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Distribution of herring larvae on Georges Bank and
in the Gulf of Maine in September 1971

by

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In June 1971, at the 21st Annual Meeting of ICNAF, a research program for joint study of the distribution, abundance and dispersion of herring larvae on Georges Bank and in the Gulf of Maine was set up.

From 9 September to 17 December 1971, USA, USSR, Fed.Rep. Germany, and France worked in relays to complete five cruises covering the aforementioned area, while coverage of the coastal areas of the Gulf of Maine, the Bay of Fundy and of Southwest Nova Scotia was done conjointly by USA and Canada.

French participation, with R/V *Cryos*, was from 9 to 24 September. The results obtained are presented in the present paper.

I. Materials and methods

In order to be able to compare the results obtained by the different participating countries, the BONGO net used by USA for ichthyoplankton studies was adopted.

At each station, oblique hauls were made using two nets of 61-cm diameter with 0.505-mm and 0.333-mm mesh size, respectively.

The correct procedure was to sample from 200 m, or as near as possible to the bottom if the depth was less, to the surface, but on account of using a cable of insufficient length it was impossible for us to lower the net below 165 m.

With the boat travelling at 3.5 knots, the BONGO was set at 50 m per minute to the desired depth then changed to 20 m per minute to 40 m. Leaving this level, the surface is reached by a series of levels separated by 2-m intervals; at each level the net is hauled for one minute. The net was equipped with a flow meter to measure the volume of water filtered.

All plankton hauls were followed by a BT and a sample of surface water for salinity measurement.

The following operations were carried out on the plankton samples:

- measure the displaced volume of the collected plankton,
- remove all fish eggs and larvae from the sample.

Only the herring larvae results are presented in this paper; the results from other species will be presented in other work. Because of the abundance of material collected, we subsampled in the majority of cases. The number of larvae has then been extrapolated to the whole sample. The larvae were then measured, by a binocular, to the nearest millimeter, using an ocular micrometer.

In addition, salinities have been determined using an Auto-Lab (Sydney, Australia) salinometer.

II. Results

Although the research program has been principally devoted to the study of pre-recruitment of herring, it seemed interesting to reserve a paragraph to the study of the plankton volumes collected. These volumes, like the distribution of herring larvae, are shown in the form of distribution maps and the results show, in the first case, the number of cm³ of plankton collected per 100 m³ of water filtered, and in the second case, the number of herring larvae per 100 m³ of filtered water. For each catch, we have used all the material collected by the two nets.

For the larvae, we attempted to establish a correlation with the hydrographic situation and compared their distribution with the temperature at different depth levels. The relation with the bottom temperatures is the most interesting. The surface isohalines are also presented.

A. Quantitative zooplankton distribution

The richest plankton zones (40 to 80 cm³/100 m³ of filtered water and over) are found in the western part of Georges Bank between 20 and 50 fms, in the Gulf of Maine between Cape Ann and Cape Elizabeth, to the south and southwest of Nova Scotia at the 50 to 100 fm levels (Fig. 1).

Regions of average density (10 to 40 cm³/100 m³ of water filtered) occupy the major part of Georges Bank, of the Gulf of Maine and also the coastal area of Nova Scotia, to 100 fms and beyond.

With the exception of certain canyons, the south edge of Georges Bank from the 50 or 100 fm to almost the deepest waters is generally poorest in plankton (less than 10 m³/100 m³ filtered water). It is the same in the coastal region near Cape Cod and Nantucket and Martha's Vineyard Islands.

B. Herring larval distribution

1) Geographic distribution

A total of 8,907 herring larvae were captured during the cruise. Except for 6 larvae taken near the coast of the Gulf of Maine, all were taken in two clearly distinct geographic zones: northern Georges Bank on the one hand, southwestern Nova Scotia and the entrance to the Bay of Fundy on the other (Fig. 2). This separation into two spawning areas confirms studies already undertaken by Tibbo and Legaré, then by Boyar, Marak and colleagues. To these two reproductive areas, it is advisable to add the coastal rim of the Gulf of Maine but in our study, very few larvae were taken there.

a. Georges Bank

The most important concentrations were found in the north part of Georges Bank. A total of 7,450 individuals were fished and their length varies from 4 to 15 mm (Fig. 3); only three specimens were larger. The most (95.5%) measured 4 to 10 mm with a mode at 8 mm and their length indicated that their hatching was recent for then they measure about 6 mm (Graham and Chenoweth, 1971). The numbers taken, however, was less than those taken by other authors in this same region, indicating that we were only at the beginning of the spawning period. In fact, as a general rule, it begins at the end of August-early September, but reaches maximum intensity at the end of September-early October. So, during trawlings after the pre-recruitment program, we encountered abundant spawning concentrations at 42°N and 67°10'W. All herring captured in these fisheries were mature and running (Stage VI).

Larvae were taken at 13 stations and their abundance varied from 4.6 to 1,874.5 per 1000 m³ of filtered water.

2) Southwest Nova Scotia and the entrance to the Bay of Fundy

In these sectors, 1,451 larvae were taken and their length varied from 5 to 16 mm, with a mode at 8 mm (Fig. 3) and the proportion of individuals larger than 9 mm (18.5%) is, however, greater than on Georges Bank. Boyar and Marak state that spawning in this region takes place from May to December with a maximum in September and October. Our observations show that the youngest, less than 10 mm long, would be hatched at the end of August-early September, while the largest would result from spawnings at the end of spring and summer.

Tables 1 and 2 indicate the number of larvae taken at each station and their lengths and frequency, respectively.

C. Relationship with temperature and salinity

With the majority of larvae having a length near that at spawning, one can deduce that the bottom temperature at the moment of capture is very close to that which

existed at the time the eggs were laid.

Under these conditions, one notes that, on Georges Bank, at the stations where one finds larvae, the bottom temperature varies from 9.6° to 17.1°C, while off Nova Scotia it varied from 8.4° to 11.1°C (Fig. 4).

In general, at stations with the highest temperature (13° to 17°C) one finds the greatest concentrations since their number is small for lower temperatures between 8° and 12°C. One should note especially at Southwest Nova Scotia, at one station where the temperature is 11.1°C, the number of larvae is high: 419.3 per 1000 m³ of filtered water.

Along the coasts, the water temperature influenced by the Labrador Current is lower than that on Georges Bank. This could have an effect on the abundance of larvae. In fact, the optimum temperature at spawning time seems to be between 13° and 17°C, which if not reached, means less spawning there than on Georges Bank.

Concerning the near-surface (5 m) temperature (Fig. 5) a homothermal layer is seen on Georges Bank where it varies from 15.5° to 17°C, while along the coast of Nova Scotia it is between 10° and 14°C.

Surface salinity (Fig. 6) varies from 32 to 32.4‰ on Georges Bank and from 32.5 to 33 ‰ off Southwest Nova Scotia.

Conclusion

The larval herring taken during this survey were mainly from two distinct geographic areas. The length of individuals is almost identical in each of the areas, except there is a greater proportion of larvae over 9 mm long in Southwest Nova Scotia than on Georges Bank, which indicates an earlier spawning in the previous region.

As already demonstrated by various authors, these spawnings are from two different stocks and the individuals of each reproduce in different water temperatures. Because larval concentrations are greater on Georges Bank, the optimum temperature for reproduction would seem to be between 13° and 17°C.

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Tibbo, S.N., and L.M. Lauzier. 1970. Seasonal distribution of larval herring in the Bay of Fundy and Gulf of Maine. *Annu. Meet. int. Comm. Northw. Atlant. Fish.*, Res.Doc. 70/52, p. 1-6.

Table 1. Number of herring larvae taken at each station, R/V *Cryos* cruise, 9-24 September 1971.

Numéro de station	Date	Nombre de larves de hareng 0,505 mm-+ 0,333 mm	Volume d'eau filtrée m ³	Nombre de larves / 1 000 m ³ d'eau filtrée	Latitude	Longitude	Profondeur mètres
2	10/9/71	0	2 168		41° 35'	69° 20'	110
4	"	111	1 406	78,9	41° 49'	68° 00'	50
5	"	165	1 958	84,2	41° 50'	67° 21'	45
6	"	1 408	2 682	524,9	41° 53'	66° 45'	60
7	"	0	1 920		41° 58'	66° 10'	80
8	"	0	3 082		42° 00'	65° 30'	1 075
9	11/9/71	0	2 380		42° 30'	65° 30'	91
10	"	0	1 444		43° 00'	65° 30'	110
11	"	0	1 440		43° 15'	65° 40'	43
13	"	235	1 106	212,4	43° 12'	66° 00'	38
14	"	0	2 144		43° 00'	66° 00'	117
15	"	0	2 184		42° 45'	66° 00'	70
16	"	0	3 158		42° 30'	66° 00'	107
17	"	0	3 308		42° 15'	66° 00'	230
18	"	0	1 744		42° 00'	66° 00'	90
19	12/9/71	0	2 364		41° 45'	66° 00'	93
20	"	0	3 102		41° 30'	66° 00'	138
21	"	0	3 208		41° 15'	66° 00'	1 750
22	"	0	2 428		41° 00'	66° 30'	124
23	"	0	1 950		41° 15'	66° 30'	85
24	"	25	2 156	11,5	41° 30'	66° 30'	85
25	"	925	2 060	450,0	41° 45'	66° 30'	71
26	"	40	2 432	16,4	42° 00'	66° 30'	82
27	"	0	3 740		42° 15'	66° 30'	215
28	"	0	3 212		42° 30'	66° 30'	264
29	13/9/71	0	2 762		42° 45'	66° 30'	142
30	"	0	2 566		43° 00'	66° 30'	127
31	"	0	1 904		43° 15'	66° 30'	72
32	"	0	1 918		43° 30'	66° 30'	92
33	"	712	1 698	419,3	43° 45'	66° 30'	75
34	"	483	2 816	239,5	44° 00'	66° 30'	72
35	"	4	2 962	1,5	44° 25'	66° 30'	192
36	"	17	2 172	7,8	44° 25'	67° 00'	121
37	"	0	2 814		44° 00'	67° 00'	161
38	14/9/71	0			44° 00'	67° 30'	192
39	"	0	3 366		43° 45'	67° 30'	220
40	"	0	2 870		43° 45'	67° 00'	150
41	"	0	2 812		43° 30'	67° 00'	202
42	"	0	3 246		43° 30'	67° 30'	215
43	"	0	3 588		43° 20'	67° 30'	187

Table 1. continued

Numéro Station	Date	Nombre de larves de hareng 0,505 mm + 0,333 mm	Volume d'eau filtrée m ³	Nombre de larves / 1 000 m ³ d'eau filtrée	Latitude	Longitude	Profondeur mètres
44	14/9/71	0	3 676		43° 20'	67° 00'	190
45	"	0	3 380		43° 00'	67° 00'	203
46	15/9/71	0	3 246		42° 45'	67° 00'	160
47	"	0	2 704		42° 30'	67° 00'	327
48	"	0	3 726		42° 15'	67° 00'	217
49	"	1 472	1 504	978,7	42° 00'	67° 00'	65
50	"	2 898	1 546	1 874,5	41° 45'	67° 00'	59
51	"	348	1 794	193,9	41° 30'	67° 00'	60
52	"	13	1 744	7,4	41° 15'	67° 00'	57
53	"	0	1 924		41° 00'	67° 00'	80
54	"	0	2 014		40° 45'	67° 00'	107
55	"	0	3 242		40° 30'	67° 00'	245
56	16/9/71	0	2 558		40° 30'	67° 30'	109
57	"	0	1 964		40° 45'	67° 30'	33
58	"	0	1 966		41° 00'	67° 30'	65
59	"	22	1 490	14,7	41° 15'	67° 25'	42
60	"	7	1 512	4,6	41° 31'	67° 30'	50
63	"	0	3 144		42° 15'	67° 30'	277
64	"	0	2 604		42° 30'	67° 30'	282
65	"	0	3 754		42° 30'	68° 00'	197
66	17/9/71	0	3 118		42° 15'	68° 00'	197
67	"	0	3 050		42° 00'	68° 00'	190
68	"	0	1 444		41° 50'	68° 00'	60
71	22/9/71	0	1 780		41° 00'	68° 00'	50
72	"	10	2 024	6,9	40° 45'	68° 00'	70
73	"	0	2 111		40° 30'	68° 00'	126
74	"	0	1 886		40° 30'	68° 30'	84
75	"	0	1 128		40° 45'	68° 30'	50
76	17/9/71	0	1 490		41° 02'	68° 31'	45
77	"	0	1 950		41° 15'	68° 30'	52
78	"	0	2 028		41° 30'	68° 30'	86
79	"	0	3 432		41° 45'	68° 30'	180
80	18/9/71	0	2 492		42° 00'	68° 30'	178
81	"	0	2 746		42° 15'	68° 30'	162
82	"	0	3 250		42° 30'	68° 30'	106
83	"	0	3 350		42° 30'	69° 00'	212
84	"	0	3 234		42° 30'	69° 30'	254
85	19/9/71	0	2 796		43° 00'	69° 30'	140
86	20/9/71	1	2 228	0,4	43° 30'	69° 30'	141
87	19/9/71	5	2 006	2,4	43° 30'	70° 00'	105

Table 1. continued

Numéro de Station	Date	Nombre de larves de hareng 0,505 mm + 0,333 mm	Volume d'eau filtrée m ³	Nombre de larves / 1 000 m ³ d'eau filtrée	Latitude	Longitude	Profondeur mètres
88	19/9/71	0	1 992		43° 15'	70° 00'	120
89	"	0	2 490		43° 00'	70° 00'	152
90	"	0	2 590		43° 00'	70° 15'	157
91	"	0	1 226		42° 45'	70° 15'	69
92	"	0	3 024		42° 45'	70° 00'	190
93	"	0	2 990		42° 30'	70° 00'	135
94	"	0	2 168		42° 15'	70° 00'	110
95	18/9/71	0	3 138		42° 00'	69° 00'	145
96	18/9/71	0	3 164		41° 45'	69° 00'	162
97	"	0	2 806		41° 30'	69° 00'	135
98	17/9/71	0	3 010		41° 15'	69° 00'	150
99	"	0	1 746		41° 00'	69° 00'	75
100	21/9/71	0	1 822		40° 45'	69° 00'	50
101	22/9/71	0	1 732		40° 30'	69° 00'	67
102	"	0	2 516		40° 15'	69° 00'	110
103	"	0	1 576		40° 15'	69° 30'	75
104	"	0	1 712		40° 30'	69° 30'	60
105	23/9/71	0	1 162		40° 47'	69° 26'	41
107	21/9/71	0	994		41° 15'	69° 24'	35
108	"	0	1 574		41° 32'	69° 30'	48
109	"	0	2 426		41° 45'	69° 30'	125
113	23/9/71	0	1 624		40° 40'	70° 00'	42
114	"	0	2 084		40° 30'	70° 00'	62
115	"	0	2 000		40° 15'	70° 00'	93
116	"	0	3 028		40° 00'	70° 00'	185
117	"	0	3 354		40° 00'	70° 30'	232
118	"	0	2 596		40° 00'	71° 00'	285
119	"	0	1 840		40° 30'	71° 00'	75
120	24/9/71	0	1 732		40° 30'	70° 30'	65
121	"	0	1 514		40° 45'	70° 30'	49
122	"	0	1 622		40° 45'	71° 00'	50
123	"	0	1 406		41° 00'	71° 00'	42
124	"	0	1 622		41° 00'	70° 40'	44
125	"	0	758		41° 12'	70° 40'	29
126	"	0	1 298		41° 15'	71° 04'	40

Table 2. Length frequency of herring larvae taken on Georges Bank and southwest of Nova Scotia.

Longueur totale en mm	Banc Georges		Nouvelle-Écosse	
	Nombre	Pourcentage	Nombre	Pourcentage
4	4	0,34		
5	105	9,0	9	2,5
6	220	18,9	77	21,7
7	239	20,6	60	16,9
8	294	25,3	91	25,6
9	230	19,8	34	9,6
10	45	3,9	25	7,0
11	5	0,43	19	5,3
12	9	0,77	15	4,2
13	5	0,43	5	1,4
14	1	0,08	1	0,28
15	2	0,17	3	0,84
16			1	0,28
17				
18	2	0,17	1	0,28
19			4	1,12
20			1	0,28
21			3	0,84
22				
23			1	0,28
24				
25				
26	1	0,08	1	0,28
27				
28			3	0,84
29				
30			1	0,28
Total	1 162		355	

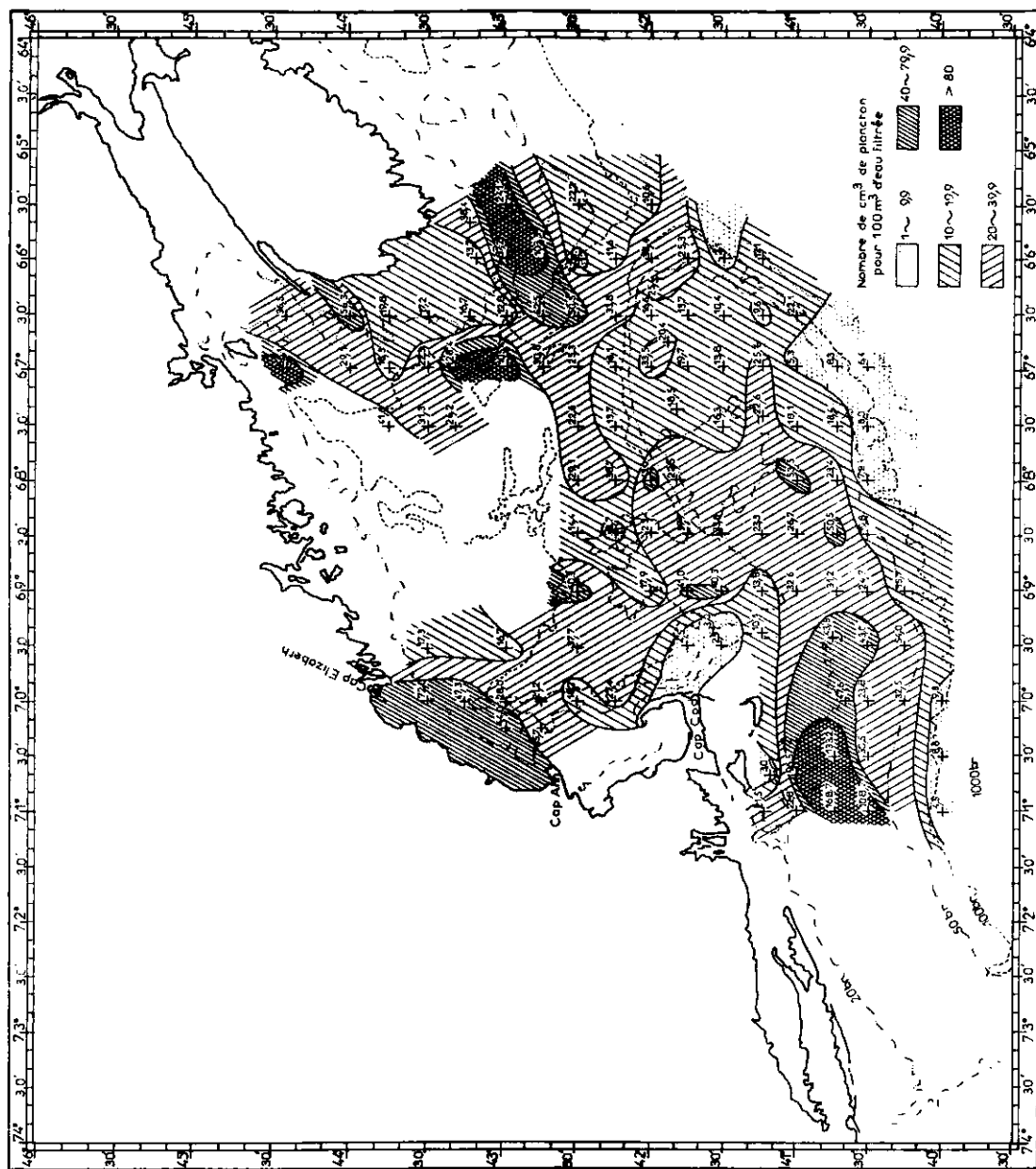


Fig. 1. Quantitative distribution of plankton per 100 m³ of filtered water.

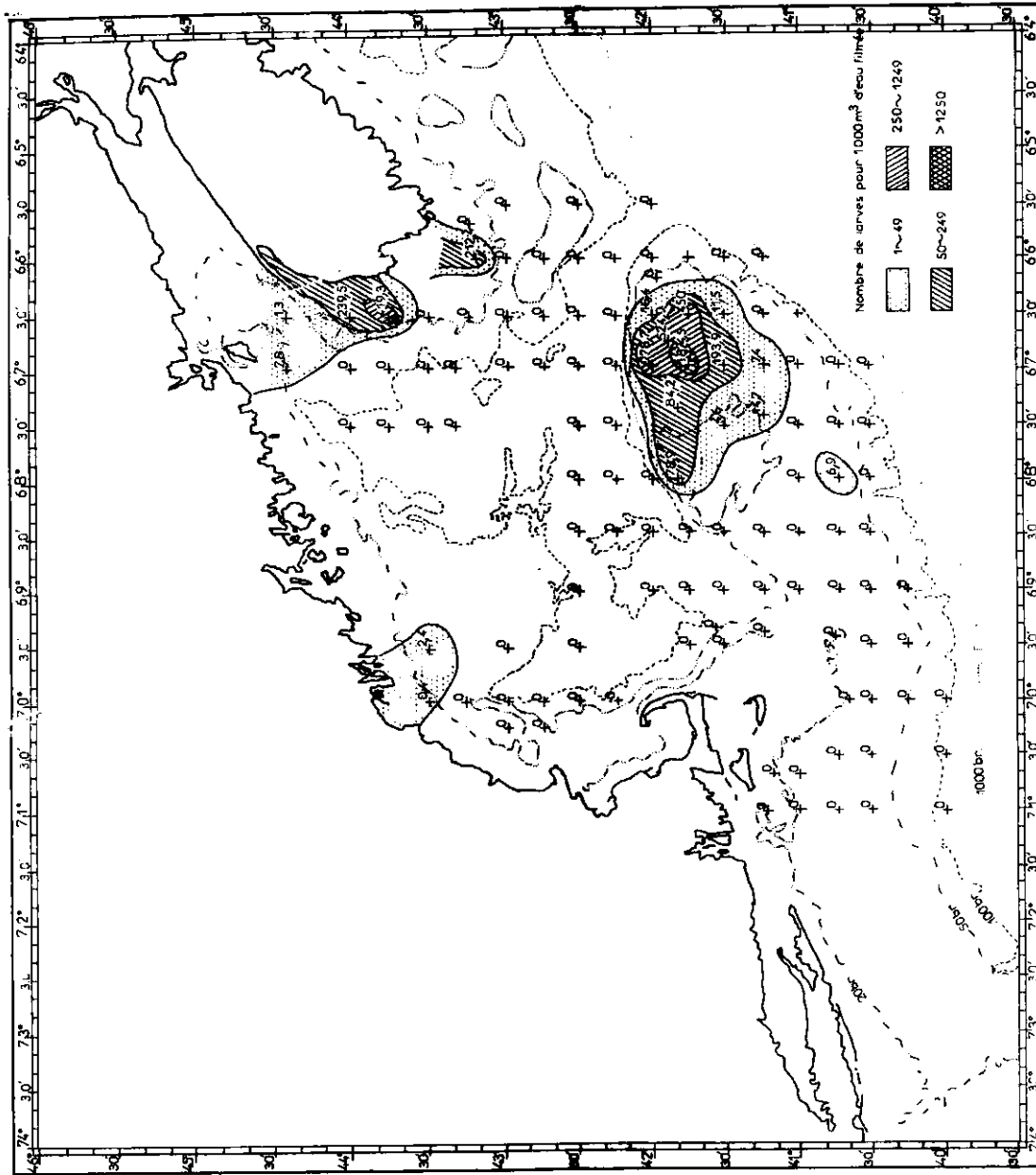


Fig. 2. Distribution and abundance of herring larvae.

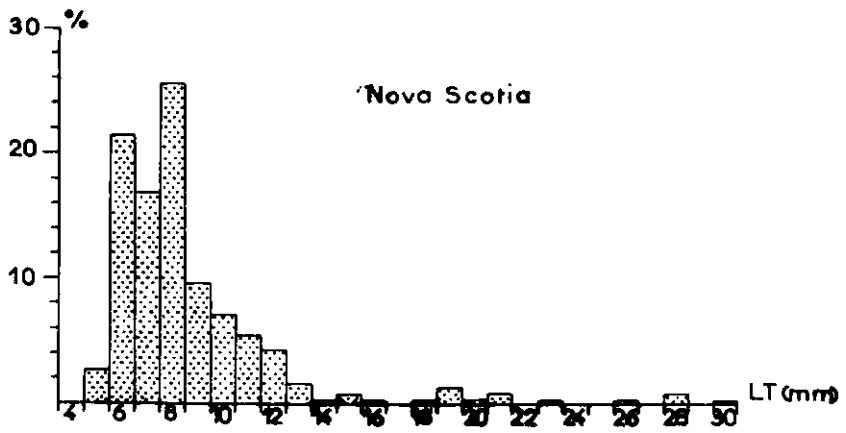
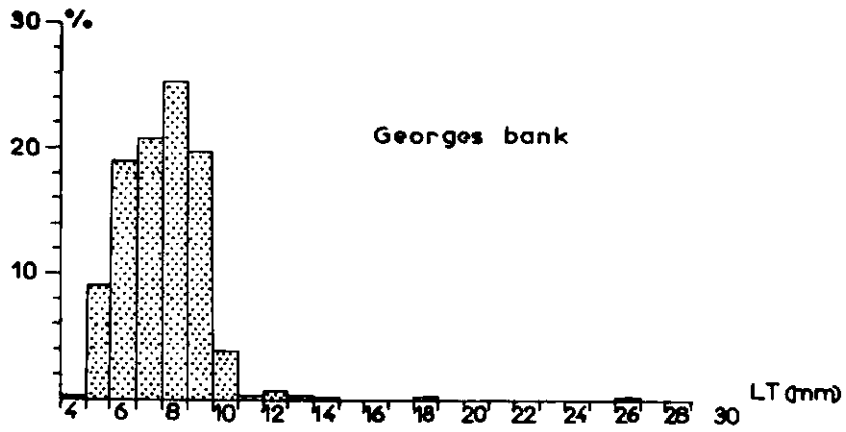


Fig. 3. Length frequency observed on herring larvae.

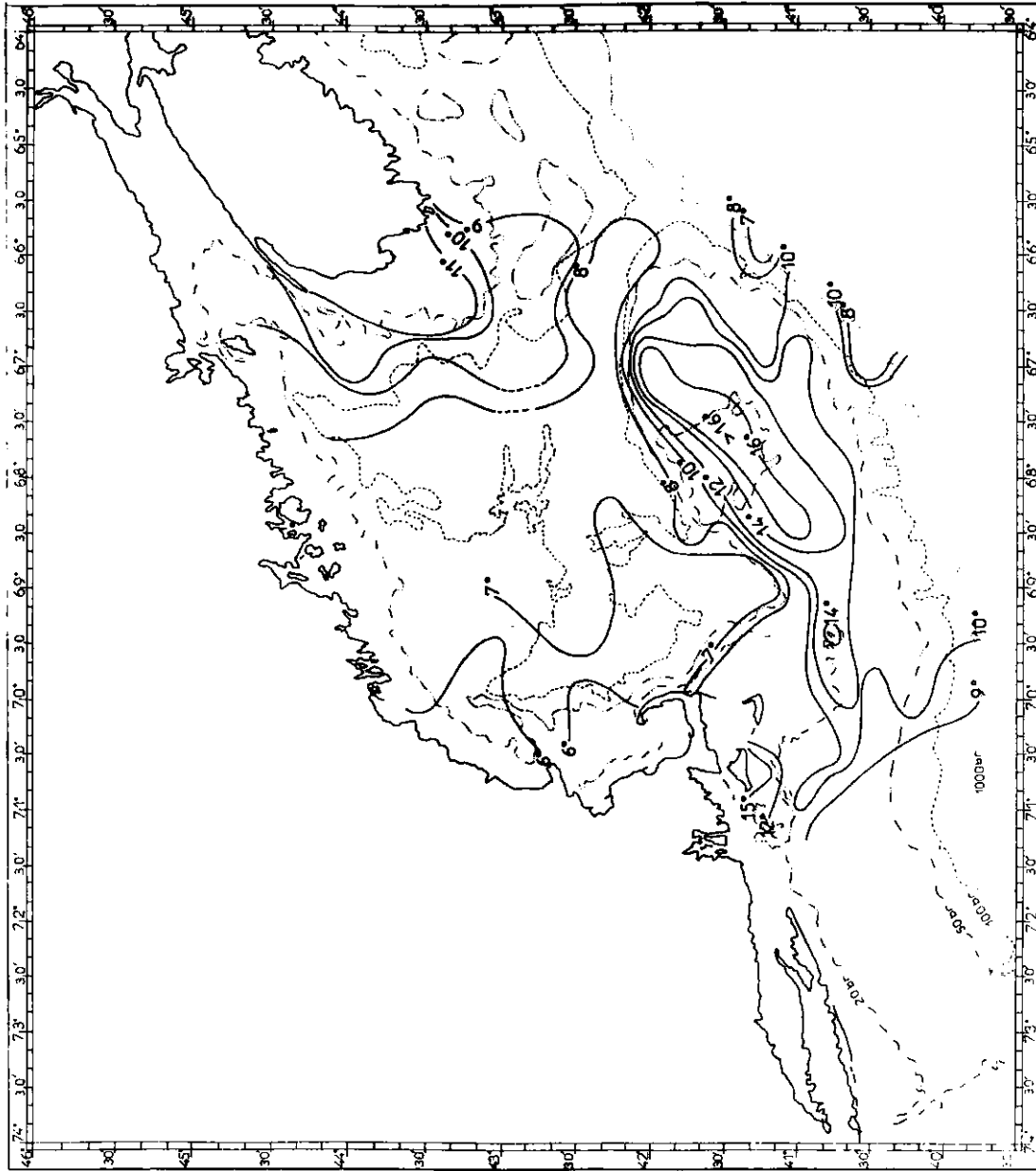


Fig. 4. Bottom temperatures.

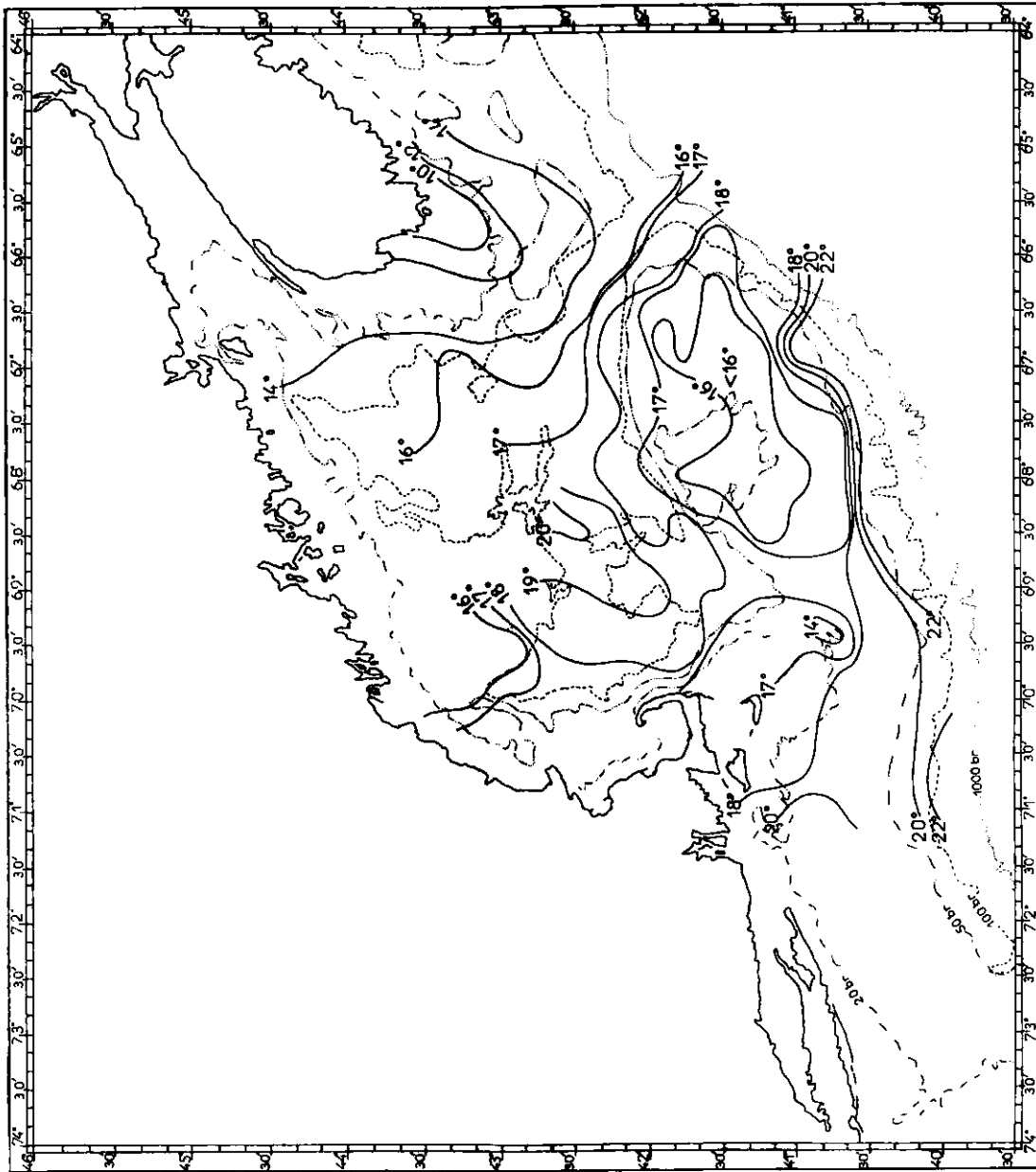


Fig. 5. Temperatures at 5-m level.

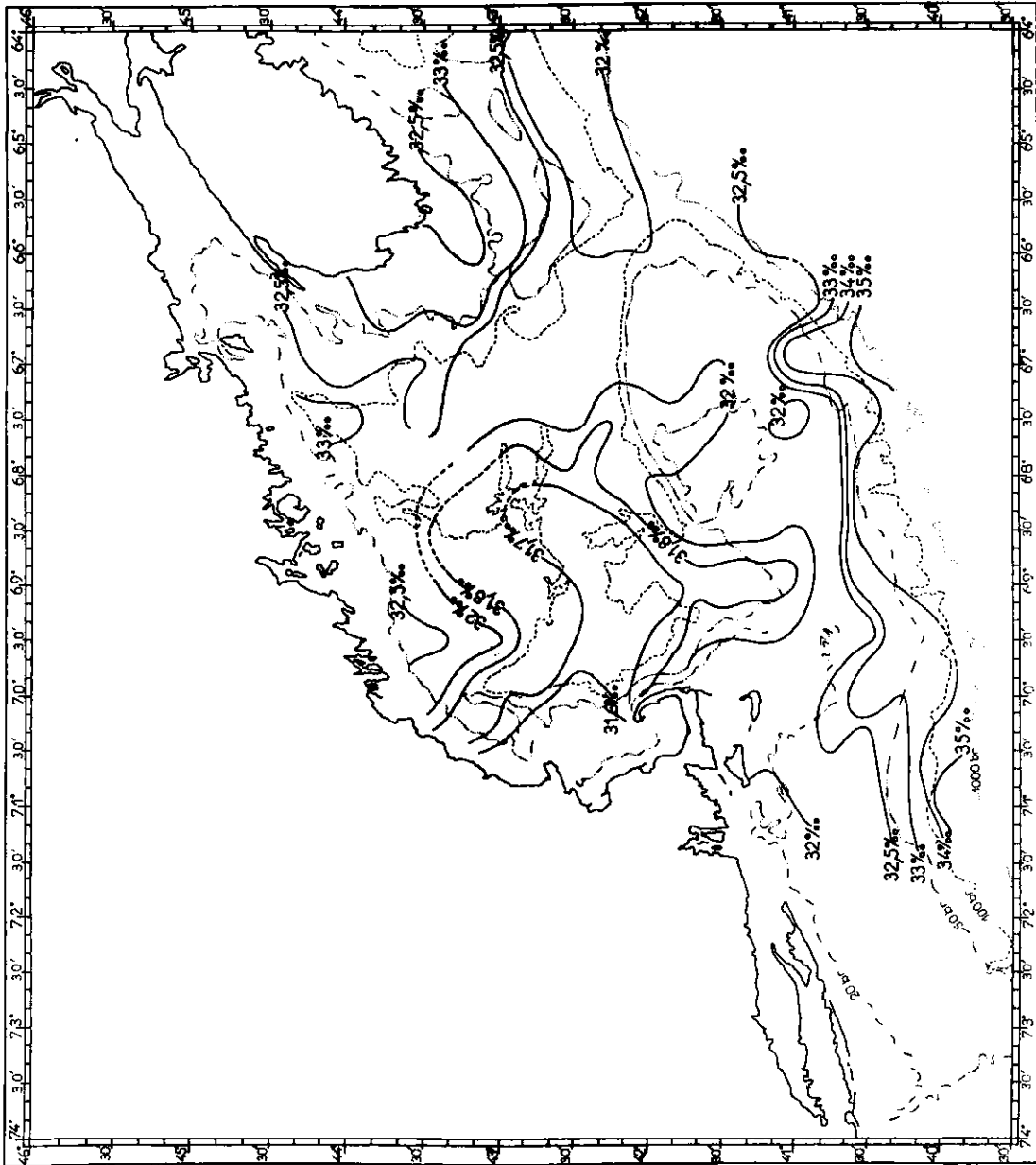


Fig. 6. Surface salinities.



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C O R R I G E N D A

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Page 1.

I. Materials and methods

4th Paragraph, lines 1-2: Please replace the sentence "With the boat travelling.... to 40 m." by "With the boat travelling at 3.5 knots, the BONGO was set at 50 m per minute to the desired depth, then hauled at 20 m per minute up to the 40-m level."

6th Paragraph, line 3: Please replace the word "remove" by "collect".

