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THE DISTRIBUTION AND ABUNDANCE OF ATLANTIC HERRING LARVAE IN THE GULF OF MAINE REGION AS DETERMINED FROM MARMAP SURVEYS, 1977-80

by

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ABSTRACT

Results of MARMAP surveys in coastal waters from Cape Hatteras to Nova Scotia during the late 1970's indicate that production of larval herring (Clupea harengus L.) continued at extremely low levels through the end of the decade. The distribution of larvae was centered around Nantucket Shoals and along the western parts of Georges Bank and the Gulf of Maine. Only isolated, low density patches of larvae occurred on Georges Bank east of 69°W longitude, or on that part of the Bank where young herring were most abundant during the 1960's.

INTRODUCTION

A comprehensive fishery ecosystems study known as MARMAP (Marine Resources Monitoring Assessment and Prediction) has been the focal point of research at the Northeast Fisheries Center (NEFC) for nearly a decade. MARMAP is built around a time series of trawl and plankton surveys designed to monitor shifts in the distribution, abundance and production of marine organisms representing different trophic levels, as well as fine scale, process oriented field and laboratory studies. It is made up of conceptually related scientific disciplines which function as a unit to simultaneously collect the kinds of biological and environmental data needed to piece together the course of events that transpire within marine ecosystems to influence the size of fish populations. Estimates of adult spawning biomass of principal fish species are derived from the surveys. By crosswalking information from all ongoing research activities within MARMAP, biologists at NEFC are working toward a level of understanding of biological and environmental interactions that will allow them to predict the size of incoming year classes (Sherman 1980). This report summarizes the distribution and abundance of Atlantic herring larvae as determined from three MARMAP surveys during autumn and winter of 1977-78, three in 1978-79 and four in 1979-80. It is intended primarily to document the ongoing monitoring surveys, and to show that larval herring production on Georges Bank continued at extremely low levels through the end of the decade.

MARMAP plankton surveys are conducted in shelf and slope waters from Cape Hatteras to Nova Scotia. Sampling intensity increased from two to six or more surveys/year in the autumn of 1976, when the program took on international dimensions through joint participation of ships and scientific personnel from Poland, USSR, FRG, GDR, Canada, France and the United States. Survey collections and measurements since 1977 include: ichthyoplankton (Berrien et al. 1979; Smith et al. 1978, 1979, 1980; Sullivan 1980); zoo-

plankton (Sherman et al. 1977, 1979; Sherman and Jones 1980); phytoplankton identification and cell counts (Esser et al. 1980; Marshall and Cohn in press); nutrients (Draxler et al. 1979); chlorophyll a measurements (Evans et al. 1979); twice-daily primary productivity measurements (O'Reilly and Busch 1979); dissolved oxygen; and temperature and salinity (Pawlowski et al. 1978; Nickerson and Wright 1980).

METHODS

Plankton stations are arranged to form transects at seven locations within the 260,000 km^2 survey area. Otherwise, they were chosen from a stratified random design used for NEFC trawl surveys (see Grosslein 1969; Clark and Wood 1978) to provide "even" coverage. We currently occupy 175 stations which are spaced at 25 to 35 km intervals. The survey area is sectioned into four subareas for analytical purposes (Figure 1). As with any program of this scale, inclement late autumn and winter weather as well as occasional vessel breakdowns are disruptive and several surveys have not been completed. Overall sampling success as measured by station occupancy has been about 78%. If more than one ship is involved in a survey we piece together the results to provide the most complete coverage possible while keeping the cruise period to about 30 days.

Methods used to collect ichthyoplankton are described in detail by Richardson and Smith (1977). Double-oblique tows are made with 61-cm bongos fitted with 0.505 and 0.333-mm mesh nets. 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. Ship speed varies between 1 and 2 kts to maintain a 45° wire angle during the tow. The 0.505-mm mesh samples are used for ichthyoplankton studies; the 0.333-mm mesh samples for zooplankton. This towing scheme differs somewhat from that used in the 1974-78 ICNAF larval herring surveys in that ICNAF stations were spaced at 27 km intervals in a grid pattern, tows were at 3.5 kts, and the bongos were lowered at 50 m/min to a maximum depth of 100 m and retrieved at 10 m/min (Lough et al. 1979). The comparative effectiveness of the two schemes for catching herring larvae is unknown but, based on some preliminary information presented by Colton et al. (1980), it seems likely that large larvae were more effectively sampled with the faster towing speed used on the ICNAF series. Extrusion of larvae <7 mm is also a source of sampling error. We include in this report results from fall and winter surveys to conform to the 1974-78 ICNAF time series but make no further attempt to compare the two data sets, primarily because of differences in collecting methods and analytical procedures.

Initial processing of MARMAP ichthyoplankton samples is completed at the Morski Instytut Rybacki, Szczecin, Poland. Larvae are identified and measured at the institute then returned to NEFC's Sandy Hook Laboratory, along with appropriate logs and eggs, within three to six months of delivery. Larvae and corresponding logs are checked at Sandy Hook, where the information on the logs is subsequently keypunched for entry into the MARMAP Information System (MIS). Pelagic eggs are identified and staged at Sandy Hook to map spawning areas and derive estimates of spawning stock biomass.

DISTRIBUTION AND ABUNDANCE OF LARVAE

Expected year to year differences in the distribution and abundance of herring larvae were observed for the three spawning seasons included in this report, but the annual similarities seem more noteworthy. For example, most of the herring larvae in our collections consistently occurred along the western edge of the Gulf of Maine; larval herring production on Georges Bank continued through the end of the decade at extremely low levels, a trend that began in 1976 (Lough et al. 1979); and no significant spawning occurred on the Bank east of 69°W longitude, where the major spawning grounds were located during the 1960's (Boyar et al. 1973).

Herring larvae first occurred in our 1977 surveys at the end of October, or during the time period that approximates the average mid-date of their hatching season (Lough et al. 1979). Our abundance estimates for 1977-78 agree with those of Lough et al. (1979) in that they are low. Most of the

larvae occurred in the Gulf of Maine (Table 1). The distribution of young herring in October was continuous but limited to shelf waters south and east of Nantucket Shoals, east of Cape Cod and the western extreme of the Gulf of Maine. From mid-November through mid-December low-density patches of larvae were scattered over Georges Bank and the eastern part of the Gulf of Maine but their distribution remained centered around Nantucket Shoals and northward along the western edge of Georges Bank, into the Gulf. By mid-February we caught larvae only in the vicinity of Nantucket Shoals (Figure 1). Although our winter survey suffered from a serious sampling shortfall on Georges Bank and the Gulf of Maine, it included that part of both subareas where herring larvae were centered from October through December.

During the 1978-79 surveys the distribution of herring larvae was extremely limited, and our abundance estimates were the lowest of the 3-year period (Table 1). In October we caught larvae only in the Gulf of Maine, where isolated patches occurred on Stellwagen Banks, off Penobscot Bay, and west of Nova Scotia near Lurcher Shoal. By the second half of November their distribution was centered east of Cape Cod, with a lesser concentration remaining off Penobscot Bay. In February-March our coverage was again limited. We caught two herring larvae, both south of Martha's Vineyard (Figure 1). The absence of young herring on Georges Bank and around Nantucket Shoals in October, a time period that represents the height of the normal hatching season, strongly suggests that larval production in that part of the survey area in 1978 was extremely poor. Although sampling shortfalls on the ensuing two surveys occurred in the eastern part of the region, with the exception of the Lurcher Shoal area we have no reason to suspect that complete coverage on the November and February-March surveys would have significantly changed our results.

The 1979 hatching season began earlier and larvae were more abundant than the combined estimates of the two previous seasons, but again larvae were almost non-existent on Georges Bank (Table 1). We found a low density concentration of larvae in the northern part of the Gulf of Maine at the end of August. By October their distribution was widespread in the Gulf, with concentrations along the western edge and to a lesser extent in the eastern Gulf near Browns Bank (Figure 2). Judging from their distributional pattern and results of the previous and preceding surveys, we suspect their October distribution was more extensive than our abbreviated coverage. The distribution of larvae remained widespread in the Gulf of Maine in November-December, especially along the western part of the Gulf. Otherwise, larvae were scarce to absent, a strong implication that for the third consecutive year larval production was insignificant on Georges Bank. By February 1980 low density concentrations were scattered, mostly in the Gulf of Maine (Figure 2).

DISCUSSION

The near absence of larvae in our winter survey samples could in part reflect avoidance, especially in those subareas where we caught larvae through the autumn months. But other factors must be considered. Lough et al. (1979) concluded that good survival of young herring on Georges Bank occurred when water temperatures were relatively warm and current patterns retained larvae on the Bank. During January, February and March 1978, water temperatures along the northeast coast of the United States were 2 to 3°C below normal with the greatest negative temperature anomalies on Georges Bank (Ingham and Haynes 1980). Temperatures were again below normal in 1978-79, marking the third consecutive winter of record low temperatures (Diaz and Quayle 1979). Weather conditions moderated in 1979-80. Our autumn abundance estimates were the highest of the 3-year period in the Gulf of Maine but they remained low on the Georges Bank and southern New England subareas. We suspect that hostile weather conditions during two of the three years described herein took a heavy toll on the larval herring population, as well as larvae of other autumn and winter spawners (Smith et al. 1978, 1979). Despite the obvious pitfalls in interpreting our results, when compared to those of the excellent earlier studies of Boyar et al. (1973) and Lough et al. (1979), we believe the limited distributional patterns and the consistently low abundance estimates provide sufficient information to conclude that larval herring production during the autumns of 1977, 1978 and 1979 was extremely low, especially on Georges Bank.

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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, 1977-80.

Year	Cruise	Date	Sub-area	# of Sta.	Size Range (mm)	Positive Stations		Mean Abundance(k)[1]		Standard Error($S\bar{x}$)		Abundance (no x 10^{10})	
						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	0.864	1.519	1.233	13.828
			GB	18	10-16	2	5	0.511	26.869	0.906	2.460	0.214	11.234
			SNE	39	8-14	2	3	0.731	0.592	1.203	0.661	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	0.962	1.308	1.469	9.379
	KE-77-11	11/25-12/13/77	GB	24	13-24	0	7	0	1.888	0	0.513	0	0.789
			SNE	26	12-25	0	2	0	4.088	0	2.456	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[2]	31-33	0	2	0	2.253	0	0.003	0	0.942
			SNE	49	25-29	0	2	0	0.465	0	1.334	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	0.899	1.717	3.292	6.928
	DE-78-06	10/24-11/22/78	GB	21	-	0	0	0	0	0	0	0	0
			SNE	47	10	1[3]	0	0.085	0	NA[3]	0	0.051	0
				120		5	7					3.343	6.928
	BE-78-04	11/16-11/29/78	GOM	52	8-22	2	7	0.356	1.173	0.683	0.452	0.349	1.149
			GB	18	6-18	1[3]	1[3]	7.655	0.243	NA[3]	NA[3]	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[2]	-	0	0	0	0	0	0	0	0
			GB	4[2]	-	0	0	0	0	0	0	0	0
			SNE	40	28-33	0	2	0	0.192	0	0.018	0	0.115
				54		0	2					0	0.115
1979-80	BE-79-01	8/11-9/2/79	GOM	38	7-11	1[3]	2	1.655	0.244	NA[3]	0.209	1.622	0.239
			GB	20[2]	-	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	1.624	1.357	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	1.037	1.320	3.522	15.719
	WI-79-03	11/15-11/21/79	GB	27	12-30	0	1[3]	0	0.216	0	NA[3]	0	0.090
			SNE	35	7-11	2	2	0.147	0.282	0.634	0.738	0.088	0.169
				110		7	22					3.610	15.978
	WI-80-02	2/20-3/10/80	GOM	47	28-47	0	4	0	0.659	0	0.578	0	0.646
	AL-80-02	2/28-4/4/80	GB	29	-	0	0	0	0	0	0	0	0
			SNE	43	23-29	0	2	0	0.141	0	0.257	0	0.059
				119		0	6						0.705

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

[2] Incomplete coverage

[3] When $n_1=1$, the mean is estimated by X/N, and its variance by X^2/n^2, where X is the single non-zero value; both are unbiased estimators (Berrien et al. 1979).

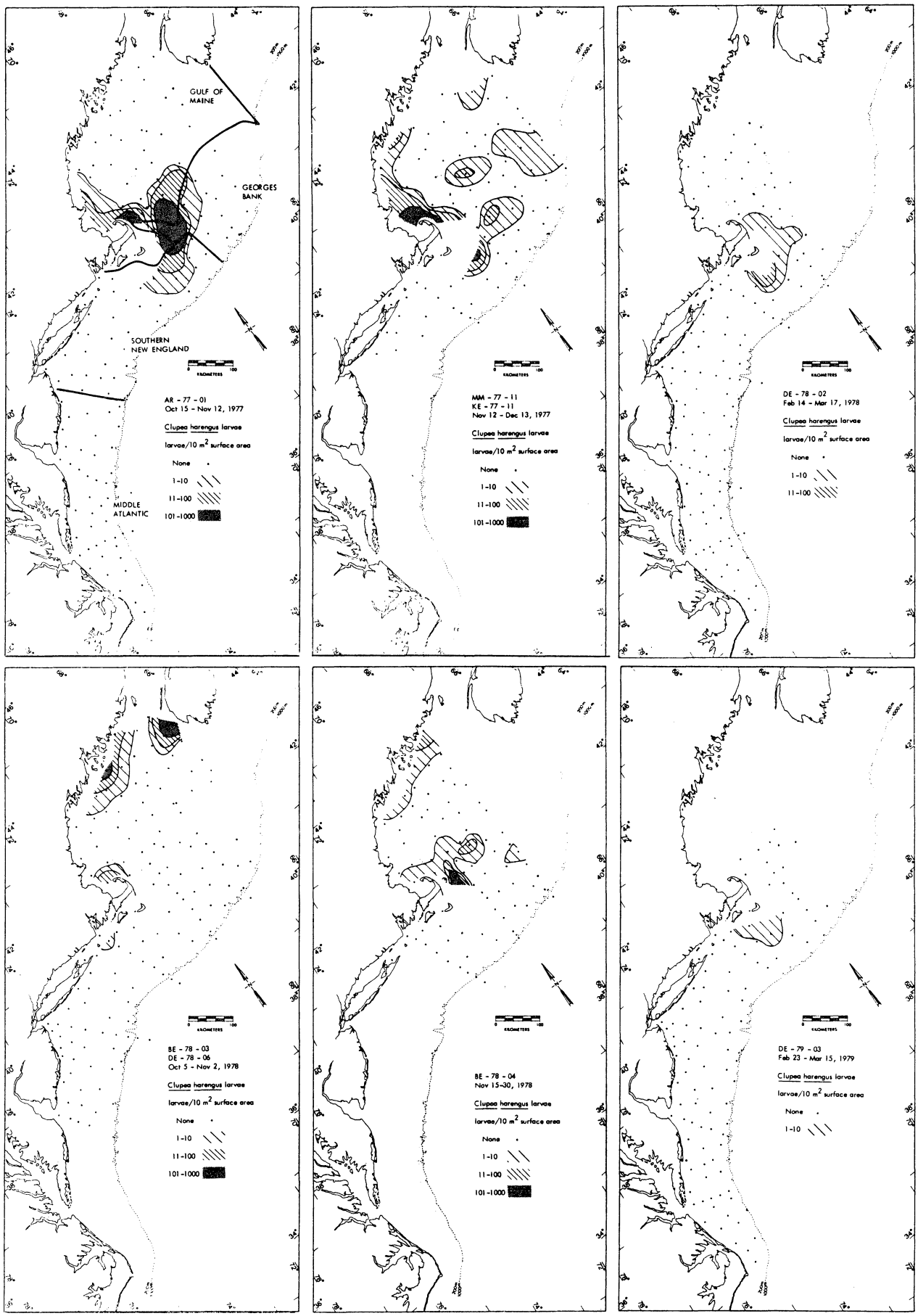

Figure 1. Distribution and abundance of Atlantic herring larvae off New England during autumn 1977 and winter 1978 (top); autumn 1978 and winter 1979 (bottom). See analytical subareas top left.

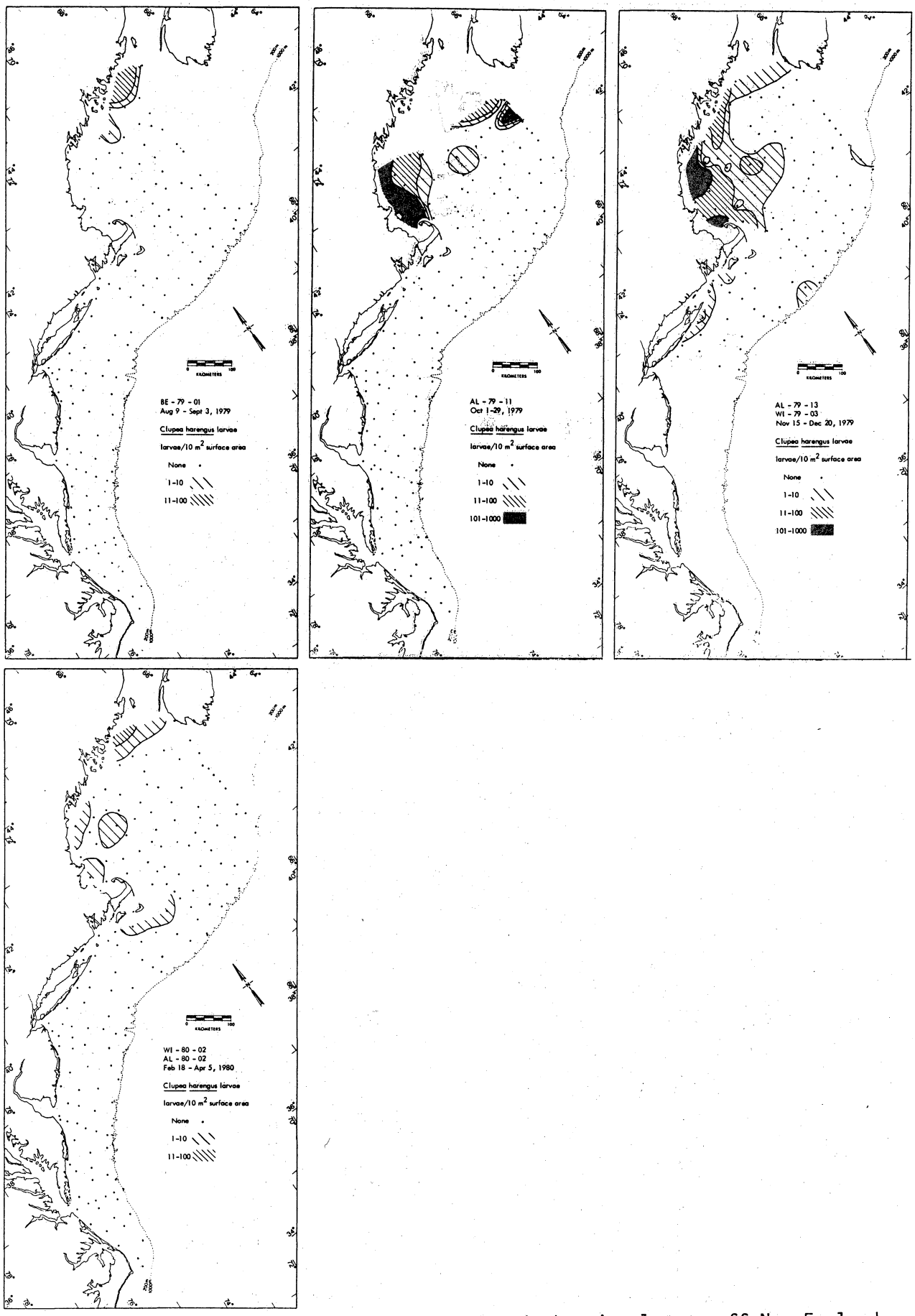

Figure 2. Distribution and abundance of Atlantic herring larvae off New England during late summer and autumn 1979 (top); and winter 1980 (bottom).