



The Sex Ratio of the Herring Spawning Population in the Georges Bank Area

by

M. Giedz
Sea Fisheries Institute
Gdynia, Poland

Introduction

The ratio of males to females within a given spawning population influences in a specific way the course of spawning and regulates indirectly the recovery rate of the stock /Makeeva, Nikolskij 1965/.

The variations of ecological conditions and the influence of fishery can modify the sex ratio in the stock /Nikolskij, 1974/. The knowledge of variations of sexual structure of a given population might be of considerable importance in case of species under industrial exploitation. This problem is of particular significance for the herring population of the George Bank area, which was heavily exploited recently /Anthony, 1976/.

This paper presents an attempt to evaluate the sex ratio variations of the spawning population of the George Bank herring during the period of 1971 - 1976.

Materials

The sex ratio was determined in samples collected from separate tows of Polish freezing trawlers /fig.1/ conducting directed herring fishery during autumn spawning period on fishing grounds of the ICNF Division 5 Ze within the time period 1971 - 1976. The fishing gear applied was a standard pelagic trawl made of polyamide twin, the mesh width of the codend measuring 44 mm. For biological analyses 100 specimen of herring were taken every time from samples counting more than 200 specimen by their share /in %/ within consecutive 1 cm length classes.

Two methods of length measuring were applied:

- to the nearest half centimeter bar of the measuring board. This method was used until 1973,
- to the nearest centimeter below on the one centimeter scale of the measuring board. This method was used after 1973.

Determination of sexes, maturity of gonads and collecting of otholits for ageing were performed. The maturity stages of gonads were estimated applying 8 grade scale, the same as used for herring in the ICES area. This scale was accepted by the ICNAF Standing Committee of Research and Surveys in 1964 and adopted for fisheries investigation in the NW Atlantic area /ICNAF ,1965/.

The samples were collected during August - November for the time period 1971 - 1975 annually /table 1, fig.1/. For purpose of this investigation 304 length samples and 141 samples for detailed biological analyses of herring were taken. During the whole period 90633 specimen were examined in detail /table 1/.

Table 1. The number of samples collected from board of Polish Freezing trawlers in Division 5Ze during 1971-1976.

Subarea		5 Ze				
		VIII	IX	X	XI	total
length measurements	number of samples	64	145	86	9	304
	number of fish measured	19160	43244	25606	2622	90633
biological samples	number of samples	25	69	43	4	141
	number of fish sampled	2472	6264	4118	370	13224

Method

Prespawning and spawning concentrations of herring occur on fishing grounds of the George Bank during September - October /Boyar, 1971/. For determination of the sex ratio of the spawning concentrations their separation from prespawning concentrations was indispensable.

To achieve this separation the period investigated was divided into time sequences by 10 days intervals and the share of fish /in%/ of a given stage of maturity was calculated in each time sequence by means of a length - maturity key. Joining the time sequences within which fish with gonads of stages of maturity VI and VII were dominating /table 2/ enabled the determination of the assembling time of spawning concentrations during consecutive years.

Table 2. Stages of gonads maturity of herring(in percent) sampled from the Georges Bank area in September-October 1971-1975.

year	month	September			October		
	10 days period	1	2	3	1	2	3
	stage of maturity						
1971	IV-V			45.2	13.5	11.6	
	VI-VII			54.3	73.0	57.4	77.0
	VIII			.4	4.6	30.8	22.3
1972	IV-V	79.4	26.3	23.7	.4		
	VI-VII		16.6	64.2	99.6	100.0	
	VIII	.6					
1973	IV-V	86.6	54.6	3.3	1.6	3.7	.4
	VI-VII	7.2	43.1	81.7	97.9	83.6	90.8
	VIII	1.6	1.6	14.7	.5	12.2	9.2
1974	IV-V	91.0	52.3	23.6	20.4	10.2	11.5
	VI-VII	7.1	44.8	66.1	76.0	89.8	64.6
	VIII	-	1.8	3.0	3.2	-	23.9
1975	IV-V	98.6	91.9	42.2	19.6	3.8	22.7
	VI-VII	-	6.1	54.0	64.1	93.8	39.5
	VIII		.3	1.4	2.7	2.4	27.8

 The appearance period of spawning concentrations

For each time sequence the following items were calculated:

- the ratio of males and females in the total number of samples,
- the ratio of males and females within consecutive years,
- the ratio of males and females in successive length classes,
- length frequency,
- age composition.

The sex ratio within samples or groups of samples was calculated following the formula of Pope /1956/.

$$p = \frac{a}{u}$$

where: p - proportion of males or females in sample,
a - the number of males or females in sample,
u - total number of fish in sample.

Discussion and results

Table 3 presents the ratio of males and females in the sampled spawning concentrations of herring during the time period 1971 - 1976. In order to illustrate it, an index of sexual structure expressed as ratio between a total number of males and a total number of fish of both sexes $\frac{a}{p+a}$ was calculated. Its value varied from 0.487 to 0.525 and the mean was equal 0.513. The deviation from the mean was rather small, and did not exceed 3% /table 3/. These results indicate that sexual structure of the spawning concentrations is stabilised with number of males slightly dominating over number of females.

Table 3. Sex ratio of herring in spawning concentrations expressed as the proportion of males in 1971-76.

Year	Ratio of males
1971	0.505
1972	0.524
1973	0.522
1974	0.487
1975	0.515
1976	0.525
Mean \pm 2SD	0.513 \pm 0.029

In spite of the before said stability of sexual structure wide variations of age and length composition of spawning concentrations were observed./fig.2/. During 1971 - 1972 the herring population consisted of 3 to 8 years old fish, with age 5 prevailing. In following years the abundant year - class 1970 has recruited to the stock and caused the reduction of modal age in the stock in 1973 and 1974.

The lack of sufficiently strong year-classes during the following years caused that the stock grew older again, which was indicated by domination of 5 year old fish in 1975 and 6 year old in 1976.

The modal lengths of herring altered as well leading to simultaneous changes in the age composition of the stock. During 1971 -1972 fish belonging to the 30 - 31 cm length classes prevailed. On the other hand, after that time, the length of dominating length classes decreased initially to 26 cm in 1973 showing however gradual increase during following years up to 32 cm in 1976.

The sex ratio of herring by given age was investigated as well. Therefore the indices of sex ratio were calculated during consecutive years of life /for ages 2 to 8, table4/. The table shows the domination of males within the younger ages and the domination of females within older age-groups. The index value for those year classes altered within a relatively narrow range between 0.569 - 0.395. The regressions reflecting the variability of males and females in number by given age intersect each other at a point which delimits on the abscissa axis the age at which males and females are equal in number. This stage herring attains at the age of 4 years.

Table 4. Sex ratio of herring during consecutive years of the life cycle expressed as the proportion of males (a = age group).

Age group	No. in sample	Proportion of males	Correlation coefficient	Regression between age groups and ratio
2	27	0.569		
3	1664	0.518		
4	2017	0.491		
5	1308	0.476	R = -0.94	0.6023-0.0238a
6	625	0.488		
7	549	0.488		
8	130	0.395		

Moreover the changes in the male - female ratio by length - classes were investigated as well. The regressions illustrating the variations of the ratio in separate length-classes of herring are shown on fig.3. During the period of 1971 - 1975 the length-classes within which the number of males and females was equal varied from 28 cm to 31 cm.

From the data presented it results that the sexual structure of the spawning concentrations was stabilized in spite of considerable abundance fluctuations of year classes constituting the herring stock. This phenomenon can be explained by:

- relatively small differences between number of males and females during consecutive years of the life cycle which, in case of herring, did not exceed 20%,
- considerable domination of fish belonging to age - groups 3,4 and 5 consisting 72% to 98% of the spawning population during the time period of 1971 - 1975 /table 5/. /The sex ratio among herring belonging to the 3 - 5 year-classes deviated slightly from unity/.

Table 5. Georges Bank herring spawning stock paramters in 1971-1975.

year	length class within which: $\frac{\sigma}{\bar{x}} = .5$	mean age	year class by number x /000/	percentage share of 450 g groups 3,4 and 5
1971	30.5 cm	5.1	3491	72
1972	31.2 cm	5.6	5659	70
1973	28.8 cm	3.3	4619	77
1974	29.4 cm	4.1	3146	97
1975	31.4 cm	5.1	1904	95

x after V.G. Anthony 1976

Age-group 4 plays a particular role in the stabilization process of the sexual structure of spawning concentrations. Herring of this age have dominated the spawning concentrations of that stock during last few years. This is the youngest age

group, fully recruited to the adult stock (Benko, Wilson 1962, Boyar 1971). The sex ratio in age-group 4 is equal to 1. Similar structure of sexes of the total herring stock was observed during spawning. Fish belonging to age-group 4 play a fundamental role in the process of the stock recovery in case of severe reduction of older year-classes abundance /i.e. due to overfishing/. Moreover, the same year-group can simultaneously balance the sex ratio which, in turn, enables an appropriate course of spawning.

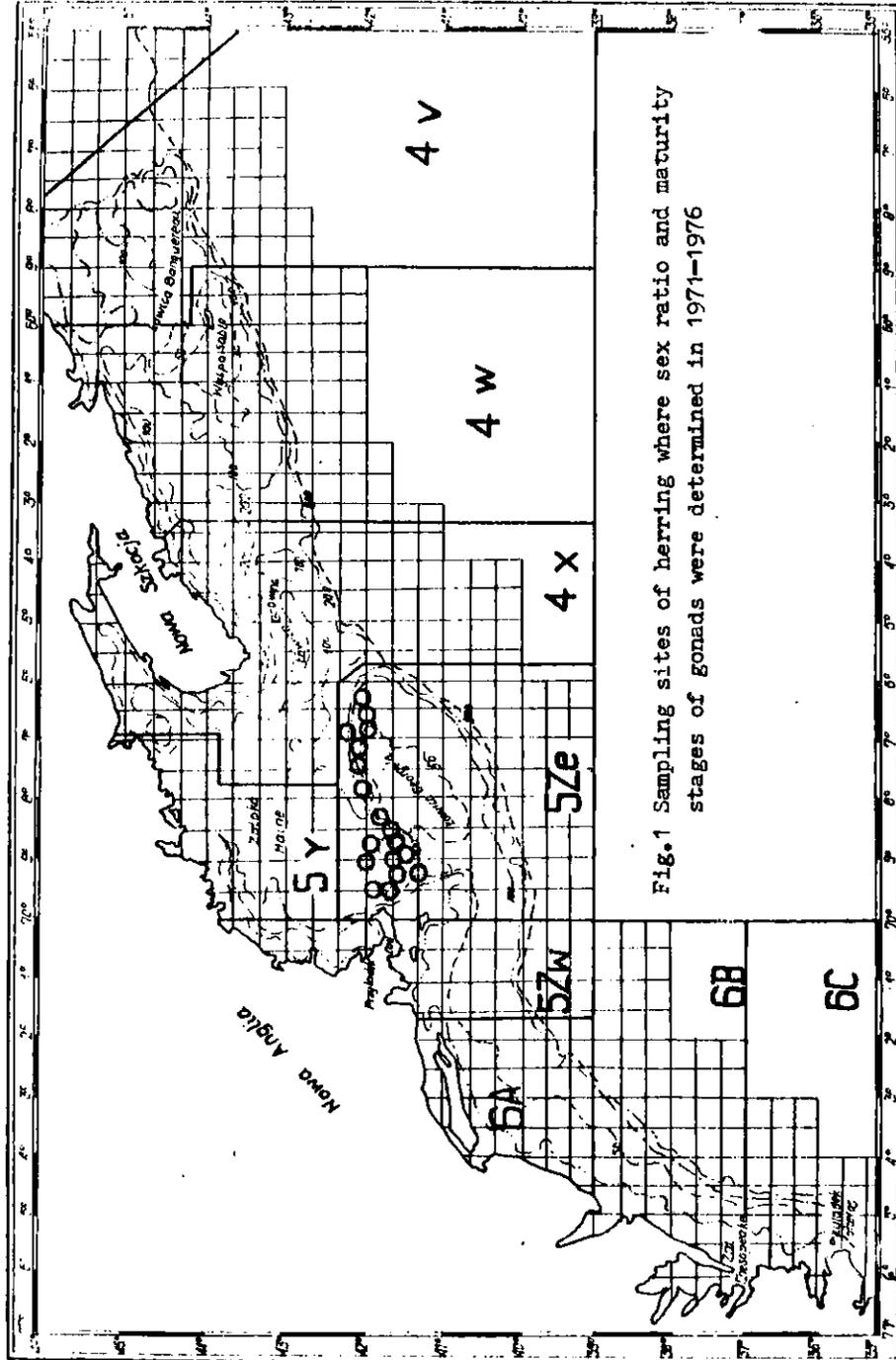
Conclusions

1. The sex ratio of the spawning concentrations of the George Bank herring stock approximated unity, while males dominated slightly over females. Such situation was maintained during the whole time period from 1971 to 1975 in spite of wide variability of abundance of year-classes forming the adult stock,
2. The variation between ratio of males to females oscillated from 0.6 to 0.4 in consecutive years of the life cycle of one year-class /from age-group 2 to 8/. Among young fish /4 years old and younger/ males dominated, while, among older fish, females were in majority,
3. During the time period 1971 - 1975 the high stability of sex ratio of the spawning populations of herring was secured by:
 - small differences between number of males and females in consecutive years of the life cycle,
 - domination of fish belonging to age-groups 3, 4 and 5 /from 72% to 97%. In these age-groups the ratio of males to females varied between 1.10 to 0.91.

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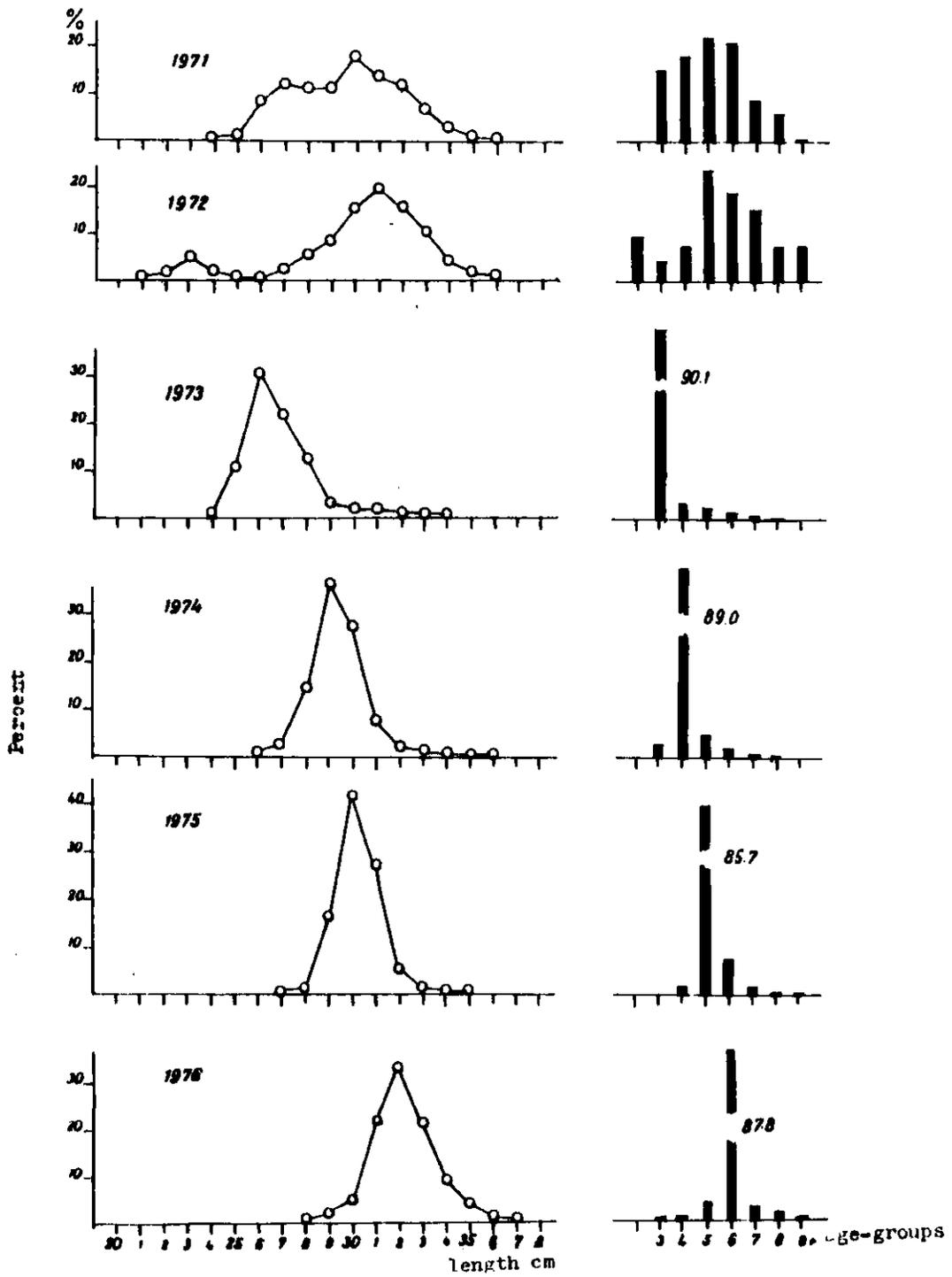


Fig.2 Length and age distribution of herring spawning concentrations in 1971 - 1976

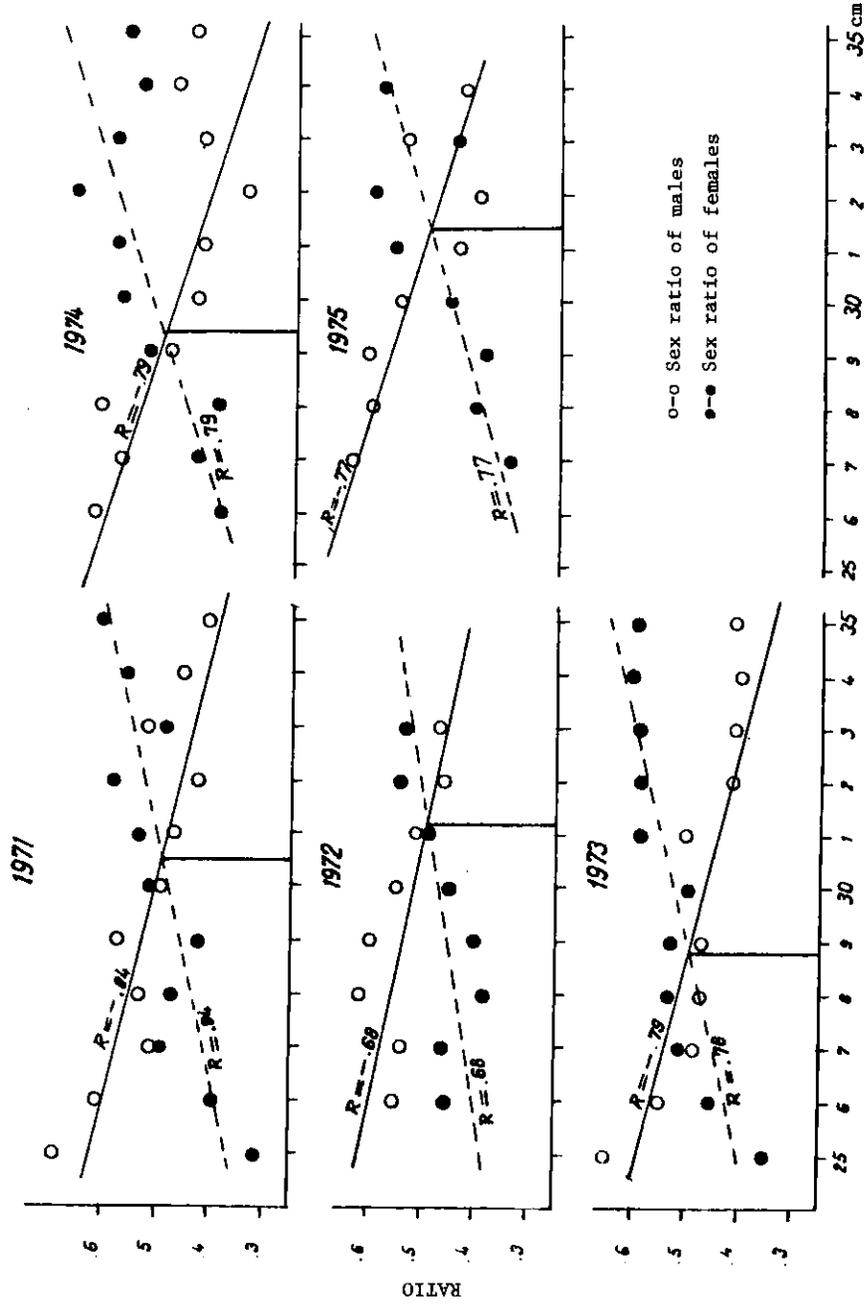


Fig.3 The index of sex ratio of herring by length in spawning concentrations in 1971 - 1975

