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The Distribution and Abundance of Atlantic Herring  
Larvae in the Gulf of Maine Region as Determined  
From MARMAP Surveys During Autumn and Winter, 1980-81

by

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ABSTRACT

Autumn and winter MARMAP ichthyoplankton surveys of coastal waters between Cape Hatteras, North Carolina and Cape Sable, Nova Scotia during 1980-81 reveal that production of Atlantic herring (*Clupea harengus* L.) larvae on Georges Bank was again poor, marking the fifth consecutive year of low production. We caught no herring larvae on the Bank, an indication that spawning activity in that part of the survey area continued in the ominous pattern of decline observed during the late 1970's. Most of the larvae occurred around the northern perimeter of the Gulf of Maine with numerically and geographically smaller concentrations in and around Massachusetts Bay.

INTRODUCTION

The Northeast Fisheries Center (NEFC) is completing the fifth consecutive year of MARMAP (Marine Resources Monitoring Assessment and Prediction) plankton surveys, as part of a comprehensive fisheries ecosystem study in coastal waters off the middle and northeastern coast of the United States. Smith et al. (1980) included a capsule description of the program and its sampling methods and objectives in their summary of the distribution and abundance of Atlantic herring larvae collected during the 1977-78 to 1979-80 spawning seasons. Sherman (1980) described the program in depth. This report updates Smith et al. (1980) by summarizing the distribution and abundance of herring larvae as determined from MARMAP surveys during the 1980-81 spawning season, and thereby provides a continuous series of survey information within the Gulf of Maine region that dates back to the early 1960's (see Boyar et al. 1973; Lough et al. 1979; Smith et al. 1980).

METHODS

With the exceptions of deleting and/or repositioning some stations, MARMAP sampling methods for fish eggs and larvae during the time period covered in this report remain unchanged from those put into practice in 1977 when survey effort increased from two to a minimum of six surveys/year. We continued to occupy 175 stations, spaced at 25 to 35 km intervals, during each survey. For analytical purposes the survey area is divided into four subareas (Figure 1). Because Atlantic herring larvae have not occurred in MARMAP collections in the southern part of the survey area, the middle Atlantic subarea is not included in our tabular analysis, although the stations occupied in that subarea are included in the figures showing the distribution of larvae.

Sampling methods for ichthyoplankton are described in detail by Smith and Richardson (1977). Double oblique tows are made with 61-cm bongos fitted with 0.505 and 0.333-mm mesh nets. Ichthyoplankton is analyzed from the 0.505-mm net. The bongos are lowered to within a few meters of bottom or to a maximum depth of 200 m at 50 m/min and retrieved at 20 m/min. Flow meters and bathy-kymographs provide us with information on the amount of water sampled, and tow profile and maximum depth for each tow, respectively. Ship speed varies, usually between 1 and 2 kts, to maintain a 45° wire angle throughout a tow. During 1980 we completed six surveys, two during the autumn spawning season of herring. We include in this report results from our winter 1981 survey to conform to the 1974-78 ICNAF time series (Lough et al. 1979). For comparative purposes, abundance information (by subarea) from earlier MARMAP surveys is also included herein.

## RESULTS

Atlantic herring larvae did not occur in our August 1980 survey as they did the previous year, perhaps because the 1980 late summer survey ended earlier in the month. It was not until midway through the following survey which began in late September that we caught herring larvae at a station in the southern part of the Gulf of Maine, east of Cape Cod. The entire Georges Bank subarea was void of larvae during early autumn, a time period that represented the height of the hatching season during the mid-1970's (Lough et al. 1979) and the period of maximum larval abundance on earlier MARMAP surveys. The distribution of larvae was continuous in the relatively shallow waters around the northern perimeter of the Gulf of Maine in late October with pockets of moderately dense concentrations on German Bank, Grand Manan Banks, and off Penobscot Bay, and isolated and areally smaller concentrations of larvae occurred in Massachusetts Bay (Figure 1). Water temperatures in the areas of larval occurrence ranged from 10.0 to 14.7°C at the surface, and 5.1 to 11.3°C on bottom. The early autumn pattern of distribution shown in Figure 1 resembles that of 1978 and 79 but differs markedly from that of 1977 when recently hatched herring were centered east of Nantucket Shoals (see Smith et al. 1980). Although the distribution of herring larvae was restricted to the Gulf of Maine, their abundance was substantially less than estimates in that subarea during the early autumn period of 1979; more than double that in 1978, the year of lowest larval abundance in the 4-year MARMAP data set; and similar to the 1977 estimate (Table 1).

Recurring periods of inclement weather slowed day-to-day progress during the late autumn survey and we ran out of allotted ship time before the survey was completed. A resultant sampling shortfall occurred in that part of the Gulf of Maine where young herring were most abundant in October. Herring larvae were scattered off southern New England around Nantucket Shoals, and along the southern part of the Gulf of Maine to the eastern limit of the survey area on German Shoals. A small but moderately dense patch of larvae again occurred in Massachusetts Bay with lesser numbers found along the eastern face of Cape Cod. Although not shown in the accompanying figure, those larvae off the Cape probably were geographically linked on Nantucket Shoals to those off southern New England (Figure 2). Water temperatures continued in their autumn decline, ranging from 5.5 to 9.2 at the surface, and 5.5 to 10.0 on bottom, at those stations where we caught larvae. Once again, we did not catch Atlantic herring larvae on Georges Bank although, as depicted in Figure 2, their distribution might have encroached upon the northern edge of the Bank. Within and between season comparisons of larval distribution and abundance are meaningless because of the sampling shortfall in the Gulf of Maine but it is apparent from our results that the height of the hatching season had passed as nearly all larvae were >10 mm in length (Table 1).

By February the distribution of herring larvae again was limited to the Gulf of Maine where we found low density concentrations of large larvae off Penobscot Bay as well as in and to the north of Massachusetts Bay (Figure 2). Water temperatures approached their annual low, ranging at positive stations from 1.1 to 4.5°C at the surface, and 1.2 to 8.7°C on bottom. Abundance estimates on the winter survey were predictably low and comparable to those for the three previous winters (Table 1).

#### DISCUSSION

For the fourth consecutive year the distribution of young herring was centered along the western and northern reaches of the Gulf of Maine where they occurred in moderate to low density concentrations. Their abundance might have been greater in this area nearer to shore where we did not sample but, based on our survey results over the past four years and the earlier studies of Boyar et al. (1973) and Lough et al. (1979), larval production on Georges Bank was again poor, following a trend that began in 1976.

A wide variety of studies have contributed to the current status of knowledge of the early life history of coastal fishes of the western North Atlantic but surveys of varying scope and intensity have provided the principal source of information on spawning cycles and the seasonal patterns of distribution of ichthyoplankton in continental shelf waters off northeastern United States (Colton 1963). For the past 25 years biologists at NEFC have been conducting ichthyoplankton surveys off the New England Coast on a regular basis (Marak and Colton 1961; Marak et al. 1962a, 1962b; Boyar et al. 1973; Colton and St. Onge 1974; Colton and Byron 1977; Lough et al. 1979; Smith et al. 1980). To our knowledge the autumn of 1980 marks the first spawning season within the above time frame that Atlantic herring larvae were not caught during the autumn-winter period on Georges Bank, the center of spawning activity during the 1960's and early 1970's (Boyar et al. 1973; Lough et al. 1979).

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Table 1. Abundance estimates for Atlantic herring larvae collected on MARMAP surveys in Gulf of Maine (GOM), on Georges Bank (GB), and off southern New England (SNE) during fall and winter 1977-81. Abundance estimates for 1977-78 through 1979-80 from Smith et al. (1980).

Year	Cruise	Date	Sub-area	# of Sta.	Size Range (mm)	Positive Stations		Mean Abundance(k) <sup>1</sup>		Standard Error(k)		Abundance (no. x 10 <sup>10</sup> )	
						Larvae <10 mm	Larvae >10 mm	Larvae <10 mm	Larvae >10 mm	Larvae <10 mm	Larvae >10 mm	Larvae <10 mm	Larvae >10 mm
1977-78	AR-77-01	10/18-11/9/77	GOM	38	8-16	4	8	1.258	14.107	0.752	8.503	1.233	13.828
			GB	18	10-16	2	5	0.511	26.869	0.351	22.978	0.214	11.234
			SNE	39	8-14	2	3	0.731	0.592	0.625	0.377	0.438	0.355
				95		8	16				1.885	25.417	
	MM-77-11	11/12-11/19/77	GOM	40	7-28	4	9	1.499	9.568	0.930	5.019	1.469	9.379
			GB	24	13-24	0	7	0	1.888	0	0.703	0	0.789
			SNE	26	12-25	0	2	0	4.088	0	3.962	0	2.449
				90		4	18				1.469	12.617	
	DE-78-02	2/16-3/16/78	GOM	26	-	0	0	0	0	0	0	0	0
			GB	6 <sup>2</sup>	31-33	0	2	0	2.253	0	1.425	0	0.942
			SNE	49	25-29	0	2	0	0.465	0	0.407	0	0.278
				81		0	4				0	1.220	
1978-79	BE-78-03	10/6-11/11/78	GOM	52	7-21	4	7	3.359	7.067	2.049	4.803	3.292	6.928
			GB	21	-	0	0	0	0	0	0	0	0
			SNE	47	10	1 <sup>3</sup>	0	0.085	0	NA <sup>1</sup>	0	0.051	0
				120		5	7				3.343	6.928	
	BE-78-04	11/15-11/29/78	GOM	52	3-22	2	7	0.356	1.173	0.274	0.457	0.349	1.149
			GB	18	6-18	1 <sup>3</sup>	1 <sup>3</sup>	7.655	0.243	NA <sup>3</sup>	NA <sup>3</sup>	4.586	0.102
			SNE	21	-	0	0	0	0	0	0	0	0
				91		3	8				4.935	1.251	
	DE-79-03	2/25-3/14/79	GOM	10	-	0	0	0	0	0	0	0	0
			GB	4	-	0	0	0	0	0	0	0	0
			SNE	40	28-33	0	2	0	0.192	0	0.134	0	0.115
				54		0	2				0	0.115	
1979-80	BE-79-01	8/11-9/2/79	GOM	38	7-11	1 <sup>3</sup>	2	1.655	0.244	NA <sup>1</sup>	0.172	1.622	0.239
			GB	20 <sup>2</sup>	-	0	0	0	0	0	0	0	0
			SNE	39	-	0	0	0	0	0	0	0	0
				97		1	2				1.622	0.239	
	AL-79-11	10/4-10/28/79	GOM	40	6-20	8	12	42.209	29.618	26.598	14.259	41.376	29.033
			GB	26	-	0	0	0	0	0	0	0	0
			SNE	50	-	0	0	0	0	0	0	0	0
				116		8	12				41.376	29.033	
	AL-79-13	11/15-12/20/79	GOM	48	6-32	5	19	3.593	16.033	2.105	6.265	3.522	15.719
			GB	27	12-30	0	1	0	0.216	0	NA <sup>3</sup>	0	0.090
			SNE	35	7-11	2	2	0.147	0.282	0.111	0.219	0.088	0.169
				110		7	22				3.610	15.978	
WI-80-02	2/20-3/10/80	GOM	47	28-47	0	5	0	0.659	0	0.465	0	0.646	
		GB	29	-	0	0	0	0	0	0	0	0	
		SNE	43	23-29	0	2	0	0.141	0	0.096	0	0.059	
			119		0	7				0	0.705		
1980-81	AL-80-10	9/26-10/29/80	GOM	54	6-21	7	11	11.663	16.833	6.851	9.177	11.432	16.501
			GB	28	-	0	0	0	0	0	0	0	0
			SNE	43	-	0	0	0	0	0	0	0	0
				125		7	11				11.432	16.501	
	AL-80-12	11/19-12/21/80	GOM	18	11-27	0	5	0	13.645	0	9.409	0	13.376
			GB	27	-	0	0	0	0	0	0	0	0
			SNE	45	5-19	2	4	0.699	0.372	0.519	0.186	0.419	0.223
				90		2	9				0.419	13.599	
	AL-81-01	2/17-3/26/81	GOM	55	7-32	1 <sup>3</sup>	9	0.104	1.507	NA <sup>1</sup>	0.381	0.102	1.477
			GB	27	-	0	0	0	0	0	0	0	0
			SNE	44	-	0	0	0	0	0	0	0	0
				126		1	9				0.102	1.477	

<sup>1</sup>k = mean number of larvae/10 m<sup>2</sup> surface area. Refer to Berrien et al. (1979) for discussion of rationale and procedures for use of  $\lambda$ -distribution which appears to describe these data. Abundance is expansion of k to reflect subarea size.

<sup>2</sup>Incomplete coverage

<sup>3</sup>When n<sub>i</sub>=1, the mean is estimated by X/n, and its variance by X<sup>2</sup>/n<sup>2</sup>, where X is the single non-zero value; both are unbiased estimators (Berrien et al. 1979).

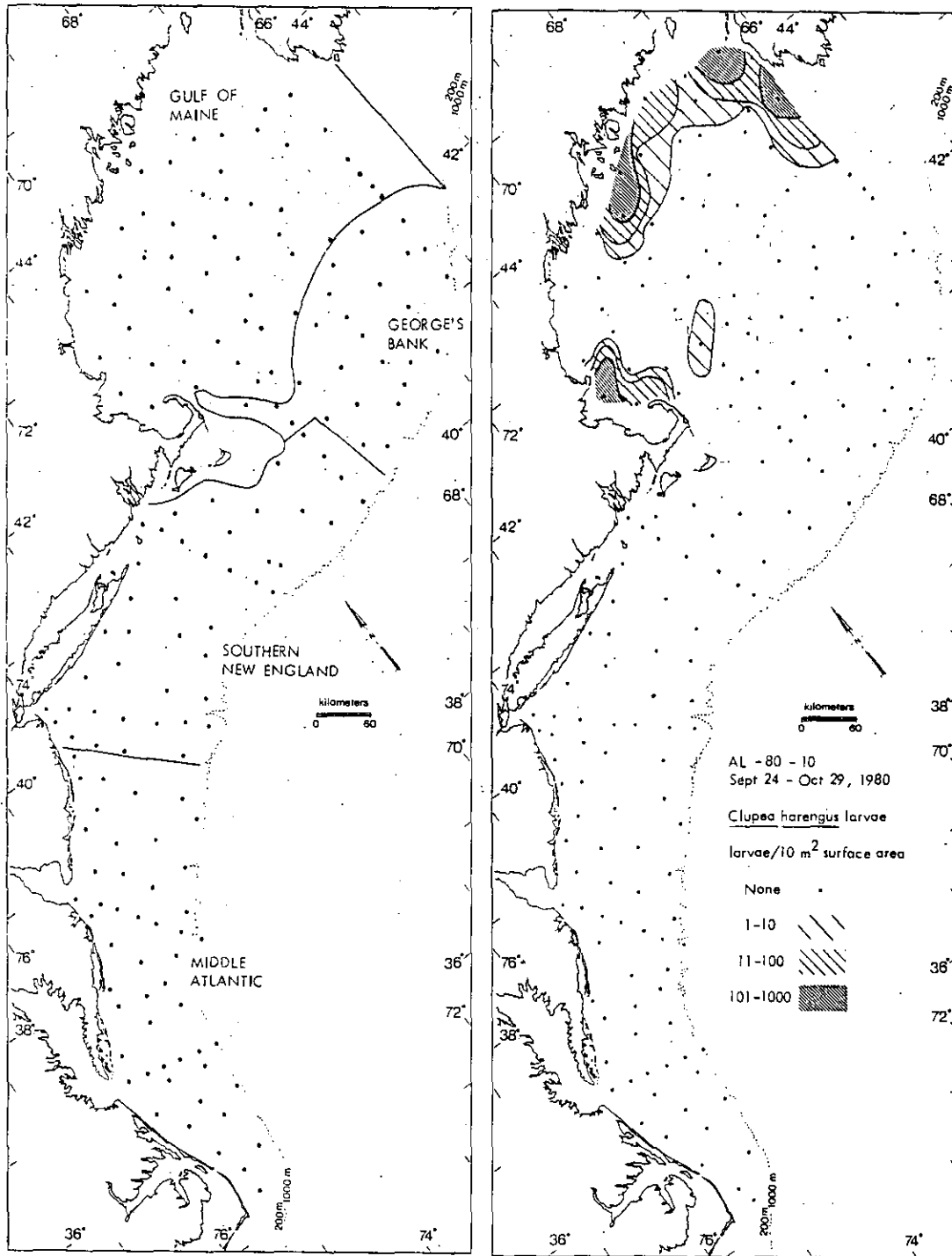


Figure 1. MARMAP Survey area off Northeastern United States showing station plan and four analytical subareas (left) and distribution and abundance of Atlantic herring larvae off New England during early autumn 1980 (right).

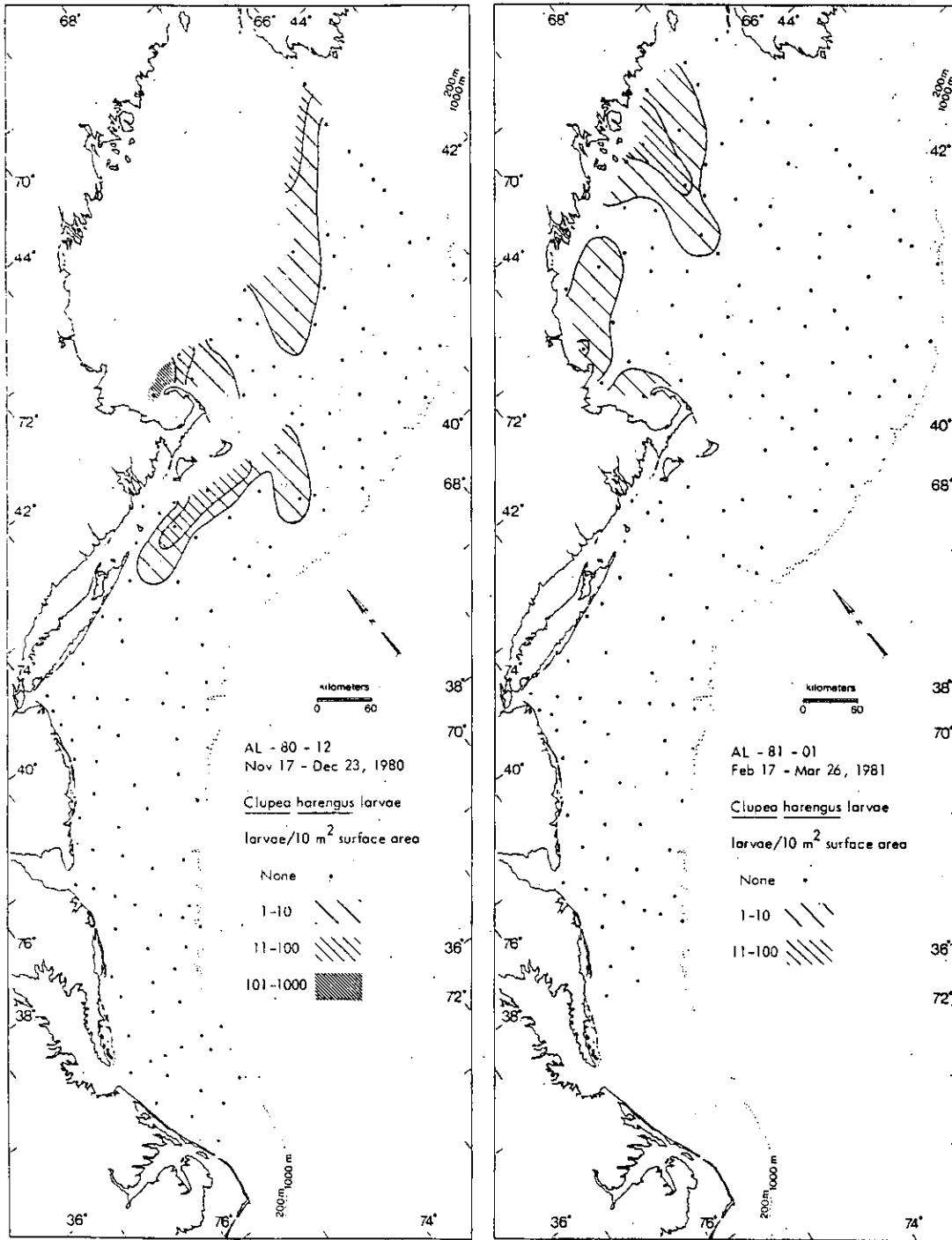


Figure 2. Distribution and abundance of Atlantic herring larvae off New England during late autumn, 1980 (left) and winter 1981 (right).

