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Autumnal distribution, abundance and dispersion of larval herring, *Clupea harengus harengus* Linnaeus, along the western coast of the Gulf of Maine in 1972

by

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INTRODUCTION

This is the second report on an annual series of four autumn cruises to survey the coastal distribution, abundance and dispersion of larval herring (Tables 1-3). The cruises were part of a cooperative survey of the Northwestern North Atlantic (U.S., France, Federal Republic of Germany, U.S.S.R., and Canada). The purpose of the surveys is to annually delineate the spawning areas of herring, to provide evidence of the discreteness of stocks, and to obtain a measure of their abundance.

MATERIALS AND METHODS

Collections were made at 63 stations (Figure 1)except during Coastal cruise 1 (*Lucille B*, 72-1) when only stations 46-56 were occupied. Stations in the central, western and southern sectors of the coast were not occupied because larvae were known to hatch later than the scheduled dates of cruise 1, September 2-6. The period of collecting for Coastal cruise 2 (*Albatros IV*, 72-7) was September 21-24; for cruise 3 (*Duchess II*, 72-1), October 18-22; and for cruise 4 (*Duchess II*, 72-2), November 6-12.

Measurements of larval length were made from the tip of the jaw to the tip of the caudal end (or fin) of the larva after preservation in 5% formalin. In a few instances, this measurement could not be made because of damage to the caudal end or fin of the larvae. These larvae were measured to the end of the caudal peduncle and when they measured 20 mm. or longer their lengths were converted to total lengths by:

$$TL = 3.47 + 1.24\ SL$$

[1] Revision of Sp.Mtg.Res.Doc. 73/12 presented to Special Commission Meeting, FAO, Rome, January 1973.

Pursuant with the recommendations of the working group on the joint surveys of larval herring in the Georges Bank-Gulf of Maine areas[1/] larval abundance is reported in this paper as total numbers of larvae per tow, total numbers of larvae per square meter, total numbers per cubic meter. These measures are also given by the size groups; less than 10 mm., 10-15 mm., and greater than 15 mm. In a few instances some larvae were damaged and could not be grouped by length. A sample of the length frequency of larvae obtained in each tow is reported. Yolk sac larvae are tabulated separately. To determine the number of larvae captured under a square meter the number of larvae was multiplied by the maximum depth sampled at given station and divided by the cubic meters of water strained. The number of cubic meters of water strained was divided into the number of larvae captured at a given station to determine the number of larvae captured per cubic meter. In formulation these measures are:

$$\text{No./m.}^2 = \frac{\text{No. larvae x depth m.}}{\text{m}^3}$$

$$\text{No./m.}^3 = \frac{\text{No. larvae}}{\text{m}^3}$$

Samples were obtained only during daylight on cruise 1 and the cruise was interrupted briefly when inclement weather drove the small coastal vessel into port. Sampling was maintained on a 24-hour basis during the second cruise with no interruptions, but some stations were omitted or shifted where the water was too shoal for the larger open-ocean vessel. Sampling was also maintained on a 24-hour basis on the third and fourth cruises, but these cruises were also interrupted briefly when inclement weather drove the coastal vessel into port. Paired Bongo nets[2/] were towed obliquely from a maximum depth of 100 m. to the surface or from as near the bottom as thought prudent. We attempted to place our tows to within a meter or two from the bottom except where peaks in the bottom made such attempts dangerous to the gear. In six instances the sampling gear touched bottom. Tows were made at 3.5 kn. and the gear was set at 50 m. per minute and retrieved at 10 m. per minute. A flow meter was placed within each net to determine the distance towed in meters. This distance was multiplied by the mouth area of the Bongo (diameter, 60 cm.) to obtain the numbers of cubic meters of water strained. Clogging of the nets did not occur during any of the cruises. Mesh sizes of the paired Bongo nets were .333 and .505; in this report only the catches from the .505 mm. are used except in five instances when only samples from the .333 mm. were available.

RESULTS

LARVAL DISTRIBUTION

Larval herring were present in the eastern sector of the coast when the first cruise was made in early September (Figure 2). By late September larvae occurred in the central and westward sectors of the coast and as far south as station 15 inshore of Jeffreys Ledge (Figure 3). About 4 weeks later larvae extended throughout the coastal sampling area (Figure 4). This westward and then southward shift (Figure 5) in abundance was attributable to five concentrations of larvae which occurred along the coast; 1) centered east of Penobscot Bay near station 50 (44° 20' N., 67° 41' W.), 2) near Boothbay Harbor and station 30 (43° 46' N., 69° 41' W.), 3) south of Portland near station 23 (43° 25' N., 70° 15' W.), 4) Jeffreys Ledge near station 12 (42° 49' N., 70° 23' W.) and 5) on Stellwagen Bank near station 2 (42° 13' N., 70° 14' W.). The first concentration was detected during the first coastal cruise. The second and third concentrations were forming during the second

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1/ Working group on joint survey of larval herring in the Georges Bank-Gulf of Maine areas (ICNAF Subareas 4X, 5Y, and 5Z) May 9-12, 1972. Annual meeting - June 1972, Int. Comm. Northwest Atl. Fish. Res. Doc. 72 - 123, 39 pp.

2/ Posgay, J. A., R. R. Marak, and R. C. Hennemuth. 1968. Development and test of new zooplankton samplers. Int. Comm. Northwest Atl. Fish. Res. Doc. 68 - 34, 7 pp.

cruise, but were pronounced during the third cruise as were the fourth and fifth concentrations. Often no larvae were captured along the offshore edge of the survey area, approximately the 50-fathom isobath. However, the stations in the vicinity of Stellwagen Bank were not sufficiently far offshore to circumscribe the concentration there.

Larval Lengths

Larval herring varied in total length from 4 to 37 mm. Those larvae less than 10 mm. long were considered recently hatched and were most abundant during the third cruise (Figure 4a). In each of the five areas of larval concentration recently hatched larvae were at first most abundant and closely grouped. With each subsequent cruise and apparently an increase in size (10-15 mm.) the larvae were more dispersed (Figure 2b-5b) until during the third and fourth cruises larvae larger than 15 mm. (Figure 4c-5c) were found throughout the coastal sampling area. Recently hatched larvae were present only as traces in the western and southern sectors of the coast during the last cruise (Figure 5a). These same sectors also yielded almost all of the larvae 10 to 15 mm. in length during the last cruise (Fig. 5b).

DISCUSSION

Possibly five major spawning areas were delineated by the occurrence of recently hatched larval herring. Hatching in these areas lasted from 21 to 48 days. Hatching was in progress in the area east of Penobscot Bay by September 6, since some larvae 10-15 mm. in length were already present and two larvae were larger than 15 mm. No recently hatched larvae were captured in the area on October 19; hatching apparently lasted at least 33 days. The second concentration of recently hatched larvae was detected south of Boothbay Harbor on September 23. Few larvae larger than 10 mm. were present in the area suggesting that hatching had just begun. No recently hatched larvae were obtained in this area on November 6, 44 days later. The same occurrence of recently hatched larvae was determined for the third concentration south of Portland. Apparently, hatching lasted there at least 48 days. The fourth concentration on Jeffreys Ledge and the fifth on Stellwagen Bank each had recently hatched larvae on October 21; these small larvae were scarce on November 11. Hatching in these two concentrations lasted at least 21 days and perhaps was slightly longer on Stellwagen Bank because larvae 10 to 15 mm. long were also taken in quantity on the bank on October 21.

Larvae with yolk sacs were not abundant in the catches (Table 4). One was captured during the second cruise and 124 during the third cruise when recently hatched larvae were most abundant. They represented 2 to 23% of the number of larvae caught at individual stations. In many instances the yolk sacs appeared partially absorbed. The yolk sac larvae were captured in concentrations of recently hatched larvae south of Boothbay Harbor, on Jeffreys Ledge and on Stellwagen Bank.

Surveys during previous years yielded recently hatched larvae throughout the coastal area, but in the autumn of 1971 larvae captured east of Penobscot Bay were all larger than 10 mm., not recently hatched. In the autumn of 1972, we began our survey east of Penobscot Bay one week earlier than in 1971. The results of our first cruise (Fig. 2a) showed that recently hatched larvae were abundant in the area and confirmed this area as a major spawning ground. The spawning ground on Stellwagen Bank was not detected in the autumn of 1971 possibly because fewer stations were occupied there than in 1972.

Table 1. List of stations and their positions for autumn coastal surveys in 1972.

Station number	Position N. Latitude	W. Longitude	Station number	Position N. Latitude	W. Longitude
1A	41° 59'	70° 15'	28	43° 31'	69° 40'
2A	41° 58'	70° 25'	29	43° 39'	69° 42'
3A	41° 54'	70° 12'	30	43° 46'	69° 41'
4A	41° 50'	70° 21'	31	43° 48'	69° 29'
5A	42° 28'	70° 22'	32	43° 43'	69° 26'
1	42° 06'	70° 18'	33	43° 37'	69° 22'
2	42° 13'	70° 14'	34	43° 42'	69° 06'
3	42° 10'	70° 27'	35	43° 46'	69° 06'
4	42° 15'	70° 35'	36	43° 50'	69° 07'
5	42° 20'	70° 22'	37	43° 43'	68° 50'
6	42° 28'	70° 30'	38	43° 58'	68° 56'
7	42° 27'	70° 43'	39	43° 57'	68° 42'
8	42° 31'	70° 36'	40	43° 50'	68° 38'
9	42° 42'	70° 27'	41	43° 46'	68° 37'
9A	42° 35'	70° 23'	42	43° 53'	68° 22'
10	42° 44'	70° 23'	43	43° 59'	68° 26'
11	42° 47'	70° 19'	44	44° 03'	68° 32'
12	42° 49'	70° 23'	45	43° 59'	68° 09'
13	42° 52'	70° 29'	46	44° 06'	68° 00'
14	42° 52'	70° 34'	47	44° 13'	68° 04'
15	42° 51'	70° 41'	48	44° 20'	68° 07'
16	43° 00'	70° 20'	49	44° 25'	67° 44'
17	43° 04'	70° 33'	50	44° 20'	67° 41'
18	43° 11'	70° 16'	51	44° 15'	67° 37'
18A	43° 10'	70° 34'	52	44° 21'	67° 15'
19	43° 10'	70° 22'	53	44° 28'	67° 18'
20	43° 20'	70° 23'	54	44° 35'	67° 20'
21	43° 20'	70° 16'	55	44° 36'	67° 10'
22	43° 19'	70° 06'	56	44° 28'	67° 10'
23	43° 25'	70° 15'			
24	43° 30'	70° 07'			
25	43° 26'	69° 53'			
26	43° 31'	69° 57'			
27	43° 38'	69° 59'			

Table 2. Station data for coastal cruise 1 during autumn 1972.

Station	Catch by size group (mm) <10	10-15	>15	Total	Number per m^2 <10	10-15	>15	Total
46	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0
48	0	14	1	15	0	2.009	0.143	2.153
49	138	12	0	150	32.198	2.862	0	35.781
50	60	26	0	86	11.934	5.171	0	17.106
51	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0
54	223	28	0	251	34.509	4.333	0	38.842
55	14	58	0	72	2.749	11.392	0	14.142
56	0	0	1	1	0	0	0.160	0.160

	Number per m^3 <10	10-15	>15	Total
46	0	0	0	0
47	0	0	0	0
48	0	0.043	0.003	0.046
49	0.671	0.058	0	0.730
50	0.138	0.060	0	0.198
51	0	0	0	0
52	0	0	0	0
53	0	0	0	0
54	1.078	0.135	0	1.213
55	0.033	0.138	0	0.172
56	0	0	0.001	0.001

Table 2. Station data for coastal cruise 2 during autumn 1972.

Station number	Catch by size group <10 mm.	10-15 mm.	>15 mm.	Total	Catch per m^2 <10 mm.	10-15 mm.	>15 mm.	Total
1A	0	0	0	0	0	0	0	0
2A	0	0	0	0	0	0	0	0
3A	0	0	0	0	0	0	0	0
4A	0	0	0	0	0	0	0	0
5A	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
9A	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	1	1	0	0	0.149	0.149
14	18	2	0	20	1.914	0.212	0	2.126
15	1	0	0	1	0.155	0	0	0.155
16	0	0	0	0	0	0	0	0
17	47	0	0	49	5.032	0	0	5.247
18	0	0	0	0	0	0	0	0
18A	0	0	0	0	0	0	0	0
19	16	4	0	20	2.147	0.536	0	2.684
20	42	0	1	46	5.418	0	0.129	5.934
21	40	1	6	48	5.168	0.129	0.775	6.202
22	0	0	3	3	0	0	0.321	0.321
23	0	0	207	207	0	0	26.418	26.418
24	2	1	1	5	0.346	0.173	0.173	0.865
25	0	0	3	3	0	0	0.435	0.435
26	0	3	8	11	0	0.392	1.048	1.440
27	12	0	1	13	2.496	0	0.208	2.704
28	0	0	2	2	0	0	0.346	0.346
29	20	0	3	23	2.545	0	0.381	2.926
30	0	0	0	0	0	0	0	0
31	0	4	5	9	0	0.460	0.575	1.306
32	0	13	16	29	0	1.528	1.880	3.409
33	0	2	3	5	0	0.312	0.469	0.782
34	0	7	7	14	0	1.485	1.485	2.970
35	0	3	26	29	0	0.429	3.719	4.148
36	0	4	4	8	0	0.711	0.711	1.422
37	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0
39	2	37	31	73	0.300	5.563	4.661	10.976
40	1	8	6	15	0.146	1.169	0.877	2.192
41	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0
43	1	19	6	33	0.123	2.340	0.739	4.064
44	4	11	4	20	0.611	1.680	0.611	3.055
45	1	4	0	5	0.112	0.450	0	0.563
46	0	1	2	3	0	0.138	0.276	0.415
47	82	64	5	151	9.644	7.527	0.588	17.759
48	2	27	18	47	0.373	5.035	3.357	8.765
49	132	119	7	258	16.658	15.017	0.883	32.558
50	262	323	11	596	35.196	43.390	1.477	80.064
51	0	0	1	1	0	0	0.126	0.126
52	0	0	3	3	0	0	0.508	0.508
53	1	4	9	14	0.184	0.739	1.664	2.589
54	344	113	19	476	47,709	15.672	2.635	66.016
55	407	277	29	713	57.553	39.170	4.100	100.824
56	31	43	29	103	5.662	7.854	5.297	18.814

Table 2. Coastal cruise 2 cont'd.

Station	Catch per m^3 <10 mm.	10-15 mm.	>15 mm.	Total
1A	0	0	0	0
2A	0	0	0	0
3A	0	0	0	0
4A	0	0	0	0
5A	0	0	0	0
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
9A	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0.001	0.001
14	0.024	0.002	0	0.027
15	0.003	0	0	0.003
16	0	0	0	0
17	0.097	0	0	0.097
18	0	0	0	0
18A	0	0	0	0
19	0.033	0.008	0	0.041
20	0.132	0	0.003	0.144
21	0.105	0.002	0.015	0.126
22	0	0	0.003	0.003
23	0	0	0.660	0.660
24	0.008	0.004	0.004	0.020
25	0	0	0.004	0.004
26	0	0.004	0.013	0.017
27	0.056	0	0.004	0.061
28	0	0	0.003	0.003
29	0.051	0	0.007	0.059
30	0	0	0	0
31	0	0.007	0.009	0.016
32	0	0.020	0.025	0.045
33	0	0.003	0.005	0.008
34	0	0.018	0.018	0.036
35	0	0.006	0.054	0.061
36	0	0.016	0.016	0.033
37	0	0	0	0
38	0	0	0	0
39	0.006	0.113	0.095	0.224
40	0.001	0.015	0.011	0.029
41	0	0	0	0
42	0	0	0	0
43	0.002	0.040	0.012	0.070
44	0.017	0.048	0.017	0.087
45	0.001	0.006	0	0.008
46	0	0.001	0.002	0.004
47	0.148	0.115	0.009	0.273
48	0.007	0.107	0.071	0.186
49	0.237	0.214	0.012	0.465
50	0.651	0.803	0.027	1.482
51	0	0	0.001	0.001
52	0	0	0.006	0.006
53	0.003	0.015	0.035	0.055
54	1.135	0.373	0.062	1.571
55	0.661	0.450	0.047	1.158
56	0.092	0.128	0.086	0.308

Table 2. Station data for coastal cruise 3 during autumn 1972.

Station	Number by size mm.			Total catch	Catch per m^2			Total
	<10	10-15	>15		<10	10-15	>15	
1A	13	70	5	88	0.869	4.863	0.334	5.887
2A	28	127	5	161	4.236	19.216	0.756	24.361
3A	9	60	5	74	0.543	3.626	0.302	4.472
4A	1	17	1	19	0.081	1.386	0.081	1.549
5A	13	7	6	26	2.129	1.146	0.982	4.259
1	116	293	13	430	17.759	44.857	1.990	65.831
2	67	54	0	121	4.379	3.529	0	7.908
3	42	182	21	245	7.367	31.926	3.683	42.977
4	4	46	4	56	0.611	7.027	0.611	8.555
5	596	103	14	713	102.628	17.736	2.410	122.775
6	28	35	5	68	6.257	7.821	1.117	15.195
7	0	55	5	60	0	8.256	0.750	9.006
8	5	48	10	63	0.605	5.816	1.211	7.634
9	125	5	2	135	25.615	1.024	0.409	27.665
9A	0	0	5	5	0	0	1.024	1.024
10	194	9	1	208	46.455	2.155	0.239	49.808
11	0	0	0	0	0	0	0	0
12	106	17	1	124	23.709	3.802	0.223	27.735
13	6	7	1	14	1.269	1.481	0.211	2.962
14	7	8	7	22	1.714	1.959	1.714	5.388
15	24	9	7	40	4.007	1.502	1.168	6.678
16	0	2	12	14	0	0.310	1.864	2.174
17	1	2	3	6	0.129	0.259	0.389	0.778
18	0	2	4	6	0	0.400	0.800	1.200
18A	7	2	1	10	0.859	0.245	0.122	1.228
19	0	1	15	16	0	0.169	2.547	2.717
20	24	20	10	54	4.211	3.509	1.754	9.474
21	1	5	20	27	0.209	1.047	4.189	5.655
22	0	1	6	7	0	0.129	0.777	0.907
23	104	34	17	158	29.778	9.735	4.867	45.239
24	12	3	25	43	1.445	0.361	3.011	5.179
25	0	2	25	27	0	0.277	3.469	3.746
26	0	2	39	41	0	0.255	4.721	4.976
27	17	24	28	53	1.982	2.799	3.265	6.181
28	0	0	1	1	0	0	0.203	0
29	0	5	1	6	0	0.735	0.147	0.882
30	24	136	21	181	5.341	30.269	4.673	40.284
31	6	17	14	37	1.299	3.682	3.033	8.015
32	0	9	19	29	0	2.053	4.336	6.618
33	0	0	1	1	0	0	0.177	0.177
34	0	1	4	10	0	0.170	0.680	1.702
35	0	10	4	16	0	2.040	0.816	3.264
36	0	8	22	32	0	1.495	4.113	5.983
37	0	3	6	12	0	0.446	0.892	1.784
38	0	1	0	1	0	0	0	0.180
39	0	40	38	80	0	5.061	4.808	10.502
40	0	2	6	8	0	0.410	1.232	1.643
41	0	0	0	0	0	0	0	0
42	0	1	1	3	0	0.276	0.276	0.830
43	0	21	27	48	0	3.841	4.938	8.780
44	0	4	4	8	0	0.551	0.551	1.102
45	0	2	11	13	0	0.258	1.418	1.676
46	0	22	8	30	0	3.260	1.185	4.446
47	0	23	21	44	0	5.433	4.960	10.394
48	0	38	34	87	0	5.180	4.635	11.861
49	3	97	60	165	0.282	9.118	5.640	15.511
50	3	32	57	92	0.307	3.275	5.834	9.416
51	1	21	32	54	0.269	5.655	8.617	14.542
52	0	1	6	7	0	0.291	1.746	2.037
53	16	11	11	40	3.417	2.349	2.349	8.543
54	9	9	23	47	1.589	1.589	4.061	8.299
55	4	8	31	47	0.788	1.577	6.111	9.265
56	1	4	146	159	0.188	0.754	27.533	29.984

Table 2. Coastal cruise 3 cont'd.

Station	Catch per m^3 <10	10-15	>15	Total
1A	0.025	0.137	0.009	0.173
2A	0.111	0.505	0.019	0.641
3A	0.025	0.172	0.014	0.212
4A	0.003	0.057	0.003	0.064
5A	0.033	0.017	0.015	0.066
1	0.311	0.786	0.034	1.154
2	0.364	0.294	0	0.659
3	0.129	0.560	0.064	0.753
4	0.013	0.159	0.013	0.194
5	1.681	1.405	0.242	1.681
6	0.118	0.147	0.021	0.286
7	0	0.179	0.016	0.195
8	0.009	0.090	0.018	0.119
9	0.320	0.012	0.005	0.345
9A	0	0	0.012	0.012
10	0.774	0.035	0.003	0.830
11	0	0	0	0
12	0.564	0.090	0.005	0.660
13	0.013	0.015	0.002	0.031
14	0.021	0.025	0.021	0.069
15	0.083	0.031	0.024	0.139
16	0	0.003	0.018	0.021
17	0.002	0.005	0.008	0.016
18	0	0.003	0.007	0.010
18A	0.042	0.012	0.006	0.061
19	0	0.002	0.034	0.037
20	0.136	0.113	0.056	0.306
21	0.003	0.016	0.067	0.091
22	0	0.001	0.010	0.012
23	0.419	0.137	0.068	0.637
24	0.040	0.010	0.083	0.143
25	0	0.002	0.034	0.037
26	0	0.002	0.053	0.055
27	0.050	0.071	0.083	0.158
28	0	0	0.002	0
29	0	0.008	0.001	0.010
30	0.079	0.451	0.069	0.601
31	0.028	0.080	0.065	0.174
32	0	0.036	0.076	0.116
33	0	0	0.001	0.001
34	0	0.001	0.006	0.015
35	0	0.030	0.012	0.048
36	0	0.028	0.077	0.112
37	0	0.005	0.010	0.021
38	0	0	0	0.004
39	0	0.075	0.071	0.156
40	0	0.004	0.012	0.016
41	0	0	0	0
42	0	0.002	0.002	0.007
43	0	0.060	0.077	0.137
44	0	0.019	0.019	0.039
45	0	0.004	0.020	0.023
46	0	0.031	0.011	0.043
47	0	0.066	0.060	0.126
48	0	0.110	0.098	0.252
49	0.007	0.233	0.144	0.397
50	0.004	0.047	0.084	0.136
51	0.002	0.055	0.085	0.143
52	0	0.003	0.018	0.022
53	0.047	0.032	0.032	0.118
54	0.039	0.039	0.101	0.207
55	0.009	0.019	0.077	0.117
56	0.002	0.008	0.302	0.329

Table 2. Station data for coastal cruise 4 during autumn 1972.

Station	Number by size mm. <10	10-15	>15	Total catch	Catch per effort m^2 <10	10-15	>15	Total
1A	0	82	80	164	0	8.457	8.251	16.914
2A	0	16	20	36	0	2.406	3.008	5.414
3A	0	15	22	37	0	1.883	2.761	4.645
4A	0	24	34	58	0	3.383	4.792	8.175
5A	9	71	28	108	0.753	5.942	2.343	9.083
1	0	234	137	371	0	14.958	8.757	23.715
2	0	19	87	106	0	6.349	29.073	35.423
3	0	35	125	160	0	6.880	24.570	31.449
4	0	6	30	36	0	1.364	6.821	8.185
5	0	1	21	22	0	0.181	3.801	3.982
6	0	15	2	17	0	2.890	0.385	3.276
7	0	4	5	9	0	0.760	0.950	1.710
8	1	46	6	53	0.175	8.042	1.049	9.266
9	0	5	11	18	0	0.908	1.998	3.270
9A	0	0	16	16	0	0	2.994	2.994
10	0	4	3	8	0	0.672	0.504	1.345
11	0	3	4	8	0	0.660	0.880	1.760
12	0	5	8	13	0	1.229	1.967	3.196
13	0	0	2	2	0	0	0.464	0.464
14	0	0	11	11	0	0	2.483	2.483
15	2	30	22	56	0.299	4.488	3.291	8.378
16	0	1	5	6	0	0.199	0.996	1.195
17	0	6	21	27	0	0.241	0.842	1.082
18	0	0	30	30	0	0	7.257	7.257
18A	1	11	12	25	0.039	0.426	0.465	0.969
19	0	0	0	0	0	0	0	0
20	0	1	8	9	0	0.179	1.429	1.608
21	0	0	15	15	0	0	2.446	2.446
22	0	0	7	7	0	0	1.435	1.435
23	1	10	1	12	0.174	1.738	0.174	2.086
24	0	0	4	4	0	0	0.685	0.685
25	0	1	10	11	0	0.195	1.949	2.144
26	0	0	18	18	0	0	2.976	2.976
27	4	4	6	14	0.617	0.617	0.925	2.159
[illegible]	0	0	6	6	0	0	0.903	0.903
29	0	0	10	10	0	0	2.300	2.300
30	0	75	95	170	0	12.524	15.864	28.388
31	0	0	12	14	0	0	2.019	2.356
32	0	0	7	7	0	0	1.245	1.245
33	0	0	6	6	0	0	1.058	1.058
34	0	2	46	48	0	0.405	9.308	9.712
35	0	4	95	99	0	0.619	14.705	15.324
36	0	0	11	11	0	0	3.131	3.131
37	0	8	22	31	0	1.664	4.577	6.449
38	0	3	26	29	0	0.659	5.708	6.366
39	0	0	42	42	0	0	8.136	8.136
40	0	5	10	16	0	1.032	2.065	3.304
41	0	3	1	4	0	0.602	0.201	0.802
42	0	1	5	8	0	0.148	0.739	1.183
43	0	0	13	13	0	0	1.843	1.843
44	0	5	39	44	0	1.079	8.417	9.496
45	0	1	2	3	0	0.167	0.334	0.501
46	0	2	4	6	0	0.390	0.780	1.170
47	0	4	50	54	0	0.702	8.778	9.480
48	0	1	87	88	0	0.166	14.479	14.645
49	0	6	4	11	0	1.153	0.769	2.115
50	0	0	2	2	0	0	0.366	0.366
51	0	3	10	13	0	1.266	4.222	5.488
52	0	3	29	32	0	0.424	4.103	4.527
53	0	0	21	21	0	0	3.645	3.645
54	0	1	0	1	0	0.216	0	0.216
55	0	0	7	7	0	0	1.146	1.146
56	0	1	36	37	0	0.168	6.045	6.213

Table 2. Coastal cruise 4 cont'd.

Station	Catch per effort m^3			
	<10	10-15	>15	Total
1A	0	0.313	0.306	0.626
2A	0	0.071	0.885	0.159
3A	0	0.075	0.110	0.186
4A	0	0.121	0.171	0.292
5A	0.014	0.110	0.043	0.174
1	0	0.277	0.162	0.439
2	0	0.087	0.398	0.485
3	0	0.130	0.464	0.593
4	0	0.039	0.195	0.234
5	0	0.003	0.052	3.982
6	0	0.074	0.010	0.084
7	0	0.019	0.024	0.043
8	0.004	0.161	0.021	0.185
9	0	0.013	0.028	0.047
9A	0	0	0.033	0.033
10	0	0.009	0.007	0.018
11	0	0.007	0.010	0.020
12	0	0.014	0.022	0.036
13	0	0	0.005	0.005
14	0	0	0.034	0.034
15	0.008	0.125	0.091	0.233
16	0	0.002	0.011	0.014
17	0	0.027	0.094	0.120
18	0	0	0.097	0.097
18A	0.004	0.047	0.052	0.108
19	0	0	0	0
20	0	0.004	0.032	0.036
21	0	0	0.034	0.034
22	0	0	0.016	0.016
23	0.002	0.024	0.002	0.029
24	0	0	0.009	0.009
25	0	0.002	0.021	0.024
26	0	0	0.033	0.033
27	0.017	0.017	0.025	0.058
28	0	0	0.009	0.009
29	0	0	0.029	0.029
30	0	0.241	0.305	0.546
31	0	0	0.028	0.033
32	0	0	0.018	0.018
33	0	0	0.010	0.010
34	0	0.004	0.090	0.094
35	0	0.008	0.201	0.210
36	0	0	0.050	0.505
37	0	0.016	0.045	0.064
38	0	0.010	0.085	0.095
39	0	0	0.129	0.129
40	0	0.013	0.025	0.040
41	0	0.005	0.002	0.007
42	0	0.002	0.011	0.017
43	0	0	0.022	0.217
44	0	0.021	0.165	0.186
45	0	0.003	0.006	0.010
46	0	0.006	0.012	0.019
47	0	0.011	0.137	0.148
48	0	0.003	0.254	0.257
49	0	0.029	0.019	0.053
50	0	0	0.006	0.006
51	0	0.016	0.053	0.069
52	0	0.005	0.045	0.050
53	0	0	0.052	0.052
54	0	0.004	0	0.004
55	0	0	0.013	0.013
56	0	0.002	0.084	0.863

Table 3. Length frequency of larval herring. Coastal cruise 1.

Station	Length mm. 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	23	Total
46-47	No larvae																
48						1			3	3	5				1		13
49		2	41	46	9		3	4	1		1						107
50			8	13	4	5	1	3	1								35
51-53	No larvae																
54		8	51	33	7	1	6	6									112
55			1		1	4	2	2									10
56																1	1
Total		10	101	92	21	11	12	15	5	3	6				1	1	278

Table 3. Length frequency of larval herring. Coastal cruise 2.

Station	Length mm. 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
[illegible]	No larvae																
14				2	9	7	1				1						
15					1												
16	No larvae																
17		1	2	9	22	13											
18	No larvae																
19	2			2	4	8	2	2									
20			2	27	11	2									1		
21			4	29	8							1			1	2	
22														3			
23			4	53	46												
24				2						1					1		
25														1	1		
26										2		1		2	2	3	
27			3	6	3										1		
28													1	1			
29			2	15	3									2		1	
30	No larvae																
31								2	1		1			2	2	1	
32								2	4	7			2	4	3	2	2
33									1			1		1	2		
34										1	2	4	2		2	1	1
35												3	7	4	4	3	1
36									2			2	3				1
37	No larvae																
38	No tow																
39						2	8	6	1	4	9	9	15	11	4		
40					1		1	2	1			4	3		1	1	1
41-42	No larvae																
43						1	2	10		1	4	2	3	1	1	1	
44					1	3	3	2	1		4	1	1			1	
45						1	2	1				1					
46										1		1					1
47			1	2	3	20	29	14	5	5	7	5	5	2	2		
48						2	1	2	1	6	10	7	7	3	3	1	1
[illegible]				1	1	21	40	15	5	5	6	2	3			1	
[illegible]				1	7	26	40	6	6	4	7	2		1			
51															1		
52															2		
53					1				1	1	1	1	3	2	1		1
54					10	23	30	9	3	5	8	5	1	3	1	2	
55					5	24	25	8	3	3	11	7	4	5	3	2	
56				1	13	17	11	5	3	6	7	11	8	4	7	7	2
Total	2	1	18	150	149	170	195	86	38	52	78	70	68	52	46	29	11

Table 3. Coastal cruise 2 cont'd.

Station	Length mm. 21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Total
11-12																
13	1															1
14																20
15																1
16																
17																47
18																
19																20
20																43
21			1		2											48
22																3
23																103
24																4
25			1													3
26				1												11
27																13
28																2
29																23
30																
31																9
32		2	1													29
33																5
34			1													14
35	3	2				1							1			29
36																8
37																
38																
39	1															70
40																15
41-42																
43																26
44		1	1													19
45																5
46																3
47																100
48		2		1												47
49																100
[illegible]																100
51																1
52			1													3
53				1												14
54		1														100
[illegible]																100
56				1												103
Total	5	8	6	4	2	1							1			1242

Table 3. Length frequency of larval herring. Coastal cruise 3.

							Length mm.										
Station	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1A					5	7	13	15	24	8	4	6	2	2			1
2A						16	10	19	34	8	6	3	3				
3A					2	7	11	17	17	8	6	1	4	1			
4A							1	2	6	6	1	1	1				
5A					8	5	1	2	3		1			2			1
1				1	8	16	13	11	24	15	5	3	3			1	
2			1	14	23	29	16	7	14	11	3	3					
3						12	17	14	19	14	9	8	3	2	1	1	
4		1				3	6	8	9	16	3	4	3	1			
5				22	49	14	4		3	4		2					
6				11	17		5	2	6	13	6	2	1	2			
7							1	8	17	18	7	2	1	1		1	1
8					1	4	7	9	12	12	5	3	7	1	1		
9			19	58	13	2	1		3	1		1				1	1
9A													1				
10		8	20	38	19	8	1	2	1	2			1				
11	No larvae																
12			4	43	32	6	2	7	3	2						1	
13				4	1	1	2	1	4								
14				1	6		1	1	2	3		1	4	1			1
15			1	4	15	4	3	1	1	1	1	2			1	3	
16										1	1	2	3	4		1	
17						1	1					1		1			1
18										1		1	2		1	1	
18A						7	1	1					1				
19												1	2			2	6
20				1	9	21	4	11		1	3	1	2		5	3	1
21				1			1	1			1	2	2	2	2	6	3
22									1				1				2
23				18	37	14	21	6	4	1		1	3	2	6	2	2
24			1	4	6	1	1	1				1	1	2	5	2	3
25											1	1	1	2	1	1	6
26									1			1	2	2	11	3	6
27				4	7	6	5	2	2	4	2	9	3	10	6	4	4
28																	
29											3	2	1				
30					5	5	13	13	14	15	17	20	6	6		1	
31					1	5	4		3	1	4	5	6	2	2		
32								2			4	3	6	5	2	2	
33																1	
											1				1	2	
							1	1	1	3	2	2				1	1
[illegible]								1		1	3	3	3	2	1		3
37									1		1	1	1				
38										1							
39								1	3	10	10	16	3	1	1	6	6
40										1	1						1
41	No larvae																
42											1					1	
43									1	2	7	4	1	1	2		
44										1	2	1			2	1	1
45										1	1			1			2
46								3	7	4	7	1				2	
47									1	6	11	5	2	1	3	2	3
48								2	11	15	8	2	6	5	7	6	4
49						2	5	21	19	8	4	2	3	6	5	3	1
50						3	7	11	12	2			2	7	5	4	10
51						1	5	9	3		2	2	4	5	3	3	7
52											1					1	
53					9	7	3	3	2			3	1	2	3	1	
54					4	5	3	1	3		1	1	4	5	4	5	4
55					3	1	1	2	1		1	3	4	5	3	7	4
56						1	1	1				2	4	6	11	9	14
Total		9	46	224	280	214	192	219	292	221	154	141	114	98	95	91	100

Table 3. Length frequency of larval herring. Coastal cruise 4.

	Length mm.																
Station	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1A						1	1	2	2	12	30	15	20	6	9	12	
2A								1		3	12	5	6	4	2	2	
3A									4	5	6	1	3	9	2	5	2
4A								2		4	18	10	6	3	5	6	1
5A					9	13	14	24	7	4	9	3		3	4	5	9
1						1	3	3	13	15	18	16	11	15	9	15	4
2						1		4	3	4	7	14	15	8	9	13	9
3								2	2	1	10	5	5	11	10	18	6
4											6	5	8	3	5	6	2
5											1		5	2	1	6	1
6						4	8	1		1	1		1				
7							1		2		1	1			1	2	
8					1	9	15	15	2	2	3	1	2	1	1	1	
9								1	1		3			3		1	2
9A												1			1	2	4
10						1		1			2						1
11							1	1			1					1	1
12										1	4	1	1			1	
13																1	1
14												2		1	2		1
15			1		1	6	3	4	2	6	9	7		7	2	3	
16						1							1	2		1	
17						3	1				2	3		5	1		1
18												1		1		1	2
18A	1					5		1		2	3			4		2	2
19	No larvae																
20											1	2	2	1	2		
21													1		1		1
22															2	1	1
23					1					1			1	3	2		1
24																1	1
25											1				1	1	2
26															1	6	3
27				1	3	1			1		2	1		2			1
28																	1
29													1	2	1	2	2
30							2	7	12	15	9	9	21	14	10	6	2
31												1		3		2	
32													1	3		2	
33																1	
34										1	1		4	2	5	4	4
35									1	2	1	2	3	9	11	15	6
36												2	1	2	1	1	1
37								1		1	6		2	2	3	1	
38									1	1	1	1	4	4	3	3	1
39												4	6	4	5	5	3
40										2	3	3			1		1
41									1		2						
42										1		2				1	
43														2			1
44									2		3	2	4	4	2	4	2
45											1						1
46											2	1				1	1
47						1			1	2		2	2	3	2	4	10
48											1	4	4	11	10	3	4
49								1	2	2	1			1			1
50																1	
51								1			2		1		1	1	1
52											3	8	2	5	4	3	3
53												1		1	1	5	4
54											1						
55																1	2
56											1	1	2	2	2	5	3
Total	1		1	1	15	47	49	72	59	88	188	137	146	168	135	184	113

Table 3. Coastal cruise 4 cont'd.

	Length mm.																
Station	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Total
1A	1	1															112
2A	1																36
3A																	37
4A	3																58
5A	2					1							1				108
1	1	3		1													123
2	10	2	5	1		1											106
3	17	11	8	4		3	1										114
4	1																36
5	1	3		1			1										22
6							1										17
7	1																9
8																	53
9		1	2	1					1								16
9A				1	3	1		1			2						16
10	1								1								7
11				1					1								7
12	2		1					1	1								13
13																	2
14		2	1	1							1						11
15		1	1	1													54
16			1														6
17		2	3	1	1			1	1		1					1	27
18	3	3		1	3	1	1	3		3	2	1	1	3			30
18A			1				2						1				24
19																	0
20		1															9
21		2	1	1	3	3	1										14
22	1	1		1													7
23	1	1			1												12
24	2																4
25	3	1		1		1											11
26	3	1		1	3												18
27	1	1															14
28	1			1	1	1	1										6
29	1		1														10
30							1										108
31				2			2		2								12
32	1																7
33	3	2															6
34	6	5	7	3	1	1	1	1			1	1					48
35	7	9	8	7	1	3		1		1	1			1			89
36		1			1												10
37	2	2	1	1	1	3			4								30
38	1		3	1		3											27
39	3		2	2	1		1	1	1		1	1					40
40			1	2			1								1		15
41					1												4
42	1	1															6
43	4		2		1	1	1	1									13
44	4	1	3	3	4	2				1		1					42
45				1													3
46	1																6
47	7	5	4	3	2	3	2	1									54
48	10	8	7	4	8	8		3			3						88
49	1	1												1			11
50				1													2
51	4		2														13
52	2	1	1														32
53	5	2	2														21
54																	1
55	3	1															7
56	5	2	2		2	6	3	1									37
Total	127	78	70	49	38	42	20	15	12	5	12	4	3	5	1	1	1886

Table 4. Occurrence of yolk sac larvae.

Coastal Cruise	Station	Number of Larvae	Percent of Catch 10 mm.
2	29	1	4.3
3	5	12	2.0
3	5	4	14.3
3	9	40	32.0
3	10	53	27.3
3	12	15	14.2

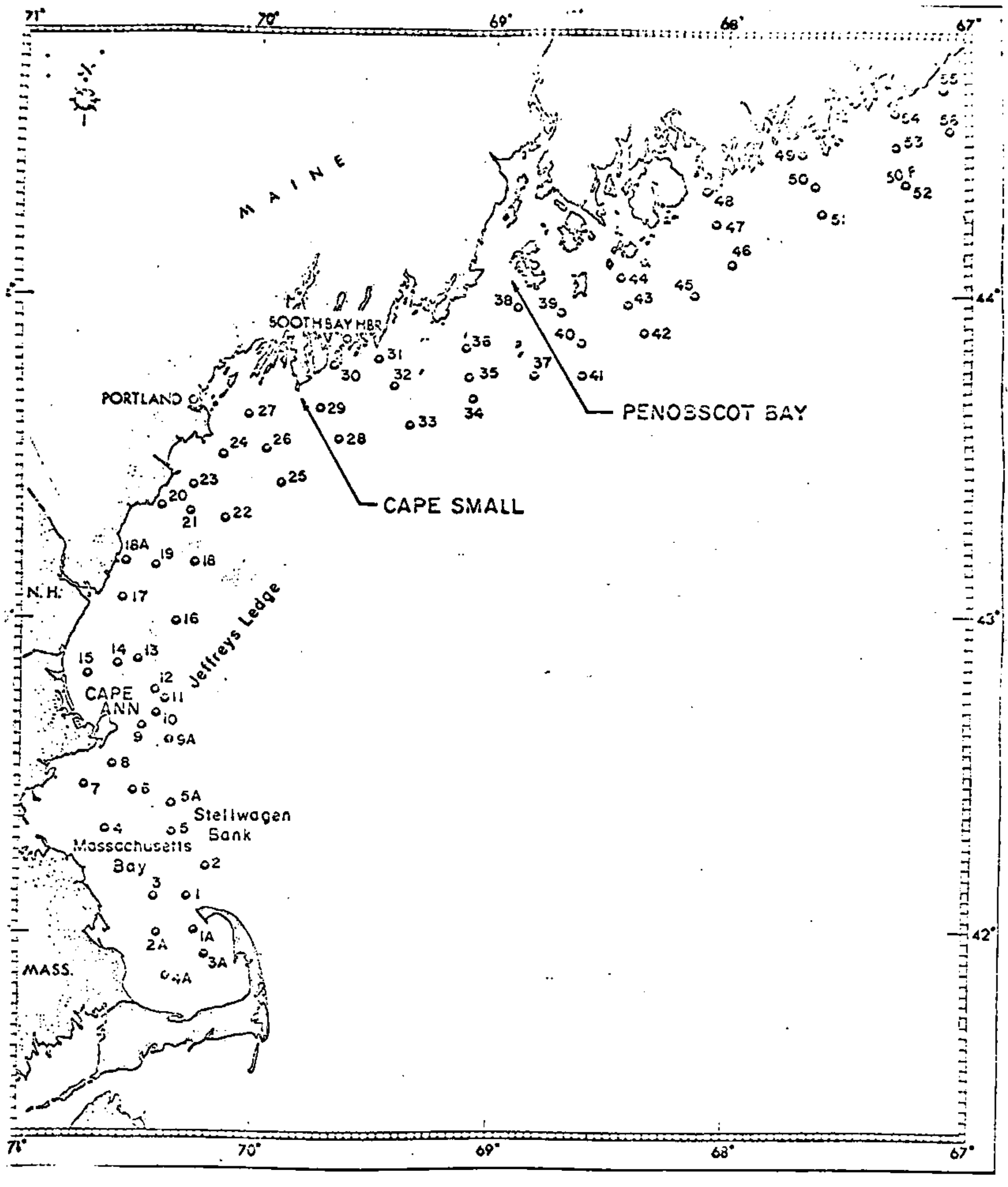


Figure 1. Station positions for larval herring surveys along the western coast of the Gulf of Maine.

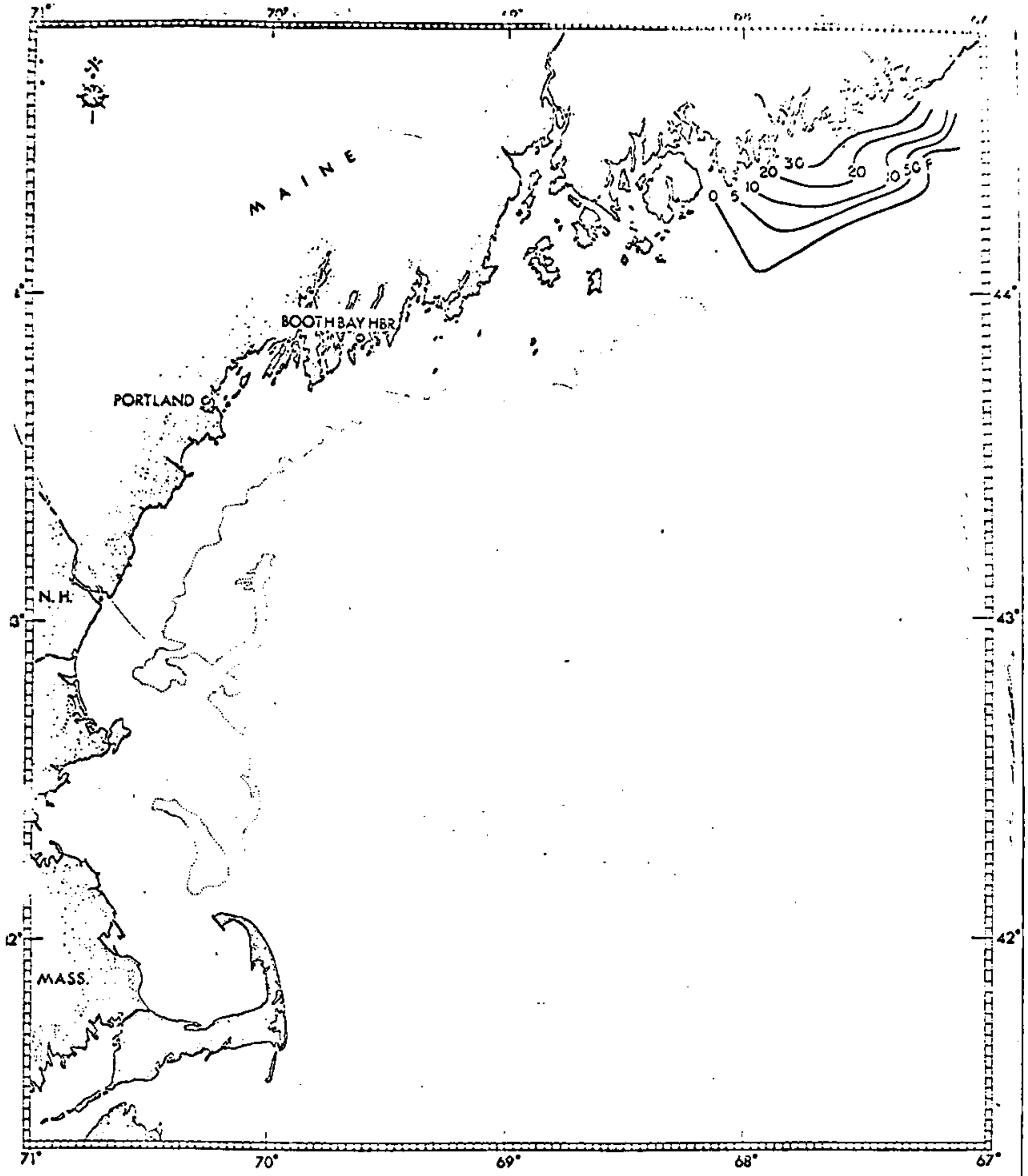


Figure 2a. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Sept. 2 - 6, 1972. Larvae less than 10 mm. long.

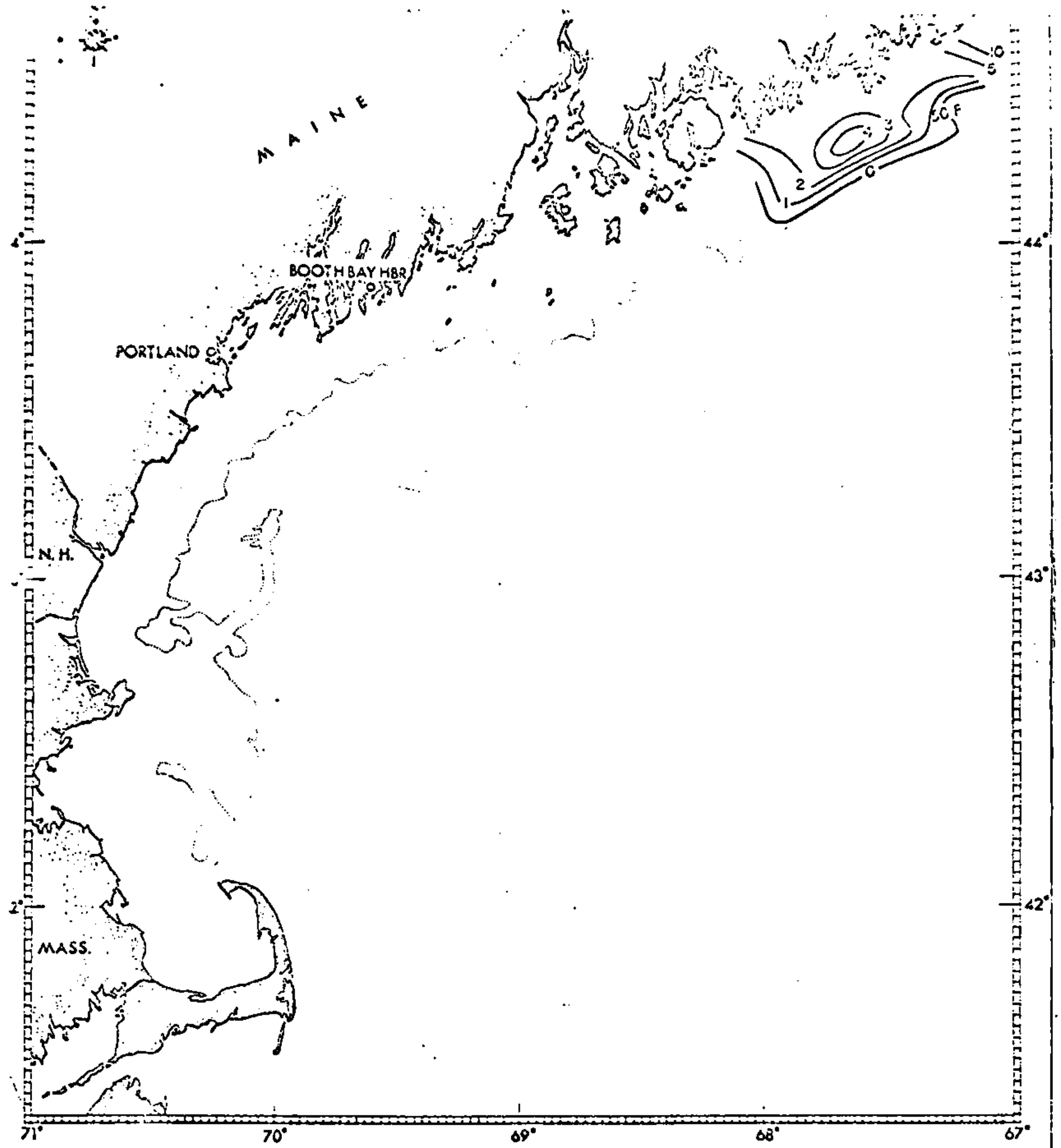


Figure 2b. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Sept. 2 - 6, 1972. Larvae from 10 to 15 mm. long.

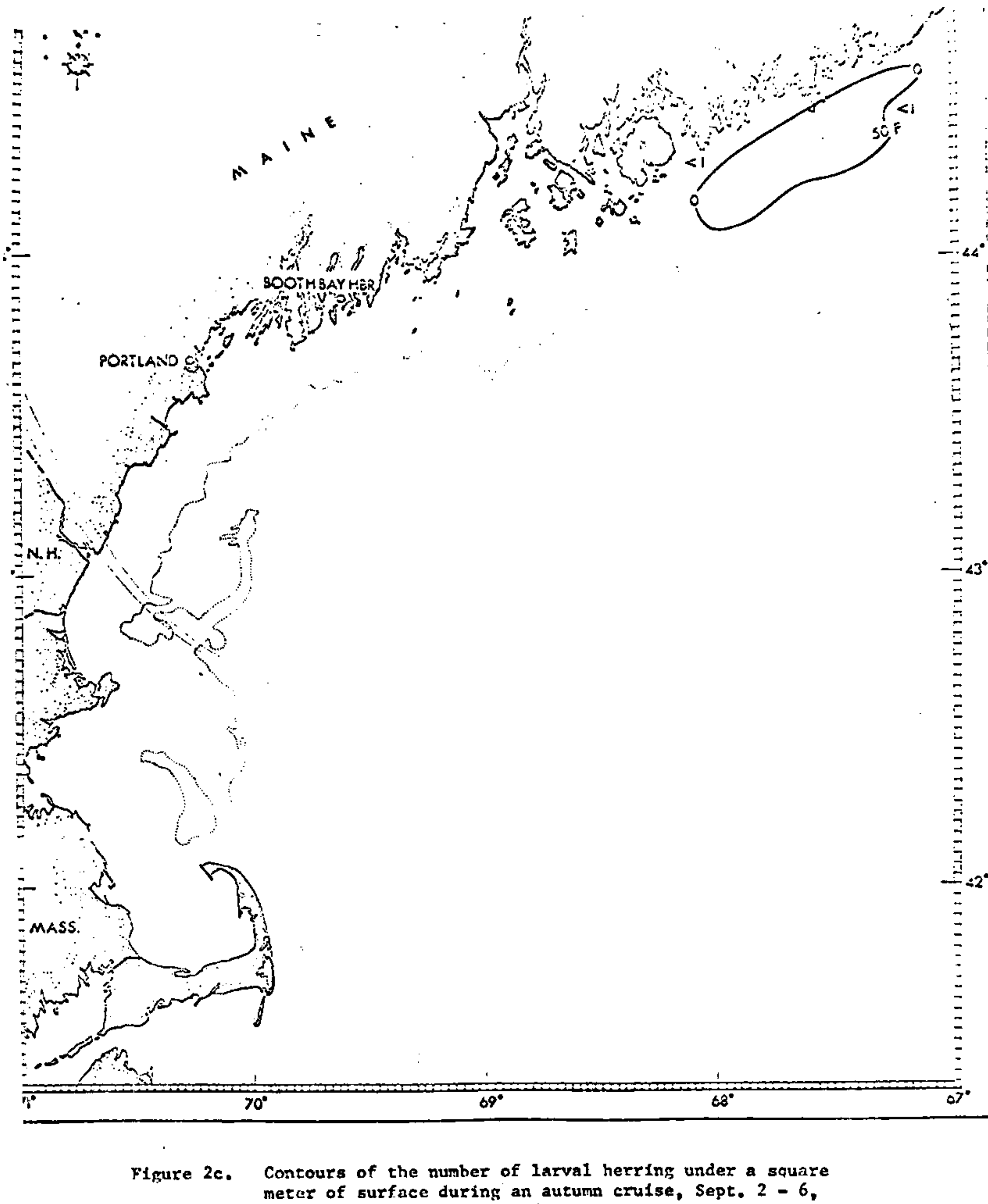


Figure 2c. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Sept. 2 - 6, 1972. Larvae longer than 15 mm.

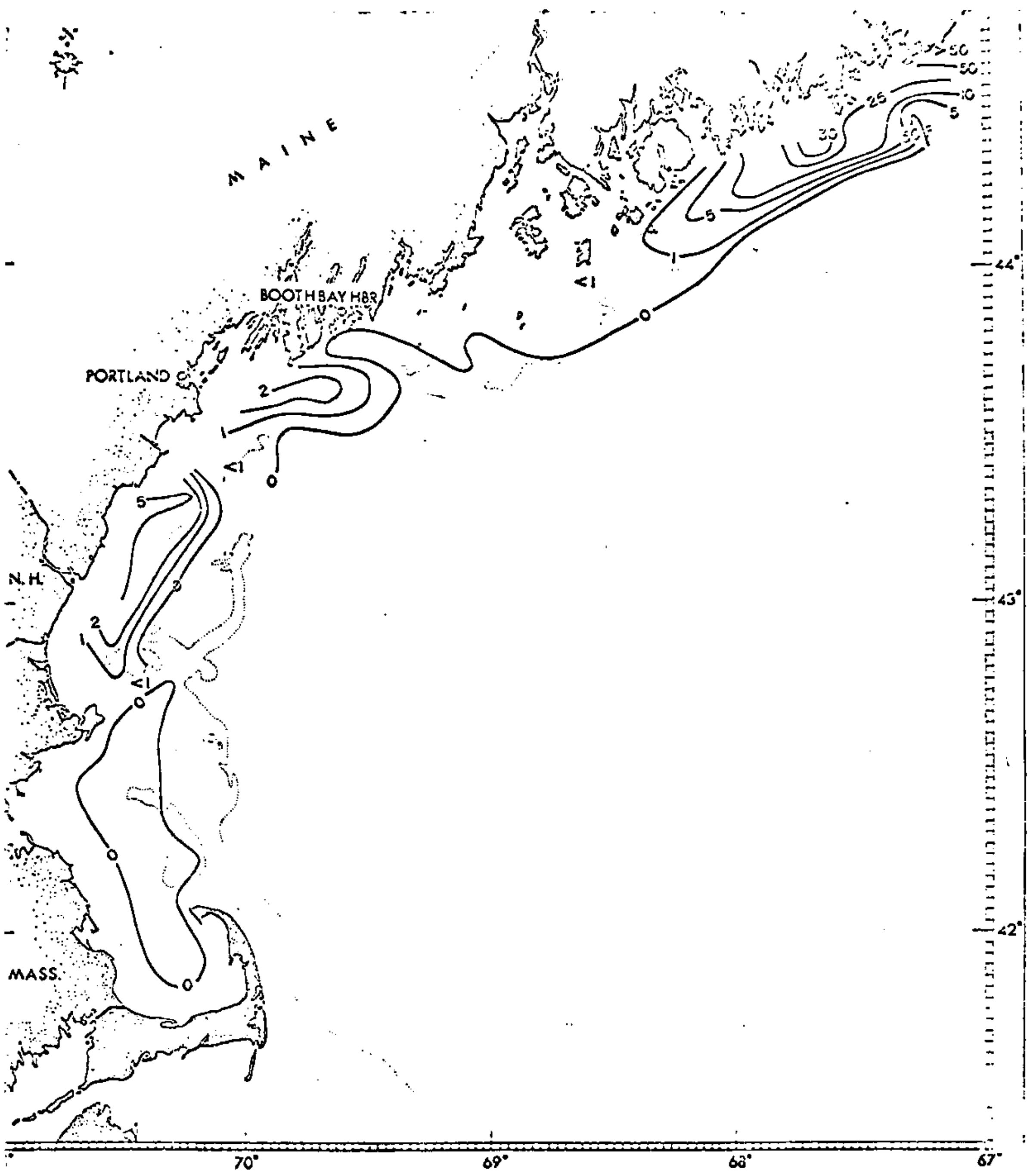


Figure 3a. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Sept. 21 - 24, 1972. Larvae less than 10 mm. long.

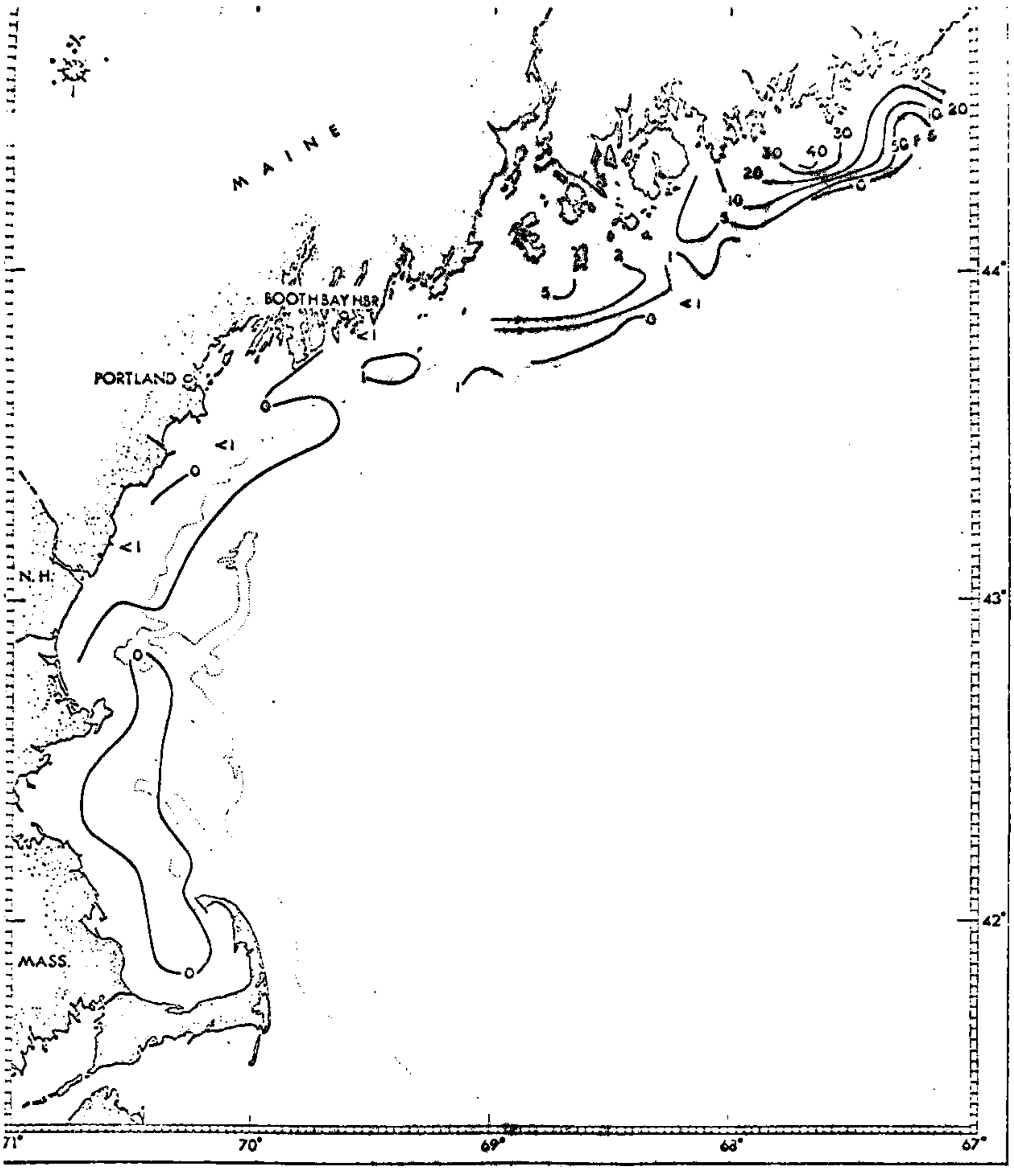


Figure 3b. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Sept. 21 - 24, 1972. Larvae from 10 to 15 mm. long.

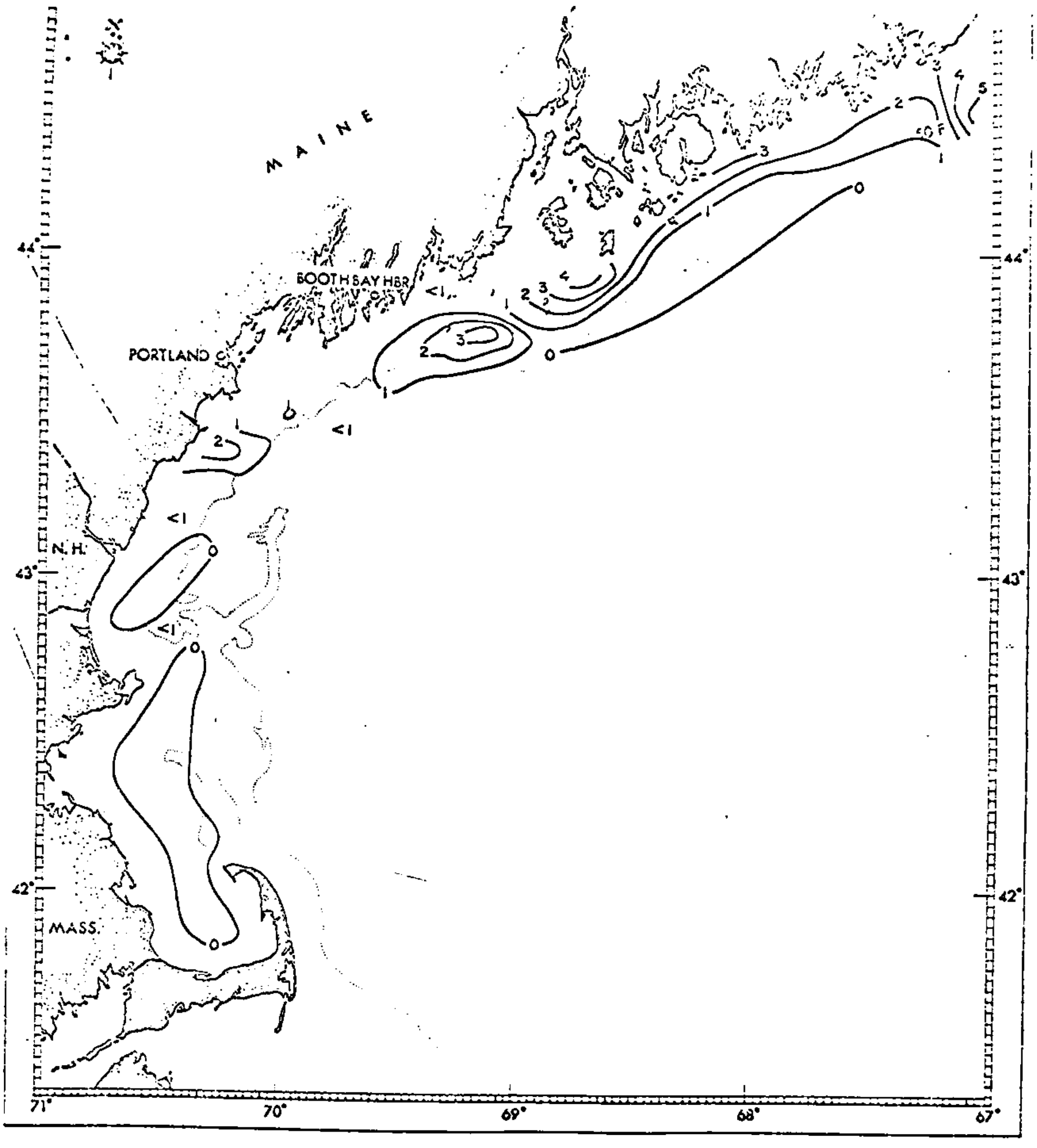


Figure 3c. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Sept. 21 - 24, 1972. Larvae longer than 15 mm.

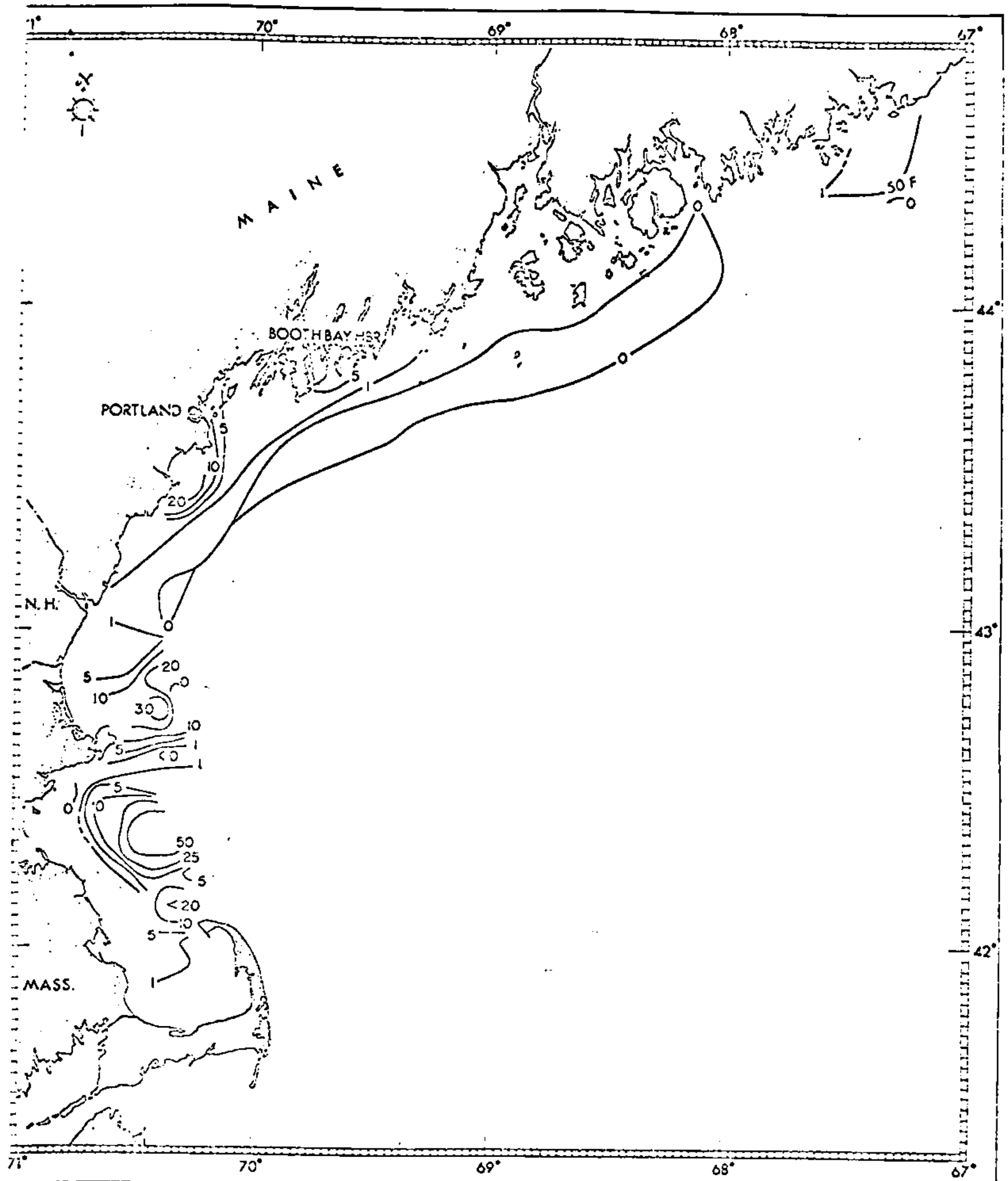


Figure 4a. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Oct. 18 - 22, 1972. Larvae less than 10 mm. long.

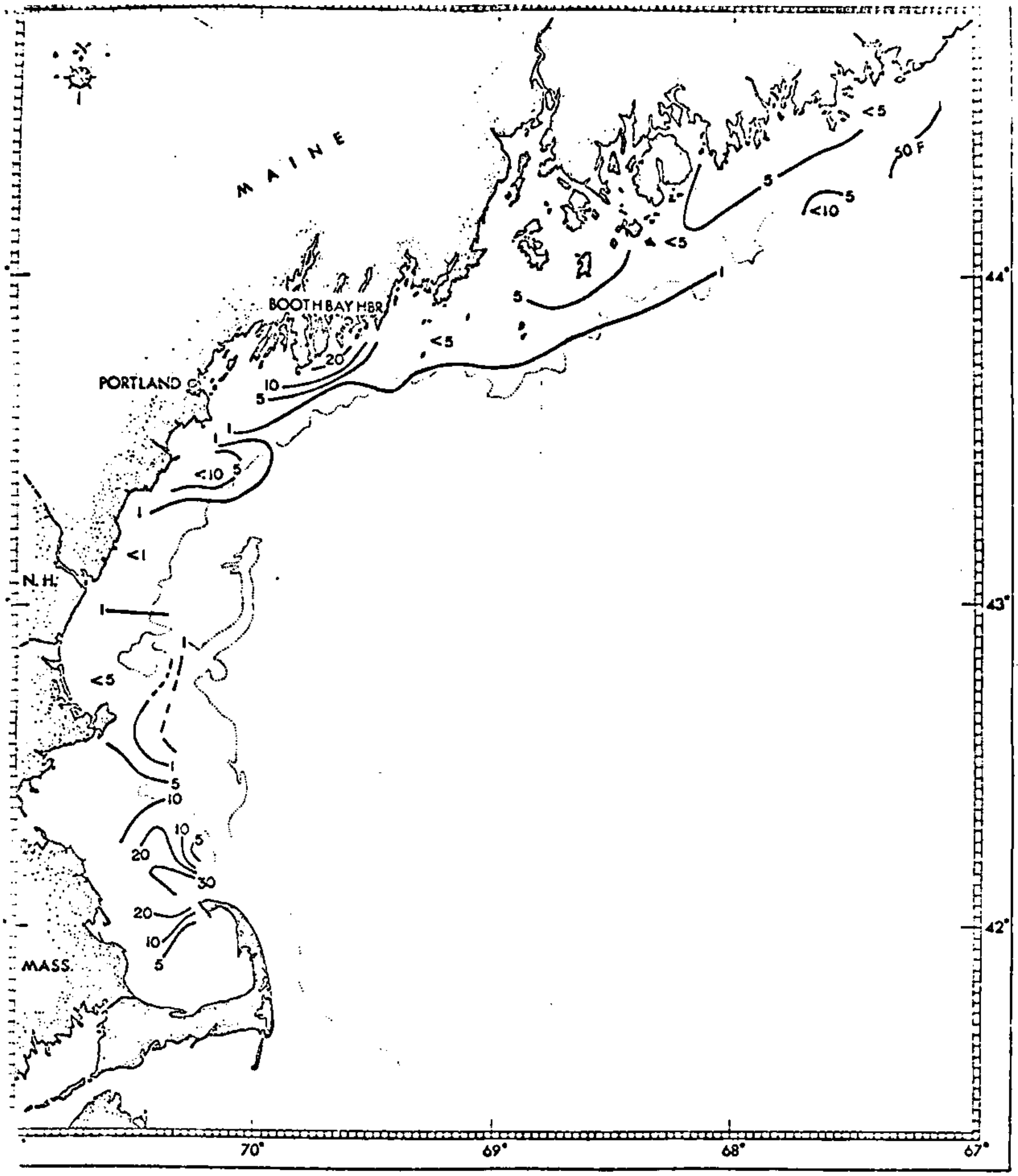


Figure 4b. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Oct. 18 - 22, 1972. Larvae from 10 to 15 mm. long.

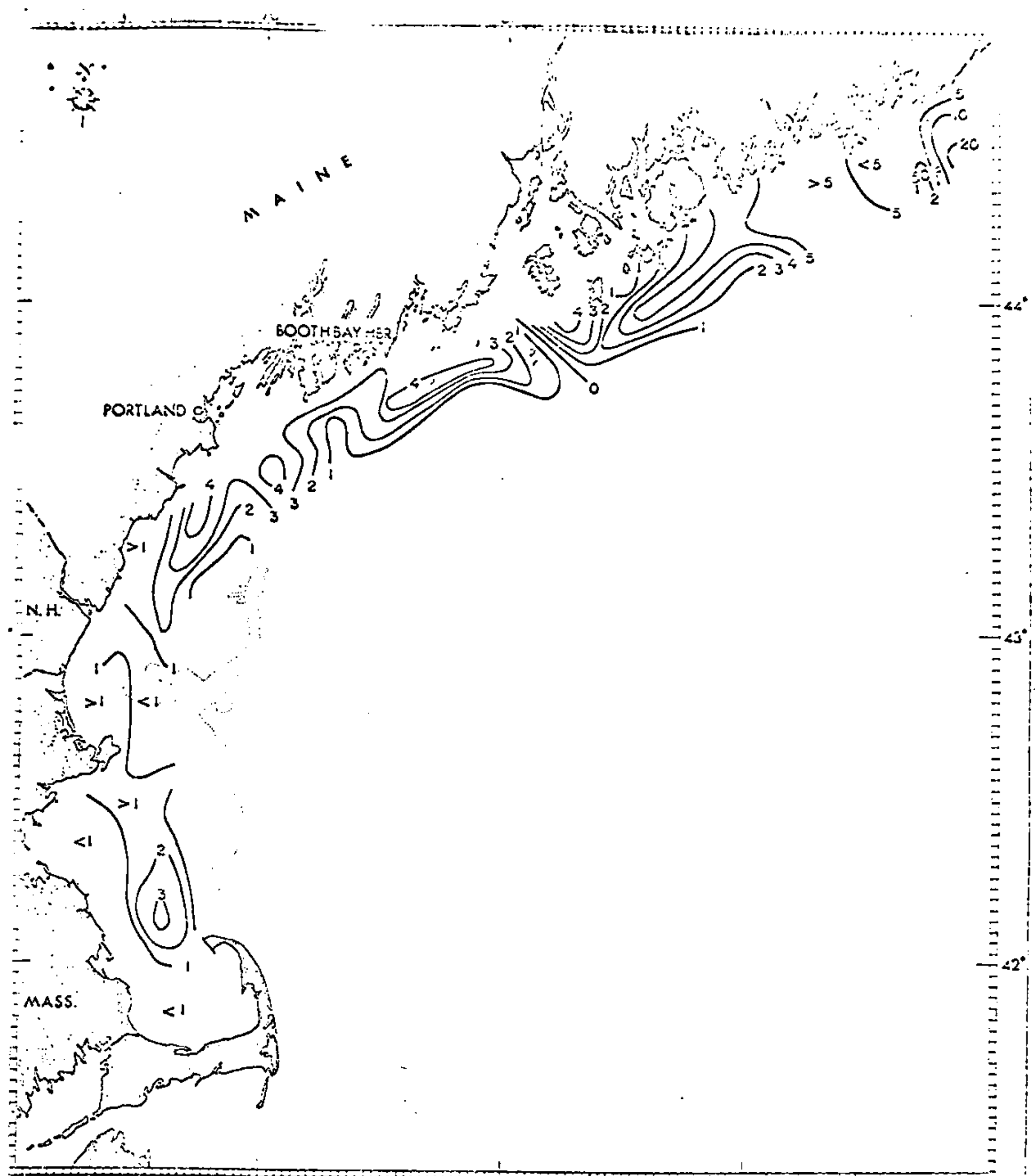


Figure 4c. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Oct. 18 - 22, 1972. Larvae longer than 15 mm.

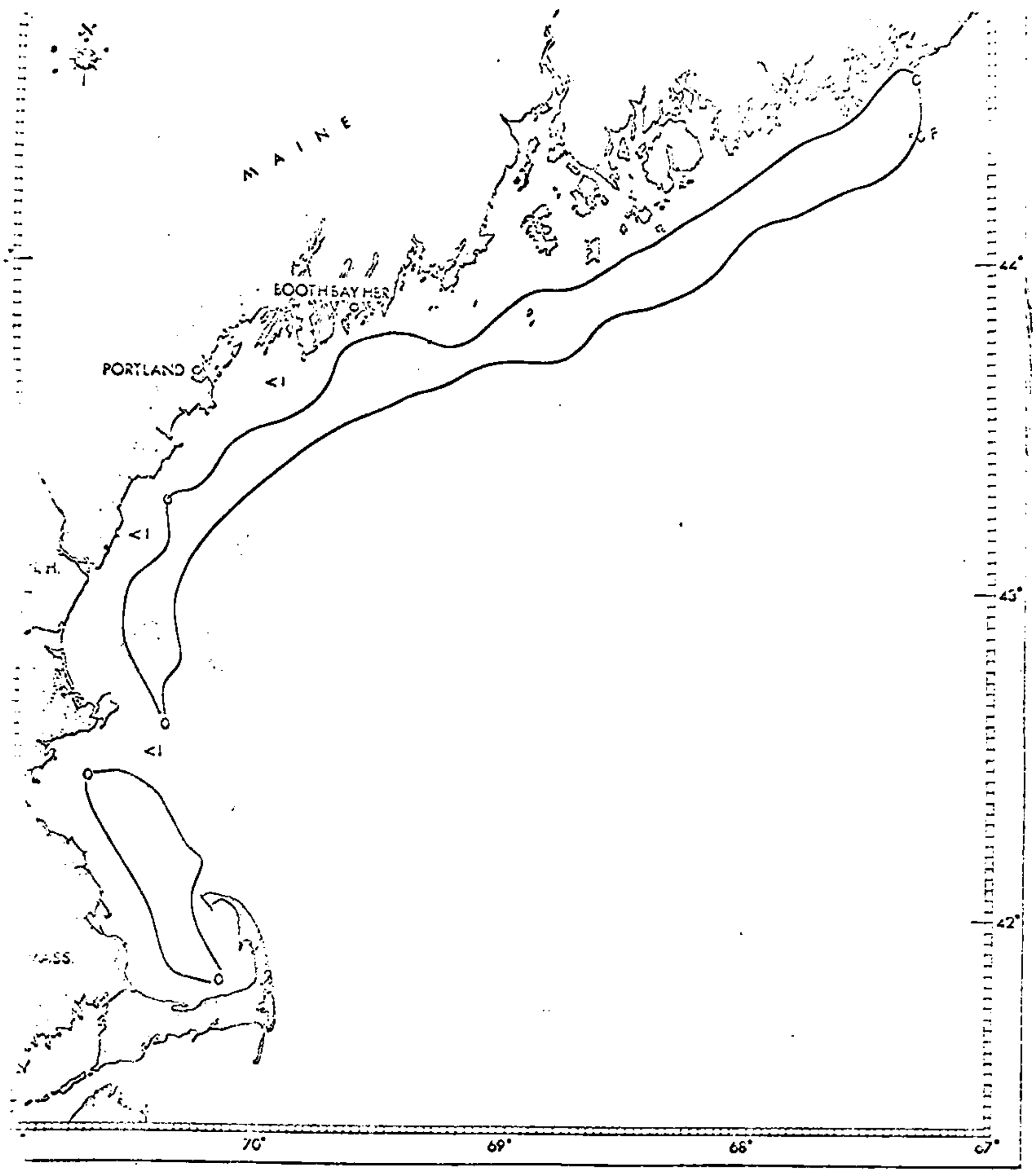


Figure 5a. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Nov. 6 - 12, 1972. Larvae less than 10 mm.

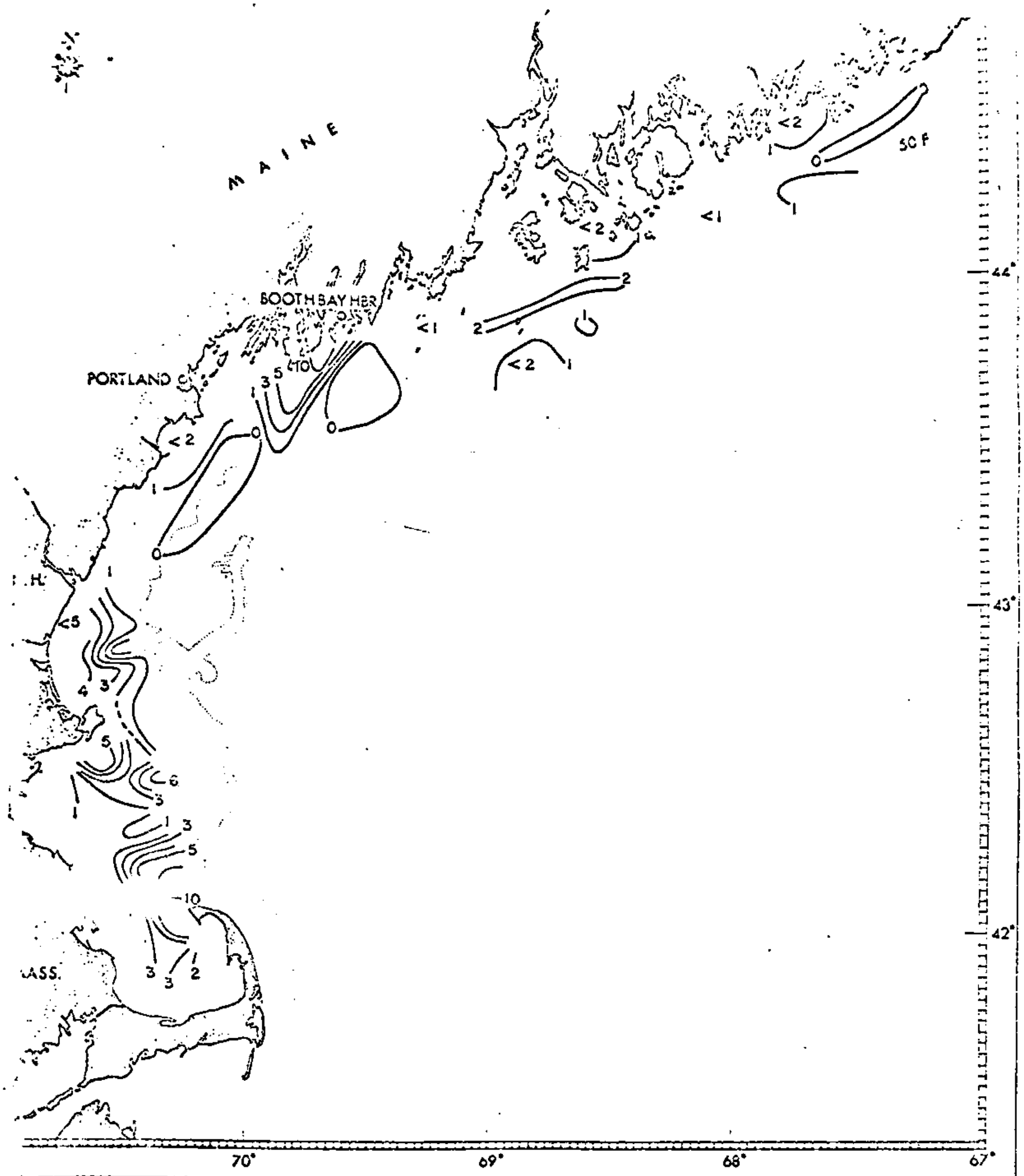


Figure 5b. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Nov. 6 - 12, 1972. Larvae from 10 to 15 mm. long.

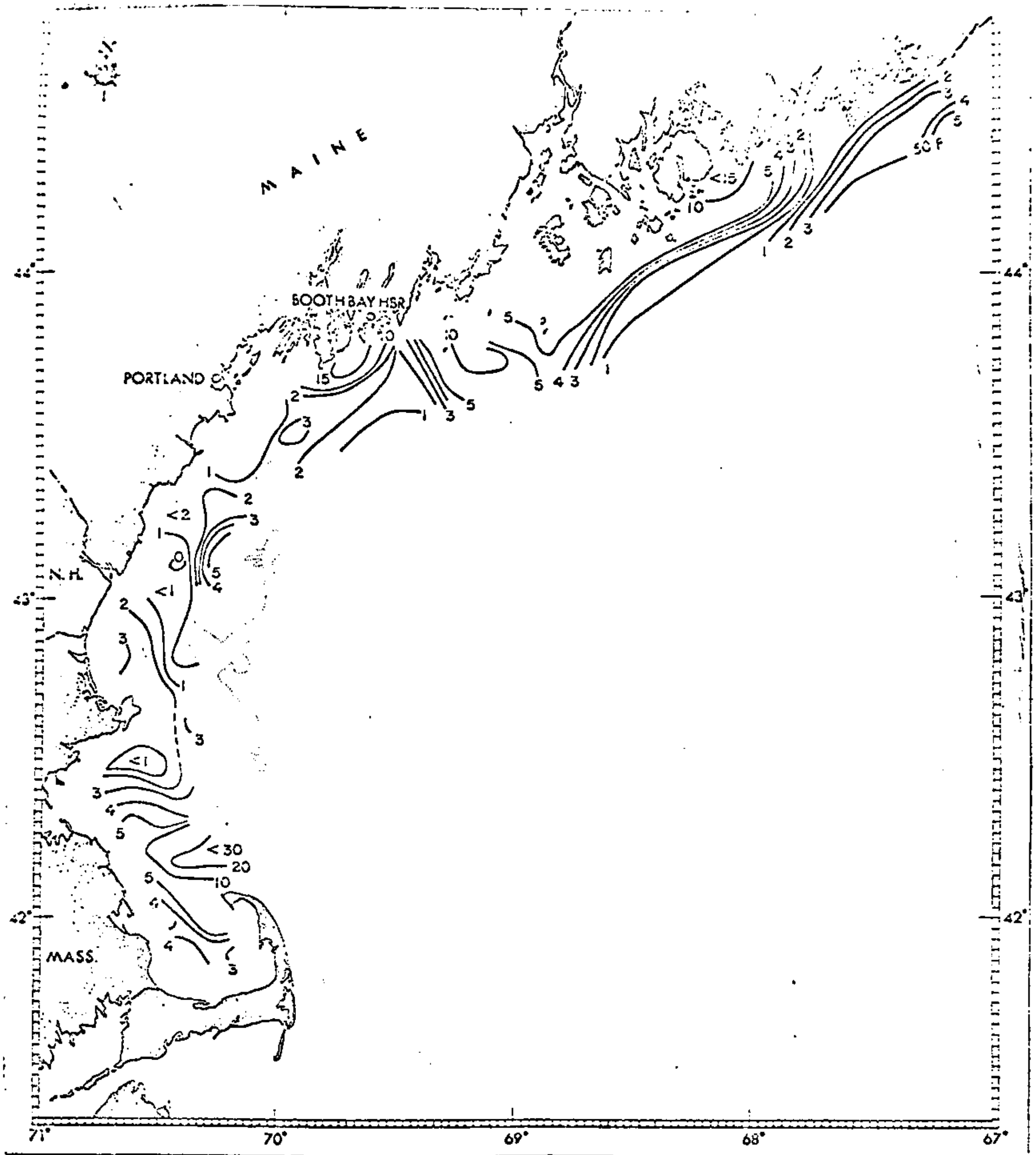
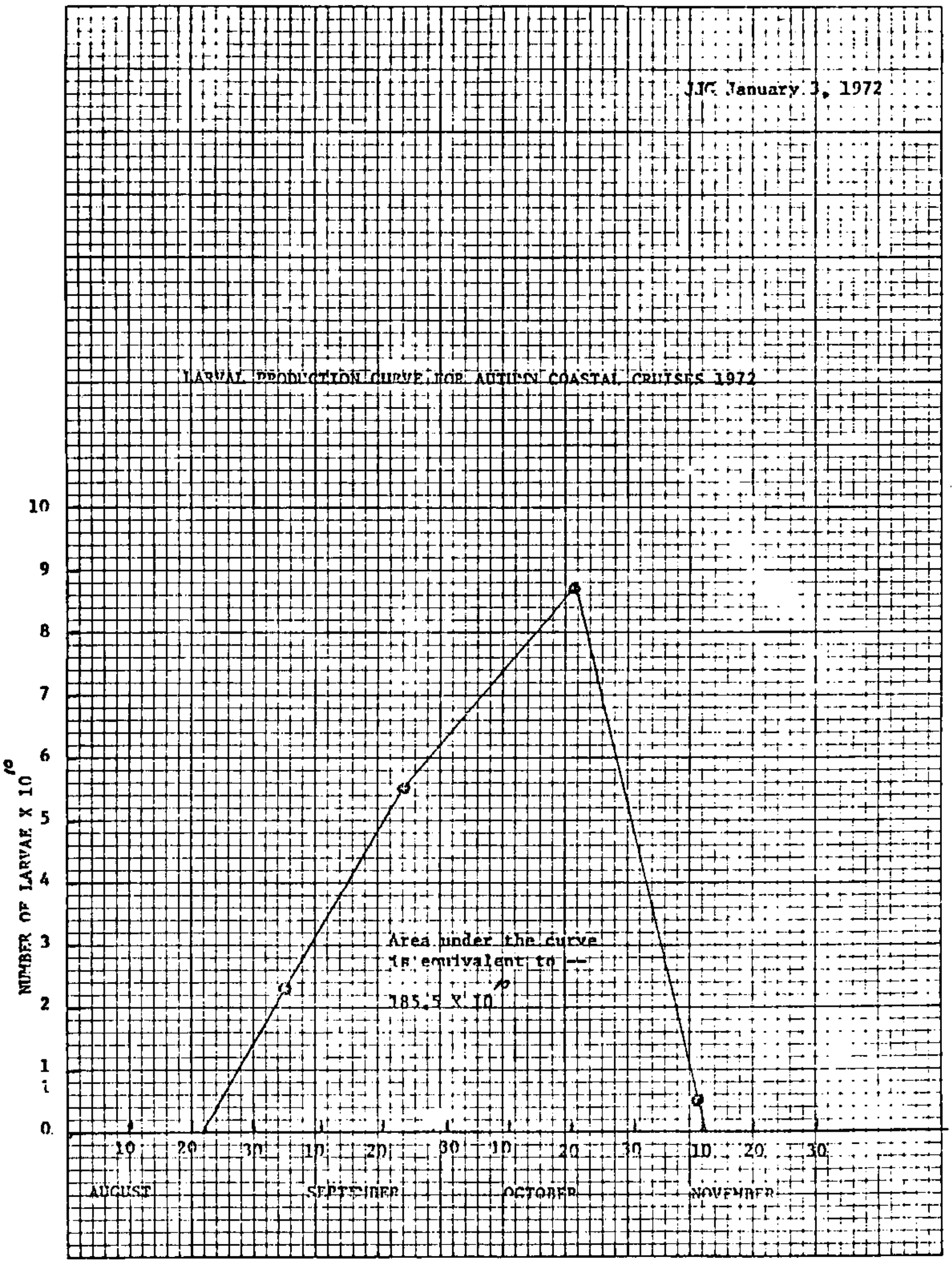


Figure 5c. Contours of the number of larval herring under a square meter of surface during an autumn cruise, Nov. 6 - 12, 1972. Larvae longer than 15 mm.

C 3



JJG January 3, 1972
LARVAL PRODUCTION CURVE FOR AUTUMN COASTAL CRUISES 1972
Area under the curve
is equivalent to --
185.5 X 10^10
NUMBER OF LARVAE X 10^10
10
9
8
7
6
5
4
3
2
1
0.
10
20
30
10
20
30
10
20
30
10
20
30
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER

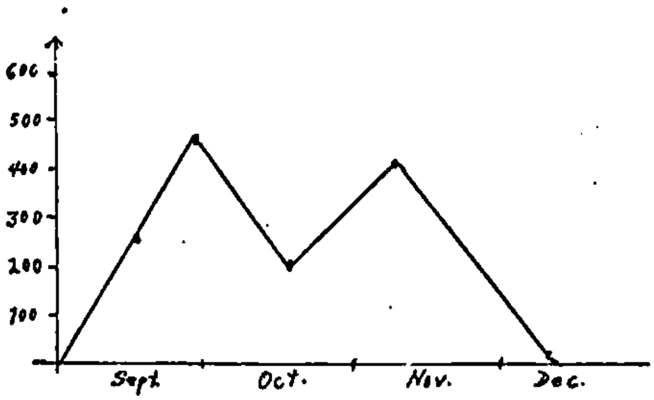
Calculation of the number of larvae less than 10 mm. long (recently hatched) during autumn cruises, 1972. Area enclosed by sampling stations is 16,817,605,200 square meters.

Cruise No.	Number of stations	Number of larvae per m²	Mean Number per m²	Number of larvae captured in the area
1	63 [1]	81.390	1.291	21,711,528,313 [2]
2	61	199.492	3.270	54,993,569,004
3	63	302.326	4.799	80,708,167,255
4	63	2.057	0.032	538,163,366

[1] In the first cruise all of the stations west of the eastern area sampled along the coast are assumed to be zero catches.

[2] All full numbers are given in case they are needed for futher calculation.

Georges Bank



Coastal Gulf of Maine

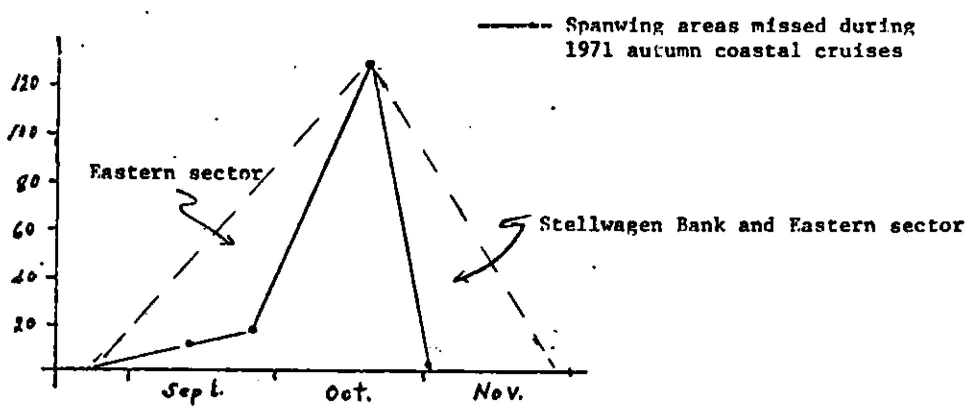


Figure 1. Total number (billions) of larvae 10 mm.