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Changes in the population structure of the herring in the Greifswalder Bodden during spawning time in spring

by

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Summary

Investigations on the spawning herring were performed in the Greifswalder Bodden during the spawning season (February/March to June) during the period 1975 - 1977. In 1977, these studies were augmented by certain morphometric measurements. Is was possible to prove that the structure of the population changes in the course of the spawning season. This is reflected by changes in parameters such as total length L_t, age, severity of parasitic infestation and also the number of vertebrae and gill trap processes. The numbers of rays in the dorsal, pectoral and anal fins which exhibited no clear changes in the course of the spawning season proved to be unsuitable as means for detecting changes in the population structure.

Résumé: Pendant la saison du frai (des mois de février/mars au mois de juin) des années 1975, 1976 et 1977 on a effectuédes études portant sur le hareng du frai de l'étang Greifswalder Bodden. Des mensurations morphométrigues spéciales ont élargi, en 1977, ces études. On a pu montré qu' au cours de la saison de frai il y a des changements dans la structure du peuplement qui s'expriment par des paramètres se modifiant, comme la longueur totale L_t, l'âge, l'intensité de la vermine de parasites, mais aussi le nombre des vertèbres et des appendices de nasse de branchies. Le nombre des radiants de nageoire des nageoires dorsal, pectoraux et anal qui n'a montré que des modifications insignificatives a prouvé être non approprié á démontrer des changements dans la structures du peuplement.

Introduction

In spring, the spawning fish stocks in the coastal waters off Ruegen form an important basis for the herring fisheries in the GDR. The optimum exploitation of these herring stocks will remain an important task facing the fishing industry in the future. This necessitates the forecasting of catches on the basis of analyses of the population structure. Such an analysis must consider the spawning fish stocks, their migration and the recruitment of larvae and young fish.

This paper deals with changes in the length, age, maturity and severity of infestation by parasites as observed in the samples during 1975, 1976 and 1977.

The above parameters and their changes within the spawning stocks provide initial indications of the fact that herring from various populations enter the coastal waters of Ruegen in the course of a spawning season. In order to obtain proof of this and to be in a position to identify the Ruegen herring stocks, extensive morphometric and meristic investigations were recommenced on the herring Clupea harengus L. in 1977.

The work undertaken by ANWAND (1962) and BERNER, WALDMANN (1962) on these spawning Stocks show that morphometric and meristic features vary widely under the influence of environmental factors, so that the unambiguous identification of the stocks will probably only be possible using biochemical means.

Material and methods

The samples were taken from the trap neths and set nets laid by the coastal fisheries in the Greifswalder Bodden during the spring herring season in 1975, 1976 and 1977. This paper based on 24 samples containing a total of 2.396 animals. The samples were taken at the sites shown in figure 1.

The following features were determined on each of the herring investigated:

- total length in cm
- sex and maturity of the gonads
- severity of parasitic infestation (only for animals obtained during 1976 and 1977).

The age was determined by examining sagitta otoliths. Although

23 samples were taken during the spawning season in the spring of 1977, only 8 of them were analysed for this paper. Only the following of the broad spectrum of meristic parameters will be considered here:

- the number of vertebrae VS
- the gill trap processes of the lower first left gill arch (Rf)
- the number of rays in the dorsal fin
- the number of rays in the left pectoral fin
- the number of rays in the anal fin.

The lengths were measured to the nearest half centimetre. The urostyl was disregarded when counting the vertebrae. Rudimentary spines were taken into account in the number of rays in the dorsal fin. In the anal fins, fin rays with a common spine were counted separately.

The maturity of the gonads was determined by means of the maturity table specified ba ICES in 1962.

The following levels were fixed for estimating the severity of parasitic infestation:

0 - no parasites
1 - isolated parasites
2 - moderate infestation (up to 10 parasites)
3 - severe infestation (more than 10 parasites)

The arithmetic mean ($\bar{x}$), the scatter (s_x) and the variation of the mean ($S_{\bar{x}}$) were determined for the length, age, maturity and parasitic infestation of the samples investigated for 1075, 1976 and 1977. These were augmented by the mean, scatter and variation of the mean for the number of vertebrae (VS), gill trap processes (RF), the dorsal fin rays (Fls_D), the pectoral finrays (Fls_P) and the anal fin rays (Fls_A) of the samples investigated for 1977.

Any differences observed in the mean values were checked for significance.

<u>Results and discussion</u>

1. The length distribution in the samples taken from 1975 to 1977

Table 1:

Sampling date	L_t (cm)	$S\bar{x}$	Sampling date	L_t (cm)	$S\bar{x}$	sampling date	L_t (cm)	$S\bar{x}$
1975			1976			1977		
II. 28.	26.5.							
III. 13.	26.8	0.19	III.			III. 4.	27.9	0.18
21.	25.4	0.15	25.	28.75	0.23	17.	26.2	0.24
						31.	25.35	0.18
IV. 4.	24.6.	0.15	IV. 1.	26.05	0.22	IV.		
18.	24.4	0.17	9.	27.95	0.21	18.	24.8	0.15
			15.	26.15	0.19			
			23.	24.7	0.18	25	24.85	0.1
			30.	25.54	0.19			
V.			V.			V. 2.	23.8	0.14
			14.	23.36	0.19	13.	22.9	0.16
			21.	23.2	0.17			
30.	23.3	0.15						
VI.			VI			VI		
						3.	22.1	0.13
12.	22.9	0.15	10.	22.6	0.16			

As the length measurements show, the total length L_t of the animals in the spawning stocks changes as the spawning season progresses. At the beginning of the spawning season, animals with a larger mean length predominate, whereas animals with the dmallest overall length were found in the samples towards the end of the spawning season.

ANWAND (1962) came to the same result. For example, he observed mean herring lengths of 24.8 cm and 24.0 cm respectively during April in 1960 and 1961. The corresponding figures for May were 23.6. in 1960 and 22.8 cm in 1961, whereas herring lengths of 21.9 cm were measured during June, 1960. The mean length over the whole spawning season was stated to be 24.6 cm in 1960 and 23.6 cm in 1961. We measured lengths of 24.8 cm for 1975, 25.4 cm for 1976 and 24.75 cm for 1977.[x] Figure 2 shows the distribution of lengths over the period covered by our studies.

x) It must be pointed out that the mean value for the total length L_t, the age and the degree of maturity are affected by the point during the spawning season when the samples are taken.

2. The age distribution in the samples investigated

Table 2: Mean age in years and the variation of the mean values for the samples taken from 1975 to 1977

Sampling date	age	$S_{\bar{x}}$	sampling date	age	$S_{\bar{x}}$	sampling date	age	$S_{\bar{x}}$
1975			1976			1977		
II. 28.	4.03	0.1						
III. 13.	4.01	0.1				4.	4,4	0.12
21.	3.60	0.07	25.	4.17	0.11	17.	4.3	0.14
						31.	3.6	0.11
IV. 4.	3.50	0.07	1.	4.25	0.12			
18.	3.30	0.08	9.	4.7	0.13	18.	3.95	0.12
			15.	4.15	0.11			
			23.	3.67	0.1	25.	3.6	0.09
			30.	3.72	0.12			
V.						2.	3.05	0.06
			14.	3.5	0.09	13.	2.8	0.07
			21.	3.4	0.1			
30.	2.5	0.06						
VI.						3.	2.5.	0.05
12.	2.3	0.05	10.	3.2.	0.06			

The results show that not only does the overall length decrease as the spawning season proceeds, but that also the spawning stocks become younger.

The distribution of the age groups among the different samples shows that herring of the year classes 4 to 6 predominate among the spawning stocks at the beginning of the spawning season.

As the spawning season progresses, the animals of the year classes 3 and 4 form the majority of the samples, the spawning stocks at the end of May and in June consisting largely of 2-year old animals. This is not quite so evident in the samples for June, 1976, where, although the overall age of the spawning stock was reduced, the dominance of the xear class 2 was not pronounced.

ANWAND (1962) also found thst the spawning stocks became younger in the course of the spawning period and published the following figures:

April, 1960 - 3.8 years	April, 1961 - 3.4 years
May, 1960 - 3.2. years	May, 1961 - 2.8 years
June, 1960 - 2.2. years	

Both the results of our investigations and results which have appeared in the literature show that changes occur in the spawning herring stocks not only during the spawning season but also from year to year with regard to the mean length and age. These are ascribed to recruitment in the different years and % growth.

Although comparison of the mean length and age figures for the herring stocks spawning in the spring of 1960 and 1961 show that both parameters were tending to decrease (ANWAND 1962), this cannot be generalised to cover the period in which our samples were taken. The mean age was 3.3 years in 1975, 3.86 in 1976 and 3.54 years in 1977. The differences between the mean values are insignificant (figure 3).

3. The distribution of sexes and maturity

Figure 4 shows the proportions of the samples accounted for by the different sexes. The sexes were evenly balanced during 1975 and 1977, females accounting for 49.8 % in 1975 and 50.8 % in 1977. In contrast, the samples taken during 1976 contained only 31.3 % female animals. Although the sexes are approximately evenly balanced at the beginning and end of the spawning season, male animals which accounted for 84 % of the specimens in the samples clearly predominated from the middle of April to the middle of May. +) Analysis of the distribution of the degree of maturity provides information on the course of the spawning process.

A general idea of the gonad maturation process for the period is given in figure 5. It can be seen that the point at which maturity has reached a stage to permit spawning has shifted. For example, in February 1975 53 % of the animals had already reached the maturation stages VII and VIII, 20 % were ready to spawn (VI) and 27 % had reached the maturation stage immediately prior to spawning. The samples taken in April, May and June contained no or only isolated animals which were not yet ready to spawn. The high proportion of animals (66 %) which had reached maturation stage VI was conspicuous in the June samples. The samples taken during 1976 contained animals which had reached the gonad maturation stages VI, VII and VIII. Herring which had reached the stage prior to spawning were found only in samples taken on the 9th and 15th of April. In contrast to the samples taken in 1975, animals which had reached maturation stage VIII were not observed until the middle of April.

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x) It is possible that the fluctuations in the proportions between the sexes was caused by a methodological error.

As in the preceding year, the proportion of animals in maturation stage VIII dropped in June, 1976, and the number of animals in maturation stage VI increased.

Table 3: Mean maturities in the 1977 samples, variation of mean values and results of comparison of the mean values

sample date	mean maturity	$S_{\bar{x}}$	r
4.3.77	4,2.	0,09	3,8
17.3.77	4,8	0,12	10,05
31.3.77	5,6	0,26	4,9
18.4.77	6,35	0,13	13,4
25.4.77	5,4	0,48	2,45
2.5.77	6,65	0,13	15.31
13.5.77	6,8	0,02	28.55
3.6.77	5,9	0,43	3,53

Animals with the maturation stages IV and V predominated in the samples taken on the 4th and 17th of March. In the subsequent month animals were ready to spawn and those immediately prior to this stage were present in the same proportions, whereas animals which were ready to spawn and spent animals predominated in the may samples. The relatively high proportion (32%) of animals in the prespawning stage in the sample taken on June 3rd, 1977, is conspicuous.

Altogether, the distribution of maturation shows that the point at which readiness for spawning occurs differs among the three years covered by our investigations. This can be explained by the fact that low water temperatures prevailed in the Greifswalder Bodden during March and April in 1976 and 1977, so that the gonads reached maturity more slowly. The availability of food is another important factor affecting maturation.

Table 4: Mean severity of parasitic infestation in the samples.
Percentage of different infestation severities,
differences between infestation severities in the 1977 samples.

sampling date	mean infestation	severity of infestation 0	1	2	3
1976					
III					
25.	2.1	10	13	34	43
IV.					
1.	0.56	68,7	13.1	12.1	6.06
9.	1.5	29	23	17	31
15.	1.34	34	21	22	23
23.	0.3	78	16	4	2
30.	0.67	64	14	13	9
V					
14.	0.2	86	10	2	2
21.	0.01	99	1	0	0
VI					
10.	0.01	99	1	0	0

sampling date	mean infestation	severity of infestation 0	1	2	3	r
1977						
4.	1.35	26.5	33.7	27.5	12.2	
17.	0.71	56.6	24.2	10.1	9.1	3.05
31.	0.37	68	21	10	2	5.4
18.	0.28	75	23	1	1	7.1
25.	0.41	62	34	4	0	11.8
2.	0.44	60	36	4	0	5.7
13.	0.32	70	28	2	0	6.9
3.	0.33	71	25	4	0	6.8

The mean severity of infestation exhibited by the samples for 1976 is 0.74 in comparison to the mean severity of infestation of 0.53 found for 1977. Analysis of the mean severity of infestation for the 1977 samples showed that, with r 3, the intensity of infestation varied significantly. There appears to be some connection between the overall length L_t and the severity of infestation, the infestation of animals with a large L_t being more severe. For example, L_t and the severity of infestation were 28.75 and 2.1 respectively on March 3rd, 1976, the corresponding figures for March 4th, 1976, being 27.9 cm and 1.35. In contrast, samples taken in May and June and containing animals with a smaller mean length were not or only slightly infested by parasites. PARSONS and HODDER (1971) in their studies on the Canso Bank and Banquereau herring also report a rise in the occurence of nematodes and in infestation severity as the fish becomw larger and, thus, older. The suitability of biological feature for distinguishing between stocks according to size or age will be further investigated.

Marking experiments (BIESTER, JÖNSSON and KRÜGER, 1975; 1976) have shown that animals arriving at the beginning of the spawning season tend to migrate the west after leaving the bodden, whereas herrings with a smaller mean overall length migrate into the Baltic in a north-eastern direction. It is an interesting fact that the intermediate host for the larval nematode Anisakis, a Euphausiacean, does not occur in the Baltic but that herring in the North Sea become infested (GRABDA 1974).

5. The number of vertebrae

The mean number of vertebrae as determined for the samples studied for the year 1977 is 55.86.

Table 5: Mean values for the number of vertebrae in the 1977 samples considiered, the variation of the mean values $S_{\bar{x}}$, the breadth of variation and the results of comparison of the mean values.

Date	VS	$S_{\bar{x}}$	breadth of variation	r
4.3.77	56.16	0.08	55-58	
17.3.77	56.14	0.08	54-58	0.17
31.3.77	56.08	0.07	54-58	0.73
18.4.77	55.76	0.08	53-58	3.33
25.4.77	55.75	0.1	49-58	3.15
2.5.77	55.80	0.08	54-58	3.0
13.5.77	55.61	0.08	53-57	4.58
3.6.77	55.58	0.08	53-58	4,80

The numbers of vertebrae were higher in March than in April, May and June. Analysis of the mean values revealed significant differences, these being relatively obvious in the samples taken in May and June.

ANWAND (1962) found that the mean numbers of vertebrae for 1960 and 1961 were 55.57 and 55.59 respectively. Further figures for the numbers of vertebrae were published by HEINCKE in 1888 - 1891 (56 = 0.056), ALTNÖDER in 1928 - 1932 (55.66 = 0.02) POPIEL in 1950 - 1952 (55.55 = 0.049) and BERNER and WALDMANN in 1954 and 1958 (55.85 and 55.7 respectively). The mean number of vertebrae determined by ourselves conforms with that found by BERNER and WALDMANN in 1954 (1962).

It is already known that the number of vertebrae of the Baltic herring is subject to fluctuation. These fluctuations are generally regarded as being due to the salinity and temperature situation in the habitat. The number of vertebrae can be used to distinguish between groups of herring of other origine (western Baltic up to 56, Baltic proper up to 55.2 vertebrae) and to relate them to their feeding and places of migration in the open sea outside of the spawning season.

The numbers of vertebrae determined by ourselves and the differences between their mean values are further proof of the fact, that the population structure of the herring spawning in the Greifswalder Bodden changes in the course of the spawning season.

In view of the relatively high values of 56.08 to 56.16 in March, it can be concluded that the animals concerned came from the Western Baltic, whereas the animals with values of up to 55.8 originated in the Central Baltic.

6. Number of gill trap processes

ANWAND (1962) found without taking the length of the herring into consideration that the mean number of gill trap processes was in the spring herring of 1960 45.97. The mean number in the samples which we studied was 45.1. Comparison of the mean values revealed that the differences between the March samples and the April, May and June samples are significant. Changes in the population structure of the spawning stock can thus also be proved by means of the gill trap processes.

7. Number of rays in the fins

7.1. The numbers of rays in the dorsal, left pectoral and anal fins are not suitable as means to indicate changes in the population structure since no significant differences were found between their mean values.

Figure 3: Different degrees of maturity in % at the various sampling dates from 1975 to 1977

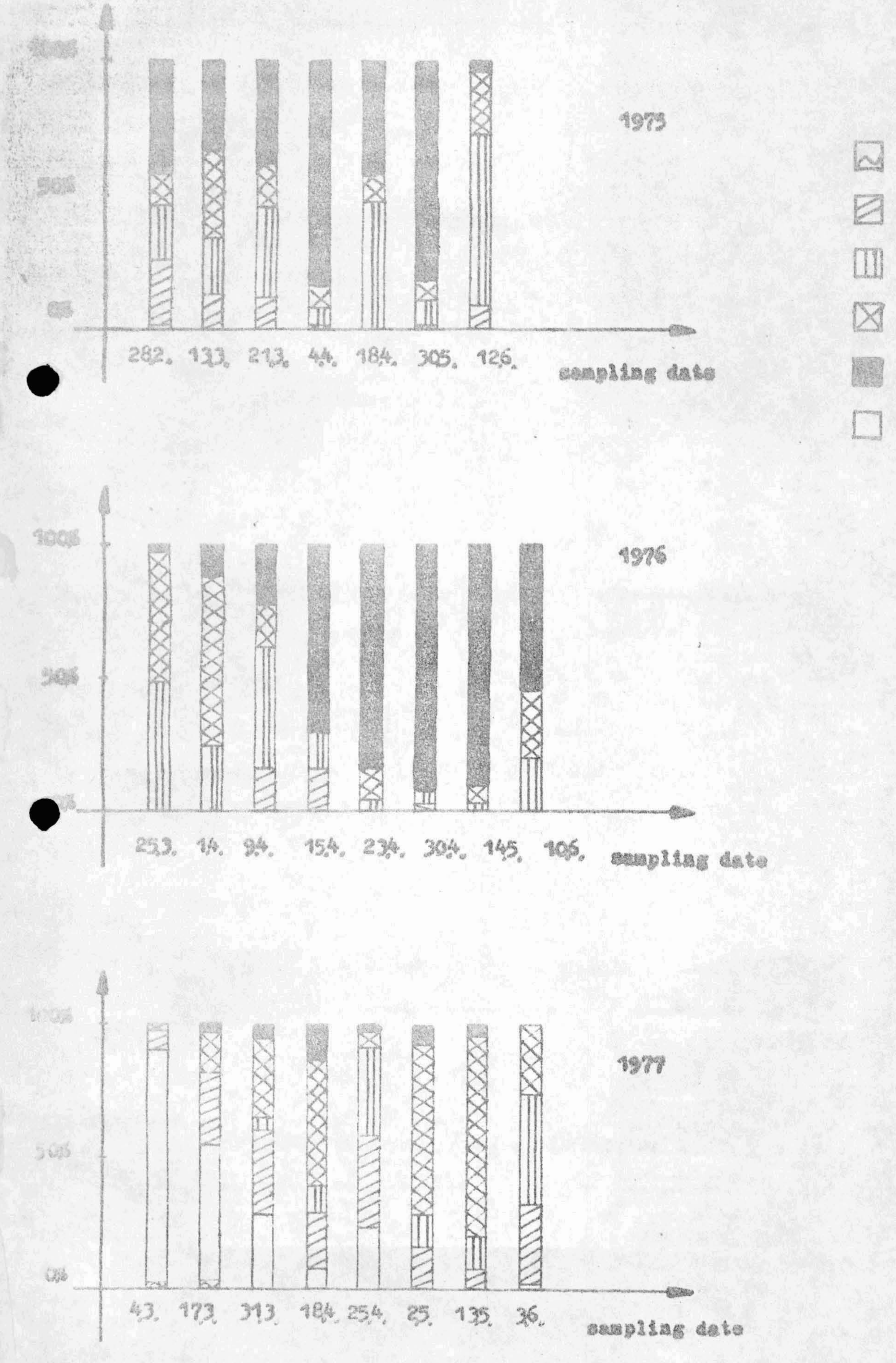


Figure 1: Sampling sites

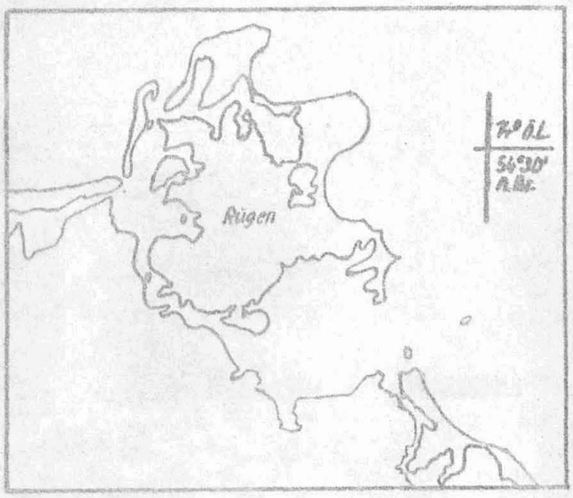
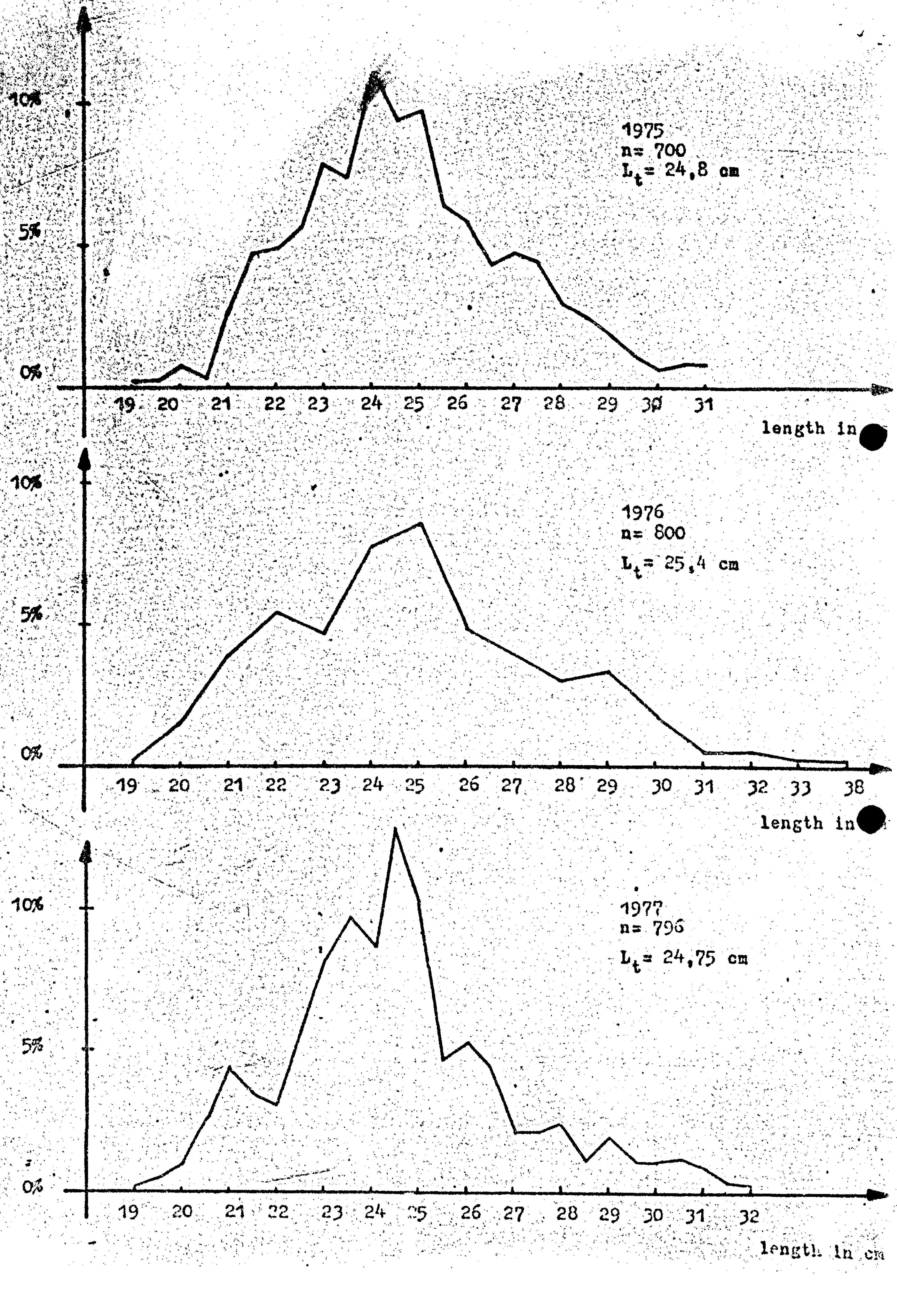


Figure 2: Length distribution over the period 1975 - 1977



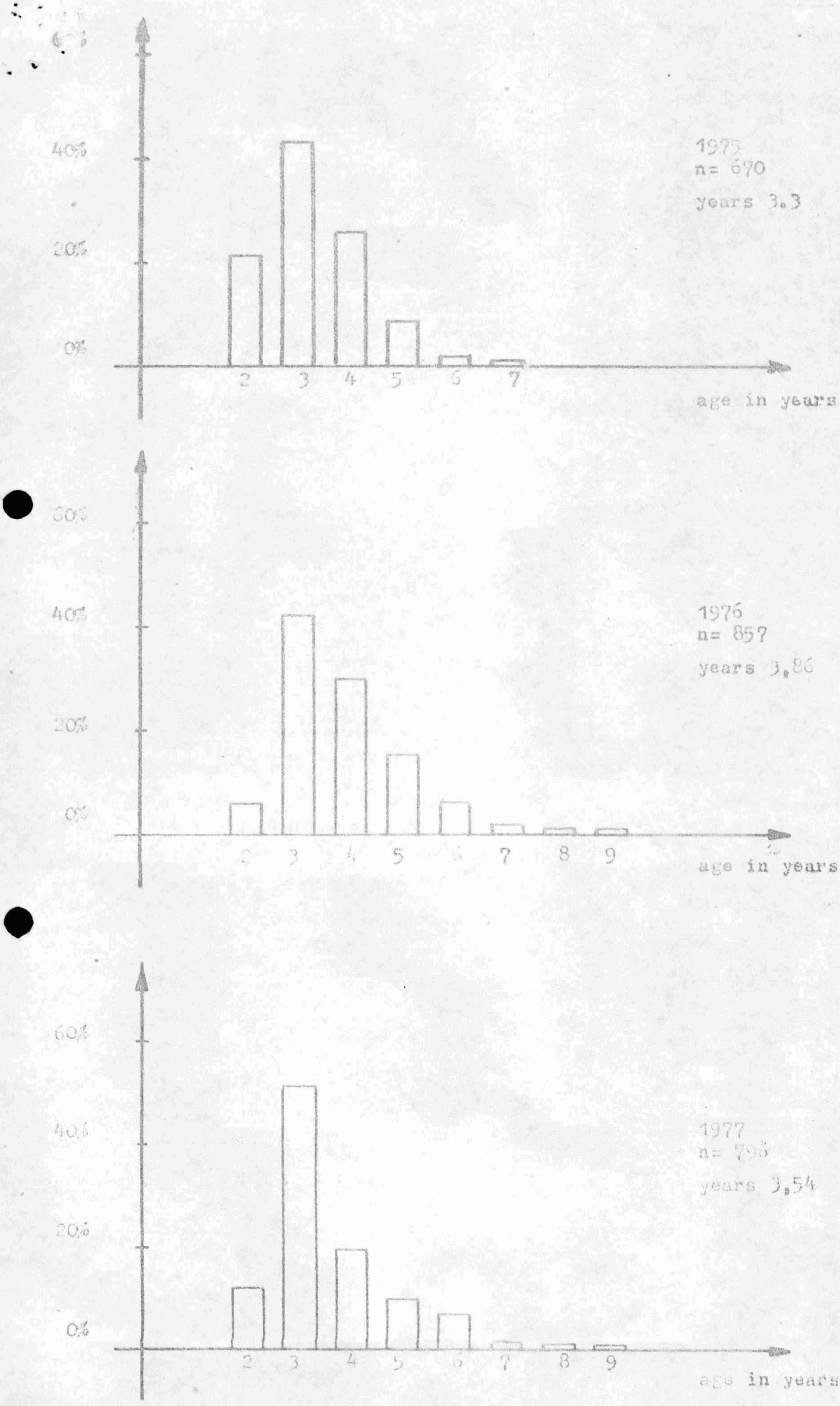


Figure 3: Age composition over the period 1975 - 1977

Figure 4: Balance of sexes in % for the years 1975 – 1977

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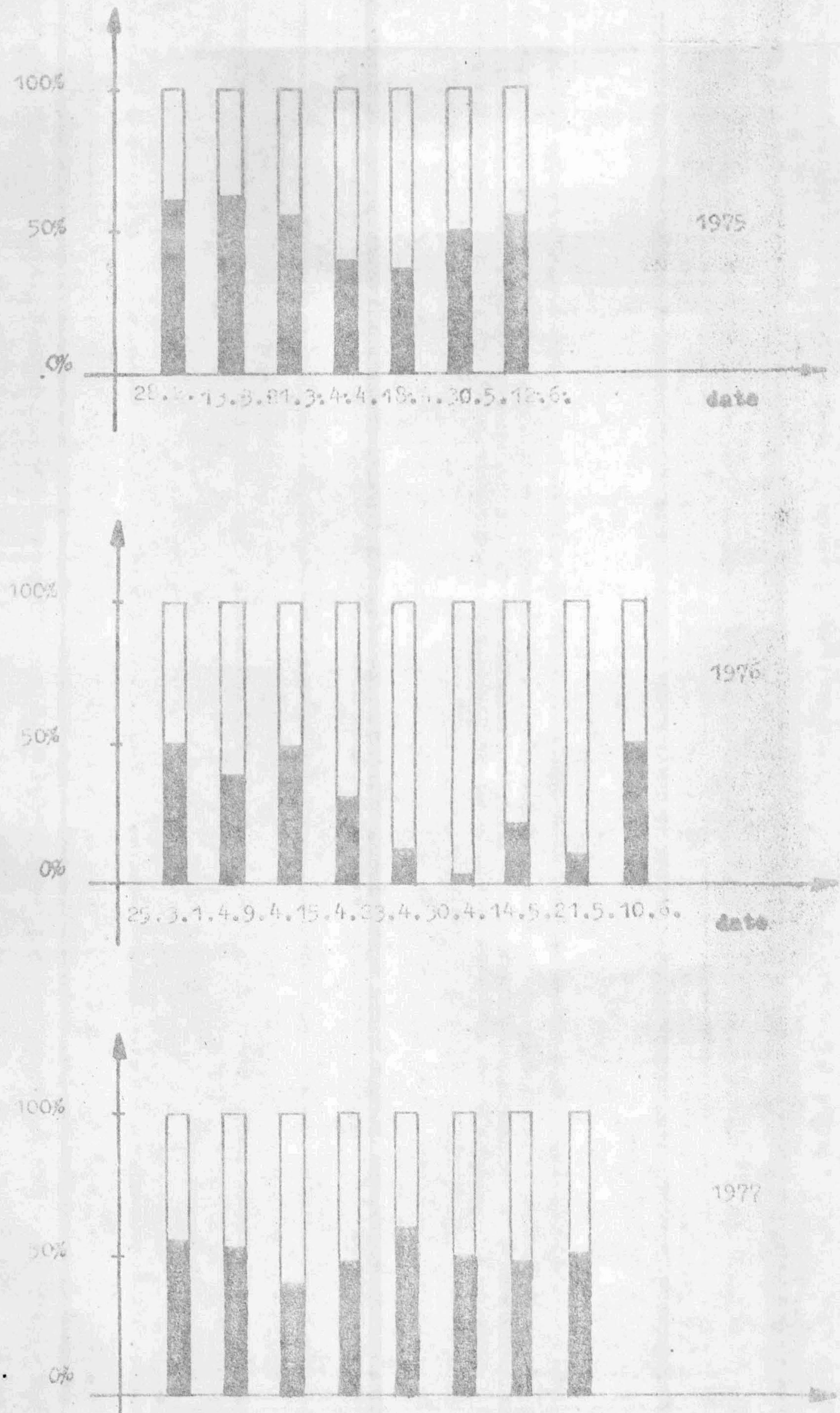
□ ♂



On average, the dorsal fin had 18.6 rays, the left pectoral fin having 17.6. ANWAND (1962) counted 17.25 fin rays in the latter fin during his studies in 1960. The average number of fin rays in the anal fin is 17.3.

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