CONTRIBUTIONS TO THE METHODICS IN HERRING-INVESTIGATIONS

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GROWTH-MEASUREMENTS.

If we examine the scale-covering of a number of small and large herrings we will find that the different individuals vary to a certain extent in the shape, number and situation of their scales. The shape of the scales may differ from the prevalent form, the number of scales in a specified row may vary slightly, and a single scale or row of scales may sometimes be found on one of the animals rather higher up or lower down than usual. But in the main a herring's scale-covering is composed of elements that will be met with again in all other herrings. If we take a row of scales along the length of the fish we shall find one scale placed regularly over every myomer; and not till we come to the portion immediately anterior to the caudal fin do anomalies occur, the scales there having a tendency to be somewhat irregularly placed.

On comparing the scale-covering of a young herring with that of an old individual we will see after a mere superficial observation that the scales of the latter have become larger, whereas their number and situation remain the same.

We are accordingly to all extents and purposes justified in assuming that the scales are organs whose growth keeps pace with the growth of the herring; and that the growth-zones on the scale, which give a lasting picture of its development, can also serve to determine the growth of the fish itself.

To establish this point I have undertaken a series of measurements of small and large herrings. As the first preliminary measurements seemed to indicate that the scale grew proportionally faster than the total length of the animal, and that this might be due to age-variations in the growth of the head and caudal fin, I measured, in addition to linear dimension V on a specified scale and the total-length of the fish L , the length of the herring's scale-covered portion T measured from the posterior edge of the

Fig. 1.

gill-cover to the commencement of the median caudal fin-ray (see Figs. 1 and 2). The scale I selected is a large one and has a characteristic shape; and it is moreover easily found as it is situated just posterior to the suboperculum. These measurements are shown in table I, where there are headings for L, T and V in mm, and for the fractions $\frac{L}{T}$, $\frac{L}{V}$ and $\frac{T}{V}$. If the scale grows in direct proportion to the total-length, the fraction $\frac{L}{V}$ must be constant for young and old animals; and similarly, if the scale grows in proportion to dimension T the fraction $\frac{T}{V}$ must be constant. Let us neglect for the present individual variations, and consider the averages in the following table:

Fig. 2.

Age of the herrings	Number of observations	$\frac{L}{T}$	$\frac{L}{V}$	$\frac{T}{V}$
1 Year	74	1.57	29.7	18.9
2 Years	36	1.56	29.0	18.5
3 »	2	1.54	27.1	17.6
4 »	11	1.52	27.4	18.1
5 »	33	1.52	28.7	18.9
6 »	218	1.52	28.3	18.6
7 »	19	1.51	28.5	18.9
8 »	2	1.51	28.4	18.6
9 »	3	1.50	27.9	18.5
10 »	6	1.51	28.6	19.1
11 »	7	1.50	27.8	18.6
12 »	1	1.50	28.3	18.9
Average				18.67

It will be seen here that there is a slight age-variation in the fractions $\frac{L}{T}$ and $\frac{L}{V}$ whereas the fraction $\frac{T}{V}$ shows practically the same value for the year-classes where the number of observations makes the averages reliable. As the ratio $\frac{L}{V}$ diminishes with increase of age the scale grows relatively quicker than dimension L, whereas the scale and dimension T grow in direct proportion to each other.

The age-variation in the fraction $\frac{L}{V}$ must under these circumstances be due to the fact that the head and caudal fin are relatively greater in young animals than they are in old ones. And we would in actual fact get the same value of the fraction $\frac{L}{V}$ for both young and old animals, if we could imagine the young herrings furnished with heads and caudal fins of proportionately the same size as those of the old ones ($\frac{L}{V} = \text{ca. } 28.1$).

These measurements show accordingly that the scale we have made use of is an organ, which in size conforms to the same conditions as other organs and dimensions of the herring. And as we can see from the scale's growth-zones how large it was at the different periods of development, so we can make deductions regarding the size of the herring at its various periods of growth with an accuracy that is limited by the individual variability in the ratios $\frac{L}{V}$ and $\frac{T}{V}$. By measuring the size of the scale as far as the 1st, 2nd, and succeeding winter-rings (which we will call respectively v_1 v_2 ...) and multiplying these sizes by the average 18.67, we determine the length of the herring's scale-covered portion in the corresponding winter-periods (these sizes we will designate T_1 T_2 ...) and we thus get $T_1 = v_1 \times 18.67$; $T_2 = v_2 \times 18.67$... It is also possible to calculate T_1 T_2 by an easier method; since, owing to the ratio $\frac{T}{V}$ being the same for both young and old animals, we can take $\frac{T_1}{v_1} = \frac{T}{V}$, and therefore $T_1 = T \frac{v_1}{V}$; and thus avoid using the constant 18.67.

The probable error in these measurements is due to the individual variability in the ratio $\frac{T}{V}$. For the 1-year groups in the table the probable error was found to be about 7 % of the average; and a calculated value $T_1 = 100$ mm will thus involve a probable error of 7 mm.

In the formula $T_1 = T \frac{V_1}{V}$ the constant 18.67, which is characteristic of the scales hitherto made use of, does not occur. The question now arises: can other scales be made use of in the same manner, or do other scales show different modes of growth in relation to L and T ?

The measurements of HEINCKE and other investigators demonstrate that the different parts of a herring's body grow differently at different periods of its life. It is therefore quite possible that scales from other parts of the body differ in mode of growth. To test this I have measured series of scales. These measurements disclosed conditions that served materially to explain the individual variation in the size of scales. They showed namely that a considerable part of the individual variation in the size of scales is due to other causes than the variability of mode of growth.

Before we proceed to discuss these measurements numerically we will consider Figs. 3, 4 and 5, which delineate graphically the scale-measurements of 3 series of scales from the same herring. The numbers along the abscissae denote the location-numbers of the scales in the series, reckoned in a backward direction from the gill-cover; the uppermost curve in each figure connects the ordinates that represent the length of the scale measured from its centre to as far as the edge, along the zigzag line (the median line in Mr. KNUT DAHL's brochure »The scales of the herring« (1)). The other curves represent the same dimension as far as to the 1st winter-ring, 2nd winter-ring, &c. In Fig. 3 we have measurements from the 7th row on the left side reckoning from the belly upwards; Fig. 4 gives measurements from the same row on the right side; while Fig. 5 delineates the measurements of the 6th row from the belly on the right side, with the numbers so arranged that scale No. 10, for instance, is located on the same myomer as scale No. 10 in Fig. 4.

If we compare Figs. 3 and 4 we will notice that the size of scales on the right and left sides do not exactly correspond. For instance if a scale on one side of the fish is larger than either of its neighbour-scales it does not follow that the same will be the case with the corresponding scale on the other side. Again a comparison of Figs. 4 and 5 makes it clear that variations in the 7th row do not involve corresponding variations in the 6th row on the same side.

We have now to investigate the variations of the scales from one growth-period to the other by comparing the curves of the winter-rings; and we will see that a scale whose size deviates

from that of its neighbour-scale has had the same mode of deviation right back to the first winter of the animal's life. Only in a few cases are there unimportant exceptions. If then the other scales vary in size similarly to the one which was used for the measurements in table I, and my measurements have satisfied

Fig. 3, 4 and 5. Measurements of 3 scale-series. Broken curves indicate, that scales have lacked or been defect.

me that such is the case, most of the individual variation in the size of the scales must be due to other circumstances than variable growth. If growth were the cause, then a scale which in a given year was let us say $\frac{1}{7}$ T might be perhaps in the next year $\frac{1}{20}$ T, and the curves of the winter-rings would in that case be quite independent of each other.

To express this in figures I measured the ratio $\frac{v_1}{V}$ in scales taken from the region behind the gill-cover, and calculated the probable error expressed in percentage of the average (see table II where the numerators in the fractions are shown under the heading l_1 , while the denominator is put at 291). Although this method involved the risk of getting scales with a different mode of growth, seeing that they were taken from several myomers, still the probable error was only 2.4 % of the average. Employing this on the example previously mentioned — a length of 100 mm — we get an error of 2.4 mm, which is about $\frac{1}{3}$ of the error we obtained according to the formula $T_1 = v_1 \times 18.67$.

The formula $T_1 = T \frac{v_1}{V}$ thus holds good for other scales than that hitherto used and as it gives far more exact results than the formula $T_1 = v_1 \times 18.67$, it is therefore to be preferred. If we wish to find the total length in the respective growth-periods $L_1 L_2 \dots$ we must multiply $T_1 T_2 \dots$ by the average-number which denotes how many times greater $L_1 L_2 \dots$ is than $T_1 T_2 \dots$ (see the table on page 6).

An approximate value for $L_1 L_2 \dots$ which we will call $l_1 l_2 \dots$ may be obtained by disregarding the age-variation in the ratio $\frac{L}{T}$ and taking $l_1 = L \frac{v_1}{V}$; $l_2 = L \frac{v_2}{V} \dots$. As these formulae are employed in the measurements that I have undertaken for the International Council I will discuss them more fully. It is obvious that they presuppose a directly proportional growth between L and V . This presupposition does not quite hold good, and the question now arises what error will result therefrom. Let us take $\frac{L_1}{T_1} = a_1$ (1) then in the same way $\frac{L}{T} = a$ (2): we have already got $l_1 = L \frac{v_1}{V}$ (3) and $T_1 = T \frac{v_1}{V}$ (4) so that from a combination of these we get

$$L_1 = l_1 \frac{a_1}{a} \text{ (5) and } l_1 = T_1 a \text{ (6).}$$

From equation 5 it appears that the correct value of L_1 is got by multiplying the calculated l_1 by a fraction whose numerator is the ratio $\frac{L_1}{T_1}$ and whose denominator is the ratio $\frac{L}{T}$. To calculate the lengths, at the formation of the 2nd, 3rd, $\dots$ winter-rings similar equations may be worked out. The individual values of $a_1 a_2 \dots$ are of course unknown; but the average values of the different year classes can be obtained, and will serve to determine the correction-multiplicator.

The following table shows the numerical values of

$$\frac{a_1}{a_2}, \frac{a_1}{a_3}, \dots, \frac{a_2}{a_3}, \dots$$

worked out in accordance with the measurements in table I.

Correction-multiplicatores for the formulae $l_1 = L \cdot \frac{v_1}{V}$, $l_2 = L \cdot \frac{v_2}{V} \dots$

$\frac{a_1}{a_2} = 1.01$	$\frac{a_1}{a_3} = 1.02$ $\frac{a_2}{a_3} = 1.01$	$\frac{a_1}{a_4} = 1.04$ $\frac{a_2}{a_4} = 1.03$ $\frac{a_3}{a_4} = 1.02$	$\frac{a_1}{a_5} = 1.04$ $\frac{a_2}{a_5} = 1.02$ $\frac{a_3}{a_5} = 1.01$ $\frac{a_4}{a_5} = 1.00$	$\frac{a_1}{a_6} = 1.04$ $\frac{a_2}{a_6} = 1.02$ $\frac{a_3}{a_6} = 1.01$ $\frac{a_4}{a_6} = 1.00$	$\frac{a_1}{a_{7-11}} = 1.05$ $\frac{a_2}{a_{7-11}} = 1.03$ $\frac{a_3}{a_{7-11}} = 1.02$ $\frac{a_4}{a_{7-11}} = 1.01$
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The multiplier, it will be noticed, does not attain higher values than 1.05.

The corrections in the values $l_1 l_2 \dots$ which can be made in this way enable us to compare these calculated lengths with directly measured lengths of smaller herrings of a corresponding age, and for this purpose they are well-adapted. However equation 6 shows that $l_1 l_2 \dots$ are merely the same as $T_1 T_2 \dots$ multiplied by a factor a , which according to the table on page 6 is practically the same for all grown animals. It is therefore quite unnecessary to introduce a correction in cases where one has to study the growth of grown animals.

We have now the means of determining $L_1 L_2$ &c., by measurements of scales situated close to the gill-cover; and, utilising these values as standard values, we can proceed to study the conditions of scales from other parts of the body, employing the formula $l_1 = L \frac{v_1}{V}$, $l_2 = L \frac{v_2}{V}$, $\dots$. It is quite possible we might find scales that grew in direct proportion to the total length and which accordingly would give us values $L_1 L_2 \dots$ without making use of any correction-multiplier.

To ascertain this I have taken measurements of the scale on every 4th myomer of a herring (see table II). The averages for each myomer will be found in the following text-table (page 12).

As standard value I have taken the corrected average of the measurements of 10 scales from the 1st myomer. The values under the headings $t_2 t_3 \dots$ denote the increment in each year and are obtained by subtraction: $t_2 = l_2 - l_1$; $t_3 = l_3 - l_2 \dots$

Lengths and increments . . .	$l_1 = t_1$	l_2	l_3	l_4	l_5	l_6	t_2	t_3	t_4	t_5	t_6
Standard values	88	156	223	249	273	291	68	67	26	24	18
Scales from myomer no. 1	84	153	222	250	273	291	69	69	28	23	18
— — — 5	87	152	221	250	273	291	65	69	29	23	18
— — — 9	84	148	216	247	272	291	64	68	31	25	19
— — — 13	83	148	217	247	272	291	65	69	30	25	19
— — — 17	84	150	217	247	271	291	66	67	30	24	20
— — — 21	86	153	221	249	273	291	67	68	28	23	18
— — — 25	89	154	220	249	272	291	66	66	29	23	19
— — — 28	89	154	221	250	272	291	65	69	29	22	19
— — — 29	91	156	220	250	272	291	65	64	30	23	19
— — — 33	91	157	223	248	274	291	66	66	27	26	17
— — — 37	92	158	223	251	273	291	66	64	28	22	18
— — — 41	90	157	225	252	273	291	68	67	27	21	18
— — — 45	93	162	229	255	275	291	69	67	25	20	16
— — — 49	96	165	232	256	275	291	70	65	24	19	16
Averages of myomers 1—49	89	155	221	250	273	291	66	66	29	23	18

If we look first at the values for l_1 l_2 &c., we will see that there is to begin with a sinking tendency till we come to myomer No. 13 where the values rise until they become maximal in the case of the posterior myomers. An examination of the values under the headings $t_1 = l_1$ $t_2 = t_3$. . . , where each year's growth is given apart, shows us that this sinking and rising is chiefly confined to the first and second year of the herring's existence. In the case of the three last years the values are lowest for the posterior myomers. The scales from the 1st to the 21st myomer give us figures so closely according, that the correction table worked out for the 1st myomer can quite well be employed for these scales, which are the ones chiefly utilised when taking scale-samples. The values from myomers 25—28 are in their uncorrected form fairly like the corrected values obtained from myomer No. 1. The largest and most distinct scales on these myomers are located in the neighbourhood of the herring's lateral line directly under the posterior half of the dorsal fin.

It is clear from the preceding remarks that the length of a herring in the previous winter-periods of its existence can be calculated in various ways:

- 1) by examining scales situated in the anterior portion of its body and adopting the correction due to the age-variation in the fraction $\frac{L}{T}$.
- 2) by examining scales from myomers 25—28, without any correction at all.
- 3) by examining several scales from different parts of the body, and taking their average without correction.

- 4) by examining a clearly-marked scale selected at random without any correction.

If not more than one scale is taken, the question arises: what accuracy do we get from alternatives 1, 2 and 4. With a view to throwing light upon this point I calculated the probable error, by measuring scales from the region just behind the gill-cover, scales from myomers 25—29, and scales taken from all parts of the body. The figures given below show the probable error of l_1 in these measurements; since it appeared that this value was the most variable, and that deviations for l_2 l_3 &c., were to a great extent dependent on deviations in l_1 .

Probable error of a determination $l_1 = 88$ mm.

Scales from the anterior part of the body	2 mm.
— — 25—29 myomer	2 —
— — all parts of the body	4 —

Obviously alternatives 1 and 2 give very exact results, but alternative 2 is to be preferred as it does not presuppose any correction. Alternative 4 likewise gives values that are useful in many cases. The tables show that in 50 cases out of 100 the measurements of every distinct scale will give values that do not deviate more than 4 mm from the true average.

With regard to the measurement-dimension on the scale selected, I recommend dimensions along a line taken fairly perpendicularly from the scale's centre on the boundary line between the striated and smooth portion of the scale (see Fig. 6). I have moreover taken the measurements of a particular scale by marking off the measurement-dimension in 10 different directions, and found that direction is rather immaterial if the centre of the scale is clearly established.

Instances of growth-measurements will be found in the following chapter. I would particularly call attention to the graphical delineation in Fig. 8.

Fig. 6.

DETERMINATION OF AGE.

As the growth-measurements discussed in the preceding chapter may in combination with other data serve to illustrate our method of determining age, I will endeavour to summarise the results of my investigations into the character of the so-called winter-rings.

The first question I will endeavour to answer is the following: Have all scales belonging to the same herring an equal number of winter-rings? To decide this point I selected herrings whose scales had a distinct structure and where accordingly complications did not arise owing to the presence of so-called secondary rings which I shall allude to subsequently. From these herrings I extracted quantities of scales (in some cases as many as 200) from different parts of their bodies. An investigation of them showed firstly that all scales on the actual body have an equal number of winter-rings, and secondly that the distance between these rings relative to each other is so far constant that scales from no matter what portion of the body may be employed for determining the growth of the herring. Instances of such parallel investigations will be found in table II and in the graphical delineations in Figs. 3, 4 and 5. Exceptions to this rule occur in the regenerated scales and also in scales which have been displaced from their true location. A scale of this latter description is shown in Fig. 7.

There are even some minute scales on the caudal fin itself, though they show practically no annual-ring structure and are to all extents and purposes unserviceable. I merely mention them here, because they have occurred in some of the scale-samples.

None of the sources of uncertainty hitherto mentioned are really of any account, since the structure of the scales gives the

necessary clues. But it is quite another matter with the accessory or secondary rings, by which are meant the ring-formations that are often visible in the broad growth-zones of a scale. These are generally faintly marked as compared with the winter-rings. Still now and then they are able to cause considerable confusion, and the question arises, how are we to avoid the uncertainty due to their appearance. I have examined series of scales where accessory rings occurred, and found that they to a very great extent answer to the name bestowed upon them by Mr. KNUT DAHL. Their occurrence is different in the different scales, and in doubtful cases accordingly we can distinguish them by examining several scales. To make sure of this and at the same time to obtain means of ascertaining what part one's personal judgment plays in determination of age, I got a number of parallel observations made. Mr. KNUT DAHL very kindly determined the ages of 100 herrings, out of which I had in 55 cases only prepared one scale; though from the remaining 45 herrings I had taken 3 scales pr. fish. I myself had made the same determinations previously. On comparing our figures we found a discrepancy of 1 year in 3 instances, where there was only one scale to examine; but our observations were absolutely in accordance in the case of the herrings from which I had taken 3 scales. On another occasion Dr. HJORT went through the growth-measurements of several hundred herrings, and his findings coincided with mine in every case but one, where I had undoubtedly made a mistake. The only conclusion to be drawn from these parallel observations is that the sources of error in determining age are small and of no significance for the biological problems to be elucidated.

It is also very often a good plan to alter the light and enlargement. It is important moreover to clean the scales thoroughly and to subject them to a careful preparation. When many investigations have to be made I lay the scales in alcohol with a covering of glass over them; but when I wish to prepare

Fig. 7.
Anomaleus scale. Regenerated in 2nd summer and displaced in 2nd winter.

scales for subsequent examination, I affix them to an object-glass with a solution of glycerine and white of egg (70 % white of egg 30 % glycerine and a little camphor), placing the smooth side of the scale against the glass and thus avoiding having any sticky substance on the striated side. If a preparation such as I have described is heated up to about 80° C. the white of egg coagulates, and the scale when required may be either imbedded in glycerine gelatine, or laid in alcohol.

We have further important evidence of the practical advantage of our method of age-determination in the close agreement in regard to distribution of year-classes which we find in cases where there are several samples of well-characterised herring-groups from the same year. I would refer the reader to the published analyses (see K. DAHL'S brochure: »The scales of the herring« (1) and Dr. HJORT'S »Circular to the Members of Committee A« (2) and »Proposal for Organisation of the International Investigations of the Herring Fisheries« (3)), where certain year-classes predominate in many samples; and I have only to add that my analyses were quite in accordance with them. Very characteristic in this respect are the analyses of samples of the typical Norse spring-herring, where the year-class which formed its first wintering in 1904 preponderates largely over all the other year-classes. Similar conditions appear in the case of other localities, as will be seen from the tables given below.

Norwegian spring herrings.

Locality and date of capture	No. of spec. analysed	Number of specimens in the year-classes											
		1906	1905	1904	1903	1902	1901	1900	1899	1898	1897	1896	1895
60° 30' N. 3° 30' E. $\frac{10}{9}$ 1909	380	1	15	197	38	26	34	22	25	17	3	1	1
60° 32' N. 3° 30' E. $\frac{1}{10}$ 1909	359	2	27	246	33	17	8	7	9	2	3	3	2
61° 20' N. 5° 0' E. $\frac{18}{8}$ 1909	291	3	33	218	19	2	3	6	7	1			

Herrings from the fjords of the Faroes.

Locality and date of capture	No. of spec. analysed	Number of specimens in the year-classes										
		1908	1907	1906	1905	1904	1903	1902	1901	1900	1899	
Skålefjord $\frac{7}{9}$ 1909	192	13	170	3	3	3						
— $\frac{21}{8}$ 1909	139	25	112	2								
Kollefjord $\frac{10}{9}$ 1909	91		87		1	2	1					
Fjords of Faroes Sept. 1909 . . .	640	3	595	16	12	7	2	1	1	1	2	

Mature herrings from Iceland.

Locality and date of capture	No. of spec. analysed	Number of specimens in the year-classes												
		1905	1904	1903	1902	1901	1900	1899	1898	1897	1896	1895	1894	older
South-Iceland $\frac{3}{6}$ 1908 . .	280	1	49	26	14	19	34	44	47	20	8	8	10	
North-Iceland $\frac{25}{7}$ 1908. .	419		6	40	28	30	39	95	74	40	31	24	10	2

These tables show us that samples from a given locality in one period of growth agree fairly closely in regard to their age-composition, when we classify them according to the number of winter-rings on the scales. We shall now compare samples from the same locality in different years. Here too our material of Norse spring-herrings reveals characteristic conditions. The following table shows how herrings with 4 winter-rings largely preponderate in 1908. In 1909 herrings with 5 winter-rings are decidedly in the majority, while herrings with 6 winter-rings preponderate in 1910.

Norwegian spring-herrings.

Year of capture	No. of herrings with 3 winter-rings	No. of herrings with 4 winter-rings	No. of herrings with 5 winter-rings	No. of herrings with 6 winter-rings	No. of herrings with 7 winter-rings
1908	4	498	174	166	159
1909		2	248	68	23
1910		3	33	18	19

I find quite analogous conditions in the catches from the Faroes, where we have observations for 1908 and 1909. This is shown by the following table.

Herrings from the Faroes.

Locality and Year of capture	No. of herrings with 0 winter-ring	No. of herrings with 1 winter-ring	No. of herrings with 2 winter-rings	No. of herrings with 3 winter-rings
Fjords of Faroes 1908	0	416	22	1
— 1909	0	41	964	21

The facts already adduced make it quite clear in my opinion that one and only one winter-ring is formed each year, and that the view Dr. G. SCHNEIDER advances in his brochure Ueber die Altersbestimmung bei Heringen (4), that several winter-rings may

be formed in a year, is quite untenable. In further support of my contention I will show a number of growth-measurements, which demonstrate that the lengths calculated from the last-formed winter-ring, in samples from 1909, have nearly the same average value as the average length of the directly measured herrings in 1908. The table below given is an example taken from the Faroe samples.

Herrings from the fjords of the Faroes Aug.—Sept. 1908 and 1909.

Average length measured directly of herrings caught 4. Aug. 1908, with 1 winter-ring within the margin of the scales.	20.0 cm.	416 herrings measured
Calculated average length, at formation of 2d winter-ring of herrings caught Aug.—Sept. 1909 with 2 winter-rings within margin.	21.5 —	964 herrings measured

Here it appears that the average length at the formation of the 2nd winter-ring is slightly higher than the average length of fish caught in August 1908 which had not yet formed their 2nd winter-ring. This is of course what we would expect to find, seeing that the fish caught on 4th August had not yet completed their annual growth.

As a final example I will show the results of age and growth investigations in a sample of young herrings caught in the north of Norway during the autumn of 1909. This sample can also be represented by typical Petersen-curves, and I accordingly give the analysis as a graphical delineation in Fig. 8.

The uppermost diagram shows the sample arranged in cm.-groups, wherefrom we obtain a quadrimodal Petersen-curve. In the next diagram each age-group is arranged by itself, and we notice that the three first modes in the Petersen-curve correspond to the three first year-classes, while the fourth mode contains the three following year-classes. The lowest diagram shows the calculated lengths, at the formation of the 1st and 2nd winter-rings, of the group of herrings which had formed 2 winter-rings inside of the edge of the scale and which were $2\frac{2}{3}$ years old. The complete accordance between all the curves in these diagrams, conclusively proves in my opinion the justice of my contention.

To determine the time during which the formation of the growth-zones takes place I occasionally investigated scales of the 1 and 2 year-old herrings which are caught at different seasons among the islands off the coast near Bergen. The samples I examined in December 1909 had a very uniform character, since

on the scales of the smallest fish which were about 1 year old there was no winter-ring inside the edge of the scale: whereas the larger herrings that were approximately 2 years old did have

Fig. 8. Young herrings from northern Norway autumn 1909.

a winter-ring. In the three first months of 1910 I was unfortunately unable to secure fish for investigation, but on $23\frac{3}{4}$ 1910 I obtained 20 herrings which I took from a catch of sprats. The two smallest of these had now developed a winter-ring just inside the edge of the scale, while the other 18 had a winter-ring well

inside of it and a second one just within the edge. These herrings had quite obviously began their summer growth. This could clearly be seen *inter alia* from the fact that the winter-ring on some scales was at the very edge along the sides, whereas it lay slightly inside of the edge in the forepart. To express in figures this newly-formed increment I calculated the percentage which the distance between the edge of the scale and the last winter-ring was of the distance between this winter-ring and the preceding one. I obtained from this an average of 12.8%.

That we are dealing here with the commencement of summer-growth is certain, if we consider that in spring-herrings which have completed these periods of growth the increment between the 2nd and 3rd winter-ring is about 80% of the increment between the 1st and 2nd winter-ring. These small herrings have accordingly formed $\frac{12.8}{80}$ or approximately $\frac{1}{6}$ of their summer-growth between December 1909 and 23rd April 1910, and in the case of these herrings at any rate it is unquestionable that what we have designated the winter-ring actually is one.

Mr. K. DAHL has in his paper (1) expressed the opinion that some herrings, born in late summer or autumn, possibly do not form a scale during their first winter of existence. Consequently the area inside the first winter-ring should in such herrings represent more than one years age and growth. In accordance therewith he found that in certain autumn-spawners of the Skagerrack and the North Sea the area of the scale within the first winter-ring was very large compared to consequent zones of growth and that in this respect the scales of this autumn-spawners presented quite another picture than the scales of spring-spawners from the Norse coast.

To solve the question if this is a general feature in all summer or autumn spawners in the international area we want a very representative material, such as is not at my disposition. Without committing myself to any statement regarding the general conditions, I will confine myself to giving the average course of growth in the group of autumn-spawning herrings from the Cattegat which formed their first winter-ring in 1904. Herrings from this locality have been examined by Mr. HJ. BROCH (5) and by Dr. G. SCHNEIDER, with a view to solving precisely the same question. For purposes of comparison I have given analogous figures for a sample of Norse spring-herrings.

Averages from 80 autumn-spawners and 246 spring-spawners.

Locality and date of capture	1904	1905	1906	1907	1908	1909	1905	1906	1907	1908	1909
	$l_1 = t_1$	l_2	l_3	l_4	l_5	l_6	t_2	t_3	t_4	t_5	t_7
Trindelen Kattegat $13/_{10}$ 1909.	126	177	213	239	255	266	51	36	26	16	11
60 32' N. 5" 20' E. $1/_{10}$ 1909	83	154	213	249	273	290	71	59	36	24	17

Growth-conditions are, it will be noticed, extremely remarkable and point to the desirability of further investigations along the same lines.

ABBREVIATIONS AND SIGNS

L = Total length in mm (see Fig. 1).

L₁ = — — — — at formation of the 1st winter-ring.

L₂ = — — — — — — — — 2d —

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T = Length of scale-covered portion in mm (see Fig. 1).

T₁ = — — — — — — — — at formation of the 1st winter-ring.

T₂ = — — — — — — — — — — 2d —

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V = Linear dimension of the scale in mm (see Figs. 2 and 6).

v₁ = — — — — — — — — within 1st winter-ring.

v₂ = — — — — — — — — — — 2d —

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$a = \frac{L}{T}, a_1 = \frac{L_1}{T_1}, a_2 = \frac{L_2}{T_2} \dots$

$l_1 = L \cdot \frac{v_1}{V}, l_2 = L \cdot \frac{v_2}{V} \dots$ (lengths).

$t_1 = l_1, t_2 = l_2 - l_1 \dots$ (increments).

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For further litterature on the subjects see *Knut Dahl*, The assessment of age and growth in Fish. Internationale Revue der gesamten Hydrobiologie und Hydrographie. Bd. II. Heft 4 u. 5.

TABLE I.

Measurements of Norwegian spring herrings caught near Bergen during the winter 1909—1910.

Herrings with 1 winter-ring.							Herrings with 1 winter-ring.						
No.	L	T	$\frac{L_1=a_1}{T_1}$	V	$\frac{L}{V}$	$\frac{T}{V}$	No.	L	T	$\frac{L_1=a_1}{T_1}$	V	$\frac{L}{V}$	$\frac{T}{V}$
1	95	61	1.56	3.2	29.7	19.1	49	119	74	1.61	3.6	33.1	20.6
2	103	66	1.56	3.7	27.9	17.8	50	119	76	1.57	4.3	27.7	17.7
3	106	68	1.56	3.5	30.3	19.4	51	119	75	1.59	4.0	29.8	18.8
4	107	67	1.60	3.5	30.6	19.1	52	119	76	1.57	4.1	29.0	18.5
5	107	69	1.55	3.7	29.0	18.7	53	120	75	1.60	4.2	28.6	17.9
6	108	68	1.59	3.9	27.7	17.4	54	120	77	1.56	3.9	30.8	19.8
7	109	68	1.60	3.5	31.2	19.4	55	121	75	1.61	4.1	29.5	18.3
8	110	69	1.59	3.6	30.6	19.2	Average 38—55: 1.576					29.57	18.78
9	110	69	1.59	3.7	29.7	18.7	56	122	77	1.59	4.0	30.5	19.3
10	110	70	1.57	3.5	31.4	20.0	57	122	78	1.56	4.1	29.8	19.0
11	111	71	1.56	4.0	27.8	17.8	58	122	78	1.56	4.0	30.5	19.5
12	112	71	1.58	3.6	31.1	19.7	59	123	78	1.58	4.0	30.8	19.5
13	112	72	1.56	4.4	25.5	16.4	60	123	79	1.56	4.5	27.4	17.6
14	112	71	1.58	3.5	32.0	20.3	61	123	78	1.58	4.2	29.3	18.6
15	113	72	1.57	4.3	26.3	16.8	62	123	78	1.58	4.1	30.0	19.0
16	113	72	1.57	4.4	25.7	16.4	63	123	79	1.56	4.2	29.3	18.8
17	114	72	1.58	4.2	27.2	17.1	64	123	79	1.56	4.1	29.3	19.3
18	114	73	1.56	4.1	27.8	17.8	65	123	81	1.52	4.0	30.8	20.2
Average 1—18: 1.574					28.97	18.41	66	124	78	1.59	4.0	31.0	19.5
19	114	72	1.58	3.7	30.8	19.5	67	124	78	1.59	3.7	33.5	21.1
20	115	74	1.55	3.9	29.5	19.0	68	124	79	1.57	4.0	31.0	19.8
21	115	74	1.55	3.7	31.1	20.0	69	124	79	1.57	3.8	32.7	20.8
22	115	73	1.58	4.0	28.8	18.2	70	124	79	1.57	4.4	28.2	18.0
23	116	74	1.57	3.9	29.8	19.0	71	125	79	1.58	4.3	29.1	18.4
24	116	74	1.57	3.9	29.8	19.0	72	125	79	1.58	3.8	32.9	20.8
25	116	74	1.57	4.2	27.6	17.6	73	127	82	1.55	4.6	27.6	17.8
26	116	74	1.57	3.9	29.8	19.0	74	134	84	1.60	4.4	30.4	19.1
27	116	74	1.57	3.8	30.5	19.5	Average 56—74: 1.571					30.22	19.27
28	116	74	1.57	3.9	29.8	19.0	Total Average: 1.573					29.68	18.87
29	116	73	1.59	3.8	30.5	19.2	Herrings with 2 winter-rings.						
30	117	74	1.58	3.5	33.5	21.2	No.	L	T	$\frac{L_2=a_2}{T_1}$	V	$\frac{L}{V}$	$\frac{T}{V}$
31	117	74	1.58	3.9	30.0	19.0	1	142	90	1.58	5.2	27.4	17.3
32	117	74	1.58	3.7	31.6	20.0	2	147	95	1.55	5.4	27.3	17.6
33	117	75	1.56	3.9	30.0	19.2	3	148	98	1.51	5.4	27.4	18.2
34	117	75	1.56	4.1	28.6	18.3	4	150	96	1.56	5.1	29.4	18.8
35	117	74	1.58	4.1	28.6	18.1	5	152	96	1.58	5.0	30.4	19.2
36	117	75	1.56	4.1	28.6	18.3	6	152	96	1.58	5.3	28.7	18.1
37	117	73	1.60	4.0	29.3	18.2	7	152	96	1.58	4.9	31.0	19.6
Average 19—37: 1.572					29.91	19.02	8	153	99	1.55	5.7	26.9	17.4
38	117	75	1.56	4.0	29.3	18.8	9	153	98	1.56	5.6	27.3	17.5
39	117	74	1.58	4.0	29.3	18.5	10	154	99	1.56	5.5	28.0	18.0
40	118	74	1.60	4.1	28.8	18.1	11	155	100	1.55	5.6	27.7	17.9
41	118	77	1.53	4.0	29.5	19.3	12	155	101	1.53	5.5	28.2	18.4
42	118	74	1.60	4.0	29.5	18.5	13	155	101	1.53	5.5	28.2	18.4
43	118	75	1.57	3.8	31.1	19.7	14	157	102	1.54	5.4	29.1	18.9
44	118	75	1.57	4.1	28.8	18.3	15	157	100	1.57	5.3	29.6	18.9
45	118	76	1.55	4.0	29.5	19.0							
46	118	76	1.55	3.9	30.3	19.5							
47	118	76	1.55	4.1	28.8	18.5							
48	118	74	1.60	4.1	28.8	18.1							

Herrings with 2 winter-rings.							Herrings with 5 winter-rings.						
No.	L	T	$\frac{L_2}{T_2}=a_2$	V	$\frac{L}{V}$	$\frac{T}{V}$	No.	L	T	$\frac{L_5}{T_5}=a_5$	V	$\frac{L}{V}$	$\frac{T}{V}$
16	157	100	1.57	5.2	30.2	19.2	1	270	179	1.51	9.5	28.4	18.9
17	159	101	1.57	5.7	27.9	17.7	2	271	177	1.53	9.4	28.8	18.8
18	159	102	1.56	5.6	28.4	18.2	3	273	176	1.55	9.5	28.7	18.5
Average 1—18: 1.557							4	273	178	1.53	10.3	26.5	17.3
19	160	102	1.57	5.1	31.4	20.0	5	274	180	1.52	10.3	26.6	17.5
20	161	104	1.55	5.3	30.4	19.6	6	277	185	1.50	9.5	29.2	19.5
21	162	104	1.56	5.7	28.4	18.3	7	277	184	1.51	9.4	29.5	19.6
22	163	108	1.51	5.0	32.6	21.6	8	277	182	1.52	9.7	28.6	18.8
23	163	106	1.54	5.6	29.1	18.9	9	278	181	1.54	10.4	26.7	17.4
24	163	104	1.57	5.6	29.1	18.6	10	279	182	1.53	10.0	27.9	18.2
25	164	107	1.53	5.5	29.8	19.5	11	279	183	1.52	9.6	29.1	19.1
26	165	105	1.57	5.9	28.0	17.8	12	281	182	1.54	9.4	29.9	19.4
27	166	107	1.55	5.5	30.2	19.5	13	282	187	1.51	9.6	29.4	19.5
28	166	107	1.55	5.6	29.6	19.1	14	282	186	1.52	9.9	28.5	18.8
29	167	109	1.53	6.1	27.4	17.9	15	283	187	1.51	9.9	28.6	18.9
30	170	108	1.57	5.4	31.5	20.0	16	283	186	1.52	9.4	30.1	19.8
31	171	111	1.54	5.8	29.5	19.2	17	283	184	1.54	9.4	30.1	19.6
32	172	111	1.55	5.8	29.7	19.2	Average 1—17: 1.523						
33	172	110	1.56	6.0	28.4	18.3	18	283	184	1.54	10.5	27.0	17.5
34	173	110	1.57	5.9	29.3	18.6	19	284	188	1.51	9.6	29.6	19.6
35	181	115	1.57	6.1	29.7	18.9	20	284	187	1.52	9.6	29.6	19.5
36	183	116	1.58	6.7	27.3	17.3	21	285	193	1.48	10.3	27.7	18.7
Average 19—36: 1.554							22	287	191	1.50	10.3	27.9	18.5
Total average: 1.556							23	288	189	1.52	10.2	28.3	18.5
Herrings with 3 winter-rings.							24	289	187	1.55	10.4	27.8	18.0
No.	L	T	$\frac{L_3}{T_3}=a_3$	V	$\frac{L}{V}$	$\frac{T}{V}$	25	289	189	1.53	9.8	29.5	19.3
1	222	145	1.53	8.3	26.8	17.5	26	290	190	1.53	9.8	29.6	19.4
2	227	146	1.55	8.3	27.4	17.6	27	292	194	1.51	9.9	29.5	19.6
Average: 1.54							28	294	196	1.50	9.9	29.7	19.8
							29	294	195	1.51	10.8	27.2	18.1
Herrings with 4 winter-rings.							30	295	196	1.51	10.4	28.4	18.8
No.	L	T	$\frac{L_4}{T_4}=a_4$	V	$\frac{L}{V}$	$\frac{T}{V}$	31	296	198	1.49	10.2	29.0	19.4
1	236	153	1.54	8.8	25.7	17.4	32	296	196	1.51	10.3	28.7	19.0
2	239	159	1.50	9.4	25.4	16.9	33	297	194	1.53	9.8	30.3	19.8
3	251	162	1.55	9.1	27.6	17.8	Average 18—33: 1.515						
4	255	167	1.53	9.0	28.4	18.6	Total average: 1.519						
5	259	171	1.51	9.3	27.9	18.4	18	283	184	1.54	10.5	27.0	17.5
6	259	172	1.51	9.6	27.0	17.9	19	284	188	1.51	9.6	29.6	19.6
7	262	174	1.50	10.0	26.2	17.4	20	284	187	1.52	9.6	29.6	19.5
8	264	174	1.52	9.6	27.5	18.1	21	285	193	1.48	10.3	27.7	18.7
9	268	176	1.52	9.5	28.2	18.5	22	287	191	1.50	10.3	27.9	18.5
10	283	191	1.48	9.9	28.6	19.3	23	288	189	1.52	10.2	28.3	18.5
11	286	188	1.52	10.0	28.6	18.8	24	289	187	1.55	10.4	27.8	18.0
Average: 1.516							25	289	189	1.53	9.8	29.5	19.3
							26	290	190	1.53	9.8	29.6	19.4
Herrings with 6 winter-rings.							27	292	194	1.51	9.9	29.5	19.6
No.	L	T	$\frac{L_6}{T_6}=a_6$	V	$\frac{L}{V}$	$\frac{T}{V}$	28	294	196	1.50	9.9	29.7	19.8
1	256	170	1.51	9.1	28.2	18.7	29	294	195	1.51	10.8	27.2	18.1
2	258	169	1.53	9.6	26.9	17.6	30	295	196	1.51	10.4	28.4	18.8
3	258	170	1.52	8.7	29.7	19.6	31	296	198	1.49	10.2	29.0	19.4
4	259	170	1.52	9.2	28.2	18.5	32	296	196	1.51	10.3	28.7	19.0
5	260	169	1.54	9.0	28.9	18.8	33	297	194	1.53	9.8	30.3	19.8
6	260	171	1.52	9.4	27.7	18.2	Average 18—33: 1.515						
7	261	169	1.54	9.1	28.7	18.6	Total average: 1.519						
8	261	170	1.54	9.4	27.8	18.1	18	283	184	1.54	10.5	27.0	17.5
9	262	170	1.54	9.6	27.3	17.7	19	284	188	1.51	9.6	29.6	19.6
10	264	170	1.55	9.9	26.7	17.2	20	284	187	1.52	9.6	29.6	19.5
11	264	173	1.53	9.6	27.5	18.0	21	285	193	1.48	10.3	27.7	18.7
12	265	173	1.53	9.7	27.3	17.8	22	287	191	1.50	10.3	27.9	18.5
13	266	173	1.54	9.7	27.4	17.8	23	288	189	1.52	10.2	28.3	18.5

Herrings with 6 winter-rings.							Herrings with 6 winter-rings.						
No.	L	T	$\frac{L_6 - a_6}{T_6}$	V	$\frac{L}{V}$	$\frac{T}{V}$	No.	L	T	$\frac{L_6 - a_6}{T_6}$	V	$\frac{L}{V}$	$\frac{T}{V}$
14	266	173	1.54	9.7	27.4	17.8	70	278	182	1.53	9.7	28.7	18.8
15	266	175	1.52	9.5	28.0	18.4	71	278	182	1.53	10.5	26.5	17.3
16	266	178	1.49	9.5	28.0	18.7	72	278	182	1.53	9.9	28.1	18.4
17	266	175	1.52	9.0	29.6	19.5	73	278	183	1.52	10.4	26.7	17.6
18	267	178	1.50	9.7	27.5	18.4	74	278	182	1.53	10.1	27.5	18.0
19	267	175	1.53	10.0	26.7	17.5	75	279	183	1.52	9.8	28.5	18.7
20	267	174	1.53	9.4	28.4	18.5	76	279	182	1.53	9.7	28.8	18.8
21	267	175	1.53	9.6	27.8	18.2	77	279	183	1.52	10.0	27.9	18.3
22	268	172	1.56	8.6	31.2	20.0	78	279	183	1.52	9.0	31.0	20.3
23	268	177	1.51	8.9	30.2	19.9	79	279	186	1.50	10.1	27.6	18.4
24	269	144	1.55	9.1	29.6	19.1	80	279	183	1.52	10.1	27.6	18.1
25	270	174	1.55	9.5	28.4	18.3	81	279	183	1.52	9.6	29.1	19.1
26	270	177	1.52	9.9	27.3	17.9	82	280	184	1.52	10.1	27.7	18.2
27	270	177	1.53	9.2	29.4	19.3	83	280	186	1.50	10.8	25.9	17.2
28	270	177	1.53	9.4	28.7	18.9	84	280	182	1.54	10.5	26.7	17.3
29	270	179	1.51	10.4	26.0	17.2	85	280	184	1.52	9.5	29.5	19.4
30	270	172	1.57	9.6	28.2	17.9	86	280	182	1.54	9.5	29.5	19.2
31	272	178	1.53	9.5	28.6	18.7	87	281	185	1.52	10.1	27.8	18.3
32	272	178	1.53	10.5	25.9	17.0	88	281	187	1.50	9.6	29.3	19.5
33	272	176	1.54	9.5	28.6	18.5	89	281	190	1.48	10.1	27.8	18.8
34	272	176	1.54	9.9	27.5	17.8	90	282	185	1.52	9.6	29.4	19.3
35	272	180	1.51	9.7	28.0	18.6	91	282	189	1.49	9.4	30.0	20.1
36	273	179	1.53	10.0	27.3	17.9	92	282	184	1.53	9.8	28.8	18.7
37	273	176	1.55	9.7	28.1	18.2	93	282	188	1.50	9.8	28.8	19.2
38	273	179	1.53	9.2	29.7	19.5	94	282	186	1.52	10.6	26.6	17.6
39	273	181	1.51	9.9	27.6	18.3	95	283	186	1.52	9.9	28.6	18.8
40	273	182	1.50	9.9	27.6	18.4	96	283	183	1.55	9.8	28.9	18.8
41	273	180	1.52	9.7	28.2	18.6	97	283	186	1.52	9.4	30.1	19.8
42	274	179	1.53	9.5	28.9	18.9	98	284	187	1.52	9.1	31.2	20.4
43	274	178	1.54	9.5	28.9	18.8	99	284	187	1.52	10.5	27.0	17.8
44	274	181	1.51	9.6	28.6	18.9	100	284	183	1.55	9.4	30.2	19.5
45	274	187	1.47	9.5	28.9	19.7	101	284	187	1.52	10.9	26.1	17.2
46	274	179	1.53	9.9	27.7	18.1	102	284	183	1.55	10.8	26.3	17.4
47	274	179	1.53	8.9	30.8	20.1	103	284	186	1.53	9.9	28.7	18.8
48	275	179	1.54	10.3	26.7	17.4	104	284	187	1.52	10.3	27.6	18.2
49	275	184	1.49	9.6	28.6	19.2	105	285	189	1.51	9.9	28.8	19.1
50	275	177	1.55	10.6	27.0	16.7	106	285	186	1.53	10.2	28.0	18.2
51	275	180	1.53	9.5	28.0	19.0	107	285	191	1.49	10.1	28.1	18.9
52	275	179	1.54	10.1	27.2	17.7	108	285	188	1.52	9.7	29.4	19.4
53	275	181	1.52	9.9	27.8	18.3	109	285	187	1.52	11.0	25.9	17.0
54	275	178	1.54	9.7	28.3	18.4	Average 55-109:			1.518		28.05	18.59
Average 1-54:			1.528		27.78	18.24	110	285	191	1.49	10.3	27.7	18.5
55	275	180	1.53	9.2	29.9	19.6	111	285	188	1.52	10.1	28.2	18.6
56	275	182	1.51	11.0	25.0	16.5	112	285	189	1.51	9.7	29.4	19.5
57	276	184	1.50	9.5	29.1	19.4	113	285	189	1.51	10.0	28.5	18.9
58	276	183	1.51	9.8	28.2	18.7	114	285	190	1.50	10.4	27.4	18.3
59	276	184	1.50	10.3	26.8	17.9	115	285	189	1.51	9.9	28.8	19.1
60	276	181	1.47	10.1	27.3	17.9	116	285	189	1.51	9.7	29.4	19.5
61	276	183	1.51	9.0	30.7	20.3	117	285	190	1.50	10.5	27.1	18.1
62	277	183	1.51	10.1	27.4	18.1	118	286	189	1.51	10.0	28.6	18.9
63	277	181	1.53	9.5	29.2	19.1	119	286	189	1.51	10.5	27.2	18.0
64	277	186	1.49	9.6	28.9	19.4	120	286	185	1.55	10.0	28.6	18.5
65	277	182	1.52	10.5	26.4	17.3	121	286	186	1.54	9.8	29.2	19.0
66	278	183	1.52	9.7	28.7	18.9	122	286	191	1.50	9.9	28.9	19.3
67	278	183	1.52	9.6	29.0	19.1	123	286	188	1.52	9.9	28.9	19.0
68	278	183	1.52	10.4	26.7	17.6	124	286	191	1.50	10.1	28.3	18.9
69	278	182	1.53	9.7	28.7	18.8	125	287	189	1.52	9.8	29.3	19.3

Herrings with 6 winter-rings.							Herrings with 6 winter-rings.						
No.	L	T	$\frac{L_6=a_6}{T_6}$	V	$\frac{L}{V}$	$\frac{T}{V}$	No.	L	T	$\frac{L_6=a_6}{T_6}$	V	$\frac{L}{V}$	$\frac{T}{V}$
126	287	186	1.54	10.2	28.1	18.2	182	294	196	1.50	9.8	30.0	19.8
127	287	189	1.52	11.2	25.6	16.9	183	294	195	1.51	10.4	28.3	18.7
128	287	189	1.52	10.6	27.1	17.8	184	295	197	1.50	10.6	27.8	18.6
129	287	191	1.50	10.3	27.9	18.5	185	295	199	1.48	10.4	28.4	19.1
130	287	191	1.50	9.6	29.9	19.9	186	295	195	1.51	9.9	29.8	19.7
131	287	190	1.51	9.7	29.6	19.6	187	295	194	1.52	10.3	28.6	18.8
132	287	187	1.53	10.5	27.4	17.8	188	295	192	1.54	10.2	28.9	18.8
133	287	190	1.51	9.9	29.0	19.2	189	295	193	1.53	10.3	28.6	18.7
134	287	188	1.53	9.7	29.6	19.4	190	295	193	1.53	9.9	29.8	19.5
135	287	191	1.50	9.3	30.9	20.5	191	295	193	1.53	10.3	28.6	18.7
136	287	192	1.49	10.1	28.4	19.0	192	295	194	1.52	10.2	28.9	19.0
137	287	188	1.53	9.8	29.3	19.2	193	295	193	1.53	10.9	27.1	17.7
138	287	190	1.51	10.9	26.3	17.4	194	296	196	1.51	10.6	27.9	18.5
139	287	188	1.53	10.4	27.6	18.1	195	296	197	1.50	10.1	29.3	19.5
140	287	190	1.51	9.5	30.2	20.0	196	296	196	1.51	11.6	25.5	16.9
141	287	191	1.50	9.5	30.2	20.1	197	296	196	1.51	10.7	27.6	18.3
142	288	189	1.52	10.6	27.2	17.8	198	297	197	1.51	10.3	28.8	19.1
143	288	190	1.52	10.6	27.2	17.9	199	297	198	1.50	10.8	27.5	18.3
144	288	188	1.53	10.3	27.9	18.3	200	298	196	1.52	10.3	29.0	19.0
145	288	191	1.51	10.2	28.2	18.7	201	298	197	1.51	9.8	30.4	20.1
146	288	189	1.52	10.2	28.2	18.5	202	299	197	1.52	9.5	31.5	20.7
147	288	191	1.51	10.4	27.7	18.4	203	299	196	1.53	10.6	28.2	18.5
148	288	188	1.53	9.8	29.4	19.2	204	299	198	1.51	10.1	29.6	19.6
149	288	189	1.52	9.8	29.4	19.3	205	299	196	1.53	10.7	28.0	18.3
150	288	189	1.52	9.2	31.3	20.6	206	299	203	1.47	10.0	29.9	20.3
151	288	188	1.53	10.8	26.7	17.4	207	300	195	1.54	10.2	29.4	19.1
152	288	192	1.50	10.3	28.0	18.6	208	300	200	1.50	10.3	29.1	19.4
153	288	192	1.50	9.2	31.3	20.9	209	300	201	1.49	9.4	31.9	21.4
154	289	193	1.50	10.1	28.6	19.1	210	302	198	1.53	10.7	28.2	18.5
155	289	190	1.52	9.8	29.5	19.4	211	302	199	1.52	10.3	29.3	19.3
156	289	189	1.53	9.2	31.4	20.6	212	302	202	1.50	10.6	28.5	19.1
157	289	190	1.52	10.2	28.4	18.6	213	302	200	1.51	10.0	30.2	20.0
158	289	192	1.51	10.2	28.4	18.8	214	302	199	1.52	10.8	28.0	18.4
159	290	186	1.56	10.2	28.4	18.2	215	304	206	1.48	11.4	26.7	18.1
160	290	191	1.52	10.2	28.4	18.7	216	304	199	1.53	10.2	29.8	19.5
161	290	188	1.54	10.6	27.4	17.7	217	305	204	1.49	10.4	29.3	19.6
162	291	190	1.53	10.6	27.5	17.9	218	310	208	1.49	11.2	27.7	18.6
163	291	191	1.52	10.7	27.2	17.8	Average 164-218: 1.513						
Average 110-163: 1.516							Total average: 1.519						
164	292	194	1.50	10.2	28.6	19.0	Herrings with 7 winter-rings.						
165	292	190	1.54	10.3	28.4	18.4	No.	L	T	$\frac{L_7=a_7}{T_7}$	V	$\frac{L}{V}$	$\frac{T}{V}$
166	292	194	1.50	10.4	28.1	18.7	1	263	170	1.55	9.9	26.6	17.2
167	292	188	1.55	10.3	28.4	18.2	2	281	185	1.52	9.5	29.6	19.5
168	292	193	1.51	10.8	27.1	17.9	3	283	185	1.53	10.3	27.5	18.0
169	292	192	1.52	10.2	28.6	18.8	4	287	193	1.49	10.4	27.6	18.5
170	292	193	1.51	9.6	30.4	20.1	5	289	193	1.49	10.2	28.4	18.9
171	293	193	1.52	10.3	28.4	18.7	6	289	190	1.52	10.8	27.7	17.6
172	293	193	1.52	10.2	28.7	18.9	7	291	196	1.48	10.2	28.5	19.2
173	293	193	1.52	10.6	27.6	18.2	8	293	196	1.49	10.8	27.1	18.2
174	293	195	1.50	10.1	29.0	19.3	9	294	192	1.53	10.7	27.5	17.9
175	293	194	1.51	9.7	30.2	20.0	10	294	193	1.52	10.4	28.3	18.6
176	293	192	1.53	10.7	27.4	17.9	11	294	193	1.52	9.9	29.5	19.5
177	293	192	1.53	10.5	27.9	18.3	12	296	197	1.50	9.7	30.5	20.3
178	293	191	1.53	10.8	27.2	17.7							
179	294	196	1.50	9.8	30.0	20.0							
180	294	198	1.48	9.9	29.7	20.0							
181	294	193	1.52	10.5	28.0	18.4							

Herrings with 7 winter-rings.							Herrings with 10 winter-rings.						
No.	L	T	$\frac{L_7}{T_7}=a_7$	V	$\frac{L}{V}$	$\frac{T}{V}$	No.	L	T	$\frac{L_{10}}{T_{10}}=a_{10}$	V	$\frac{L}{V}$	$\frac{T}{V}$
13	297	199	1.49	10.2	29.1	19.5	1	318	214	1.49	11.6	27.4	18.5
14	298	197	1.52	10.3	28.9	19.1	2	319	210	1.52	11.3	28.2	18.6
15	298	200	1.49	11.1	26.9	18.0	3	323	213	1.53	11.5	28.1	18.5
16	304	200	1.52	10.0	30.4	20.0	4	324	216	1.50	11.2	28.9	19.3
17	307	204	1.50	10.7	28.7	19.1	5	325	217	1.50	11.1	29.3	19.6
18	308	208	1.48	10.8	28.5	19.3	6	335	225	1.49	11.3	29.7	19.9
19	309	211	1.46	10.2	30.3	20.7	Average: 1.505 28.60 19.07						
Average: 1.506 28.50 18.90							Herrings with 11 winter-rings.						
No.	L	T	$\frac{L_8}{T_8}=a_8$	V	$\frac{L}{V}$	$\frac{T}{V}$	No.	L	T	$\frac{L_{11}}{T_{11}}=a_{11}$	V	$\frac{L}{V}$	$\frac{T}{V}$
1	276	182	1.52	9.4	29.4	19.4	1	313	205	1.53	11.1	28.2	18.5
2	307	205	1.50	11.2	27.4	18.3	2	314	209	1.50	11.5	27.3	18.2
Average: 1.510 28.40 18.85							3	320	216	1.48	11.5	27.8	18.8
Herrings with 9 winter-rings.							4	323	211	1.53	10.7	30.2	19.7
No.	L	T	$\frac{L_9}{T_9}=a_9$	V	$\frac{L}{V}$	$\frac{T}{V}$	5	324	215	1.51	11.6	27.9	18.5
1	302	201	1.50	10.9	27.7	18.4	6	324	224	1.45	11.7	27.7	19.2
2	303	200	1.52	10.9	27.8	18.3	7	328	221	1.48	12.7	25.8	17.4
3	327	219	1.49	11.6	28.2	18.9	Average: 1.497 27.84 18.61						
Average: 1.503 27.90 18.53							Herrings with 12 winter-rings.						
No.	L	T	$\frac{L_{10}}{T_{10}}=a_{10}$	V	$\frac{L}{V}$	$\frac{T}{V}$	No.	L	T	$\frac{L_{12}}{T_{12}}=a_{12}$	V	$\frac{L}{V}$	$\frac{T}{V}$
							1	334	223	1.50	11.8	28.3	18.9

TABLE II.

Measurements of scales from a Norwegian spring-herring 6 years old, total-length $L = 291$ mm., based on the formulae $l_1 = L \cdot \frac{v_1}{V}$,

$$l_2 = L : \frac{v_2}{v} \dots, t_1 = l_1 - 0 = l_1, t_2 = l_2 - l_1 \dots$$

	$l_1=t_1$	l_2	l_3	l_4	l_5	l_6	t_2	t_3	t_4	t_5	t_6		$l_1=t_1$	l_2	l_3	l_4	l_5	l_6	t_2	t_3	t_4	t_5	t_6	
Scales from the region behind the gill-cover	85	155	220	249	272	291	70	65	29	23	19		91	154	220	250	273	291	63	66	30	23	18	
	83	151	221	252	274	291	68	70	31	22	17		88	150	216	248	271	291	62	66	32	23	20	
	80	151	224	251	273	291	71	73	27	22	18		84	147	214	245	271	291	63	67	31	26	20	
	83	153	225	250	273	291	70	72	25	23	18		89	159	225	259	273	291	70	66	34	24	18	
	83	148	219	248	273	291	65	71	29	25	18		91	158	225	251	273	291	67	67	26	22	18	
	81	148	217	246	272	291	67	69	29	28	19		91	158	222	250	274	291	67	64	28	24	17	
	85	154	219	245	270	291	69	65	26	25	21		90	154	221	248	272	291	64	67	27	24	19	
	89	158	227	255	274	291	69	69	28	19	17		90	152	218	247	271	291	62	66	29	24	20	
	85	156	225	253	275	291	71	69	28	22	16		89	152	220	248	272	291	63	68	28	24	19	
	86	157	225	254	273	291	71	68	29	19	18		84	145	215	247	272	291	61	70	32	25	19	
	92	153	219	248	272	291	61	66	29	24	19		89	156	220	251	273	291	67	64	31	22	18	
	87	153	219	248	272	291	66	66	29	24	19		92	155	219	248	271	291	63	64	29	24	20	
	91	153	223	251	274	291	62	70	28	23	17		90	156	224	249	273	291	66	68	25	24	18	
	89	152	218	247	273	291	63	66	29	26	18		89	162	228	252	274	291	73	66	24	22	17	
	92	160	230	255	275	291	68	70	25	20	16		95	162	228	254	275	291	67	66	26	21	16	
	89	153	226	253	276	291	64	73	27	23	15		92	158	225	251	274	291	66	67	26	23	17	
	90	151	218	248	273	291	61	67	30	25	18		85	151	218	246	271	291	66	67	28	25	20	
	89	153	219	249	273	291	64	66	30	24	18		92	162	226	252	273	291	70	64	26	21	18	
	86	148	220	247	272	291	62	72	27	25	19		80	149	218	245	270	291	69	69	27	25	21	
	88	154	219	247	271	291	66	65	28	24	20		90	157	223	249	273	291	67	66	26	24	18	
	82	147	217	246	272	291	65	70	29	26	19		86	149	219	248	272	291	63	70	29	24	19	
	84	148	218	247	271	291	64	70	29	24	20		93	159	223	249	271	291	66	64	26	22	20	
	87	149	217	248	272	291	62	68	31	24	19		83	148	218	247	271	291	65	70	29	24	20	
	91	154	221	251	274	291	63	67	30	23	17		90	160	227	253	274	291	70	67	26	21	17	
	87	151	215	246	270	291	64	64	31	24	21		94	156	224	249	273	291	62	68	25	24	18	
	90	152	222	250	273	291	62	70	28	23	18		91	157	224	250	272	291	66	67	26	22	19	
	85	148	215	245	271	291	63	67	30	26	20		88	153	222	247	271	291	65	69	25	24	20	
	86	148	217	248	272	291	62	69	31	24	19													
	87	150	220	249	272	291	63	70	29	23	19		Averages	89	155	222	249	272	291	66	67	28	23	19
	84	148	219	248	272	291	64	71	29	24	19		Scales from myomer nr. 1	85	156	221	252	274	291	71	65	31	22	17
	87	151	220	247	272	291	64	69	27	25	19			85	154	219	245	270	291	69	65	26	25	21
	91	154	221	249	273	291	63	67	28	24	18			85	155	220	249	272	291	70	65	29	23	19
	86	148	217	246	272	291	62	69	29	26	19			83	148	219	248	273	291	65	71	29	25	18
	86	151	218	248	272	291	65	67	30	24	19			81	148	217	246	272	291	67	69	29	26	19
	88	150	219	248	271	291	62	69	29	23	20			85	154	219	245	270	291	69	65	26	25	21
	85	149	217	246	271	291	64	68	29	25	20			88	153	222	250	273	291	65	69	28	23	18
87	148	218	250	272	291	61	70	32	22	19		82		150	223	252	273	291	68	73	29	21	18	
83	143	216	245	270	291	60	73	29	25	21		85		156	225	253	275	291	71	69	28	22	16	
87	149	216	245	270	291	62	67	29	25	21		86		157	225	254	273	291	71	68	29	19	18	
87	147	216	246	271	291	60	69	30	25	20														
84	147	215	245	271	291	63	68	30	26	20		Averages		85	153	221	249	273	291	68	68	28	24	18
85	147	217	247	271	291	62	70	30	24	20		Corr. standard values	88	156	223	249	273	291	68	67	26	24	18	
87	150	218	248	271	291	63	68	30	23	20														
Averages	87	151	219	248	272	291	64	69	29	24	19	Myomer nr. 5	85	150	215	247	270	291	65	65	32	23	21	
Scales from myomers nr. 25—29	92	156	221	247	270	291	64	65	26	23	21		89	157	223	253	276	291	68	66	30	23	15	
	88	161	226	250	273	291	73	65	24	23	18		91	156	222	249	272	291	65	66	27	23	19	
	91	157	220	250	271	291	66	63	30	21	20		89	151	220	249	273	291	62	69	29	24	18	
	90	155	220	248	272	291	65	65	28	24	19		86	148	218	249	272	291	62	70	31	23	19	
	85	151	219	248	272	291	66	68	29	24	19		84	149	218	248	272	291	65	69	30	24	19	
	87	155	220	248	272	291	68	65	28	24	19													

	$l_1=t_1$	l_2	l_3	l_4	l_5	l_6	t_2	t_3	t_4	t_5	t_6		$l_1=t_1$	l_2	l_3	l_4	l_5	l_6	t_2	t_3	t_4	t_5	t_6
	83	148	218	248	273	291	65	70	30	25	18		90	155	220	248	272	291	65	65	28	24	19
	87	160	231	257	276	291	73	71	26	19	15		85	151	219	248	272	291	66	68	29	24	19
Averages	87	152	221	250	273	291	65	69	29	23	18		87	155	220	248	272	291	68	65	28	24	19
													91	154	220	250	273	291	63	66	30	23	18
													88	150	216	248	271	291	62	66	32	23	20
Myomer nr. 9.	87	149	215	247	272	291	62	66	32	25	19		84	147	214	245	271	291	63	67	31	26	20
	79	148	214	245	271	291	69	66	31	26	20												
	80	148	218	249	272	291	68	70	31	23	19	Averages	89	154	220	249	272	291	66	66	29	23	19
	84	150	217	249	273	291	66	67	32	24	18												
	87	150	216	248	273	291	63	66	32	25	18	Myomer nr. 28.	89	159	225	259	273	291	70	66	34	24	18
	89	151	217	246	271	291	62	66	29	25	20		91	158	225	251	273	291	67	67	26	22	18
	84	148	215	245	271	291	64	67	30	26	20		91	158	222	250	274	291	67	64	28	24	17
	86	150	218	248	272	291	64	68	30	24	19		90	154	221	248	272	291	64	67	27	24	19
	83	146	219	248	273	291	63	73	29	25	18		90	152	218	247	271	291	62	66	29	24	19
	82	146	216	246	270	291	64	70	30	24	21		89	152	220	248	272	291	63	68	28	24	20
	83	145	216	246	272	291	62	71	30	26	19		84	145	215	247	272	291	61	70	32	25	19
Averages	84	148	216	247	272	291	64	68	31	25	19	Averages	89	154	221	250	272	291	65	67	29	24	19
Myomer nr. 13.	82	152	221	251	274	291	70	69	30	23	17	Myomer nr. 29.	89	156	220	251	273	291	67	64	31	22	18
	80	148	218	248	272	291	68	70	30	24	19		92	155	219	248	271	291	63	64	29	23	20
	83	149	219	249	274	291	65	70	30	25	17	Averages	91	156	220	250	272	291	65	64	30	23	19
	86	154	219	248	273	291	68	65	29	25	18												
	88	151	217	247	272	291	63	66	30	25	19	Myomer nr. 33.	93	158	223	254	275	291	65	65	31	21	16
	85	148	216	245	272	291	63	68	29	27	19		95	160	225	252	273	291	65	65	27	21	18
	82	146	213	246	271	291	64	67	33	25	20		90	158	223	249	274	291	68	65	26	25	17
	83	145	214	246	270	291	62	69	32	24	21		92	161	227	255	274	291	69	66	28	19	17
	78	143	212	244	271	291	65	69	32	27	20		91	156	222	255	273	291	65	66	23	18	18
Averages	83	148	217	247	272	291	65	69	30	25	19		92	155	219	250	272	291	63	64	31	22	19
													86	151	220	249	274	291	65	69	29	25	17
Myomer nr. 17.	85	154	221	248	273	291	69	67	27	25	18		87	153	228	246	276	291	66	75	18	30	15
	86	155	223	250	273	291	69	68	27	23	18	Averages	91	157	223	251	274	291	66	66	27	23	17
	88	151	219	249	271	291	63	68	30	22	20												
	91	155	224	250	274	291	64	69	26	24	17	Myomer nr. 37.	99	165	228	253	275	291	66	63	25	22	16
	85	152	214	244	271	291	67	62	30	27	20		95	160	220	249	272	291	65	60	29	23	19
	83	150	215	247	270	291	67	65	32	23	21		94	161	226	252	273	291	67	65	26	21	18
	80	144	211	244	270	291	64	67	33	26	21		85	154	221	247	271	291	69	67	26	24	20
	82	148	216	246	271	291	66	68	30	25	20		92	153	221	250	272	291	61	68	29	22	19
	81	146	216	246	271	291	65	70	30	25	20		87	152	220	252	274	291	65	68	32	22	17
	80	146	215	244	269	291	66	69	29	25	22												
Averages	84	150	217	247	271	291	66	67	30	24	20	Averages	92	158	223	251	273	291	66	64	28	22	18
Myomer nr. 21.	85	155	227	250	272	291	70	72	23	22	19	Myomer nr. 41.	99	168	235	257	274	291	69	67	22	17	17
	89	157	233	255	276	291	68	76	22	21	15		92	164	231	255	275	291	72	67	24	20	16
	89	163	224	254	274	291	74	61	30	20	17		92	157	225	250	273	291	65	68	25	23	18
	85	153	219	249	273	291	68	66	30	24	18		86	153	223	252	274	291	67	70	29	22	17
	80	148	218	247	273	291	68	70	29	26	18		90	156	221	251	272	291	66	65	30	21	19
	88	153	217	249	272	291	65	64	32	23	19		87	156	222	252	274	291	69	66	30	22	17
	90	155	221	249	274	291	65	66	28	25	17		81	151	220	248	272	291	70	69	28	24	19
	85	150	218	246	271	291	65	68	28	25	20												
	84	148	216	246	271	291	64	68	30	25	20	Averages	90	157	225	252	273	291	68	67	27	21	18
	84	150	217	248	271	291	66	67	31	23	20												
Averages	86	153	221	249	273	291	67	68	28	23	18	Myomer nr. 45.	97	168	232	260	278	291	71	64	28	18	13
													93	162	229	255	275	291	69	67	26	20	16
Myomer nr. 25.	90	158	224	255	274	291	68	66	31	19	17		95	158	224	249	272	291	63	66	25	23	19
	92	156	221	247	270	291	64	65	26	23	21		86	157	225	251	272	291	71	68	26	21	16
	88	161	226	250	273	291	73	65	24	23	18		94	160	228	254	275	291	66	68	26	21	19
	91	157	220	250	271	291	66	63	30	21	20		96	166	233	256	274	291	70	67	23	18	17

	$l_1=t_1$	l_2	l_3	l_4	l_5	l_6	t_2	t_3	t_4	t_5	t_6		$l_1=t_1$	l_2	l_3	l_4	l_5	l_6	t_2	t_3	t_4	t_5	t_6	
	91	160	228	255	275	291	69	68	27	20	16		96	161	227	253	274	291	65	66	26	21	17	
	95	165	232	257	276	291	70	67	25	19	15		98	165	235	258	277	291	67	70	23	19	14	
	89	162	232	255	276	291	73	70	23	21	15		96	164	230	256	275	291	68	66	26	19	16	
Averages	93	162	229	225	275	291	69	67	25	20	16		96	162	228	255	274	291	66	66	27	19	17	
													95	168	233	258	276	291	73	55	25	18	15	
													92	169	237	258	277	291	77	68	21	19	14	
Myomer nr. 49.	98	171	235	257	276	291	73	64	22	19	15		Averages	96	165	232	256	275	291	70	65	24	19	16
	93	161	228	253	273	291	68	67	25	20	18													