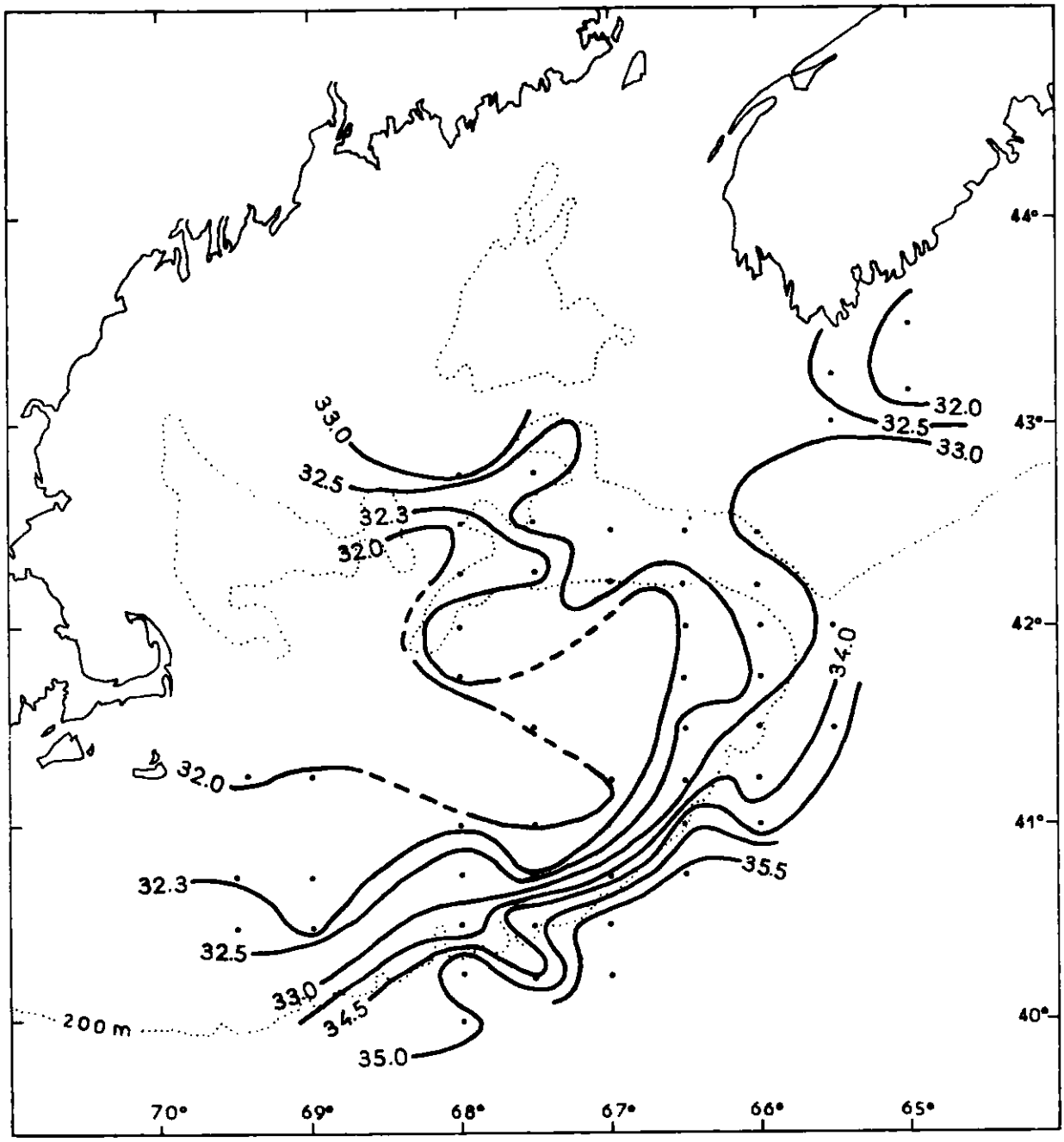

Fig. 10. Distribution of salinities at the thermocline level.