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Scale Character and Growth Rate

A study on small
fat herring from North Norway

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Preface.

Mahhargo Soeprapto has been studying marine biology at the University of Oslo for 5 years under a grant from the Norwegian Students' Association. The present paper is based on his thesis for the degree «magister scientiarum». It is the result of an investigation planned in collaboration with the Marine Research Institute, Directorate of Fisheries, for which I beg to acknowledge our debt of gratitude.

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July, 1958

Johan T. Ruud

Introduction

From the time when scientists first began to study the life history of the food fishes, the migratory fish have been an object of special attention, particularly those species whose migrations appeared most difficult to comprehend, and whose far-reaching influence on the yield of the fishery played a most important part in the economical conditions of whole coastal districts.

In the first place the herring and its movements have for years been most zealously studied, especially in the seaboard countries of Northern Europe, where the economic importance of this fish can hardly be overrated.

It is true that the results obtained do not provide an absolutely final solution of all the problems presented by the life history of the herring.

We have, however, by the application of the various morphological, hydrographical and biographical means of investigation, undoubtedly arrived at so extensive an elucidation of the question that we no longer stand, as formerly, helpless and indeterminate in face of the vicissitudes occuring in the herring fisheries.

On this occassion I would like to offer my cordial thanks to Director Gunnar Rollefsen, Messrs Finn Devold and Thorolv Rasmussen at the Marine Research Institute Directorate of Fisheries in Bergen, who gave me permission to borrow the material and advised me in my work.

Finally, I would like to thank Mr. Arvid Hylen M. Sc. for his kind help.

Previous investigations

The introduction of the scale analysis in the herring investigations led not only to the discovery of the great fluctuations in the numerical strength of the year-classes, but also greatly increased the understanding of the life history and migrations of the Atlanto-Scandian herring.

Lea, who had an intimate knowledge of the scale of the herring, found that the appearance of the winter rings varied in different ways.

The rings found in a single scale are rarely quite alike, and there is a difference between the corresponding rings in the scales of herrings from different waters.

I would like to quote Lea's words (1929, p. 22). He writes: «In general it may be said that the peculiarities that may be observed on the scales of the herring, taken together, form a picture of the dependence of the herring, its reaction to the environment and the changes of environment in which it has lived and which it has passed through, during the course of its life».

Lea mentions that the winter-rings are as a rule sharper in the young herrings taken in northern Norway, than in the herrings taken at the southern part of the west-coast and classified them as northern- and southern-type respectively (See plate p. 12).

Runnstrøm (1936) analysed a large quantity of scale material from Atlanto-Scandian herring and found, that the number of «Southern-type» scales decreased and the number of «Northern-type» increased from the south to the north. In samples of small fat herring from Hordaland and Rogaland, 92.6 % were of «S-type» and 7.4 % of «N-type». In Møre 51.9 % were of «S-type» and 48.1 % of «N-type», and in Troms 6.1 % of «S-type» and 93.9 % of «N-type».

Lea (1929), Ottestad (1934) and Runnstrøm (1936) showed that small fat herring grow faster in southern than in northern waters. Consequently a correlation can be found in the scale-character and growth between «Southern-type» and the fast-growing herring, and «Northern-type» and the slow-growing herring.

Owing to the fact that the emigration from the coast and the sexual maturity of the herring are both dependent on growth, the fast growing herring, represented by a majority of «S-type», will leave the coast earlier and be sexually mature earlier than the slow-growing herring comprising mainly «N-type».

The winter herring will therefore consist of unequal components in varying numbers from the fast-growing herring of southern origin (mainly «S-type») and the slowgrowing herring of northern origin (mainly «N-type»). According to Østvedt (1958) the richest year-classes are dominated by the northern component.

Material and methods

The material for the present study was scales collected by Lea and Rasmussen from samples of small fat herring fished in the years 1920 to 1925 in Troms and Nordland, between Eidsfjord in Vesterålen an Gryllefjord in Torsken.

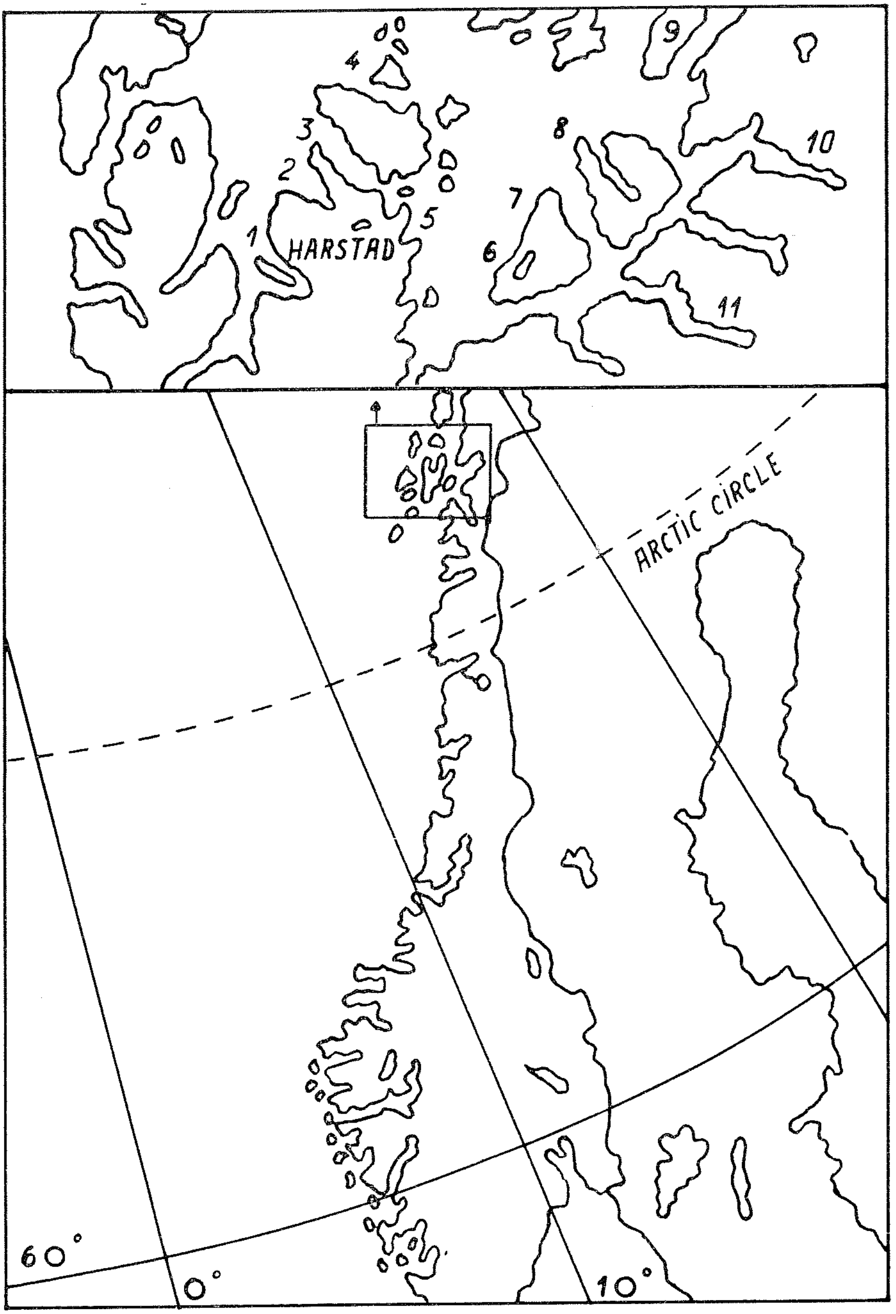


Fig. 1. The location of the sampling area in northern Norway. The numbers given in the upper square refers to the samples locality.

During the analysis it was found most expedient to concentrate on samples taken within a fairly short interval of time, from the middle of August to the middle of September in the two years 1920 and 1921.

Thus the scales examined were taken in the growth period of the herring, and the last growth increment, between the last winter-ring and the edge, is not complete. However, earlier winter-rings are conspicuous and age determinations and measurements of the full growth zones can be made in spite of the character of the scale's edge.

The material thus finally analysed consisted of 8 samples from 5 localities in 1920, and 12 samples from 9 localities in 1921, altogether 3950 herring scales.

The loalities are fairly concentrated in the fjord system of southern Troms, as shown on the map (Fig. 1). The samples were first classified according to type of winter rings, namely «Northern» and «Southern» as defined by Lea (1929).

The measurements of the growth zones in the scales were performed in accordance with the usual routine as described by Lea (1929).

The calculation of lengt increments were made graphically with an instrument developed by Rasmussen.

Age composition and scale character of the small fat herring in 1920 and 1921

In Tables 1 and 2 the results of the age-analyses are given for each individual sample taken in the two years, and in the bottom line the average age-distribution for the total material collected in the year in question.

In comparing the results from the two years, a great difference is noteworthy:

In 1920, age-group II, year-class 1918 dominated all samples to a very great extent. In 1921, age-group I, year-class 1920 dominated most of the samples and as an average there were nearly twice as many of age group I as of age-group II.

Age-group III in 1921 (year-class 1918) was rather more numerous (3.5 %) than the corresponding age-group the year before (1.9 %), but the numbers are small and of little significance.

It should be remembered, however, that the III group will normally emigrate from the small fat herring and enter the oceanic stage in shoals of large fat herring.

It was the dominance of the year-class 1918 in 1920, and the fact that the same year-class disappeared from the fat herring samples the

Table 1. *Age-distribution and scale charachter, 1920.*

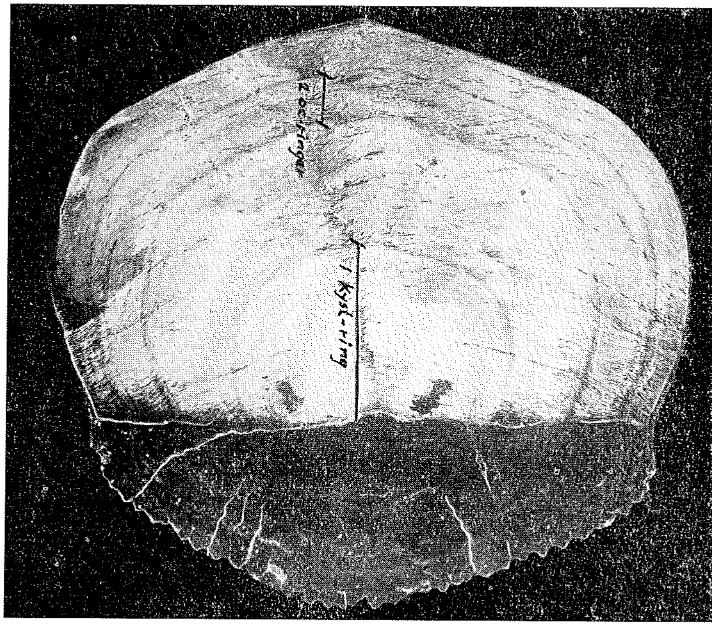
Sample locality	Date	Age groups I	II	III	IV	Total number	S-type number	S-type %	N-type number	N-type %
5^{I}	14/8	10	152	4	—	166	17	10.2	149	89.8
10	16/8	9	195	3	—	207	16	7.7	191	92.3
11^{I}	16/8	7	202	16	4	229	18	7.9	211	92.1
11^{II}	18/8	71	149	3	—	223	21	9.4	202	90.6
5^{II}	19/8	66	139	2	—	207	19	9.2	188	90.8
7	27/8	6	176	—	—	182	21	11.5	161	88.5
10	28/8	3	184	2	1	190	21	11.1	169	88.9
8	1/9	34	197	1	—	232	21	9.1	211	90.9
Total		206	1394	31	5	1636	154		1482	
%		12.6	85.2	1.9	0.3			9.4		90.6

Table 2. *Age-distribution and scale charachter, 1921.*

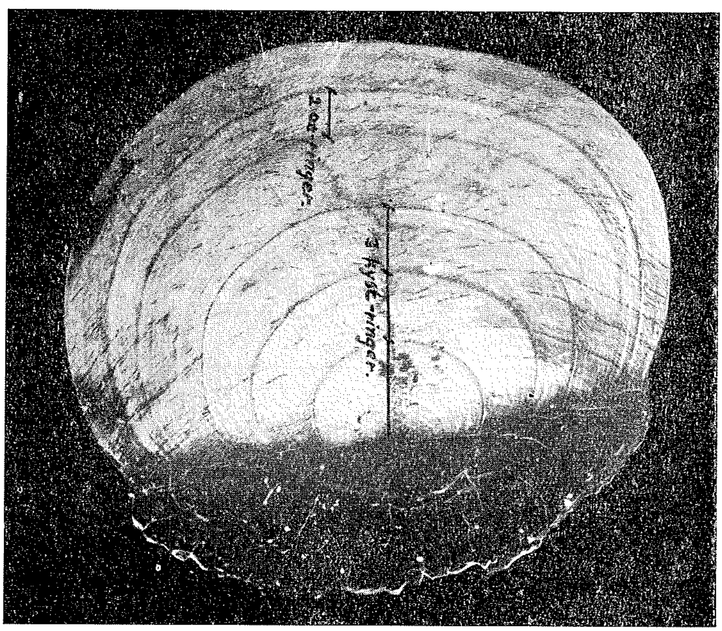
Sample locality	Date	Age groups I	II	III	IV	Total number	S-type number	S-type %	N-type number	N-type %
1	10/8	147	61	—	—	208	12	5.8	196	94.2
2	14/8	113	81	3	—	197	14	7.1	183	92.9
3	18/8	163	36	—	—	199	11	5.5	188	94.5
5	23/8	99	101	7	—	207	8	3.9	199	96.1
9^{I}	23/8	217	12	—	—	229	13	5.7	216	94.3
9^{II}	24/8	124	33	1	—	158	10	6.3	148	93.7
4	26/8	66	104	12	—	182	14	7.7	168	92.3
7^{I}	27/8	39	79	42	—	160	8	5.0	152	95.0
8^{I}	27/8	162	16	—	—	178	14	7.9	164	92.1
7^{II}	30/8	93	118	8	—	219	19	8.6	200	91.4
8^{II}	6/9	105	71	3	—	179	25	14.0	154	86.0
6	16/9	100	92	6	—	198	8	4.0	190	96.0
Total		1428	804	82	—	2314	156		2158	
%		62.8	34.7	3.5				6.7		93.3

following year, while the immigrant recruit-spawners in 1921 were dominated by 5 year old herring, which led Lea to the discovery that there must exist a stage in the life history of the Norwegian herring, which is intermediate between the small fat herring found in coastal waters, and the immigrants of recruit-spawners.

The dominance of the year-class 1918 in 1920 is in accordance with the fact that this year-class was richer than any of the neighbouring year-classes.



4 year old winter herring, Southern-type.



6 year old winter herring, Northern-type.

Table 3. *Growth increments in cm of the II-group in 1920.*

Sample locality	Northern-type				Southern-type			
	Number	t_1	t_2	t_3	Number	t_1	t_2	t_3
5^{I}	137	8.89	5.29	4.77	15	9.05	5.24	4.79
10^{I}	179	9.05	5.24	4.57	16	9.03	5.61	4.49
11^{I}	184	9.77	5.60	4.69	18	9.49	5.68	4.72
11^{II}	133	9.53	5.38	4.53	16	9.43	5.31	4.85
5^{II}	125	8.65	4.92	4.80	14	8.31	5.04	4.93
7	155	8.90	5.10	4.72	21	8.73	5.40	4.55
10^{II}	163	8.93	5.34	5.02	21	8.85	5.36	5.03
8	177	8.75	5.26	4.98	20	8.62	5.19	4.99
Total	1253	9.06	5.26	4.76	141	8.94	5.35	4.79

The year-class 1918 dominated the spring herring fishery for several years from 1923.

Sund (1945) has calculated its relative strength and it was the first really rich year-class since 1904, and was until 1935 surpassed only by the year-classes 1930 and 1934.

Tables 1 and 2 confirm that the number of individuals of older age-groups than II are very small and inadequate for a comparative study of growth increments. The following analyses are, therefore, confined to herring of the II group in 1920 and 1921.

From the table is seen that «N-type» scales dominate in all samples constituting from 88.5 % (Locality 7, 1920) to 96.1 % (Locality 5, 1921). Within these limits the composition varies quite irregularly. This is, however, in good agreement with results obtained by Runnstrøm (1936).

Comparison of growth-increments for herring of Northern and Southern-type

Tables 3 and 4 show the results of the scale measurements for each sample as calculated mean growth increments, $t_1 = l_1$, t_2 and the incomplete last growth period t_3. The number of individuals measured in each sample is also stated.

For our purpose the incomplete increment t_3 is without interest, because the samples are taken over an interval of about one month within the growth period, and in the following discussion only t_1 and t_2 will be considered.

The tables reveal that the mean values vary somewhat from sample to sample.

The variation can be summarized as follows:

Year	Northern-type		Southern-type	
	t_1	t_2	t_1	t_2
1920	8.65—9.77	4.92—5.60	8.31—9.49	5.04—5.68
1921	8.49—9.52	4.11—5.13	8.90—10.03	4.10—5.48 (3.30)

Table 4. *Growth increments in cm of the II-group in 1921.*

Sample locality	Northern-type				Southern-type			
	Number	t_1	t_2	t_3	Number	t_1	t_2	t_3
1	56	8.83	4.79	4.96	5	8.90	4.70	4.80
2	74	9.47	4.85	4.81	7	9.69	4.69	4.77
3	33	9.19	4.24	5.11	3	9.37	4.10	4.53
5	95	9.15	4.83	5.18	6	9.22	5.05	5.22
9^{I}	12	8.49	4.94	5.23	—	—	—	—
9^{II}	33	9.04	4.65	5.16	—	—	—	—
4	95	9.26	4.45	4.95	9	9.20	4.80	5.36
7^{I}	73	9.50	5.13	5.07	6	10.03	5.48	4.98
8^{I}	15	9.43	4.11	4.83	1	9.50	3.30	5.20
7^{II}	105	9.52	4.82	5.15	13	9.85	4.78	5.37
8^{II}	61	9.22	4.76	5.35	10	9.66	4.79	5.15
6	88	9.26	4.76	5.29	4	9.48	5.35	4.93
Total	740	9.27	4.80	5.07	64	9.51	4.90	5.09

The difference are thus in some cases more than one centimetre. In the «Southern-type», the scantiness of the material refutes further discussion but for the «Northern-type» we have investigated the homogeneity by a χ^2 test, with the following result.

For the 8 samples from 1920, χ^2 is calculated as 153.60 for t_1, and 103.70 for t_2, which for 56 degrees of freedom means that P (probability) in both cases is below 0.01.

For the 12 samples from 1921 the χ^2 was 58.25 and 66.68 respectively, which for 33 degrees of freedom give probabilities below 0.01 in both cases.

The 8 samples from 1920 and the 12 samples from 1921 cannot, therefore, be considered homogeneous as regards growth, and the material from herring with southern scale character cannot, therefore, be added to give an adequate sample for comparison of growth rates in «N» and «S»-type herring.

herring of «Northern» and «Southern-type». There may be a difference in the first summer growth, but not knowing the history of the herring shoals sampled, we cannot exclude the possibility that the shoals have been formed in the first autumn or winter by herrings of somewhat different earlier history.

On the other hand, we may presume that herring of northern and southern-type in the shoals sampled have been living under identical growth conditions in the two last summers.

Conclusions

From the mean values it can be seen that herring of the «Southern-type» in both years have the same growth rate as those of the «Northern-type».

The conclusion must be, therefore, that the correlation, «N-type» — slow growth —, «S-type» — faster growth —, as revealed by an analysis of mature winter-herring, is due to the dominance of fast-growing «S-type» herring of southern origin in the composite «S-type» winter-herring, and vice versa, a dominance of slow growing herring of northern origin in the composite samples of «N-type» winter-herring.

This conclusion is not incompatible with the observations made by Marty (1956), that growth rates tend to decrease when the stock is rich and the observation of Østvedt (1958), that a rich stock seems to be dependent on a rich influx of «N-type» herring.

Admittedly it is a weakness pertaining to the present material that the «S-type» herrings are few in the samples and it would be worthwile investigating fat herring from the waters of Møre—Trøndelag to see if any significant difference in growth-rates of «S» and «N»-type can be discerned there.

The strong dominance of the year-class 1918 as II-group in 1920 shows that a rich year-class of herring under such circumstances as then prevailed, may be recognised at the early stage of II-group, a point well worth noting for routine survey purposes.

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Table. 5.

Samples 1920	t_1 (N) – t_1 (S)	t_2 (N) – t_2 (S)	t_3 (N) – t_3 (S)
5^{I}	– 0.16	0.05	– 0.02
10^{I}	0.02	– 0.37	0.08
11^{I}	0.28	– 0.08	– 0.03
11^{II}	0.10	0.07	– 0.32
5^{II}	0.34	– 0.12	– 0.13
7	0.17	– 0.30	0.17
10^{II}	0.08	– 0.02	– 0.01
8	0.13	0.07	– 0.01
Mean $\bar{x}$	0.12	– 0.09	– 0.03
S	0.155	0.803	0.512
Students t	6.19	0.90	0.051
P	< 0.001	> 0.05	> 0.05

Table 6.

Samples 1921	t_1 (N) – t_1 (S)	t_2 (N) – t_2 (S)	t_3 (N) – t_3 (S)
1	– 0.07	0.09	0.16
2	– 0.22	0.16	0.04
5	– 0.07	– 0.22	– 0.04
4	– 0.06	– 0.35	– 0.41
7^{I}	– 0.53	– 0.35	0.09
7^{II}	– 0.33	0.04	– 0.22
8	– 0.44	0.03	0.20
Mean $\bar{x}$	– 0.25	– 0.09	– 0.03
S	0.569	0.916	0.719
Students t	3.08	0.72	0.029
P	< 0.001	> 0.05	> 0.05

It remains then, as a basis for comparison, to compare the growth-rates of «N» and «S»-type, in the individual samples.

For this purpose some samples must be left out from 1921 where there are less than 5 individuals of «S-type» specimens, namely the samples 3, 9^{I}, 9^{II}, 8 and 6. There remains 7 samples, shown in table 4.

When the growth-rates within the individual samples are compared, t_3 i. e. the growth in the last summer, can be included in the comparison, although the samples are caught at different times within the period August—September.

The calculation gave the results showed in tables 5 and 6.

The results of these comparisons are that with regard to growth in the second and third summer there are no significant difference between