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A Possible Environmental Influence on Potential[1/] Stock-Recruitment Relations of Herring, *Clupea harengus*, Along the Maine Coast

by

Joseph J. Graham
Maine Department of Marine Resources
Fisheries Research Laboratory
West Boothbay Harbor, Maine 04575

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1/During the 1980 meeting of the NAFO Scientific Council, the author presented a slide suggesting a relationship between a progeny index and spring larval abundance from the central Maine coast. The index was based in part on stock size estimated by Dr. Vaughn Anthony. At the request of Dr. Marvin Grosslein, chairman of the larval herring task force, this document was written utilizing the new estimates of egg production presented at the meeting by Dr. Anthony.

Stock-recruitment relationshops are difficult to establish for herring populations of the northwest North Atlantic because some aspect of the environment perhaps intervenes during the herring's early life history. This paper explores the possibility that a winter period of larval mortality may represent such an intervention. The data used are: 1) the potential number of eggs available each year from the western Gulf of Maine stock; 2) the estimates of larval mortality during the winter, a period perhaps critical to the production of larvae in the spring before their metamorphosis into juvenile form; and 3) estimates of spring larval abundance.

Anthony and Waring (1980) estimated egg production for mature herring of the Gulf of Maine stock by year (1968-1979) and by age (3-12). They kindly permitted the author to use their estimates in this document. Estimates of egg production declined only slightly from 1968-1971 (32×10^{12}-29×10^{12}) and then dropped to the lowest value for all years in 1973 (12×10^{12}), rose again in 1975 (20×10^{12}) and declined to a low again in 1978 (12×10^{12}).

Graham (1980) estimated mortality for larval year classes during the winters of 1964-1973 and 1977 within the central coast of Maine. He found that a higher winter mortality preceded a lower abundance of larvae in the subsequent spring. Estimates of winter survival, egg production and spring larval abundance are given in Table 1 for 1968-1973 and 1977, years when all three types of estimates are available for comparison.

Because the data are few, a progeny index was calculated and simple correlation coefficients were used in comparisons. The autumnal egg production was multiplied times the winter survival rate of the larvae to obtain a progeny index which anticipated the abundance of larvae in the spring for each year class (Table 1). Comparisons were made individually between estimates of spring larval abundance and the natural logarithms of 1) egg production, 2) larval survival, and 3) the progeny index.

Table 2 records the results of the comparisons which suggested that the interaction of autumnal egg production and larval survival in winter probably anticipated the spring larval abundance better than larval survival alone. Egg production was not significantly correlated with the spring estimates of abundance. Figures 1 and 2 illustrate the significant results; regression lines were drawn to facilitate comparison of the two figures.

These results would be anticipated if larval mortality in winter was critical to spring larval abundance and the production of eggs was indicative of larval abundance at the end of autumn, the beginning of the critical period. Further, for the critical mortality to intervene in the potential stock-recruitment relation, 1) the number of eggs obtained from that portion of the stock spawning along the coast must be proportional to the number of eggs obtained for the entire stock of the western Gulf of Maine, and 2) the estimates of spring abundance must be indicative of recruitment to the coastal fishery of Maine. These assumptions can be met only partially because of considerable changes in the herring populations between the 1960s and the 1970s. The herring stock of the western Gulf of Maine was consistently large until the early 1970s when the adult fishery reached its peak and the stock decreased. Spring estimates of larval abundance during the 1960s were perhaps indicative of recruitment to the fishery along the entire coast, but from 1971 onward this agreement was lost. Perhaps in the 1970s estimates of spring abundance were primarily representative of only the central coastal area within which they were obtained, especially during 1977. Further discussions of these assumptions and others associated with the data are given by Anthony and Waring (1980) and Graham (1980).

Graham (1980) suggests that if such a critical period exists the causes of the density independent mortality may be related to the vicissitudes of the environment. Assuming this is true, it would appear difficult to utilize successfully a management plan which depends on an implied stock-recrutiment relation for rebuilding the stock of the western Gulf of Maine over a longer period of time (10 years). Also, it would appear difficult to utilize a multispecies management plan with confidence if one of the major forage fishes (herring) is capable of determining its year class strength somewhat independently of other fish species. In contrast, the critical period might be helpful to the herring. The herring has been in the seas for many years geologically and in recent times has provided a good fishery along the coast of Maine for many years. Possibly, the critical period might be that "little bit of luck" occurring in the life history of the herring to confound environmental stresses.

REFERENCES

Anthony, V.C. and G.T. Waring. 1980. Estimates of herring spawning stock biomass and egg production for Georges Bank-Gulf of Maine Region. NAFO SCR Doc. 80/IX/135, Ser. No. N209:43 p.

Graham, J.J. 1980. Production of larval herring, *Clupea harengus*, along the coast of Maine (1964-1978) and its relation to recruitment mechanisms of the sardine fishery. NAFO SCR Doc. 80/IX/123, Ser. No. M192:30 p.

Table 1. Comparison of a progeny index with the production of larval herring in the central coast of Maine during the spring. The index is calculated from the estimated number of eggs obtained from the spawning stock of the Gulf of Maine in a given year multiplied times the observed winter mortality of each larval year class.

Spawning Year	Egg Production x 10^9 (a)	Larval Survival (b)	Index (a)(b)	Larval Catch No./100 m^3
1968	31727.0	.126	3997.6	1.26
1969	30120.5	.036	1084.3	0.73
1970	27802.1	.080	2224.2	1.40
1971	28666.5	.677	19407.2	1.61
1972	20112.5	.255	5128.7	1.34
1973	12060.7	.159	1917.6	0.98
1977	15308.7	.082	1255.3	0.94

Table 2. Correlation coeeficients of comparisons.

Spring Abundance vs.	Correlation Coefficient	Probability
egg production	.354	.754 (.05)
larval survival	.783	.754 (.05)
progeny index	.874	.874 (.01)

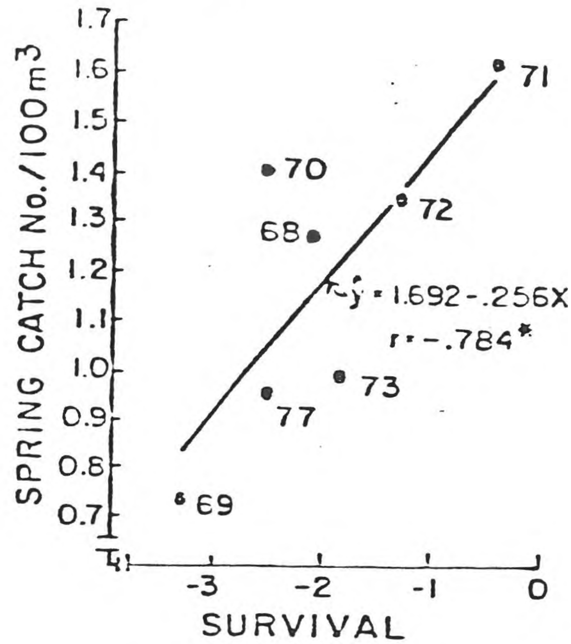

Figure 1. Comparison of larval survival in winter and larval abundance in the spring for year classes 1968-1973 and 1977. Rates of larval survival are in natural logarithms; the data are listed in Table 1.

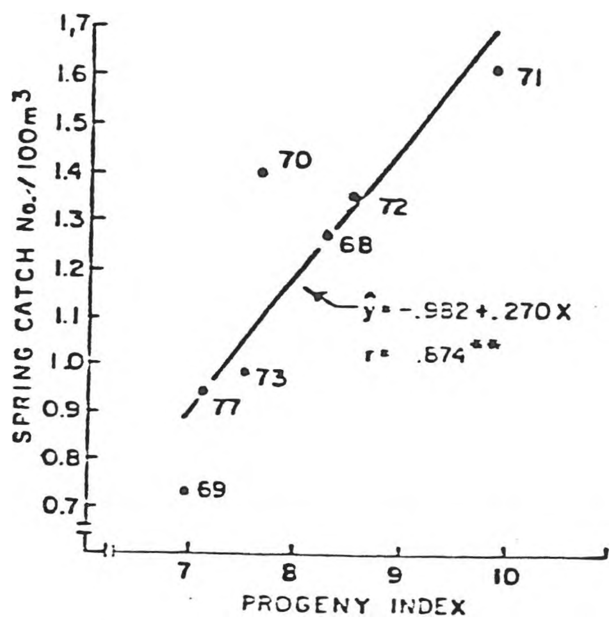

Figure 2. Comparison of a progeny index anticipating spring abundance and the observed estimates of spring abundance for year classes 1968-1973 and 1977. The progeny index is in natural logarithms; the data are listed in Table 1.