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Stages of maturity of gonads in herring from Georges Bank

by

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INTRODUCTION

While attaining maturity, the gonads of herring undergo successive stages of development. With respect to herring stock on Georges Bank, this problem is insufficiently understood and an attempt is made in this paper to elucidate it.

MATERIALS AND METHOD

Investigations of the various stages of development of herring gonads were based on detailed analyses of samples taken from individual hauls on board of commercial factory trawlers. These vessels conducted specialized fishing for mackerel in the winter and spring and for herring in the summer and autumn, in Divisions 5Z and 6A of the ICNAF Area (Northwest Atlantic) during 1971-75. The gear used was a pelagic trawl of polyamide twine with a mesh size of 44 mm in the codend.

Each detailed analysis was carried out on about 100 herring. The method used for their selection from samples was the percentage representation of length classes after measuring the total length of each fish. Two measuring methods were used: up to 1973 herring were measured to the nearest $\frac{1}{2}$ centimeter on a scaled rule, and from 1974 onwards the fish were measured to the centimeter below on a measuring board graduated in cm. The samples collected during the 5-year period (Fig. 1) are arranged by month and division in Table 1.

Table 1. Numbers of herring sampled for length and analyzed for maturity from commercial catches in Div. 5Z and 6A during 1971-75.

ICNAF Div.	Month	<u>Length measurements</u>		<u>Biological analyses</u>	
		No. of samples	No. of fish	No. of samples	No. of fish
6A	Feb	7	1,827	3	305
	Mar	8	2,257	6	516
	Apr	3	737	2	200
5Z	May	41	12,625	30	2,903
	Jun	54	16,071	36	3,536
	Jul	19	5,783	9	857
	Aug	64	19,160	25	2,472
	Sep	145	43,244	69	6,264
	Oct	86	25,606	43	4,118
	Nov	9	2,622	4	370
5Z+6A	Total	436	129,932	227	21,541

The detailed analysis consisted of determining the sex and the stage of maturity of the gonads. The latter was estimated on the basis of an 8-grade scale used in herring investigations in the ICES Area (Northeast Atlantic) and adopted by the ICNAF scientific committee in 1964 for use in the Northwest Atlantic (ICES, 1963; ICNAF, 1964).

A numerical index of gonad maturity, determined from the percentage of gonads in particular stages of development in consecutive time intervals of one month or 10 days, was adopted for the investigations. This index was calculated from total length-gonad maturity keys. The data used in the keys were as follows: (a) number of males and females in consecutive stages of gonad development in each length class (data originating from detailed analyses); (b) number of herring in consecutive length classes (results of length measurements of fish). Thus the percentage of fish with gonads in the various stages of development in consecutive months was calculated (Table 2).

Table 2. Percentage of herring with gonads at various stages of maturity in consecutive months of the years 1971-75. (10-day periods are represented by the digits, 1, 2 and 3 under the months in the table heading.)

Sex	Maturity stage	Feb	Mar	Apr	May	Jun	Jul	Aug		Sep			Oct			Nov
		1-3	1-3	1-3	1-3	1-3	1-3	1-2	3	1	2	3	1	2	3	1-3
Male	VIII+II	37	45	12	5	9	3	2	3	1	1	1	1			
	III	1	2	27	41	34	14	5	1	-	-	-	1			
	IV				1	6	22	24	13	9	11	2	1			
	V						8	15	30	27	24	9	8	4	3	1
	VI+VII VIII									4	13	31	39	44	37	15
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Female	VIII+II	55	42	21	4	7	6	3	4	1	1	1				
	III		4	30	42	35	18	16	4	1	-	1	2	-	2	
	IV					9	23	38	26	25	14	4	1	-	1	
	V						1	5	15	24	17	11	3	2	1	
	VI+VII VIII									2	12	31	40	39	26	10
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Total	VIII+II	92	87	33	9	13	9	4	7	2	2	2	1			
	III	1	6	57	83	69	32	21	5	1	1	2	3	-	2	
	IV				1	15	45	51	39	34	26	6	2	-	1	
	V						9	20	45	51	41	20	11	6	4	1
	VI+VII VIII									6	25	62	79	83	63	25
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											4	2	11	21	73	

RESULTS AND DISCUSSION

Table 2 gives the percentages of herring (ages 3 to 8) with gonads at various stages of maturity during the 10 months from February to November, in the years 1971-75. The sequence of occurrence of the maturity stages for sexes combined are shown in Fig. 2. The herring gonad development cycle covers the period from winter to autumn (Judanov, 1966; Boyar *et al.*, 1972). Two sub-periods can be distinguished: the resting (spent) period and that of sexual activity. The first covers stages VIII and II and lasts from November to April, whereas the second (stages III to VII) extends from April to October. The boundaries between the sub-periods are in April and November, as indicated by the vertical lines in Fig. 2.

There is no gonad activity during the November-April rest period, when only two stages (VIII and II) are evident (73% in November, 92% in February and 87% in March (Table 2)). The gonads undergo transformation in the April-November sub-period from stage III to VII, the peak of development gradually being reached in October. This process is not, however, simultaneous in all fish, thus giving a series of frequency distributions which overlap to a greater or lesser degree. Despite this, there are periods which appear to correspond to the prevalence of particular stages of gonad development (Table 3). The periods in which consecutive stages are dominant decrease gradually, the longest stage being III lasting more than 90 days and the shortest stage being V lasting 30 days. The changes taking place in the herring gonads can be traced by the modal frequency of fish in the consecutive stages. The points representing herring in the consecutive stages occurring in the greatest number have been inserted on a common time axis (Fig. 3). Two peaks are evident, one in May at stage III and the second in October at stages VI and VII. The modal values for these periods range between 80% and 85%, composed with about 50% for the stages in July-September.

This may indicate homogeneity regarding the maturity of herring in the periods investigated. It can be seen from the histogram (Fig. 3) that there is little variety of stages both at the beginning and the end of the period. During the middle part of the July-September sub-period, however, the homogeneity diminishes, the periods characteristic of individual stages begin to overlap, and the rate of change of gonad development accelerates. The great differentiation of maturity of gonads during that time most likely results from the fish being at various stages of readiness for the approaching spawning. The reason for this may be found in the availability of food during the period of intensive feeding (Benko and Wilson, 1962).

Table 3. Periods during which different stage of maturity of gonads predominated in herring samples.

Stage of maturity	Time range of dominant stage	No. of days
VIII+II	- 30 Mar	>60
III	Apr 1 - 30 Jun	90
IV	Jul 1 - 20 Aug	50
V	Aug 21 - 20 Sep	30
VI+VII	Sep 21 - 30 Oct	40
VIII	Nov 1 -	>30

From the percentages of male and female herring in the various stages of gonad development (Table 2), the modal frequency of fish in consecutive stages of gonad maturity, the distribution of males and females in the particular stages of development in consecutive time intervals and the periods of predominance of the successive stages can be determined (Fig. 4 and 5). The process of activating of the gonads generally follows that described above for sexes combined. There are no noticeable differences between males and females from the beginning of the year to July. During the first 20 days of August, the female gonads develop somewhat faster, following which there is a slowing down and the rate of change favours males. A substantial percentage of individuals with gonads at different stages of maturity appears when stages IV and V predominated, e.g. during 1-20 August, males and females at stages other than stage IV account for about 25%. Differences between the periods of stages IV and V are evident for males and females as follows: stage IV predominance lasts for about 50 days in the case of males and for 70 days in the case of females, a difference of 20 days; the corresponding values for stage V are 30 days for males and only 10 days for females. However, the total time in which the two stages predominate in both males and females is the same (80 days).

Although the rate at which the gonads of males and females develop through stages IV and V varies, both sexes commence spawning almost simultaneously, the males being only slightly ahead of the females. This is undoubtedly one of the biological characteristics of the species.

The period of predominance of stages VI and VII is similar in the case of both males and females (40 days) but the modal frequency for males is greater (Fig. 4 and 5). This would indicate earlier maturity of the male gonads.

The differences in the rates at which consecutive stages of gonad maturity in both sexes are attained prior to and during spawning may result from the necessity for the Georges Bank herring stock to become adapted to the environmental conditions on the spawning grounds (Benko and Wilson, 1962). The earlier maturity of the male gonads up to stage VI is probably due to the males having to wait for the females to spawn and the need for the supremacy of males during the actual spawning. This question has not yet been explained in full and requires further study.

CONCLUSIONS

1. The period of activation of herring gonads covers about 7 months (April to October) in both males and females, during which the gonads undergo 5 maturity stages from III to VII.
2. The rate of gonad development gradually accelerates from 90 days during stage III to 30 days during stage V.
3. The rate of change in gonad development is not uniform in both sexes. There are no noticeable differences from the beginning of the year to August. The females reach stage IV somewhat faster than males in August, but towards the end of the month the rate of gonad development of males is greater and this accelerated rate is maintained by males until the end of October.

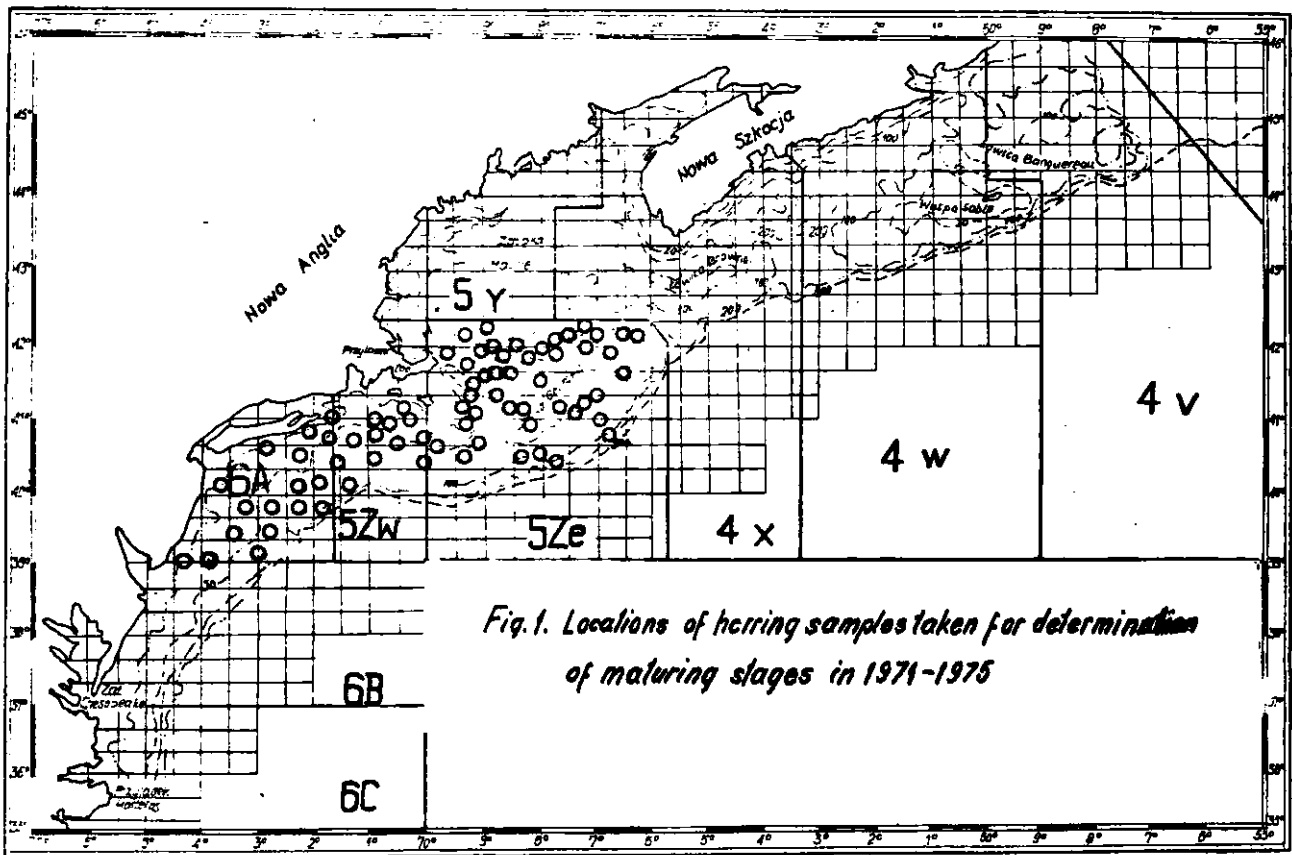
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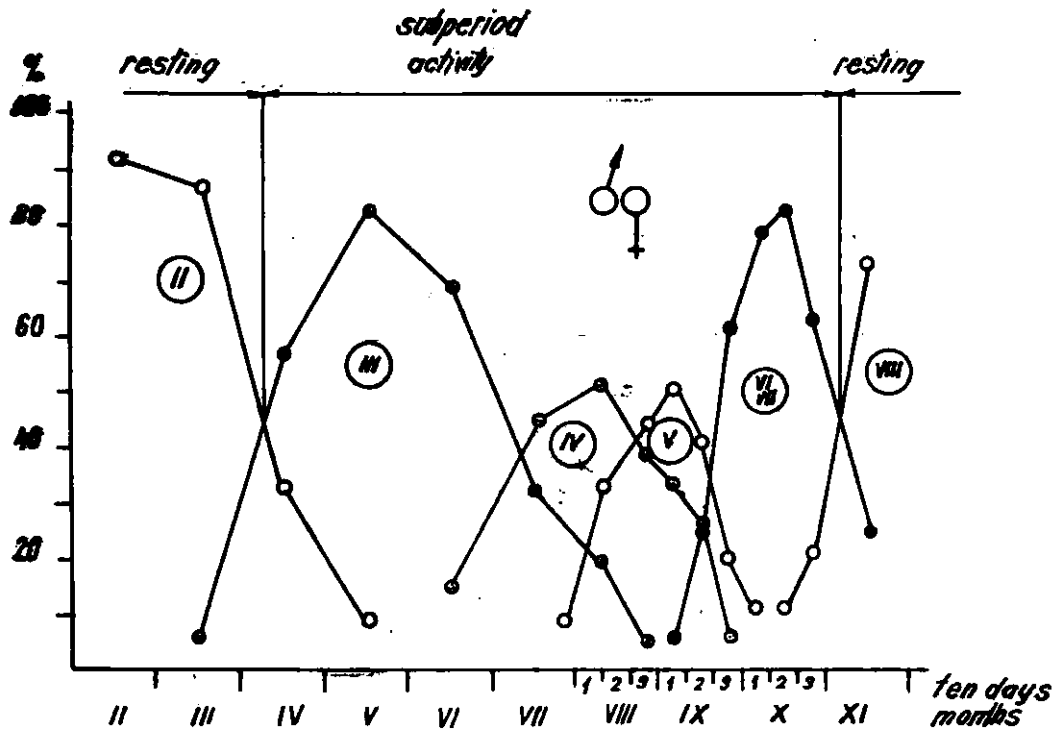


Fig. 2. Distributions of numbers of herrings in successive maturing stages

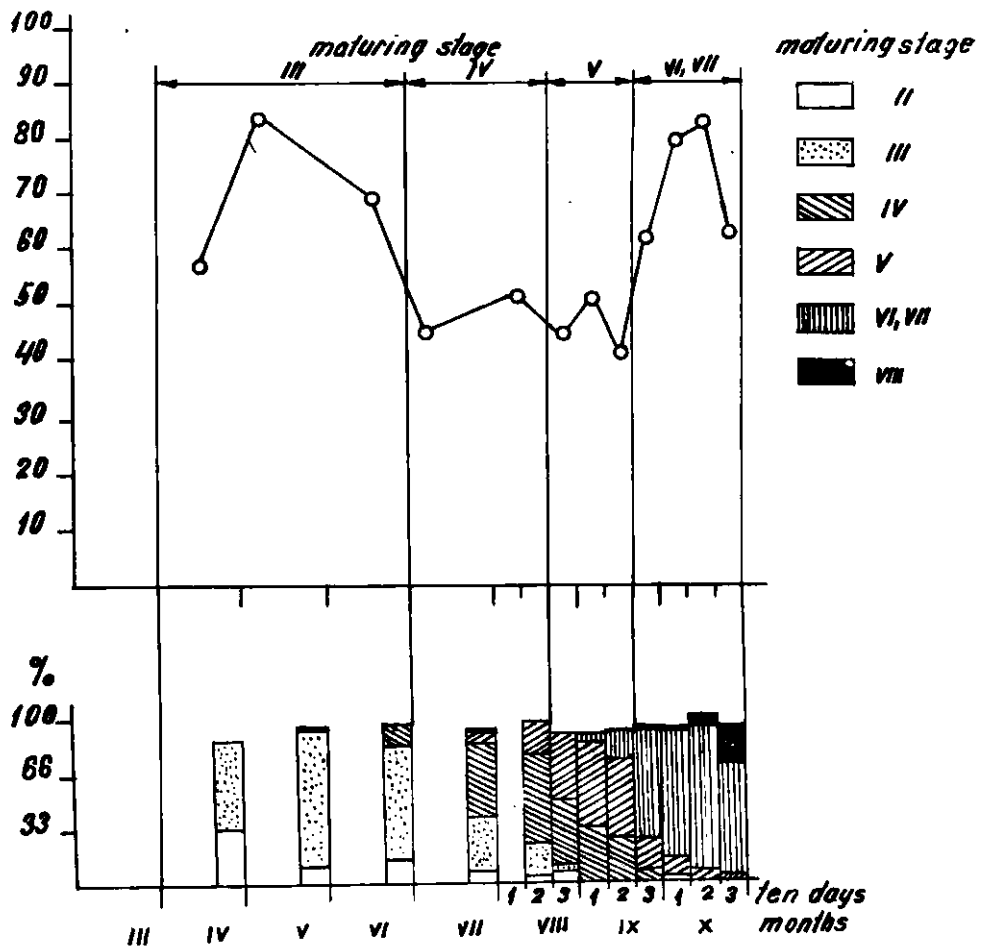


Fig. 3. Prevailing numbers of herring in successive maturing stages

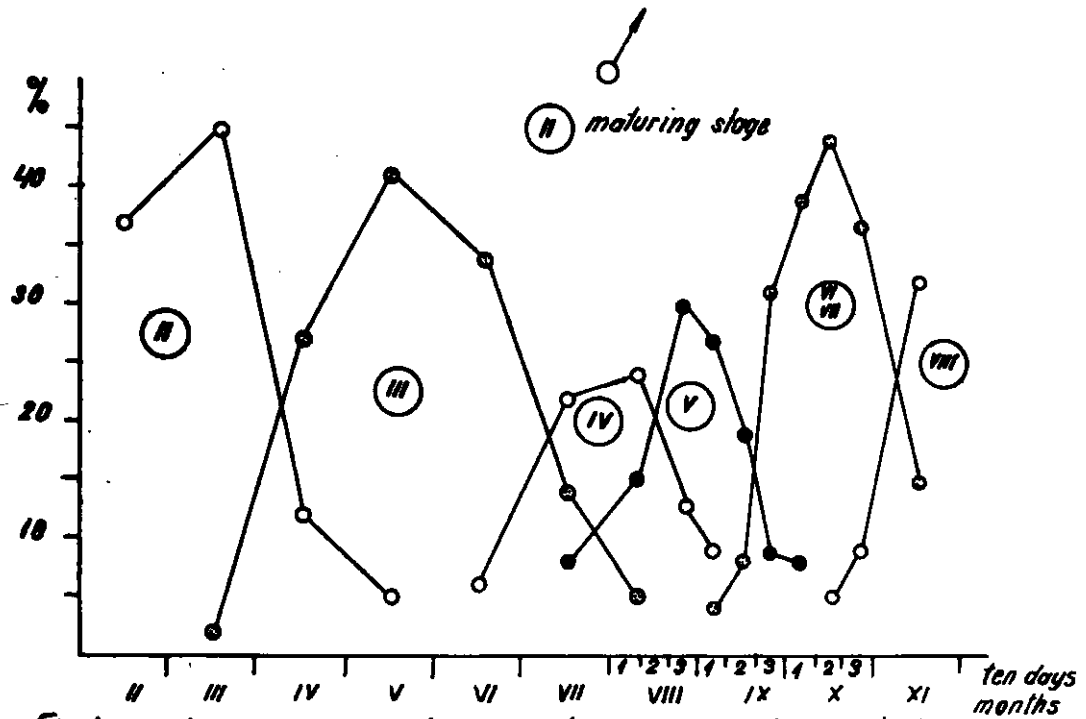


Fig. 4. Distribution of number of males in successive periods of time

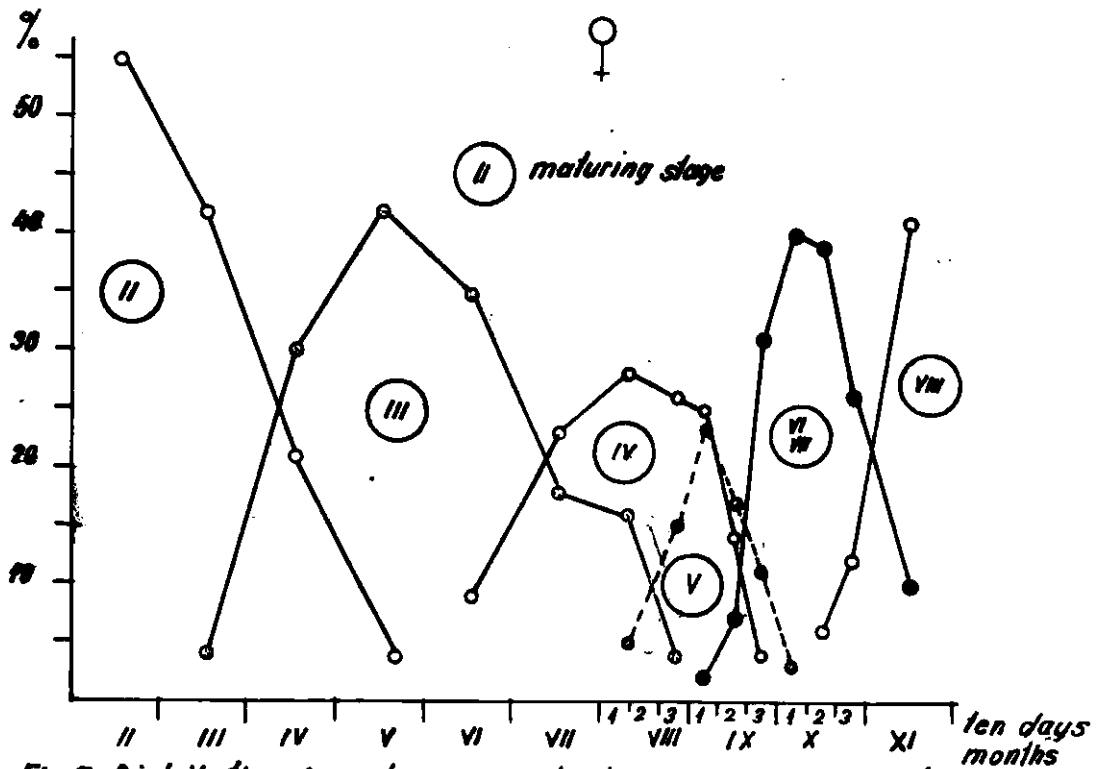


Fig. 5. Distribution of numbers of females in successive periods of time