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WORKING GROUP ON JOINT SURVEY OF LARVAL HERRING

IN THE GEORGES BANK-GULF OF MAINE AREAS

(ICNAF SUBAREAS 4X, 5Y, AND 5Z)

May 9 - May 12, 1972

Boothbay Harbor, Maine

List of Participants

Mr. Dan Miller	Canada
Dr. Dietrich Schnack	Fed. Rep. of Germany
Dr. David Au	USA
Mr. H. C. Boyar	"
Mr. John B. Colton	"
Dr. Joseph J. Graham	"
Mr. Robert Marak	"
Dr. George J. Ridgway (Chairman)	"

Description and Objectives of the Experiment

At the 1971 ICNAF Annual Meeting it was agreed to mount a joint survey of larvae herring in the Georges Bank-Gulf of Maine areas to delimit the major spawning grounds in these areas, to obtain relative estimates of spawning stock size and to obtain information about larval drift and dispersal. Offshore cruises were made sequentially on a standardized grid pattern, and using standardized gear and methods, during the period 5 September to 17 December 1971 by the following research vessels:

Cryos (France) 9 - 24 September
Delaware II (USA) 21 September - 4 October
Viandra (USSR) 9 - 25 October
Walther Herwig (Fed. Rep. of Ger.) 31 October - 12 November
Albatross IV (USA) 2 - 17 December

During the period 9 September to 8 November four alongshore cruises in the Gulf of Maine were made, using the same standard procedures, from Massachusetts Bay to Machias Bay on board the small US research vessel Rorqual. An alongshore cruise in the Bay of Fundy and southwest Nova Scotia was also made in October by the Canadian research vessel Prince but different gear and sampling procedures were used, and by the time of the Workshop the Canadian samples had not been sorted.

Methods

In order to provide for comparability of data collected by the various nations, the United States was asked to lay out proposed cruise tracks and provide a set of standard procedures. The United States also agreed to supply the sampling gear to be used by all participating countries. At each designated station a tow was made at 3.5 knots using paired 60 cm bongo-type ichthyoplankton samplers. The sampling was from 200 meters, or at shallower stations, as close to the bottom as practical. During each tow

the nets were deployed at as close to 50 m/min as was practical. During retrieval on each tow the upper 40 meters were sampled in 20 steps, separated by 2-meter intervals, with one minute at each step. The rate of retrieval was continuous at 20 m/min in the deeper tows up to the 40 m level where the tow was changed to step-oblique as in shoal water. Samples were preserved in 5% buffered formalin. All herring larvae were to be sorted and counted. Samples of up to 100 were measured (total length).

Historical Data Base

To provide an historical data base, the Working Group reviewed the following documents:

- Joseph J. Graham, Stanley B. Chenoweth and Clarence W. Davis
Abundance, Distribution, Movements and Lengths of Larval Herring
Along the Western Coast of the Gulf of Maine. (In Press).
- H. C. Boyar, Robert R. Marak, Frank E. Perkins and Roger A. Clifford
Seasonal Distribution of Larval Herring (Clupea harengus harengus L.)
in the Georges Bank-Gulf of Maine Area from 1962-1971. ICNAF Res.
Doc. 71/100
- Iles, T. D.
The Retention Inside the Bay of Fundy of Herring Larvae Spawmed
off the Southwest Coast of Nova Scotia. ICNAF Res. Doc. 71/98.
- Messiah, S. N., S. N. Tibbo and L. M. Lauzier.
Distribution, Abundance and Growth of Larval Herring (Clupea
harengus L.) in the Bay of Fundy Gulf of Maine Area. Fisheries
Research Board of Canada Technical Report No. 277.

Reports by Participating Nations

Reports, some of them preliminary, on the cruises made by participating nations or tabulations of data were available for examination by the Working Group. Material available is listed below:

- R. L'Herrou and D. Briand
ICNAF Res. Doc. 72/62
- K. A. Honey and S. B. Chenoweth
ICNAF Res. Doc. 72/8
- J. J. Graham, C. W. Davis, S. B. Chenoweth and B. C. Bickford
ICNAF Res. Doc. 72/7
- J. B. Colton
ICNAF Res. Doc. 72/9
- D. Schnack
Tabulations of data from the Walther Herwig cruise
- A. S. Noskov
Tabulations of data from the Viandra cruise

Data not available in ICNAF documents are presented in the Appendix.

Results

a. Qualitative Results: The significant sites of larval production detected in the survey were as follows.

Georges Bank: Spawning is concentrated on the northern edge; significant numbers of larvae were first detected during the second half of September and small larvae were found until the middle of November. Drift and dispersal is in a southwesterly direction in the clockwise gyre. An additional spawning site apparently occurs in the western part of the Bank just east of the channel. Spawning occurs here later than on the northern edge. Very few larvae were found outside the 100-m isobath. By December, larvae were widely dispersed over the Bank.

Nantucket Shoals: Larvae were detected in significant numbers in this area (west of the Great South Channel) first in early November. Dispersal is apparently southwestward but may also be in part northeastward across the channel on to Georges Bank. This area has been included with Georges Bank when making quantitative estimates.

Nova Scotia: The Trinity Ledge-Lurcher Shoal area was readily detectable in the surveys with larvae in significant numbers obtained in the second half of September. These larvae were larger than those taken on Georges Bank at the same time. Major drift is northward along the eastern side of the Bay of Fundy.

Southwestern Gulf of Maine: The first concentration of larvae detected in this area was off Cape Elizabeth, Maine, during the latter part of September. Dispersal of this group of larvae was mainly shoreward into Saco Bay and perhaps Casco Bay. Concentrations of larvae in the Jeffreys Ledge-Stallwagen Bank areas were detected about the middle of October with dispersal shoreward. Virtually no larvae were found on the oceanic side of Jeffreys Ledge.

Eastern Sector of the Maine Coast: A group of larvae, centered off Frenchman's Bay, was found in the first half of September. This larval group and larvae from subsequent spawnings persisted into early November with dispersal inshore and southwestward along the coast. The origin of these larvae is unknown but they may result from spawning on Grand Manan Bank and areas north of Grand Manan Channel.

b. Quantitative results: In order to obtain a measure of abundance of larvae in a given area, one must calculate the mean number of larvae caught per unit volume of water in the area and multiply by the total volume in the area, or calculate the mean number of larvae under a unit of area and multiply by the total area under consideration. Because the tow profile used in these surveys did not sample all layers of the water column equally, it was necessary to make the simplifying assumption that all larvae caught were in the upper 40 meters (the catch data obtained support the reasonableness of this assumption). In this segment of the tows the various layers were sampled equally within the limits of reproducibility of the methods. A theoretical calculation of the volume of water sampled in the upper 40 meter section of the tow was made and checked against the mean of values for volumes of water filtered in actual 40 meter tows. These values checked quite closely and were used to convert larvae per tow values to larvae per square meter values. The conversion factor for the inshore Gulf of Maine cruises was 0.05, the offshore cruises 0.057 because the inshore vessel operated at 4 rather than 3.5 knots. In the case of the Albatross IV cruise, a single oblique rather than a stepped oblique haul was made and a different but appropriate method was used for calculation once again assuming that a negligible fraction of the larvae were caught below 40 meters.

Using the methods outlined above, preliminary calculations of total larval abundance were made at the Rome meeting. These indicated a ratio of about 6 between the peak abundance of larvae in the Georges Bank and Gulf of Maine areas. At the present workshop meeting, size composition data were available for all cruises and larval abundance was calculated as numbers of larvae under a square meter of water for three size categories. The abundance of larvae less than 10 mm long was summed for the various cruises in the Coastal Gulf of Maine and Georges Bank-Nantucket Shoals areas to obtain estimates of larval production. These summations are presented in Table 1 and plotted in Figure 1. A rough estimate of the relative numbers of larvae produced in the two areas was obtained by comparing the areas under the larval production curves in Figure 1. According to this estimate, in 1971 10 times as many larvae were produced on Georges Bank - Nantucket shoals as in Coastal Gulf of Maine. The figure for the coastal Gulf of Maine is undoubtedly an underestimate since the onset of larval production in the eastern section was missed.

c. Drift and Dispersal of Herring Larvae: In the limited time available to the Working Group, it was not possible to make a detailed study of the information on drift and dispersal inherent in the results of the cruises. Some limited conclusions are presented in the section on qualitative results. As a start on the detailed considerations of drift and dispersal that are possible, the Working Group calculated and plotted catch rates for each size category for the offshore cruises. These are presented in figures 2 through 18. The Working Group felt that a more detailed consideration of dispersal was possible and desirable but would require the concerted effort of one or more interested scientists from participating countries for a period of several weeks.

d. Oceanography: The oceanographic data collected on most of the cruises were available to the working party but no detailed consideration was possible. Charts for the Cryos cruise are available in ICNAF Res. Doc. 72/62; data from the Albatross IV cruise are presented in ICNAF Res. Doc. 72/9. Plots from the Delaware II cruise are presented in the appendix. Bottom temperatures seem to be the most significant feature in relation to larval production. The oceanographic data should be considered in detail in connection with any further analysis of drift and dispersal.

Recommendations

The Working Group agreed that larval surveys of the type carried out in 1971 have special value in the assessment of spawning stock size; therefore, the Working Group recommended that such surveys be continued for several years in order to obtain measures of year to year fluctuation in the abundance of the spawning stocks.

The Working Group discussed ways of improving future joint surveys and made the following recommendations.

1. Significant improvement would be made if a tow profile were used that samples all layers of the water column equally. The Working Group agreed that sampling should be conducted to a maximum depth of 200 meters or as close to the bottom as practical. A single oblique haul with wire payed out at 50 meters per minute is suggested with the vessel underway at 3.5 knots. If time of tow is less than 15 minutes, two sequential tows should be made with gear payed out again as soon as it surfaces. Vessel speed should be maintained at 3.5 knots throughout the tow.
2. Identical gear should be used on all cruises during the survey. Paired 60 cm Bongo nets of 505 microns and 333 microns mesh size should be used. A four-foot V-fin depressor shall be used. Calibrated flow meters should be mounted inside each net. Wire 6 mm in diameter shall be used. The United States will provide identical gear for each cruise. Bathykymographs will be attached during each tow.
3. The Working Group agreed that the cruise track used in 1971 with some exceptions delineated the major concentration of larval herring in the area. Lack of coverage by Canadian vessels in the Bay of Fundy was the major limitation. Stations need to be added on Stellwagen Bank and east of Cape Cod. Stations on Nantucket Shoals and westward can be omitted during September but more coverage in these areas is needed in November and December.

A station should be added between stations 94 and 95. Stations 38, 39, 42, 43 and 83 can be omitted. Time saved by omitting these stations should be applied to increasing the density of coverage on Georges Bank.

4. The cruises made in 1971 covered the period of larvae production reasonably well although the time of onset of hatching was not established in Nova Scotia or on Georges Bank. Short cruises to these areas in early September would thus be advantageous. In order to obtain accurate larval production curves more closely spaced cruises would be required.
5. The Working Group made the following suggestions in regard to standardization of reporting. Larval abundance should be reported as numbers of larvae per tow, numbers of larvae per square meter, and numbers of larvae per cubic meter. These measures of abundance should be reported by size groups. Size distributions should be given by size groups of less than 10 mm, 10-15 mm, and greater than 15 mm. If possible, a randomly selected sample of 100 larvae from each tow and each net should be measured and the length frequency reported for each tow and net. Yolk sac larvae should be separately tabulated.
6. Oceanographic observations should consist of at least BT's. Ancillary information on non-tidal drift obtained from releases of sea-bed drifters and drift bottles would be useful.

Table 1. Total number (billions) of larvae <10 mm for time and area.

Ship	Date	Georges Bank	Coastal Gulf of Maine
USA RORQUAL	9 Sept. - 16 Sept.		9.4
France CRYOS	10 Sept. - 24 Sept.	260	
USA RORQUAL	22 Sept. - 1 Oct.		15.2
USA DELAWARE	21 Sept. - 3 Oct.	470	
USSR	9 Oct. - 25 Oct.	200	
USA RORQUAL	13 Oct. - 25 Oct.		130
USA RORQUAL	27 Oct. - 8 Nov.		1.7
Germany W. HERWIG	31 Oct. - 12 Nov.	420	
USA ALBATROSS	2 Dec. - 17 Dec.	17	

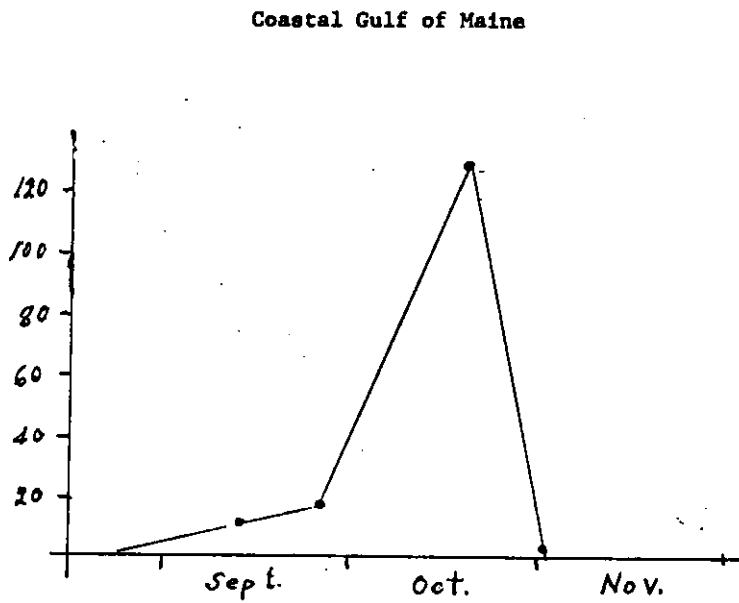
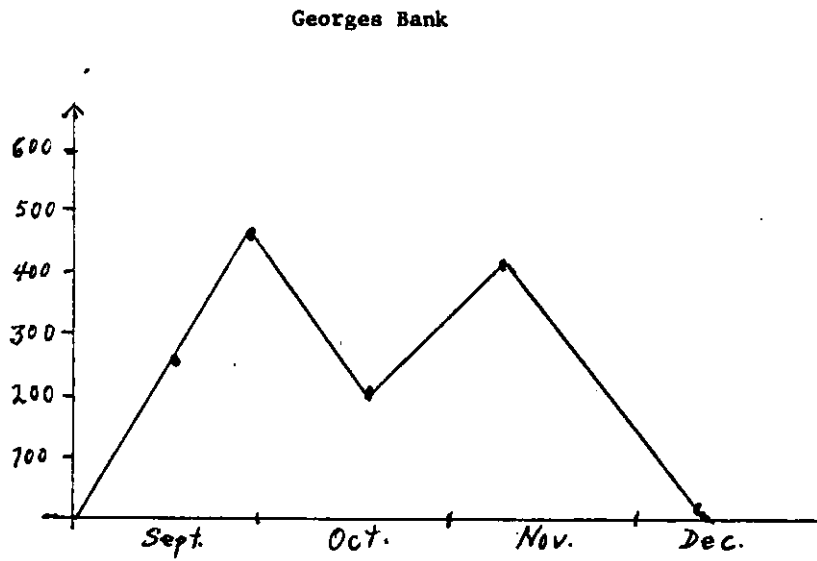
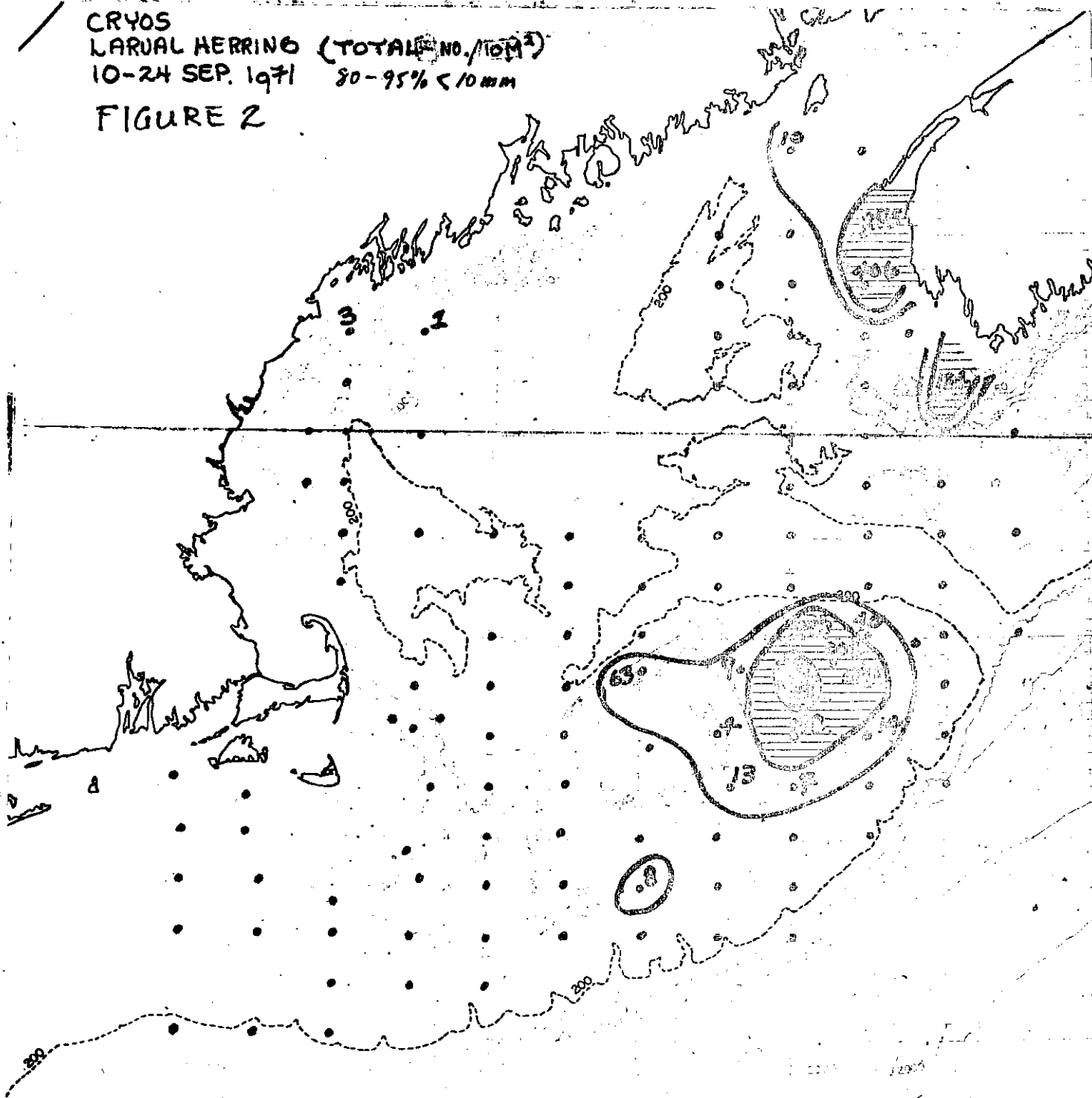


Figure 1. Total number (billions) of larvae 10 mm.

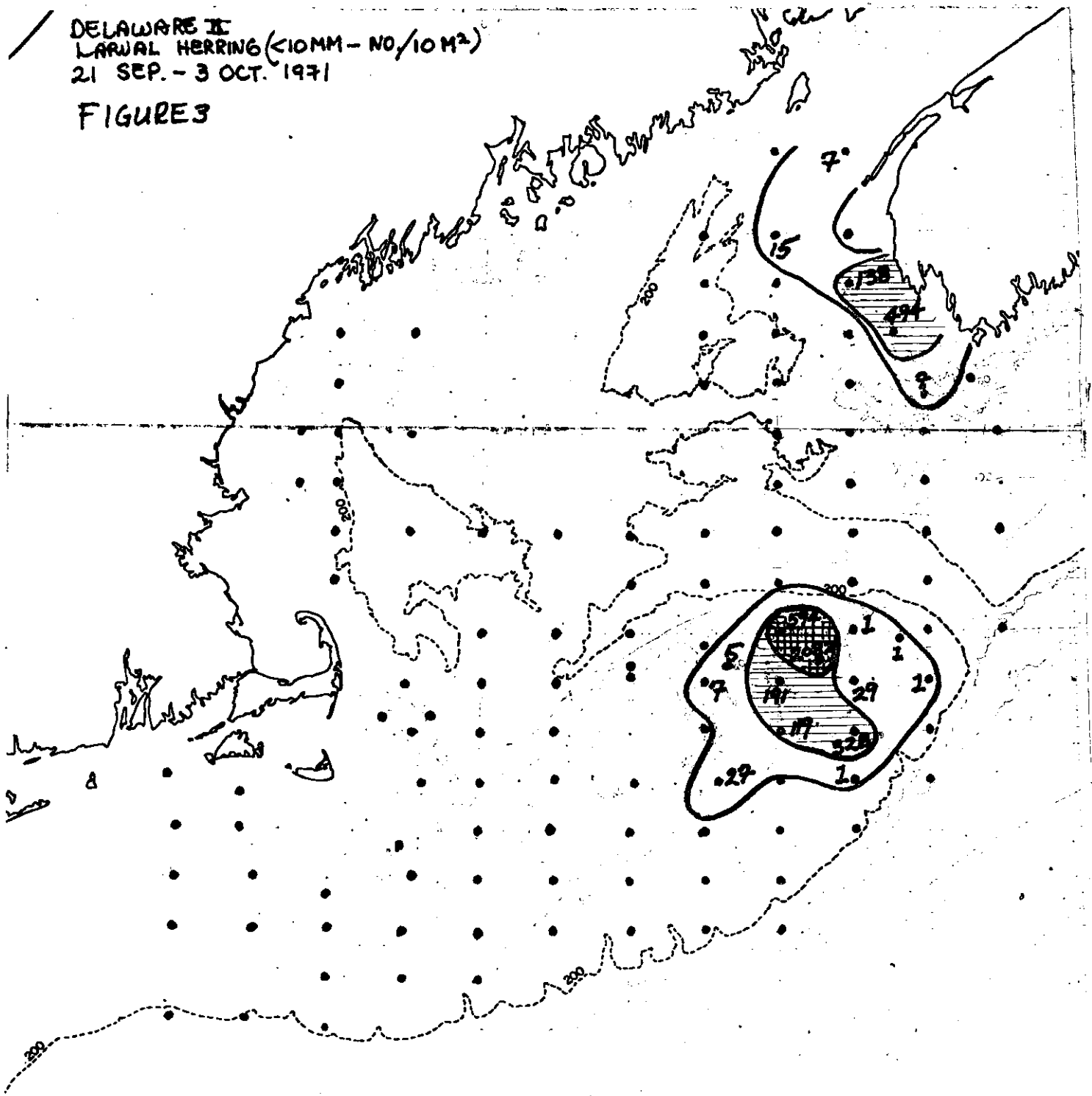
CRYOS
LARVAL HERRING (TOTAL NO./10M²)
10-24 SEP. 1971 80-95% < 10mm

FIGURE 2



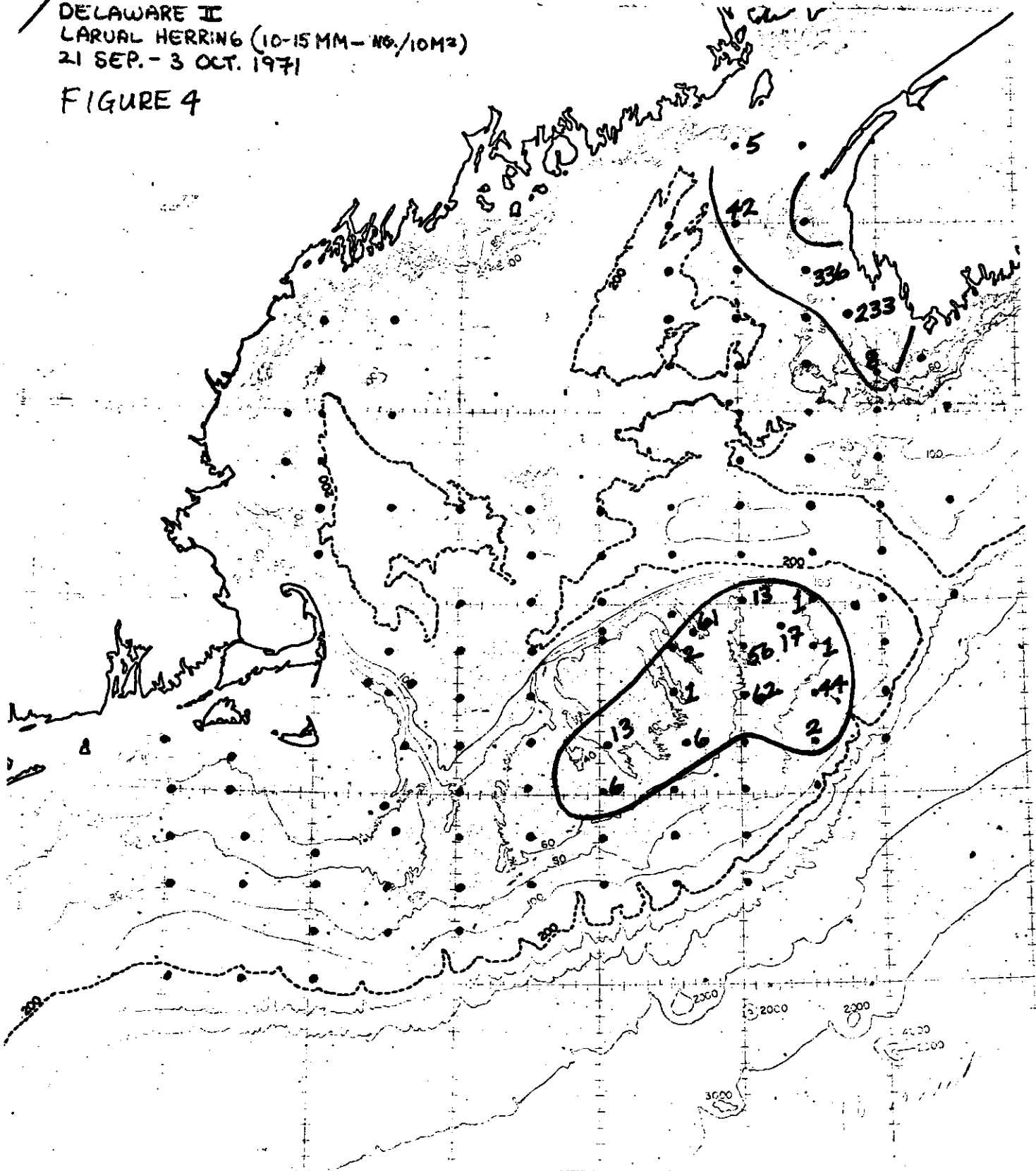
DELAWARE II
LARVAL HERRING (<10MM - NO./10M²)
21 SEP. - 3 OCT. 1971

FIGURE 3



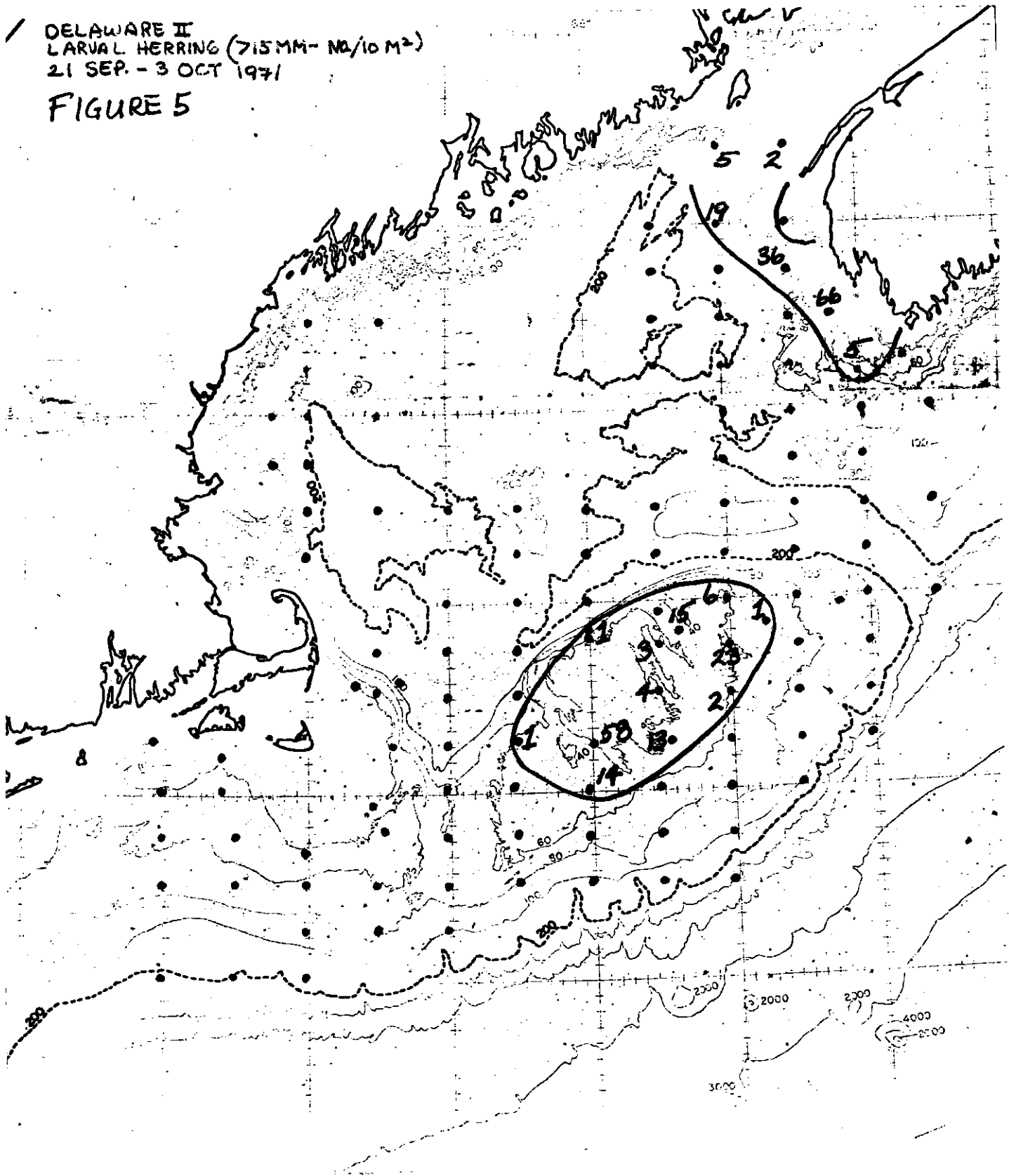
DELAWARE II
LARVAL HERRING (10-15 MM - NO./10M²)
21 SEP. - 3 OCT. 1971

FIGURE 4



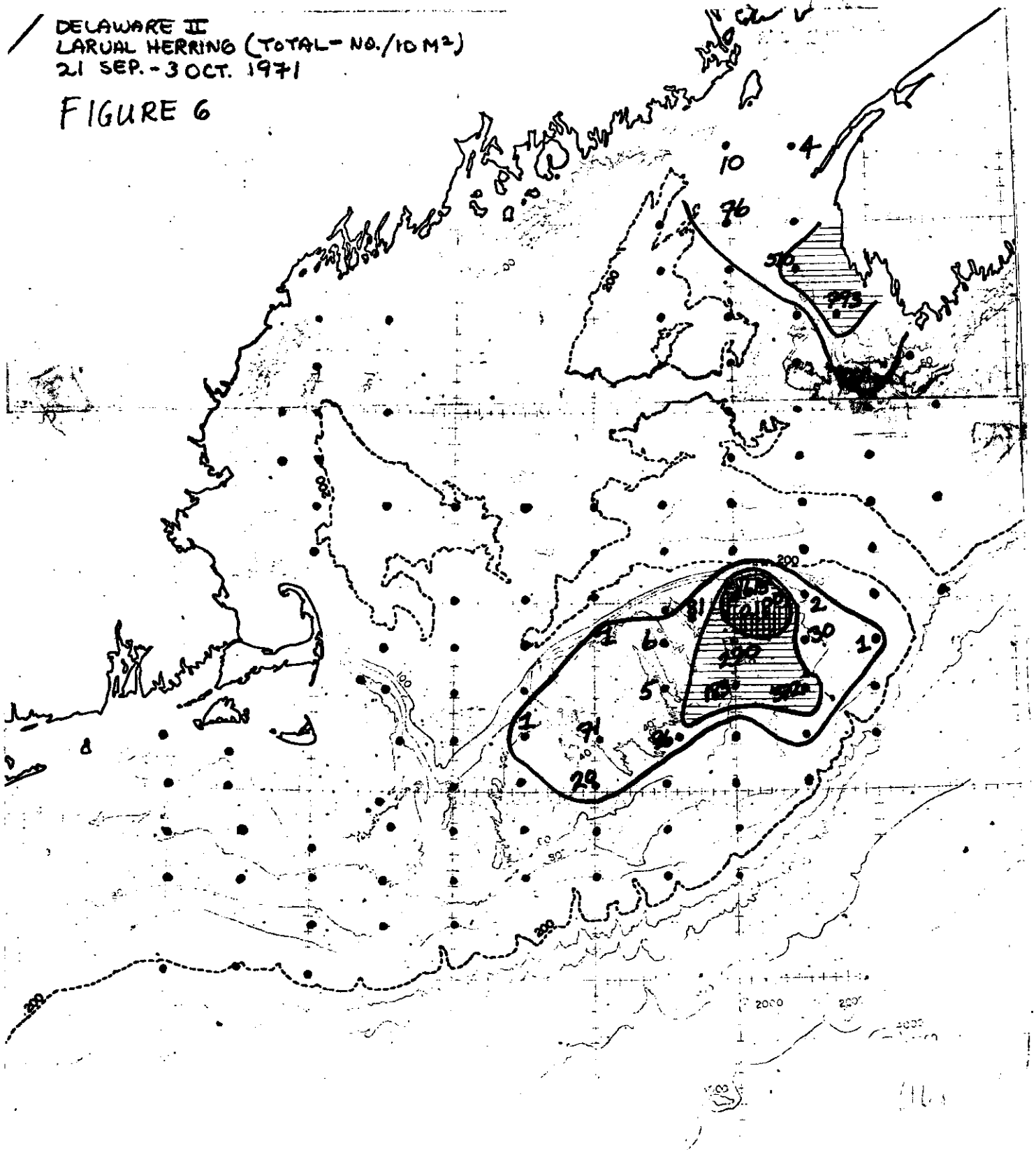
DELAWARE II
LARVAL HERRING (715MM- NO/10 M²)
21 SEP. - 3 OCT 1971

FIGURE 5



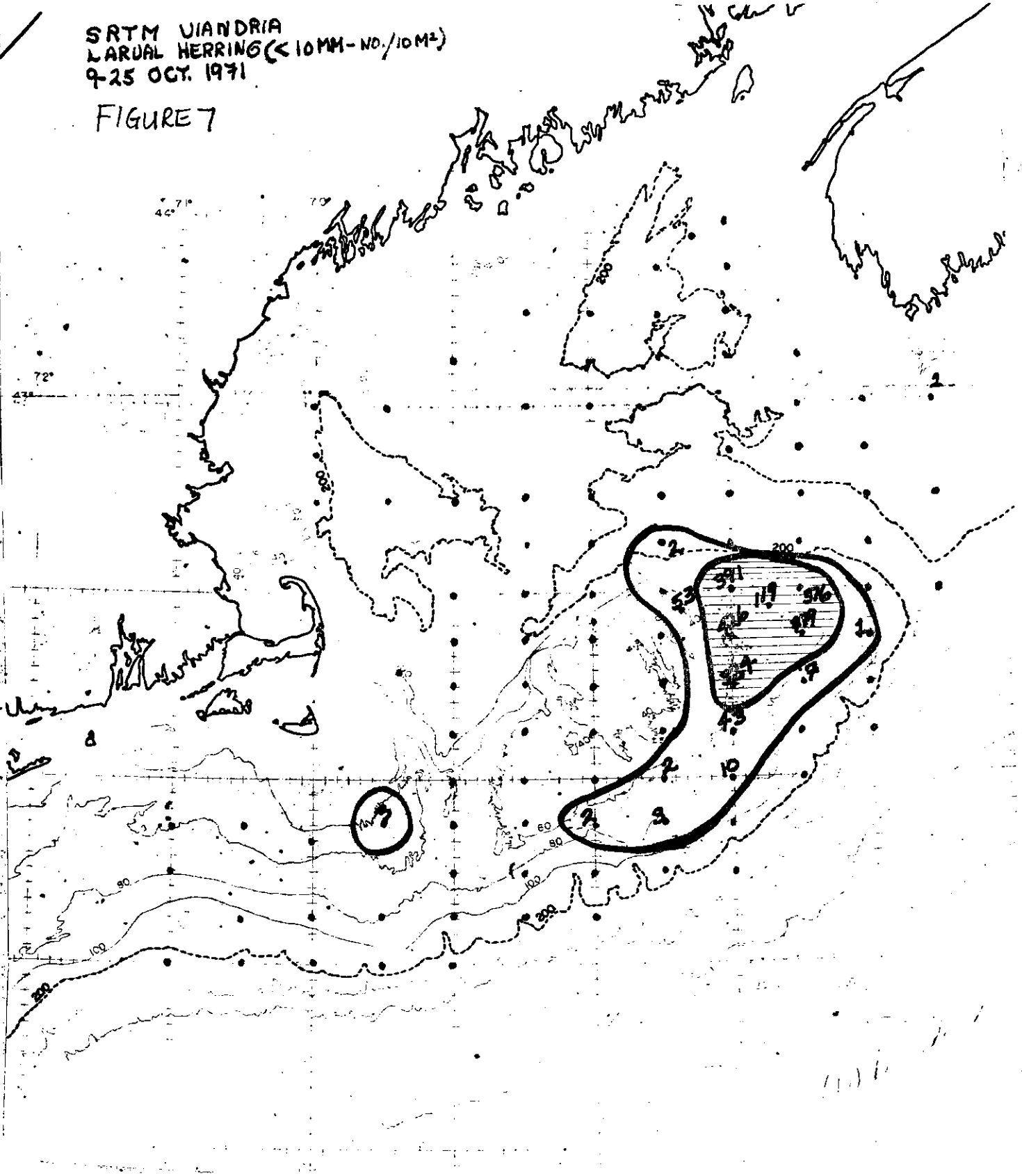
DELAWARE II
LARVAL HERRING (TOTAL - NO./10 M²)
21 SEP. - 3 OCT. 1971

FIGURE 6



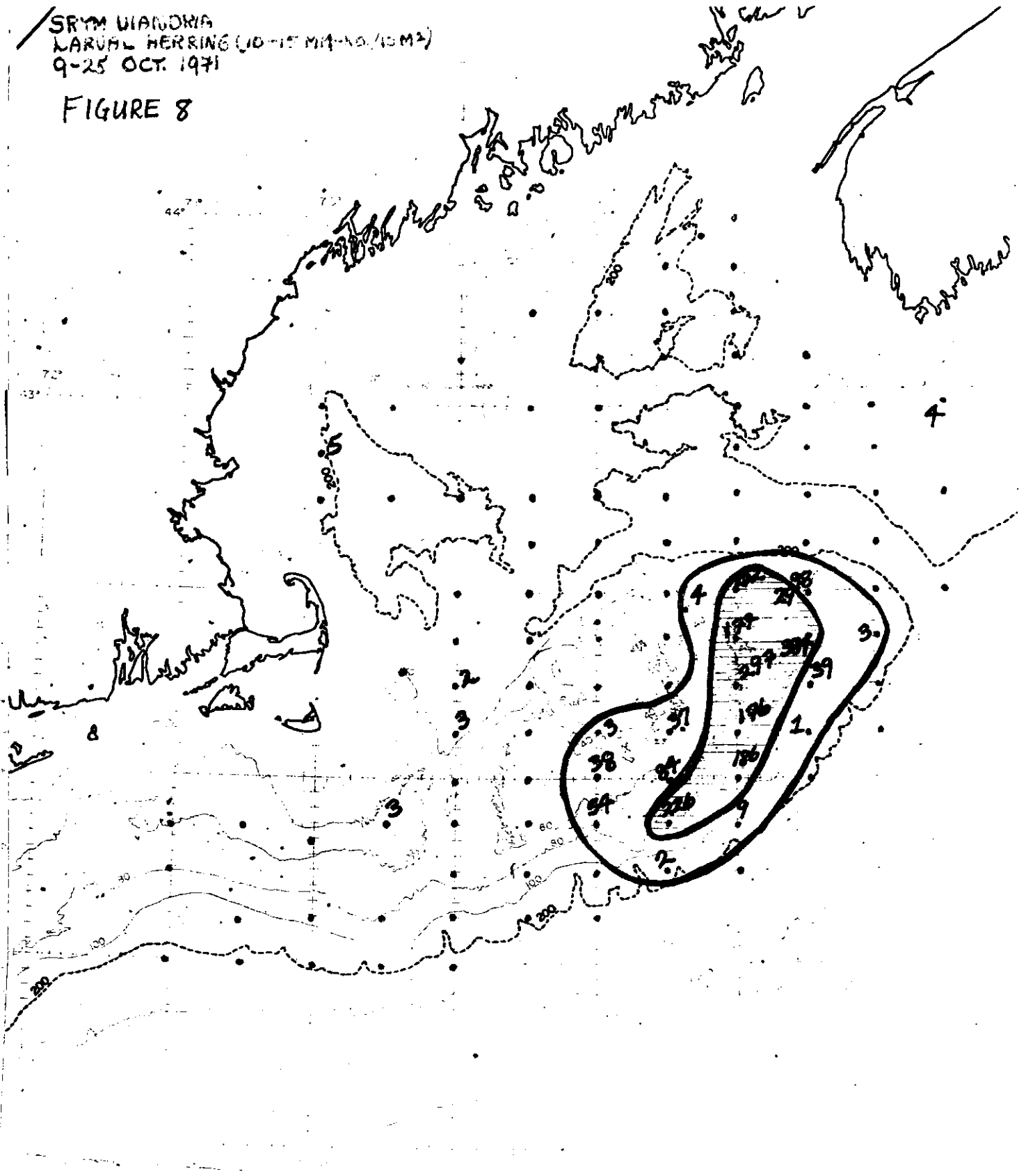
SRTM VIANDRIA
LARVAL HERRING (<10MM-NO./10M²)
9-25 OCT. 1971

FIGURE 7



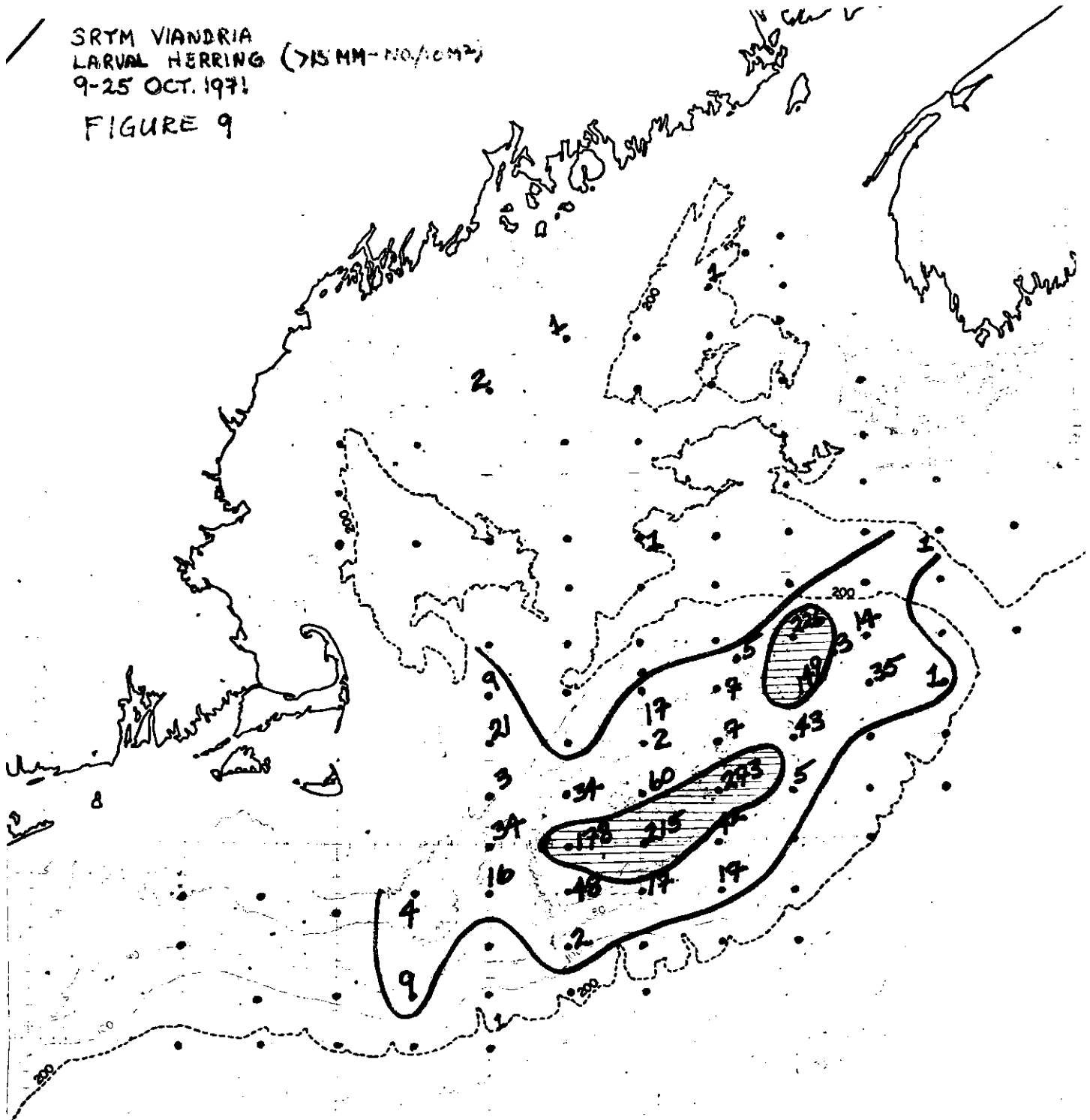
SRYM VIANDRIA
LARVAL HERRING (10-15 MM - NO. 10 M²)
9-25 OCT. 1971

FIGURE 8



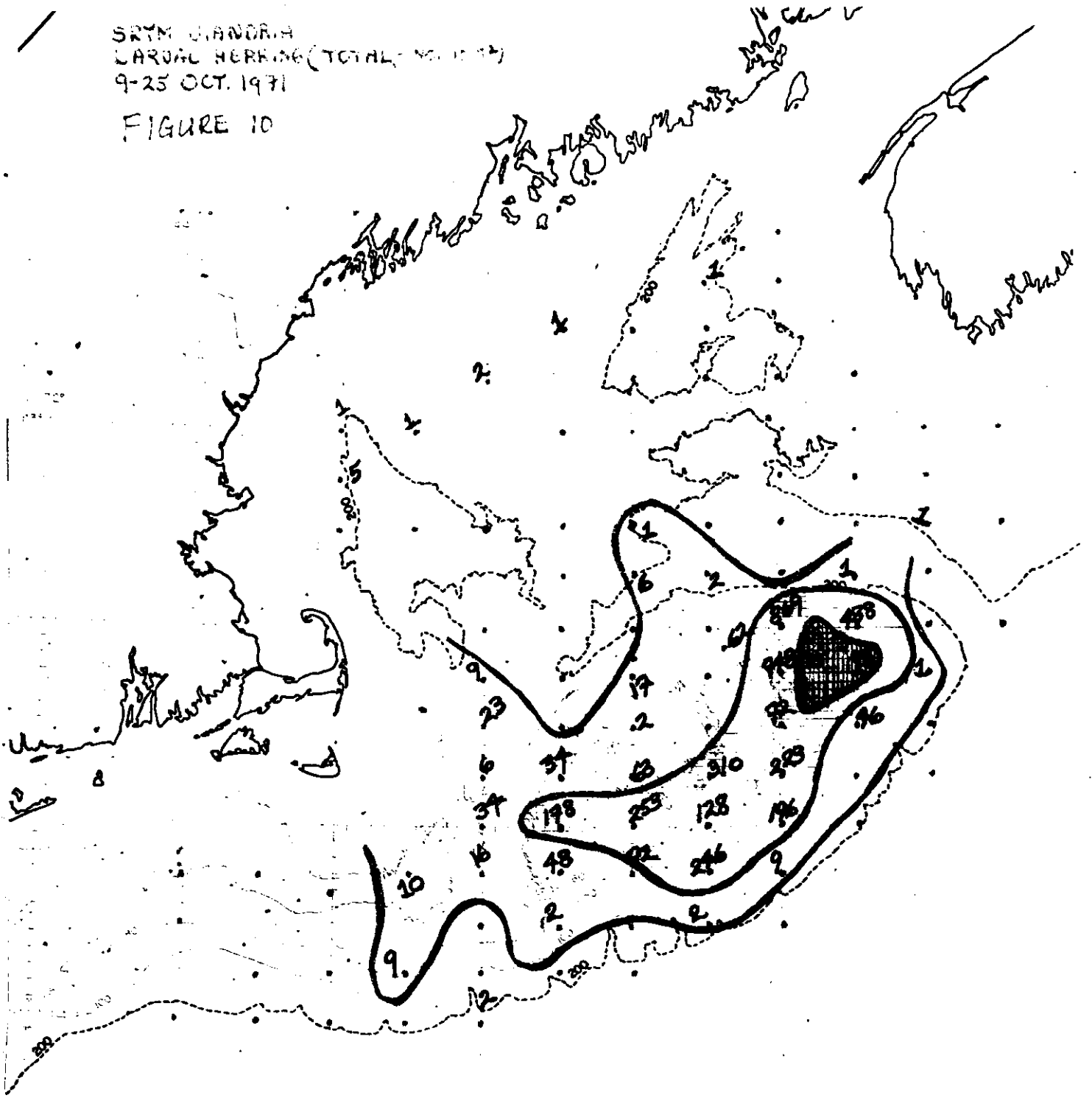
SRYM VIANDRIA
LARVAL HERRING (>15MM-NO./10M²)
9-25 OCT. 1971

FIGURE 9



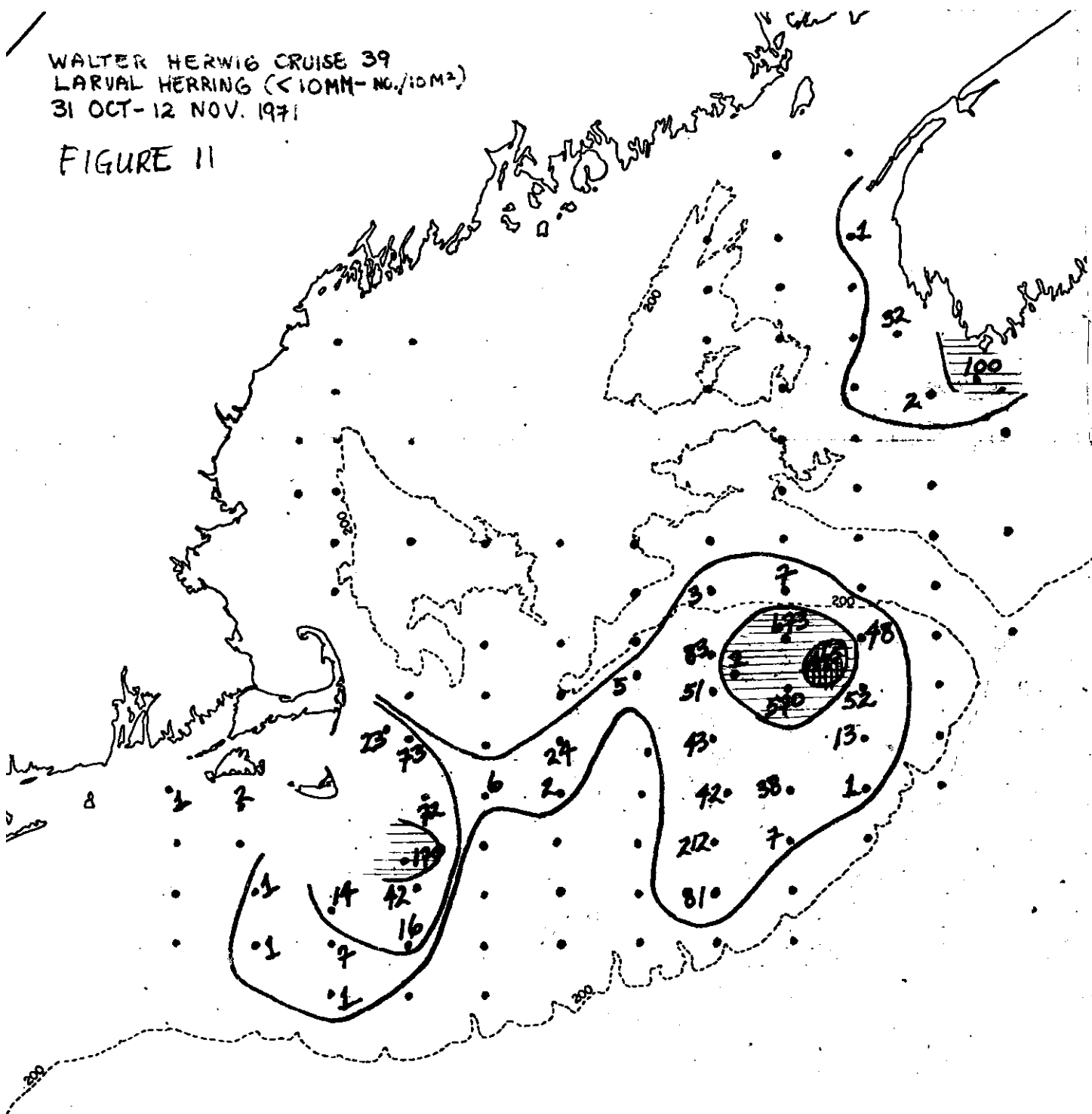
SRYM DIANDRIA
LARVAL HERRING (TOTAL NO. 1034)
9-25 OCT. 1971

FIGURE 10



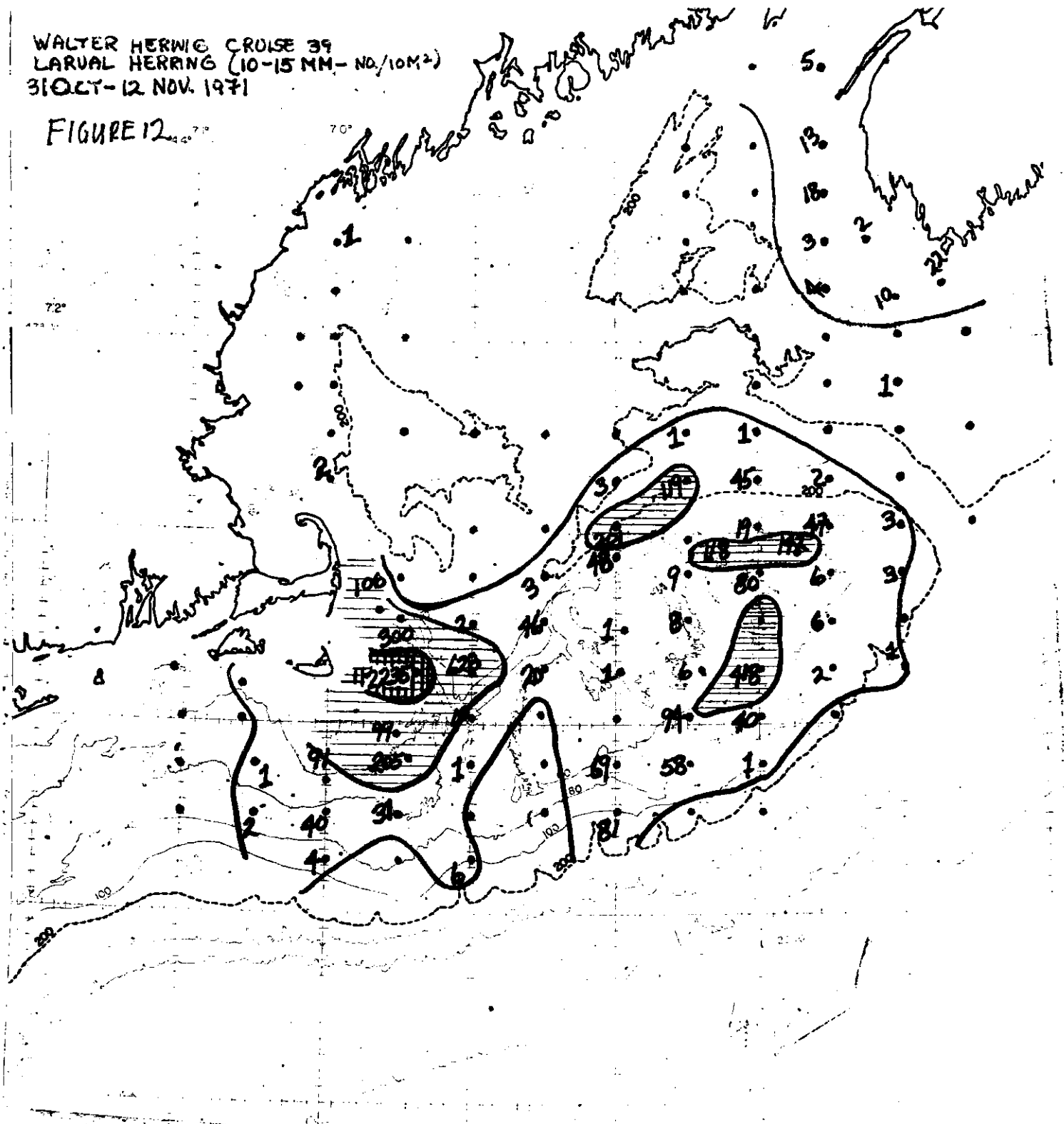
WALTER HERWIG CRUISE 39
LARVAL HERRING (<10MM-NO./10M²)
31 OCT-12 NOV. 1971

FIGURE 11



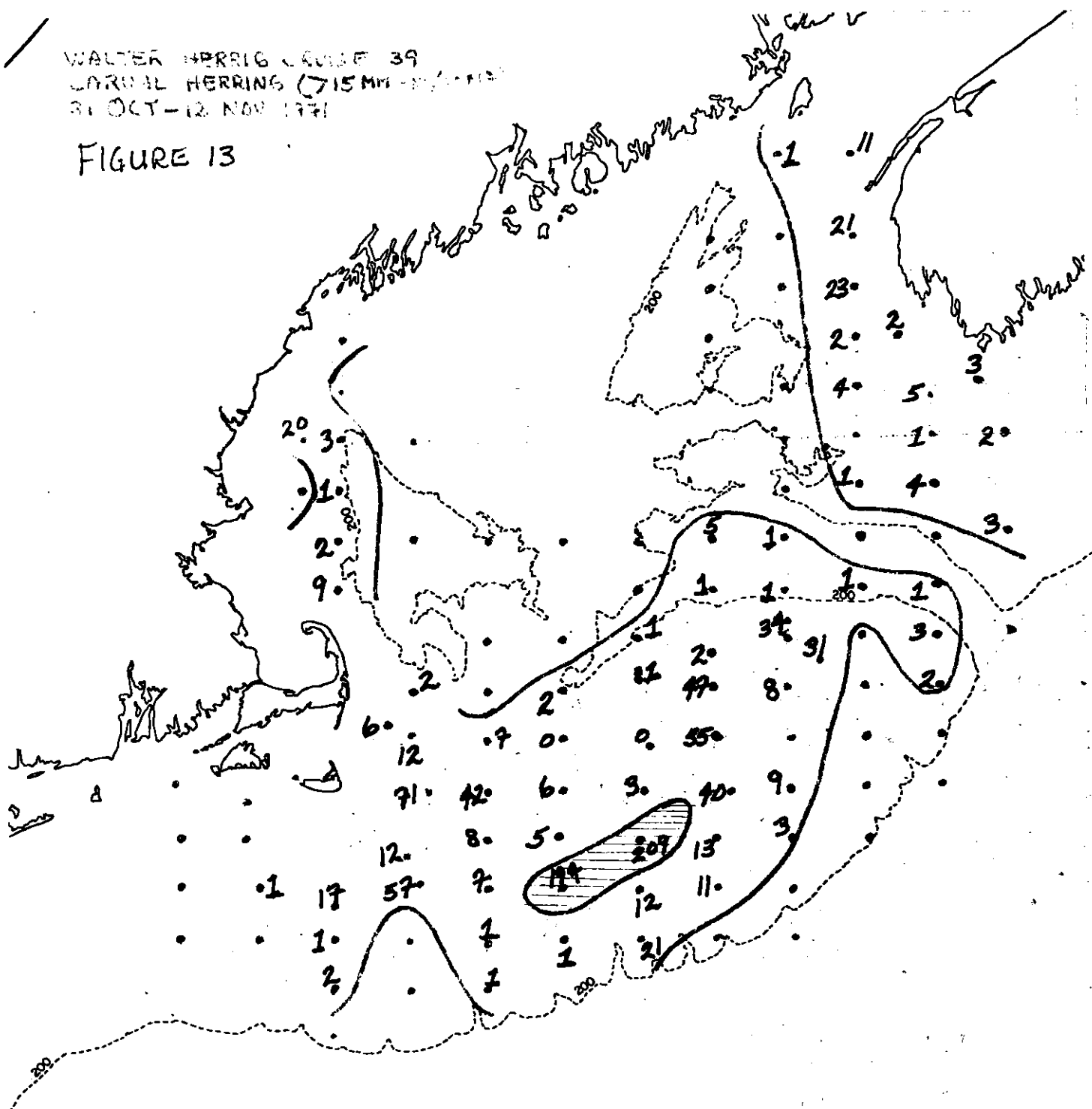
WALTER HERWIG CRUISE 39
LARVAL HERRING (10-15 MM - NO./10M²)
31 OCT - 12 NOV. 1971

FIGURE 12



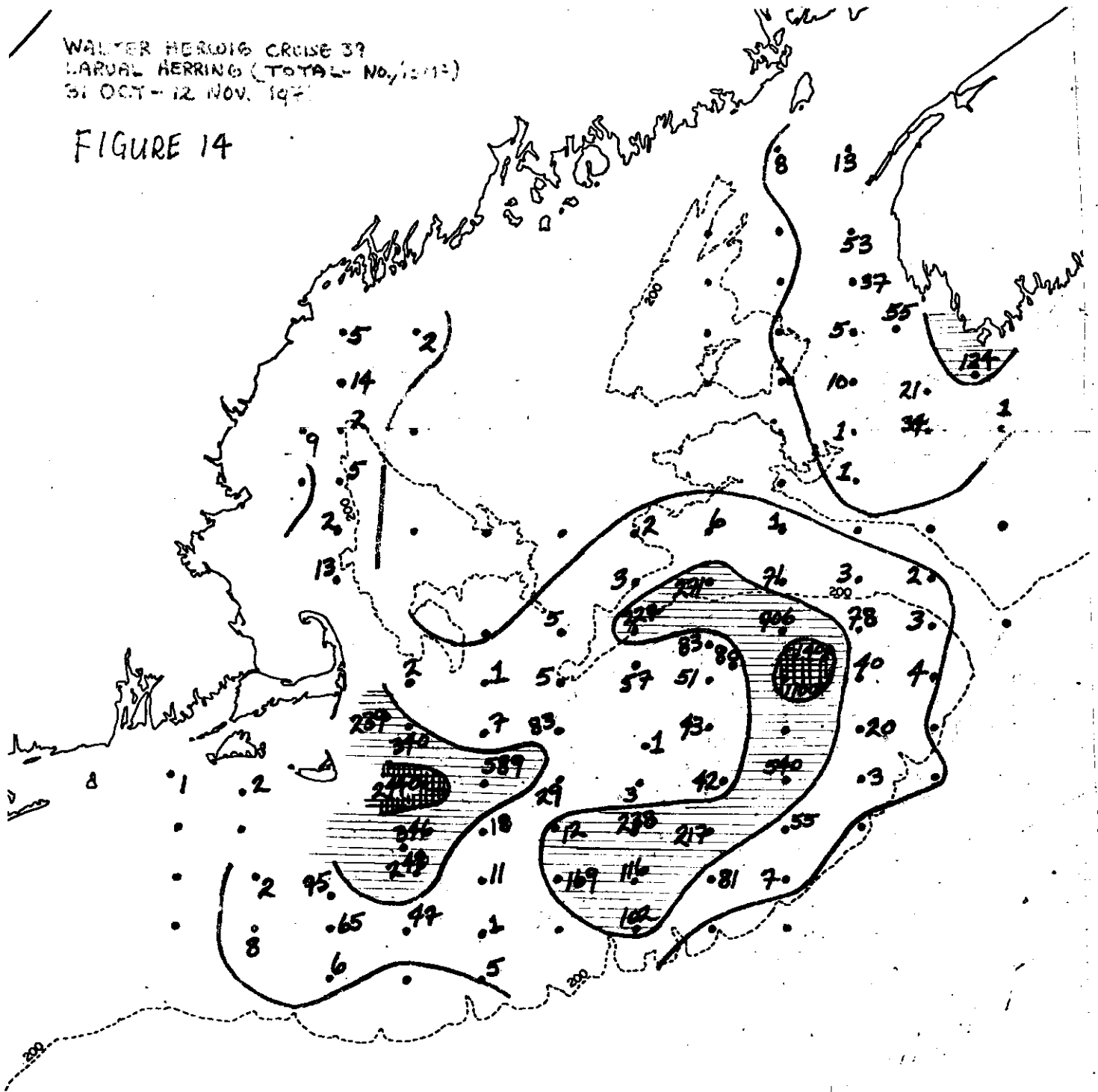
WALTER HERRIG LEGUE 39
LARVAL HERRING (75MM - 100MM)
31 OCT - 12 NOV 1971

FIGURE 13



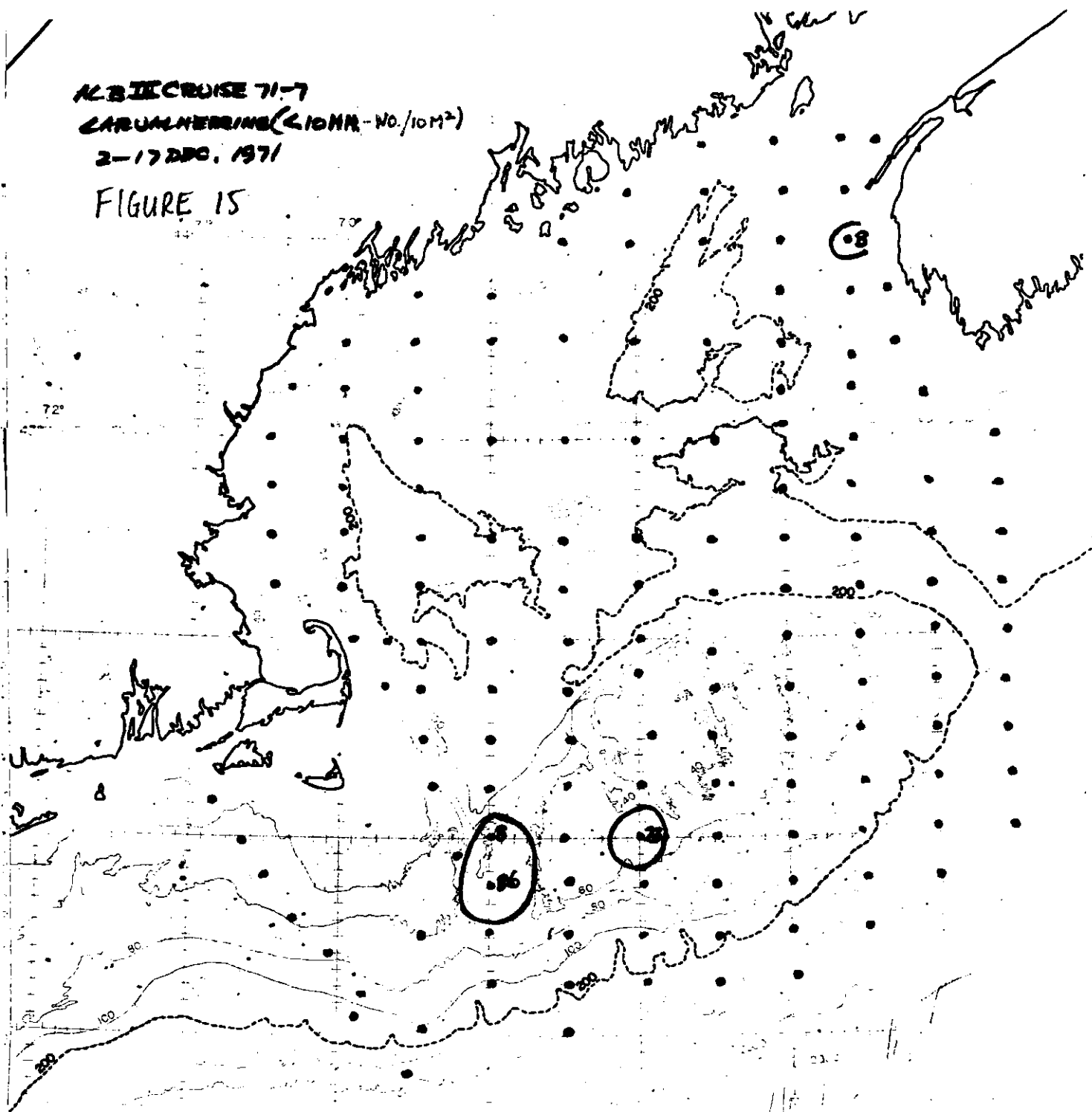
WALTER HERLOIG CRUISE 39
LARVAL HERRING (TOTAL - No./1000)
31 OCT - 12 NOV. 1971

FIGURE 14



ALBIE CRUISE 71-7
CARUAL HERRING (GIONN - NO./10M²)
2-17 DEC. 1971

FIGURE 15

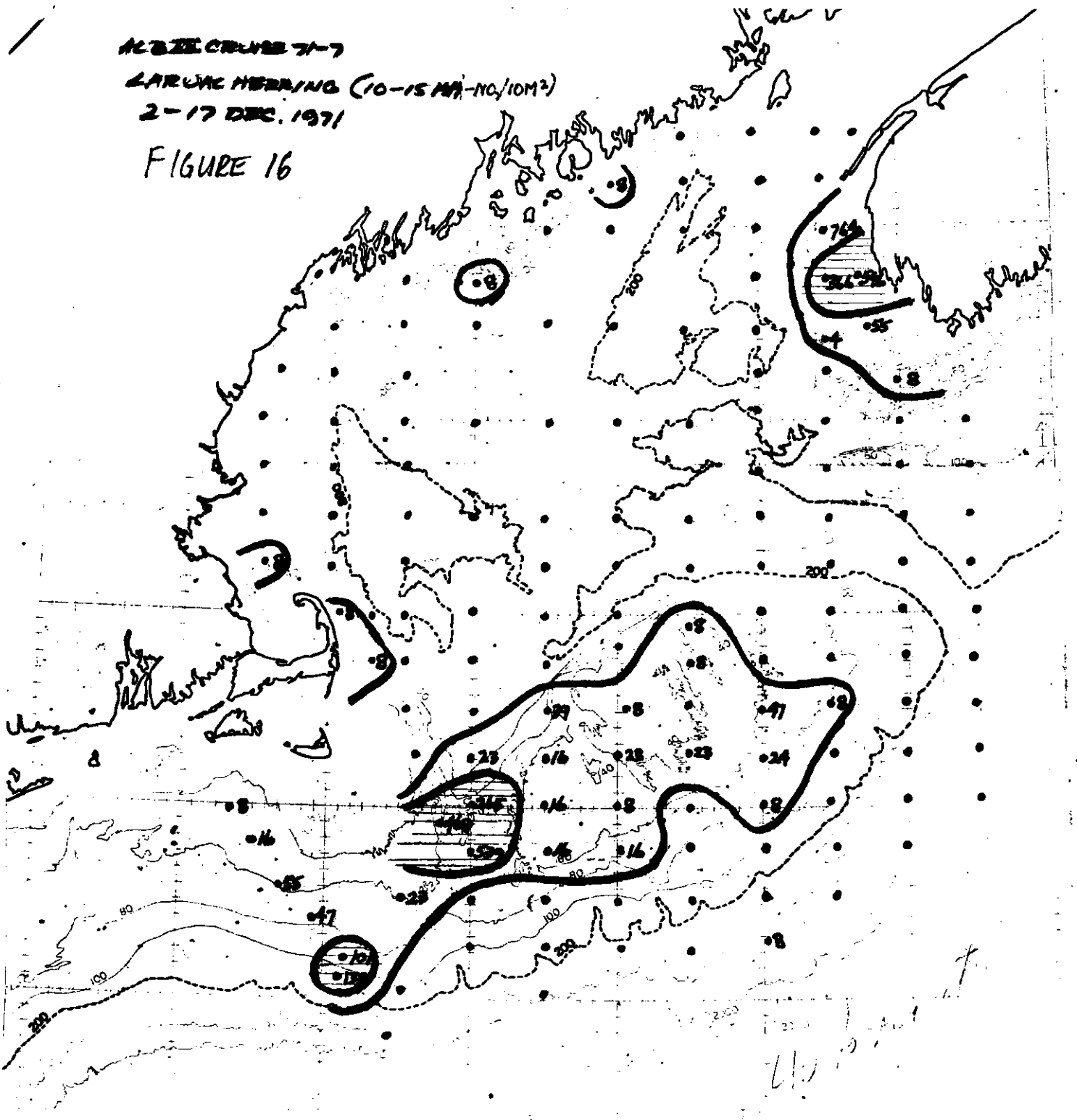


ALBIE CRUISE 71-7

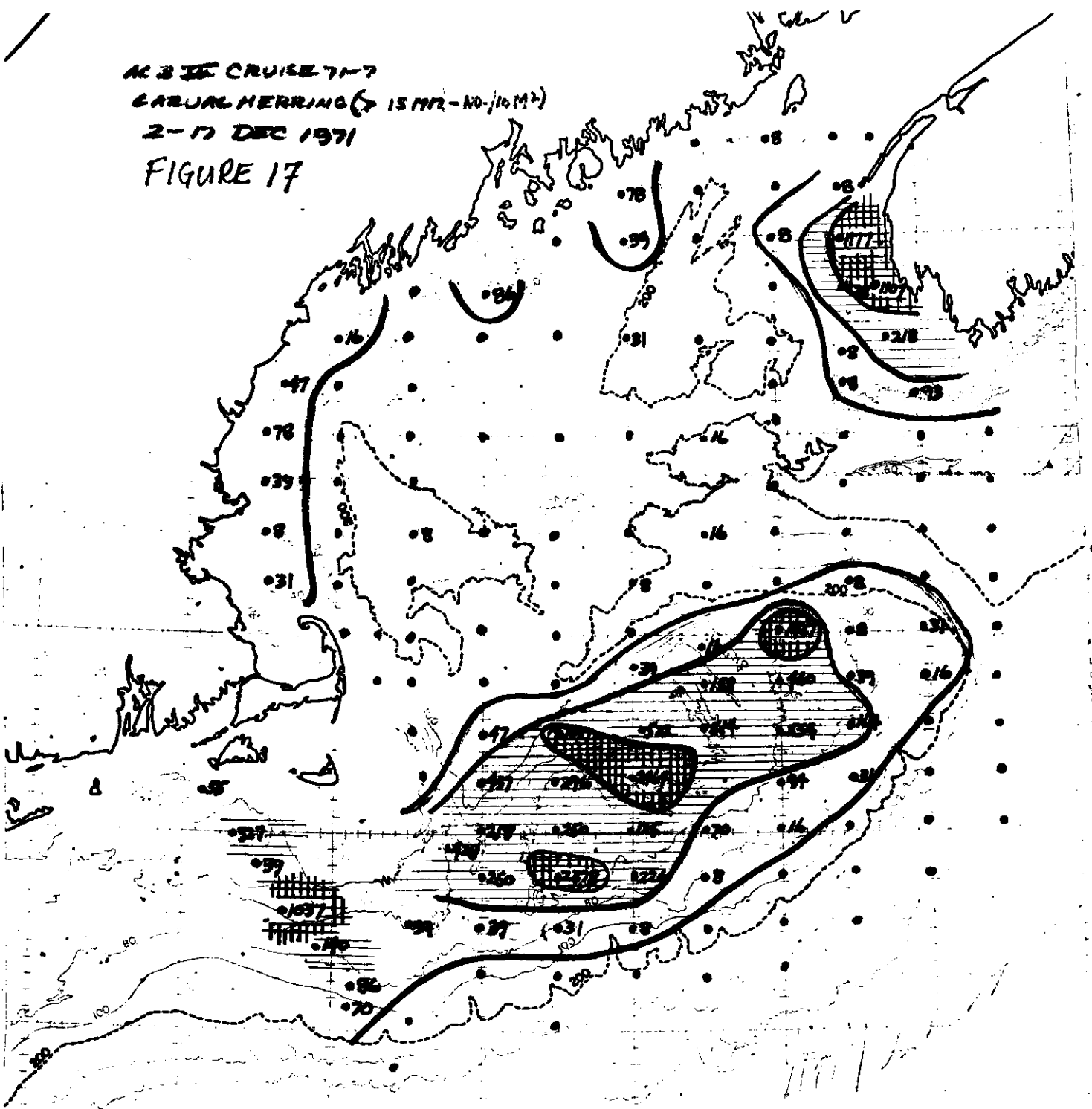
LARVAL HERRING (10-15 NOV-NOV/10M²)

2-17 DEC. 1971

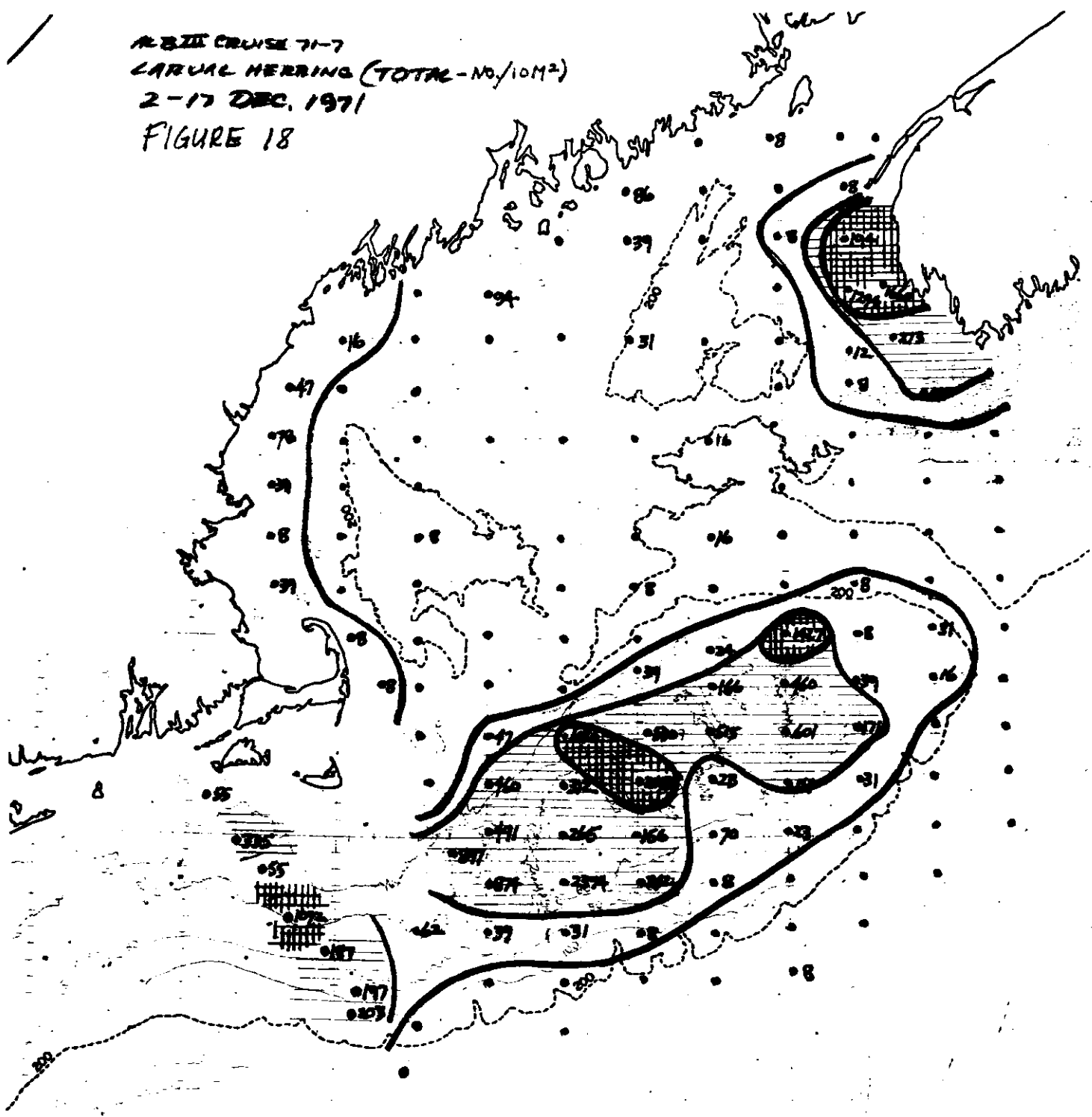
FIGURE 16



AC 3 IS CRUISE 71-7
CARUAL HERRING (7 15 MT - NO. /10 MT)
2-17 DEC 1971
FIGURE 17



ALBII CRUISE 71-7
LARVAL HERRING (TOTAL-NO./10M²)
2-17 DEC. 1971
FIGURE 18



Appendix Table 1. Size composition of larval herring.

DELAWARE 71-4, 21 September - 4 October

Station	Less than 10 m	10-14.9	15 up	Station	Less than 10 m	10-14.9	15 up
2	--	--	--	51	209	108	4
3	--	--	--	52	--	--	--
4	--	--	--	53	--	--	--
5	9	107	27	54	--	--	--
6	3652	29	2	55	--	--	--
7	1	0	0	56	--	--	--
8	--	--	--	57	--	--	--
9	--	--	--	58	--	--	--
10	--	--	--	59	47	99	23
11	--	--	--	60	0	2	7
12	867	408	115	61	1	3	6
13	13	14	8	62	--	--	--
14	--	--	--	63	--	--	--
15	--	--	--	64	--	--	--
16	--	--	--	65	--	--	--
17	--	--	--	66	--	--	--
18	--	--	--	67	--	--	--
19	1	0	0	68	0	0	1
20	--	--	--	69	--	--	--
21	--	--	--	70	0	22	102
22	--	--	--	71	0	11	25
23	2	3	0	72	--	--	--
24	576	77	0	73	--	--	--
25	51	2	0	74	--	--	--
26	1	1	0	75	--	--	--
27	--	--	--	76	--	--	--
28	--	--	--	77	0	0	2
29	--	--	--	78	--	--	--
30	--	--	--	79	--	--	--
31	--	--	--	80	--	--	--
32	--	--	--	81	--	--	--
33	242	589	64	82	--	--	--
34	--	--	--	83	--	--	--
35	1	1	4	84	--	--	--
36	0	8	8	85	--	--	--
37	27	74	34	86	--	--	--
38	--	--	--	87	--	--	--
39	--	--	--	88	--	--	--
40	--	--	--	89	--	--	--
41	--	--	--	90	--	--	--
42	--	--	--	91	--	--	--
43	--	--	--	92	--	--	--
44	--	--	--	93	--	--	--
45	--	--	--	94	--	--	--
46	--	--	--	95	--	--	--
47	--	--	--	96	--	--	--
48	--	--	--	97	--	--	--
49	2797	22	10	98	--	--	--
50	335	98	41	99	--	--	--
				100	--	--	--

101-126 - no herring

-- no herring

Appendix Table 2.

LENGTH AND SPEED OF HERRING LARVAE 3. MARCH 1971
 STATION 8002 "VILLAGER" IN ZONE 5, 3 - 23 OCTOBER, 1971

St. #	Position	Date	Time (Start)	Hour (duration)	Speed	Distance	Depth	Length											No of larvae measured	Total catch	Mean size	Notes
								4-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0	16.1-18.0	18.1-20.0	20.1-22.0	22.1-24.0	24.1-26.0				
1	41°35'N 69°20'W	9.10.71	00.02	33	3.5	1.70	160															No herring larvae
2	41°45'N 68°30'W	9.10.71	04.24	36	3.6	2.20	170															1/2 of the sample processed, no herring larvae
3	41°49'N 65°00'W	9.10.71	07.36	24	3.5	1.40	47															No herring larvae
4	41°50'N 67°21'W	9.10.71	11.18	25	3.5	1.46	55	2	3	1	2	1	1	1	1	1	1	1	47	103	88	1/2 of the sample processed, 7 h. larvae def.
5	41°53'N 66°45'W	9.10.71	14.45	26	3.5	1.45	64	4	3	5	12	5	2	2					100	264	89	
6	41°53'N 66°10'W	9.10.71	17.47	28	3.5	1.76	90															1/2 of the sample processed, no herring larvae
7	42°00'N 65°30'W	9.10.71	21.55	1.05	3.5	4.90	920															1/2 of the sample processed, no herring larvae
8	42°30'N 65°30'W	10.10.71	02.29	29	3.5	1.80	98															1/4 of the sample processed, no herring larvae
9	43°00'N 65°30'W	10.10.71	06.32	34	3.7	2.20	126	1	1	1	1	2							6	12	3.7	1/2 of the h. larvae catch processed
10	43°00'N 66°00'W	10.10.71	09.19	29	3.5	2.54	112	14	7	16	7	16	33						100			1/2 of the sample processed, no herring larvae
11	42°45'N 66°00'W	10.10.71	11.38	27	3.5	1.89	73															1/2 of the sample processed, no herring larvae
12	42°30'N 66°00'W	10.10.71	15.57	40	3.5	2.24	190												1	2	16.2	1/2 of the h. larvae catch processed
13	42°15'N 66°00'W	10.10.71	16.22	43	3.9	2.90	260												100			No herring larvae
14	42°00'N 66°00'W	11.10.71	18.56	32	3.9	1.97	98															No ichthyoplankton

Appendix Table 2. (Continued)

LENGTH AND NUMBER OF HERRING LARVAE CAUGHT BY
SRDM 8002 "VLANDRA" IN SUBAREA 5, 9 - 25 OCTOBER, 1971

St. No.	Position	Date	Time (Start)	Haul duration	Speed	Distance	Depth	Length										Total larvae catch	Mean Size	Notes
								61-80	81-100	101-120	121-140	141-160	161-180	181-200	201-220	221-240	241-260			
15	41°45'N 66°00'W	12.10.71	02.10	38	3.5	2.21	97 102	1	5	1							7	11.1		
16	41°30'N 66°00'W	12.10.71	04.45	40	3.7	2.45	160 200	103	114	123									No ichthyoplankton	
17	41°15'N 66°00'W	12.10.71	07.45	41	3.6	2.47	1680 1700												No herring larvae	
18	41°00'N 66°30'W	12.10.71	13.29	35	3.5	2.25	145 140												No herring larvae	
19	41°15'N 66°30'W	12.10.71	15.48	31	3.5	1.70	91 90	1									1	11.0		
20	41°30'N 66°30'W	12.10.71	18.05	27	3.5	1.63	89	10	37	19	2						63	80	12 h. larvae det.	
21	41°45'N 66°30'W	12.10.71	20.40	26	3.4	1.59	74 75	9	27	29	14	14	4	1	1	1	100	2102	1/2 of the sample processed	
22	42°00'N 66°30'W	12.10.71	23.14	25	3.6	1.79	81 80	1	19	57	6	6	8	2	1		100	356	1/2 of the sample processed	
23	42°15'N 66°30'W	13.10.71	03.09	41	3.5	2.28	231 232									1	100	2	23.4	1/2 of the sample processed
24	42°30'N 66°30'W	13.10.71	06.32	45	3.5	2.43	260 280													No herring larvae
25	42°45'N 66°30'W	13.10.71	09.32	37	3.7	2.39	140 147													No herring larvae
26	43°00'N 66°30'W	13.10.71	11.54	34	3.5	1.96	120 138													No ichthyoplankton
27	43°15'N 66°30'W	13.10.71	14.47	26	3.5	1.50	66 68													1/2 of the sample processed, no herring larvae
28	44°00'N 67°00'W	13.10.71	23.30	40	3.5	2.04	155 163													No herring larvae

LENGTH AND NUMBER OF HERRING LARVAE CAUGHT BY
SERIES 8002 "VIANDRA" IN SUBAREA 5, 9 - 25 OCTOBER, 1971

St. No.	Position	Date	Time (Start)	Haul Duration	Speed	Distance	Depth	Length											Total catch	Mean Size	Notes								
								41-60	61-80	81-100	101-120	121-140	141-160	161-180	181-200	201-220	221-240	241-260				261-280	281-300	301-320					
29	43°55'N 67°16'W	14.10.71	01.50	41	3.5	2.50	170																		1		No ichtyoplankton		
30	43°45'N 67°30'W	14.10.71	04.07	42	3.5	2.56	220							1											100	1	178		
31	43°45'N 67°00'W	15.10.71	21.18	40	3.6	2.39	160							100															No ichtyoplankton
32	43°30'N 67°00'W	15.10.71	18.22	43	3.5	2.46	220																						No herring larvae
33	43°30'N 67°30'W	14.10.71	06.35	40	3.5	2.50	220																						1/2 of the sample processed, no ichtyoplankton
34	43°30'N 68°00'W	14.10.71	10.13	44	3.4	2.46	220																						1/2 of the sample processed, no ichtyoplankton
35	43°30'N 68°29'W	14.10.71	13.51	41	3.5	2.40	178							1	1											2	2	192	
36	43°15'N 69°00'W	14.10.71	17.51	39	3.5	2.50	168																			100	4	126	1/4 of the sample processed
37	43°00'N 68°30'W	14.10.71	21.21	39	3.6	2.35	185																			100			1/2 of the sample processed, no herring larvae
38	43°00'N 68°00'W	15.10.71	00.09	40	3.5	2.50	184																						1/2 of the sample processed, no herring larvae
39	43°15'N 68°00'W	15.10.71	03.29	43	3.5	2.48	217																						1/2 of the sample processed, no ichtyoplankton
40	43°15'N 67°30'W	15.10.71	07.42	45	3.5	2.81	200																						1/2 of the sample processed, no ichtyoplankton
41	43°15'N 67°00'W	15.10.71	10.50	45	3.6	2.62	196																						1/2 of the sample processed, no ichtyoplankton
42	43°00'N 67°00'W	15.10.71	13.21	44	3.5	2.54	190																						1/2 of the sample processed, no ichtyoplankton
							206																						No ichtyoplankton

Appendix Table 1 (Continued)

LENGTH AND NUMBER OF HERRING LARVAE CAUGHT AT
STATION "VIANDRA" IN SUMBERA, 9 - 25 OCTOBER, 1971

St. No.	Position	Date	Time (Start)	haul duration	Speed (knot)	Distance	Depth	Length								Total Mean Size	Notes			
								41-60	61-80	81-100	101-120	121-140	141-160	161-180	181-200			201-220	221-240	241-260
43	12°45'N 67°00'W	15.10.71	15.43	37	3.5	2.40	190													No herring larvae
44	42°20'N 67°00'W	15.10.71	18.10	42	3.5	2.52	316													1/2 of the sample processed, no herring larvae
45	42°15'N 67°00'W	15.10.71	20.49	43	3.5	2.31	300													1/2 of the sample processed, no herring larvae
46	42°00'N 67°00'W	15.10.71	23.30	29	3.4	1.66	66													1/4 of the sample processed
47	41°45'N 67°00'W	15.10.71	01.39	25	3.5	1.50	53	17	23	7	4	18	6	10	5	3	2			1/4 of the sample processed
48	41°30'N 67°00'W	15.10.71	04.10	25	3.5	1.50	64	23	30	17	16	3	5	1						3/4 of the sample processed
49	41°15'N 67°00'W	15.10.71	05.32	25	3.5	1.68	66	17	32	33	4	2								1/2 of the sample processed
50	41°00'N 67°00'W	15.10.71	08.39	28	3.4	1.56	73	5	45	44	6									1/2 of the sample processed
51	40°45'N 67°30'W	16.10.71	10.55	60	3.6	1.78	100	5	45	41	5									1/2 of the sample processed, 1 h. larvae def.
52	40°30'N 67°30'W	16.10.71	13.36	44	3.5	2.85	900	5	1											No herring larvae
53	40°30'N 67°30'W	16.10.71	16.15	37	3.6	2.08	138	2	1											No herring larvae
54	40°45'N 67°30'W	16.10.71	18.27	24	3.5	1.75	38	1	21	50	21	5	2							1/2 of the sample processed
55	41°00'N 67°30'W	16.10.71	20.50	26	3.4	1.49	67	1	6	22	27	13	7	2						1/2 of the sample processed, 29 h. larvae def.
56	41°15'N 67°30'W	16.10.71	23.17	22	3.5	1.18	39	2	10	30	22	15	7	3	1					1/2 of the sample processed

Appendix Table 2 (Continued)

LENGTH AND NUMBER OF HERRING LARVAE CAUGHT BY
SERIES 0002 "VILKINIA" IN SUMMERS 5, 9 - 25 OCTOBER, 1971

St. No.	Position	Date	Time (Start)	Haul duration	Speed	Distance	Depth	Length										Total catch	Mean Size	Notes		
								41-60	61-80	81-100	101-120	121-140	141-160	161-180	181-200	201-220	221-240				241-260	261-280
57	41°30'N 87°25'W	17.10.71	01.58	30	3.5	1.20	38												3	12	20.5	1/4 of the sample processed
53	41°45'N 87°30'W	17.10.71	04.35	25	3.5	1.62	48												5	12	21.2	1/2 of the sample processed, 1 h. larvae det.
59	41°56'N 87°30'W	17.10.71	06.18	23	3.5	1.61	38												100			3/2 of the sample processed, no herring larvae
60	42°05'N 87°30'W	18.10.71	07.05	45	3.6	2.70	248												1	4	7.4	1/2 of the sample processed, 1 h. larvae det.
61	42°30'N 87°30'W	18.10.71	11.30	45	3.5	2.70	305												100			1/2 of the sample processed, no ichthyoplankton
62	42°30'N 88°00'W	18.10.71	14.23	42	3.5	2.70	292												1	2	17.6	1/2 of the sample processed
63	42°15'N 88°00'W	18.10.71	17.00	46	3.6	2.70	210												5	10	14.0	1/2 of the sample processed
64	42°00'N 88°00'W	18.10.71	19.48	44	3.7	2.73	190															1/2 of the sample processed, no herring larvae
55	41°45'N 88°00'W	18.10.71	22.35	17	3.2	0.93	35												10	30	21.7	1/2 of the sample processed, 5 h. larvae det.
66	41°30'N 87°56'W	19.10.71	00.37	14	3.5	0.60	30												2	4	23.9	1/2 of the sample processed
67	41°15'N 88°00'W	19.10.71	02.28	20	3.5	1.20	40												52	110	20.5	1/2 of the sample processed, 5 h. larvae det.
68	41°00'N 88°00'W	19.10.71	07.30	27	3.5	1.82	49												99	444	18.4	1/4 of the sample processed
69	40°45'N 88°00'W	19.10.71	06.52	28	3.5	1.90	74												55	126	14.7	1/2 of the sample processed, 8 h. larvae det.
70	40°30'N 88°00'W	19.10.71	09.22	33	3.5	2.12	107															No herring larvae

Appendix Table 2 (continued)

LENGTH AND NUMBER OF HERRING LARVAE CAPTURED
 STATION 0002 "VIADRA" IN SURABAYA 5, 9 - 25 OCTOBER, 1971

Station	Position	Date	Time (Start)	Haul duration	Speed	Distance	Depth	Length							Frequency	Total catch	High stage	Notes
								41-60	61-80	81-100	101-120	121-140	141-160	161-180				
71	03°15'N 68°30'W	19.10.71	12.17	43	3.5	2.35	5-45 2-30											No herring larvae
72	40°45'N 58°50'W	19.10.71	14.55	59	3.5	2.81	158 120											No herring larvae
73	40°50'N 63°30'W	19.10.71	17.46	29	3.5	1.73	86 82						2	4	174			1/2 of the sample processed
74	40°45'N 68°30'W	19.10.71	20.20	26	3.4	1.49	55 57						100	84	205			31 h. larvae def.
75	41°00'N 68°30'W	20.10.71	02.07	25	3.5	1.40	48						100	312	235			1/2 of the sample processed
76	41°15'N 68°30'W	20.10.71	04.45	30	3.5	1.70	58 55						100	60	203			1/4 of the sample processed
77	41°30'N 68°30'W	20.10.71	07.03	29	3.5	1.71	93 84						100					1/4 of the sample processed, 40 herring larvae
78	42°00'N 68°30'W	20.10.71	10.53	40	3.5	2.38	181 190											1/2 of the sample processed, no herring larvae
79	42°15'N 68°30'W	20.10.71	13.38	38	3.5	2.30	177 184											No herring larvae
80	42°30'N 63°50'W	22.10.71	15.54	47	3.5	2.70	214 225											1/2 of the sample processed, no herring larvae
81	42°30'N 69°00'W	20.10.71	19.35	45	3.5	2.50	225 238											1/2 of the sample processed, no herring larvae
82	43°30'N 69°30'W	20.10.71	23.20	43	3.5	2.44	265 293											1/2 of the sample processed, no leptocephalon
83	43°00'N 63°30'W	21.10.71	03.43	40	3.5	2.26	158 175						1	2	252			1/2 of the sample processed
84	43°00'N 64°53'W	21.10.71	06.34	43	3.5	2.69	212 225						100	2	19.6			1/2 of the sample processed

LENGTH AND NUMBER OF HERRING LARVAE CAUGHT BY
NETS BOOZ "VIANDRA" IN SURFSEA 5, 9 - 25 OCTOBER, 1971

St. No.	Position	Date	Time (Start)	Haul duration (min)	Haul Speed (knots)	Distance (km)	Depth (m)	Length frequency											Total catch	Mean Size	Notes	
								41-60	61-80	81-100	101-120	121-140	141-161	161-180	181-200	201-220	221-240	241-260				261-280
35	42°45'N 73°00'W	21.10.71	09.24	42	3.7	2.60	177 180	3	79	25								4 100	8	72.1	1/2 of the sample processed	
36	42°53'N 69°52'W	21.10.71	12.15	42	3.5	2.45	240 180															No ichtyoplankton
37	42°50'N 69°50'W	21.10.71	23.42	38	3.5	2.35	145 140															No ichtyoplankton
38	41°45'N 59°00'W	22.10.71	02.08	40	3.5	2.50	155 150	1	0	3	1							2 100	16	20.3	1/2 of the sample processed	
39	41°50'N 59°00'W	22.10.71	04.50	37	3.5	2.41	148 150	1	1	3	1	4						20 100	40	18.6	1/2 of the sample processed	
40	41°15'N 69°00'W	22.10.71	06.42	36	3.5	2.35	155 158	1	1	2								4 100	8	11.2	1/2 of the sample processed	
41	41°00'N 69°00'W	22.10.71	09.01	31	3.6	1.82	80	25	25	50								75 100	60	21.2	1/4 of the sample processed	
42	40°45'N 69°00'W	22.10.71	11.19	31	3.6	1.81	30 75											14 100	28	21.2	1/2 of the sample processed	
43	40°30'N 69°00'W	22.10.71	13.58	31	3.5	1.80	75 75															1/4 of the sample processed
44	40°15'N 69°20'W	22.10.71	15.05	32	3.5	1.80	110 130															1/2 of the sample processed, no herring larvae
45	40°00'N 69°00'W	22.10.71	18.15	45	3.6	2.70	1250 350											2 100	2	15.6		
46	40°00'N 69°55'W	22.10.71	21.22	35	3.8	1.95	115 115															No herring larvae
47	40°15'N 69°50'W	22.10.71	23.37	30	3.5	1.85	80											7 100	16	18.9	1/2 of the sample processed, 1 h. larvae det.	
48	40°45'N 69°30'W	23.10.71	03.08	24	3.5	1.45	47	2	1	2	1							7 100	18	13.5	1/2 of the sample processed, 2 h. larvae det.	

Appendix Table 2. (Continued)

LENGTH AND NUMBER OF HERRING LARVAE CATCHED BY SEIN SOO2 "VIANDA" IN SUBAREA 5, 9 - 25 OCTOBER, 1971

St. No.	Position	Date	Time (Start)	Haul duration	Speed	Distance	Depth	Length	frequency											Total larvae caught	Mean Size	Notes											
									41-60	61-80	81-100	101-120	121-140	141-160	161-180	181-200	201-220	221-240	241-260				261-280	281-300	301-320								
95	40° 40' N 70° 00' W	23/10/71	06.20	25	3.5	1.60	48																										1/2 of the sample processed
96	40° 45' N 70° 30' W	23/10/71	03.06	26	3.6	1.78	84																										1/4 of the sample processed, no herring larvae
97	40° 45' N 71° 00' W	23/10/71	22.55	28	3.5	1.78	80																										1/4 of the sample processed, 1 h. larvae def.
98	40° 15' N 71° 00' W	24/10/71	03.08	35	3.5	2.50	119																										1/4 of the sample processed (POBT)
99	40° 00' N 71° 00' W	24/10/71	05.53	45	3.6	2.70	312																										No herring larvae
100	40° 00' N 70° 30' W	24/10/71	13.05	43	3.5	2.45	210																										No herring larvae
101	40° 15' N 70° 50' W	24/10/71	16.52	30	3.6	1.77	110																										1/2 of the sample processed, no herring larvae
102	40° 05' N 70° 05' W	25/10/71	06.50	30	3.6	1.80	95																										1/4 of the sample processed, no herring larvae
103	40° 00' N 70° 00' W	25/10/71	04.10	36	3.6	2.40	153																										1/2 of the sample processed, no herring larvae

Appendix Table 3.

Number of herring larvae caught
in the 505 micron net by Walther Herwig

Date collected	Station number	Number of herring larvae caught		Date collected	Station number	Number of herring larvae caught	
		<10 mm	Total			<10 mm	Total
6 Nov. 1971	5	3	140	6 Nov. 1971	63	5	475
5 Nov. 1971	6	2570	2888	"	64	0	11
31 Oct. 1971	8	0	0	"	65	0	3
31 Oct. 1971	9	0	5	7 Nov. 1971	66	0	6
31 Oct. 1971	10	0	2	"	67	0	398
1 Nov. 1971	11	176	218	"	68	8	100
1 Nov. 1971	12	56	96	"	69	0	1
1 Nov. 1971	13	4	36	"	70	0	6
"	14	0	60	"	71	0	417
3 Nov. 1971	16	0	0	"	72	0	204
"	17	0	1	"	73	0	179
"	18	0	6	8 Nov. 1971	74	0	17
"	19	0	7	"	75	0	296
"	20	0	0	"	76	0	197
4 Nov. 1971	21	0	3	"	77	4	50
"	22	0	0	"	78	42	145
"	23	2	5	"	79	0	8
"	24	23	35	"	80	0	9
"	25	57	70	"	81		
"	26	84	137	"	82	0	0
"	27	0	6	"	83	0	0
"	28	0	0	9 Nov. 1971	84	0	0
"	29	0	1	"	85	0	0
3 Nov. 1971	30	0	1	"	86	0	3
"	31	6	18	"	87	0	8
2 Nov. 1971	32	0	8	"	88	0	24
1 Nov. 1971	33	0	65	"	89	0	4
"	34	1	93	"	90	0	16
"	35	0	22	"	91	0	0
2 Nov. 1971	36	0	14	10 Nov. 1971	92	0	8
"	37	0	0	"	93	0	4
"	38	0	0	"	94	0	22
"	39	0	0	"	95	0	0
2 Nov. 1971	40	0	0	"	96	0	1
"	41	0	1	"	97	0	12
"	42	0	0	10 Nov. 1971	98	10	1033
3 Nov. 1971	43	0	0	11 Nov. 1971	99	0	32
"	44	0	0	"	100	0	19
4 Nov. 1971	45	0	0	"	101	0	1
5 Nov. 1971	46	0	0	"	102	0	9
"	47	0	1	"	103	0	0
"	48	13	125	"	104	28	83
"	49	1180	1239	"	105	74	434
"	50	1000	1837	"	106	298	607
"	52	66	948	10 Nov. 1971	107	127	4272
"	53	12	97	"	108	128	596
"	54	0	13	"	109	0	3
"	55	0	0	"	110	41	410
6 Nov. 1971	56	0	0	11 Nov. 1971	113	25	132
"	57	0	143	"	114	13	114
"	58	8	384	"	115	1	10
"	59	0	73	12 Nov. 1971	119	0	0
"	60	16	76	"	120	2	14
"	61	0	90	"	121	1	3
"	62	2	145	"	122	0	0
				"	123	0	0
				"	124	0	0
				"	125	3	3
				"	126	2	2

Appendix Table 4. Station locations, catch and size composition of larval herring. ALBATROSS IV Cruise 71-7 December 2-17, 1971.

Station No.	Location	No. Herring Larvae			Total
		<10	.505 + .333 10-15	>15	
1	43°00' 65°30'			2	2
2	42°45' 65°30'				
3	42°30' 65°30'				
4	42°15' 65°29'				
5	42°00' 65°30'				
6	41°45' 65°30'				
7	41°30' 65°30'				
8	41°15' 65°30'				
9	41°00' 65°30'				
10	40°45' 66°00'				
11	41°00' 66°00'				
12	41°15' 66°00'				
13	41°30' 66°00'				
14	41°45' 66°00'			2	2
15	42°00' 66°00'			4	4
16	42°15' 66°00'				
17	42°30' 66°00'				
18	42°45' 66°00'				
19	43°00' 66°00'				
20	43°12' 66°00'		1	12	13
21	43°30' 66°12'				35
22	43°45' 66°16'				212
23	44°00' 66°30'				244
24	43°45' 66°30'				166
25	43°35' 66°30'				2
26	43°15' 66°30'				1
27	43°00' 66°30'				
28	42°45' 66°30'				
29	42°30' 66°30'				
30	42°15' 66°30'				1
31	42°00' 66°30'				1
32	41°45' 66°30'				5
33	41°30' 66°30'				22
34	41°15' 66°30'				4
35	41°00' 66°30'				
36	40°45' 66°30'				
37	40°30' 66°30'				
38	40°15' 67°00'				1
39	40°30' 67°00'				
40	40°45' 67°00'				
41	41°00' 67°00'				3
42	41°15' 67°00'				15
43	41°30' 67°00'				77
44	41°45' 67°00'				59
45	42°00' 67°00'				183
46	42°15' 67°00'				
47	42°30' 67°00'				
48	42°45' 67°00'				
49	43°00' 67°00'				
50	43°15' 67°00'				
51	43°30' 67°00'				
52	43°45' 67°00'				
53	44°00' 67°00'			1	1
54	44°15' 66°56'				
55	44°15' 66°30'			1	1

Appendix Table 4. (Continued)

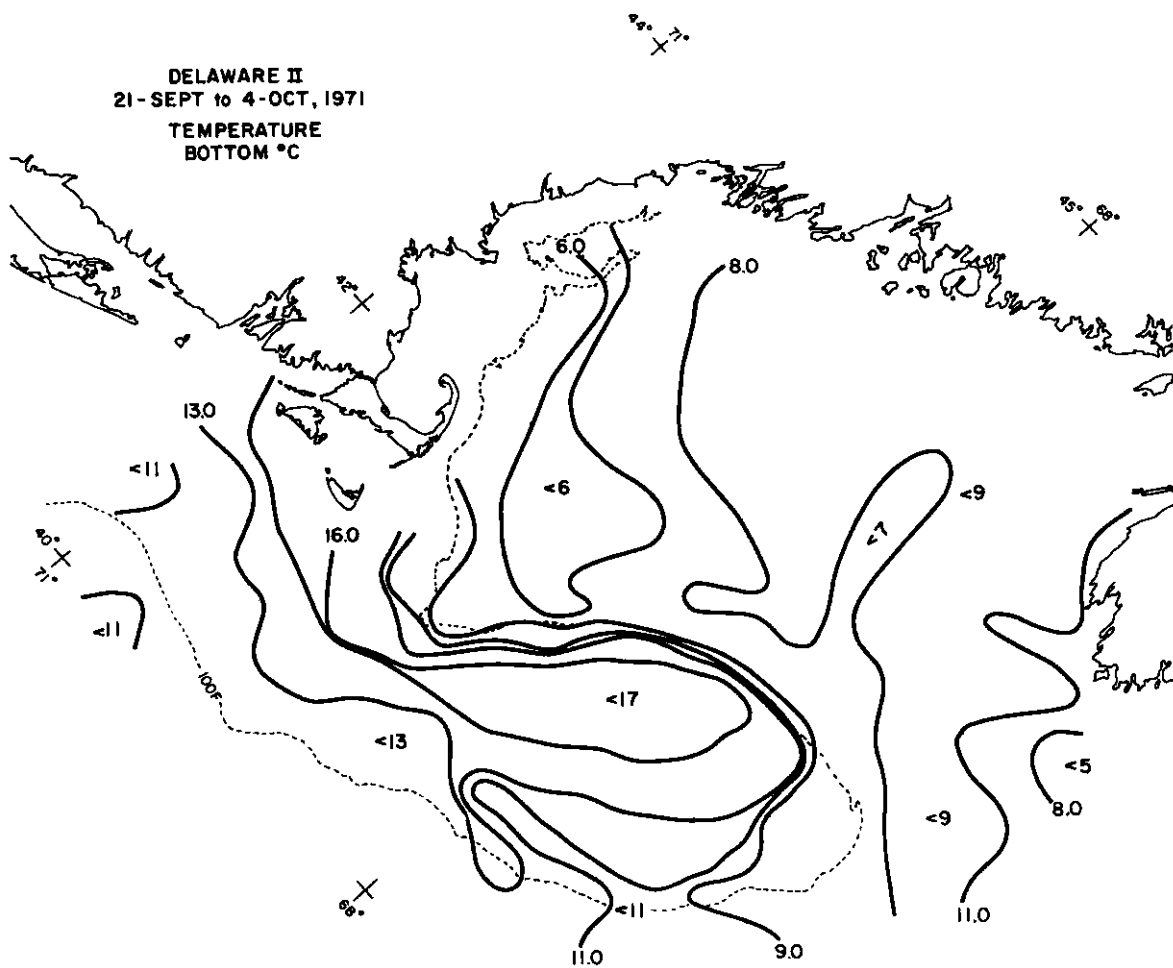
Station No.	Location	No. Herring Larvae .505 + .333			Total
		<10	10-15	>15	
56	44°30' 66°15'				
57	44°30' 66°30'				
58	44°30' 67°00'			1	1
59	44°26' 67°30'				
60	44°15' 67°30'				
61	44°00' 67°30'				
62	---				
63	43°30' 67°30'				
64	---				
65	43°00' 67°30'			2	2
66	---				
67	42°30' 67°30'			2	2
68	42°15' 67°30'				
69	41°56' 67°30'		1	2	3
70	41°45' 67°30'		1	20	21
71	41°30' 67°30'			66	66
72	41°15' 67°25'		3	189	200
73	41°00' 67°30'			9	9
74	40°45' 67°30'			1	1
75	40°30' 67°30'				
76	40°15' 67°30'				
77	---				
78	40°15' 68°00'				
79	40°30' 68°00'			1	1
80	40°45' 68°00'		2	29	31
81	41°00' 68°00'	3	1	16	20
82	41°15' 68°00'		3	316	319
83	41°30' 67°55'		1	67	68
84	41°45' 68°00'				
85	42°00' 68°00'				
86	42°15' 68°00'			1	1
87	42°30' 68°00'				
88	43°00' 68°00'				
89	43°30' 68°00'				
90	44°00' 68°00'			4	4
91	44°15' 68°00'			5	5
92	44°00' 68°30'		1	10	11
93	43°30' 68°30'				
94	43°00' 68°30'				
95	42°30' 68°30'				
96	42°15' 68°30'				
97	42°00' 68°30'				
98	41°45' 68°30'				
99	41°30' 68°30'		5	133	138
100	41°15' 68°30'		2	38	40
101	41°00' 68°30'				34
102	40°45' 68°30'				309
103	40°30' 68°30'				4
104	40°15' 68°30'				
105	40°00' 68°30'				
106	40°15' 69°00'				
107	40°30' 69°00'			5	5
108	40°45' 69°00'	11	69	32	112
109	41°00' 69°00'	1	34	28	63
110	41°15' 69°00'		3	56	59

Appendix Table 4. (Continued)

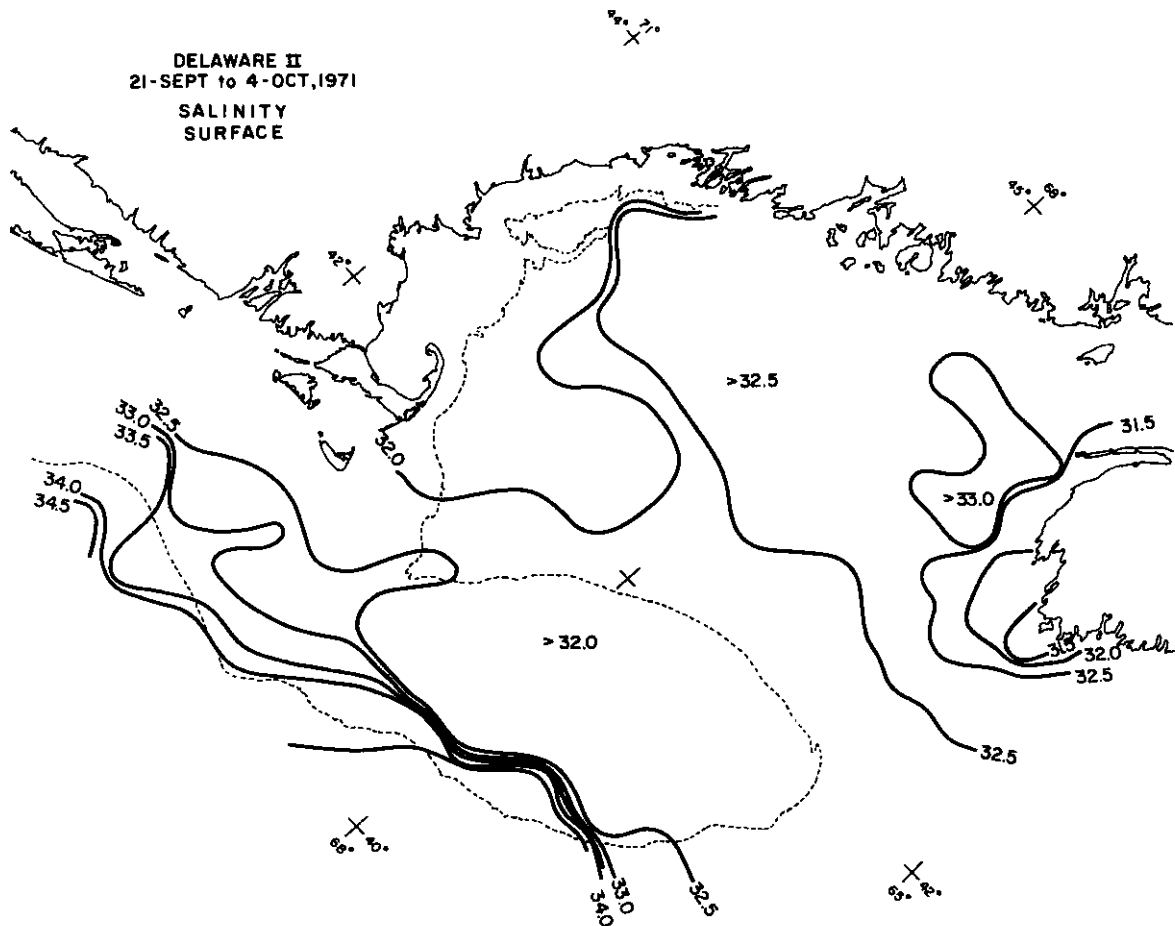
Station No.	Location	No. Herring Larvae .505 + .333			Total
		<10	10-15	>15	
111	41°30' 69°00'			6	6
112	41°45' 69°00'				
113	42°00' 69°00'				
114	42°30' 69°00'				
115	43°00' 69°00'				
116	43°30' 69°00'				
117	43°45' 69°00'			1	1
118	43°45' 69°30'				11
119	43°30' 69°30'				
120	43°15' 69°30'				
121	43°00' 69°00'				
122	42°45' 69°30'				
123	42°30' 69°30'			1	1
124	42°15' 69°30'				
125	42°30' 70°00'				
126	42°45' 70°00'				
127	43°00' 70°00'				
128	43°15' 70°00'				
129	43°30' 70°00'			2	2
130	43°15' 70°25'			6	6
131	43°00' 70°20'			10	10
132	42°45' 70°30'			5	5
133	42°30' 70°30'			1	1
134	42°15' 70°30'		1	4	5
135	---				
136	42°15' 70°00'				
137	42°00' 69°57'		1		1
138	42°00' 69°45'				
139	42°00' 69°30'				
140	41°45' 69°30'				
141	41°45' 69°45'		1		1
142	41°30' 69°35'				
143	41°15' 69°25'				
144	40°54' 69°14'		60	55	115
145	40°30' 69°30'		3	5	8
147	40°00' 69°30'				
148	39°47' 69°35'				
151	40°11' 69°54'		13	11	24
152	40°05' 69°57'		17	9	26
153	40°23' 70°07'		6	18	24
154	40°37' 70°20'		7	133	140
155	40°48' 70°31'		2	49	51
156	40°58' 70°40'		1	42	43
157	41°12' 70°53'			7	7



Appendix Figure 1.



Appendix Figure 2.



Appendix Figure 3.

