REPORT ON NORWEGIAN FISHERY AND MARINE INVESTIGATIONS VOL. III NO. 1

AGE, MATURITY AND QUALITY

OF

NORTH SEA HERRINGS

DURING THE YEARS

1910—1913

BY

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BERGEN
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1917

Table of contents.

This work on the North Sea herrings was begun in the summer of 1913, but owing to other pressing work and to the author's stay abroad for some time the final elaboration has been delayed. A further delay was caused by the loss of a lot of clichées in the great fire of Bergen in January this year, and very possibly this disaster might even cause an additional delay by retarding the printing of the publication.

Simultaneous with the elaboration of the material from the North Sea, a lot of samples from the adjacent waters, viz: the Skager Rack, Cattegat, the Belt Seas, the west coast of Great Britain and the coast of Ireland were examined. Afterwards the work was however limited to the North Sea proper and the rest of the material was left for publication later on. Some preliminary results of the investigations have been published in Dr. Johan Hjort's: „Fluctuations in the Great Fisheries of Northern Europa." The growth question of the herring races of Northern Europe has been studied by Mr. Einar Lea and a report on the matter will soon be published.

Here I will take the opportunity to thank Dr. Johan Hjort for his kind interest in the work and for his valuable suggestions on many points — suggestions based on his broad knowledge of the biological conditions relating to the fisheries. I am also indebted to my colleague Mr. Einar Lea, for the communication of many interesting facts derived from his studies, which has been of great help to me in my work. Also to Mr. James Chumley, Glasgow, who has most carefully revised my manuscript, I herewith offer my sincere thanks.

Bergen March 1916.

Paul Bjerkan.

I. The Samples.

The material treated of in these investigations consists of herring-samples collected during the years 1910—1913 in various parts of the North Sea. Most of the samples, especially those from the northern parts of the region, were collected by the Norwegian fishery research S/S „Michael Sars“ during several cruises in Norwegian and Shetland waters and southward to the Dogger Bank. For some of the other samples we are indebted to the Fishery Boards of England, Scotland and Holland. A few samples were purchased, when herrings from certain fishing grounds were unobtainable in any other way.

As might be expected the material thus obtained is somewhat unequal in character. Some of the samples were measured and scaled and the maturity and amount of fat estimated, when the the herrings were fresh or on ice, while other samples had been preserved. The number of individuals in each sample varies greatly, sometimes being counted by tens, and sometimes amounting to 600 or more. The following list gives the number of individuals in each collection, and indicates whether they were examined in the fresh condition or preserved in salt or formalin.

Most of the herrings were taken in spring and summer; from the southern part of the region we have some samples taken in late summer and late antumn up to the middle of December, but very few samples were taken in winter, and from January to March none at all. This is unavoidable, being dependent on the fishing seasons, and on the fact that most of the research expeditions take place in the spring and summer months.

For each year all the samples obtained have been arranged chronologically according to the fishing-regions. The various stocks of herrings in many cases overlap the boundaries of the regions, and thus

we have in the discussions to rearrange the samples according to the leading principles in each case.

1910.

North-Eastern part:

Coll. no. 15, „Revkanten“	60° 30′ N.		28/7	372	indiv.,	salt.
„ „ 16,	62° 18′ N.	4° 28′ E.	8/9	21	—„—,	formalin
„ „ 17,	60° 38′ „	2° 48′ „	14/9	63	—„—,	„
„ „ 18,	59° 48′ „	3° 16′ „	15/9	104	—„—,	„
„ „ 20,	58° 37′ „	2° 31′ „	17/9	15	—„—,	„
„ „ 21,	60° 31′ „	2° 39′ „	13/10	272	—„—,	„
„ „ 22,	60° 36′ „	2° 56′ „	27/10	75	—„—,	„
„ „ 23,	60° 28′ „	2° 53′ „	28/10	145	—„—,	„
„ „ 24,	60° 23′ „	2° 31′ „	11/11	134	—„—,	„

Dogger Bank:

„ „ 25,	55° 22′ N.	2° 23′ E.	18-19/9	286	—„—,	„
„ „ 26,	—„—	—„—	21/9	194	—„—,	„
„ „ 27,	55° 12′ „	1° 50′ „	24/10	155	—„—,	„

Faroe Islands:

„ „ 28,	Skaalefiord		/4	204	—„—,	fresh

Shetland:

„ „ 19,	59° 56′ N.	1° 50′ E.	16/9	84	—„—,	formalin
„ „ 29,	48 miles S. by E. of Bard Head		19/7	220	—„—,	salt

East Coast of England:

„ „ 30,	24 miles E. of Spurn Lightship		8-9/7	485	—„—,	fresh
„ „ 31,	Off North Shields		/7	528	—„—,	„
„ „ 32,	17 miles E. by S. of Lowestoft		17/10	534	—„—,	„
„ „ 33,	52° 50′ N.	2° 30′ E.	14/11	492	—„—,	„
„ „ 34,	Off Lowestoft		/10	193	—„—,	formalin

Holland:

„ „ 67,	Zuiderzee, Helder		/6	190	—„—,	formalin

1911.

North-Eastern part:

Coll. no. 13,	60° 39′ N.	2° 57′ E.	5/5	90	indiv.	formalin
„ „ 14,	—„—	—„—	6/5	21	—„—,	„

Coll. no. 15,	60° 44′ N.	3° 30′ E.	8/5	59	indiv.	formalin
„ „ 16,	61° 4′ „	2° 37′ „	15/5	43	—„—,	„
„ „ 17,	61° 44′ „	0° 25′ „	31/5	34	—„—,	„
„ „ 18,	60° 53′ „	2° 49′ „	17/6	112	—„—,	„
„ „ 19,	60° 46′ „	2° 48′ „	22/6	110	—„—,	„
„ „ 20,	60° 49′ „	2° 50′ „	23/6	59	—„—,	„
„ „ 21,	61° 9′ „	2° 24′ „	29/6	64	—„—,	„
„ „ 22,	60° 51′ „	2° 52′ „	6/7	103	—„—,	„
„ „ 23,	60° 18′ „	3° 2′ „	7/7	88	—„—,	„
„ „ 24,	60° 36′ „	3° 3′ „	20/7	36	—„—,	„
„ „ 25,	—„—	—„—	21/7	223	—„—,	„
„ „ 26,	60° 27′ „	3° 15′ „	22/7	97	—„—,	„
„ „ 27,	59° 58′ „	3° 16′ „	25/7	77	—„—,	„
„ „ 28,	60° 3′ „	3° 16′ „	26/7	262	—„—,	„
„ „ 29,	60° 8′ „	3° 11′ „	3/8	104	—„—,	„
„ „ 30,	60° 8′ „	3° 12′ „	4/8	83	—„—,	„
„ „ 31,	60° 3′ „	3° 12′ „	7/8	102	—„—,	„
„ „ 32,	59° 55′ „	3° 13′ „	8/8	49	—„—,	„
„ „ 33,	59° 55′ „	3° 14′ „	9/8	57	—„—,	„
„ „ 34,	59° 52′ „	3° 13′ „	10/8	134	—„—,	„
„ „ 35,	60° 21′ „	2° 55′ „	30/9	92	—„—,	„

Dogger Bank:

„ „ 36,	55° 18′ N.	3° 18′ E.	18/9	164	—„—,	„
„ „ 37,	55° 21′ „	3° 14′ „	19/9	136	—„—,	„
„ „ 38,	—„—	—„—	20/9	65	—„—,	„
„ „ 39,	55° 25′ „	2° 56′ „	22/9	110	—„—,	„
„ „ 40,	55° 23′ „	2° 38′ „	23/9	137	—„—,	„
„ „ 41,	54° 8′ „	2° 15′ „	11/9	390	—„—,	salt

Shetland:

„ „ 42,	59° 37′ N.	1° 10′ W.	13/5	21	—„—,	formalin
„ „ 43,	59° 18′ „	0° 15′ „	8/6	174	—„—,	„
„ „ 44,	59° 27′ „	0° 8′ „	9/6	184	—„—,	„
„ „ 45,	59° 25′ „	0° 22′ E.	19/6	101	—„—,	„
„ „ 46,	59° 23′ „	0° 33′ „	20/6	26	—„—,	„
„ „ 47,	60° 7′ „	1° 41′ „	21/6	131	—„—,	„

Coll. no.	48, 59° 51′ „ 0° 51′ E.	24/7	177	indiv.,	formalin
„ „	49, 60° 32′ „ 0° 8′ „	29/8	119	—„—,	„
„ „	50, 60° 30′ „ 0° 15′ „	30/8	309	—„—,	„
„ „	51, 60° 7′ „ 2° 0′ „	2/9	110	—„—,	„
„ „	52, 59° 5′ „ 1° 20′ „	26/6	33	—„—,	salt
„ „	53, 53 miles E.S.E. of Bard Head	30/5	79	—„—,	„
„ „	54, 30 „ S.E. „ —„—	13/6	81	—„—,	„
„ „	55, 45 „ S.E. „ —„—	20/6	86	—„—,	„
„ „	56, 70 „ E. by S. ½ S „ —„—	27/6	80	—„—,	„
„ „	57, 70 „ E.S.E „ —„—	3/7	76	—„—,	„
„ „	58, 40 „ S. by W. „ Bressay Light	6/6	91	—„—,	„
„ „	59, Landed at Lerwick	13/5	93	—„—,	„
„ „	60, — „ —	autumn/winter	474	—„—,	„
„ „	61, — „ Shetland	/7	242	—„—,	„

East Coast of Scotland:

„ „	62, 58° 6′ N. 0° 10′ E.	10/6	124	—„—,	„
„ „	63, 56° 20′ „ 0° 20′ „	14/6	92	—„—,	„
„ „	64, Landed at Grangemouth	20/9	128	—„—,	„
„ „	65, — „ Aberdeen	6/6	238	—„—,	„
„ „	66, — „ —	25/7	200	—„—,	„
„ „	67, — „ —	24/8	217	—„—,	„
„ „	68, — „ Fraserburgh	6/6	266	—„—,	„
„ „	69, — „ —	25/7	205	—„—,	„
„ „	70, — „ —	29/8	227	—„—,	„
„ „	71, — „ —	23/9	253	—„—,	„
„ „	72, — „ —	29/9	305	—„—,	„
„ „	73, Wick Sea	25/7	236	—„—,	„
„ „	74, —„—	19/8	246	—„—,	„

East Coast of England:

„ „	75, 16 miles E. by N. of Spurn Point	20/9	394	—„—,	fresh
„ „	76, 40 „ S.S.E. of North Shields	26/5	86	—„—,	salt
„ „	77, 32 „ E. „ —„—	27/5	78	—„—,	„
„ „	78, 27 „ E.N.E. „ —„—	5/6	84	—„—,	„
„ „	79, 16 „ E.N.E. „ —„—	12/6	84	—„—,	„
„ „	80, 20 „ E.N.E. „ —„—	19/6	86	—„—,	„

Coll. no.	81, 22 „ E. by N. of North Shields	26/6	87	indiv.,	salt
„ „	82, 33 „ N.E. by E. „ —„—	3/7	82	—„—,	„
„ „	83, 20 „ E.N.E. „ —„—	30/8	422	—„—,	„
„ „	84, 55° 45′ N. 0° 5′ W.	18/7	86	—„—,	„
„ „	85, 52° 35′ E. 2° 35′ E.	13/11	504	—„—,	fresh

Without locality:

„ A,	obtained Holland (coast of Holland?)	20/6	148	—„—,	formalin
„ B,	— Hamburg (Dogger Bank?)	27/9	233	—„—,	salt
„ C,	— —„— (—„— ?)	20/10	266	—„—,	„

1912.

North-Eastern part:

Coll. no.	11, 61° 9′ N. 2° 19′ E.	10-11/6	161	—„—	fresh
„ „	12, 57° 31′ „ 6° 54′ „	21-22/7	32	—„—	formalin
„ „	13, 57° 43′ „ 5° 28′ „	22-23/7	98	—„—	„
„ „	14, 57° 26′ „ 3° 43′ „	23/7	12	—„—	„
„ „	15, 58° 21′ „ 3° 4′ „	24-25/7	184	—„—	salt
„ „	16, 58° 53′ „ 3° 18′ „	25/7	314	—„—	formalin
„ „	17, 59° 40′ „ 3° 22′ „	26/7	206	—„—	„

Shetland:

„ „	18, 15 miles S.S.E. of Bressay	/7	92	—„—	salt
„ „	19, 50 „ S.S.W. „ —„—	/7	85	—„—	„
„ „	20, 30 „ S.S.E. „ Fair Isle	12/6	88	—„—	„
„ „	21, 5 „ S.S.E. „ Sherries, Fetlar	12/6	105	—„—	„
„ „	22, 9 „ W. „ Fitfull Head	12/6	70	—„—	„

East Coast of England:

„ „	23, 52° 52′ N. 2° 17′ E.	14/11	521	—„—	fresh
„ „	24, 52° 40′ „ 2° 5′ „	14/10	613	—„—	„
„ „	25, 53° 38′ „ 0° 40′ „	18/9	378	—„—	„
„ „	26, 30 miles E. by S. of Tynemouth	16/7	495	—„—	„
„ „	27, 28 „ E.S.E. „ —„—	13/8	442	—„—	„

1913.

East coast of England:

Coll, no.	6, 54° 50′ N. 1° 0′ W.	15/5	714	—„—	fresh
„ „	7, 52° 55′ „ 2° 22′ E.	20/11	429	—„—	„
„ „	8, 27 miles E. of Lowestoft	16/12	457	—„—	„

Storrow's samples from England and the Dogger Bank:

Coll. A,	10 miles E. of Longstone		$^{6}/_{6}$	69	indiv.
„ B.	10 „ E. „	—„—	$^{19}/_{6}$	66	—„—
„ C,	10—12 miles E. of Dunstanborough Castle		$^{16}/_{7}$	107	—„—
„ D.	10—12 „ E. of Dunstanborough Castle		$^{17}/_{7}$	83	—„—
„ E.	15 miles E. by S. of Seahouses		$^{19}/_{8}$	78	—„—
„ F,	24 „ E. ½ S.	of Tyne	$^{18}/_{8}$	97	—„—
„ G,	24 „ S. E. by E,	„ —	$^{29}/_{8}$	100	—„—
„ H,	20 „ E,	„ —	$^{1}/_{9}$	100	—„—
„ I,	23 „ E. by N.	„ —	$^{2}/_{9}$	100	—„—
„ J,	20 „ E. by N.	„ —	$^{6}/_{9}$	198	—„—
„ K,	18 „ E.N.E.	„ —	$^{8}/_{9}$	198	—„—
„ L,	17 „ S.E. ½ S.	„ —	$^{12}/_{9}$	203	—„—
„ M,	25 „ E.S.E.	„ —	$^{13}/_{9}$	105	—„—
„ N,	85 „ S.E. by E. ¼ E	„ —	$^{15}/_{9}$	195	—„—
„ O,	80 „ S.E. by E. ½ E.	„ —	$^{16}/_{9}$	164	—„—
„ P,	80 „ E.S.E. southerly	„ —	$^{17}/_{9}$	188	—„—
„ Q,	120 „ E. ½ N.	„ —	$^{18}/_{9}$	160	—„—
„ R,	62 „ E.S.E	„ —	$^{19}/_{9}$	95	—„—
„ S,	75 „ E.S.E.	„ —	$^{22}/_{9}$	160	—„—
„ T,	75-79 „ S.E. by ½ E.	„ —	$^{23}/_{9}$	151	—„—
„ U,	125 „ E. ¼ N.	„ —	$^{25}/_{9}$	158	—„—
„ V,	125 „ E. ¼ N.	„ —	$^{29}/_{9}$	160	—„—
„ W,	122 „ E. by N.	„ —	$^{3}/_{10}$	116	—„—
„ X,	118 „ E. ½ N.	„ —	$^{6}/_{10}$	159	—„—

This list shows that the number of samples taken each year is very variable; in 1910 there were 21, in 1911 76, in 1912 17 and in 1913 only 3 samples. For 1913, however, I have been able to add 24 samples from English waters from the Dove Marine Laboratory's preliminary publication: Herring Races — B. Size, Age, Growth and Maturity by B. Storrow (1914, p. 59—). These samples make a very welcome addition for the year 1913, and help to fill up blanks from those waters in the preceding years.

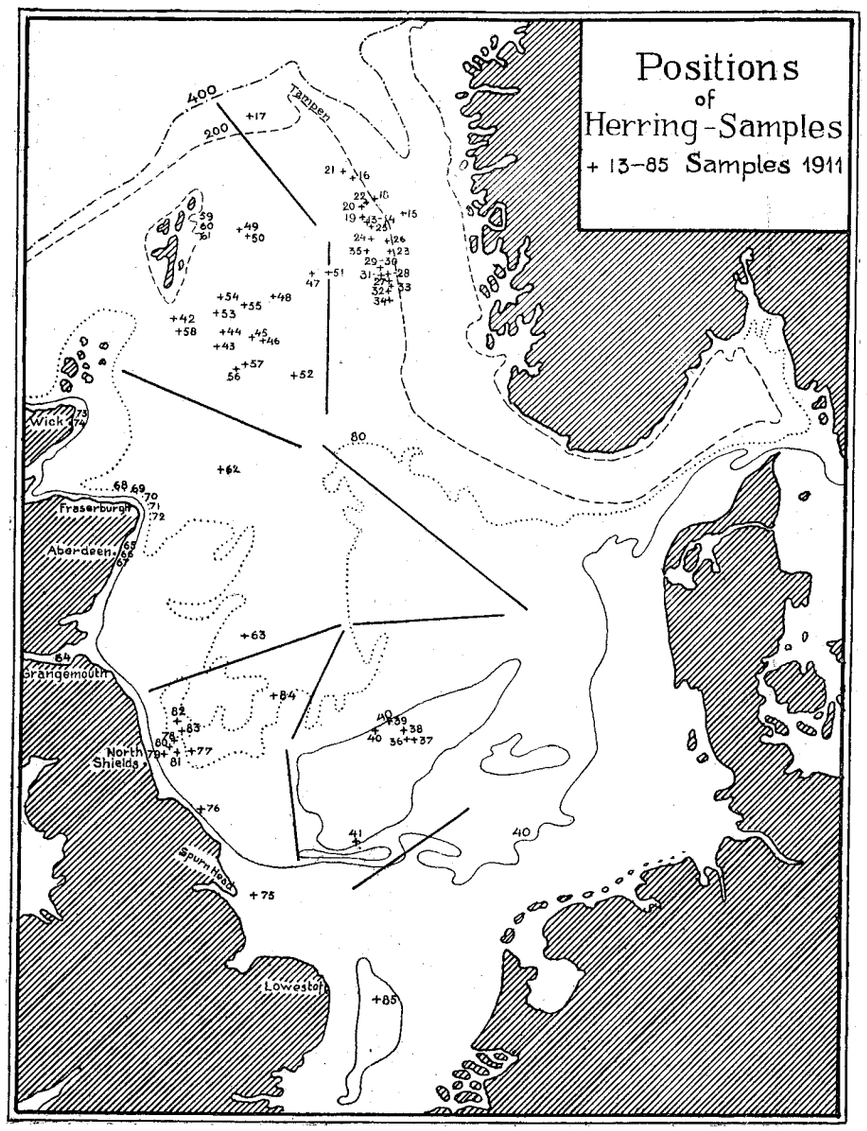

Fig. 1. Positions of the herring-samples taken in the year 1911.

One sample, viz: coll. no. 28 (1910) does not belong to the North Sea, but I have found this sample from the Faroe Islands very useful in explaining some facts respecting the herring stock from the Northern part of the North Sea.

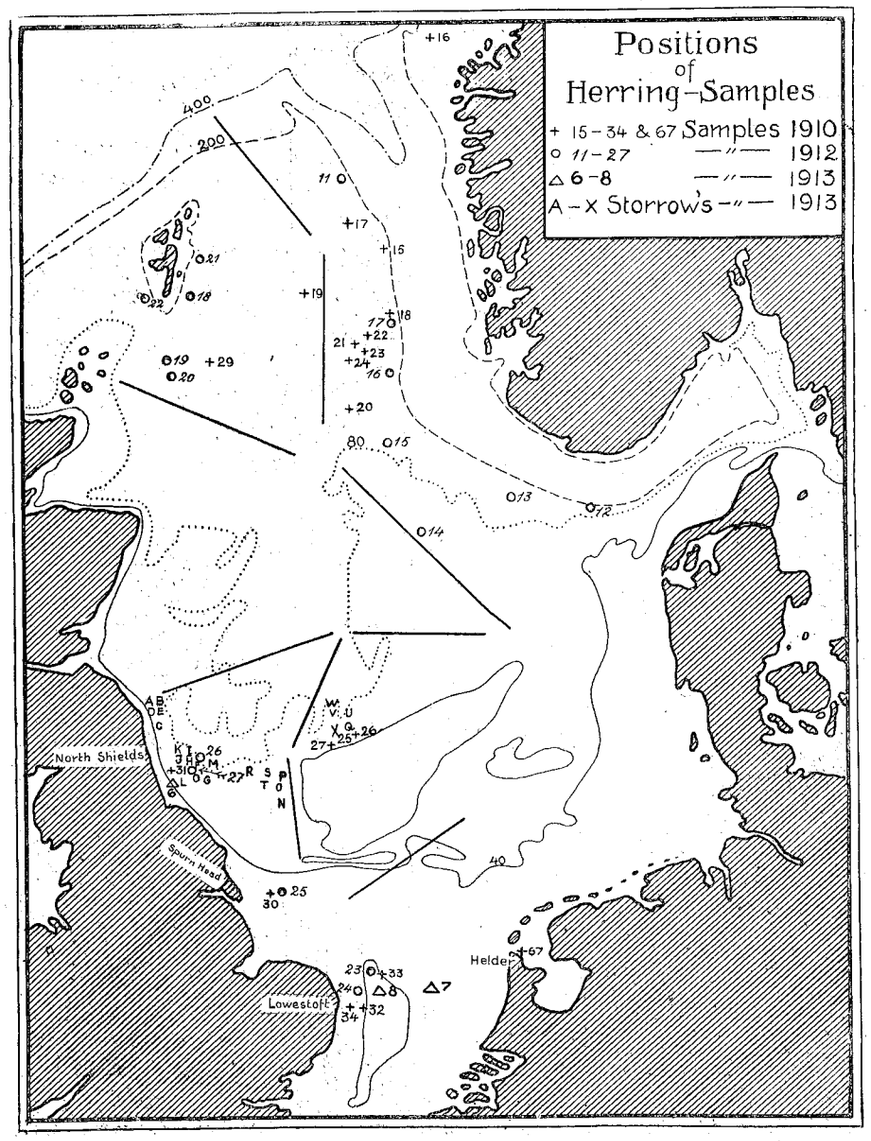

Fig. 2. Positions of the herring-samples taken in the years 1910, 1912 and 1913.

The above list and the two maps of the North Sea (figs. 1 and 2) give the exact positions where the herrings of each sample were taken. In some cases it has not been possible to obtain detailed information about the position. The samples from Scotland, for instance, having

only the landing place and date of capture, but as we know the principal fishinggrounds used by the fishermen of those places, we may make a shrewd guess as to the position by comparing the composition of the samples with those from the neighbouring regions. Three other samples taken in 1911 (two bought in Hamburg and one obtained in Holland) are quite uncertain as to locality of capture. They might have been taken in the Shetland waters, east of Scotland or in the Dogger Bank region. These samples have been entered in the above list for the year 1911 as colls. A, B and C. We may however later on venture to indicate the probable fishinggrounds from a study of the composition as to age and maturity.

II. The Gear.

Most of the material was taken by drift net, the only exceptions being the Zuiderzee sample (coll. 67, 1910) taken by „zegen" (seine) and Storrow's samples L—X (1913) taken by trawl. The drift nets used by the herring fishers in the North Sea vary in width of mesh, which has, doubtless, a selective influence on the composition of the catches, — an influence that cannot be measured directly, but may perhaps be estimated indirectly.

The following figures show the variation in the size of mesh in the gear used in the North Sea and adjoining waters:

				cm.
North Sea:				
Dutch herring	drift nets,	Width of mesh	(from knot to knot)	2.9—3.0
German „	—„—	—„—	—„—	2.9—3.0
Norwegian „	—„—	—„—	—„—	2.7—2.9
English [1]) „	—„—	—„—	—„—	2.6—2.8
Scottish „	—„—	—„—	—„—	2.5—2.6
English „	trawl	—„—	—„—	2.5
Coast waters:				
Dutch „reepnets"		—„—	—„—	2.3—2.4
„ „Zegen" herring seine		—„—	—„—	1.8
„ „Sardelen" „		—„—	—„—	0.7—0.9
Norwegian large herring nets		—„—	—„—	3.1—3.5
—„— fat „ „		—„—	—„—	2.2—2.6
—„— spring herring seine		—„—	—„—	1.6—2.0
—„— sprat nets		—„—	—„—	1.0—1.2
—„— „ seine		—„—	—„—	0.9—1.5

[1]) During the spring herring fishery drift nets are used with meshes down to 2.3 cm. (from knot to knot).

The fabric of the thread used in the different nets varies greatly. The English herring trawl has a very coarse texture, and the meshes are double threaded, so that they are actually much narrower than indicated by the figures.

Delsman (1914, p. 173—) has dealt with the selective influence of the gear, and is of opinion that most of the differences found in the catches from the North Sea might be due to differences in the gear used. He thinks (p. 178) it probable that the composition of the herring shools is pretty uniform, at least as regards the adults (three years old and over), the individuals of the younger age-groups being more numerous, and the individuals of the older age-groups less numerous, the older they are. He is led to this conclusion by catches taken by drift net, seine and „sardelen" seine in the Zuiderzee, compared with samples taken by drift nets with different sized meshes in the North Sea.

In the Norwegian herring fishery both seines and nets with very different sized meshes are used. According to Hjort (1914, p. 14—) the different stages of herring, viz: small herring, fat herring, large herring and spring herring are mostly found separately, so that the different kinds of herring are principally limited to certain districts along the coast. The large herrings (fulls) are exclusively caught by drift nets, and the spring herrings (spawning herrings) by seine, purse seine and nets. Most of the samples of spring herring were taken by seine, and we have thus an opportunity of comparing seine-caught and drift-caught herrings as to their age-composition.

Hjort (l. c, p. 219) has published the results of the large and spring herring fisheries for the winter 1913—1914. The large herrings were taken by drift nets with very large meshes (3.1—3.5 cm. from knot to knot), and the spring herring mostly by seine, but notwithstanding this both kinds of herrings agree very closely as regards age-composition. In this instance at least we must admit that the coincidence in the composition of the two kinds must be due to the actual composition of the schools and not dependent on the gear used.

In fig. 26 (see below), I have, according to Lea: „Fiskets Gang", 1915, No. 29, shown the invasion of a young and rich yearclass (1910) among the Norwegian spring herring during the months af February, March and April. The 3 samples were taken by seine, but

among the drift-caught herring during the same season we may also recognise this invasion, as shown by fig. 3. Now the new yearclass is six years younger, and the herrings relatively smaller than those of the predominant yearclass (1904), for which the herringfishers at the time had adopted their drift-nets, and yet the invasion is felt in the drift-caught samples almost as strongly as in the seine-caught samples[1]). Both figures show that the composition of the herring schools does not always agree with Delsman's sketch at least as regards the northern waters. The age frequency curves may be unimodal with an old

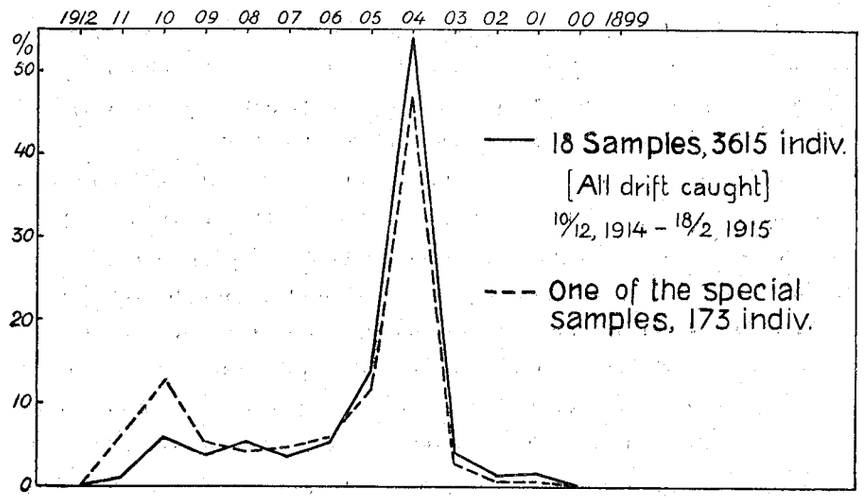

Fig. 3. Age-composition of Norwegian herring samples showing that very different age-groups are caught by drift nets.

yearclass predominating, bimodal or even trimodal according to the number of rich yearclasses; Among the material under consideration bimodal age frequency curves occur in Shetland waters 1912 (fig. 13).

Delsman (1914, fig. 1, pl. II) demonstrates that a difference of 1/10 cm. in the mesh (meshes 2.4 and 2.5 cm. from knot to knot) may cause a difference in the catches to such an extent that the modes

[1]) The same fact is brought out very conclusively by a statement of the Norwegian fishery agent in England, Mr. Johnsen, December 27, 1915: „A remarkable feature of the fishery is the abnormal large herrings caught in the same nets, in which smaller herring is the rule. There is no parallel to these old yearclasses on the coast of Ayr, the average weight being ca. 1 pound."

of the length frequency curves differ about one cm.; the two samples referred to were taken in different localities. During these investigations I have found, among the Lowestoft herrings and in other cases too, that the average length of the different age groups might differ one cm. and more for all the age groups in the samples taken during the same month. As this was the case with the predominant age group as well, there was a difference in the length frequency curves quite like that indicated by Delsman. As the samples were taken during the same fishery I have taken it for granted that similar implements were used in both cases.

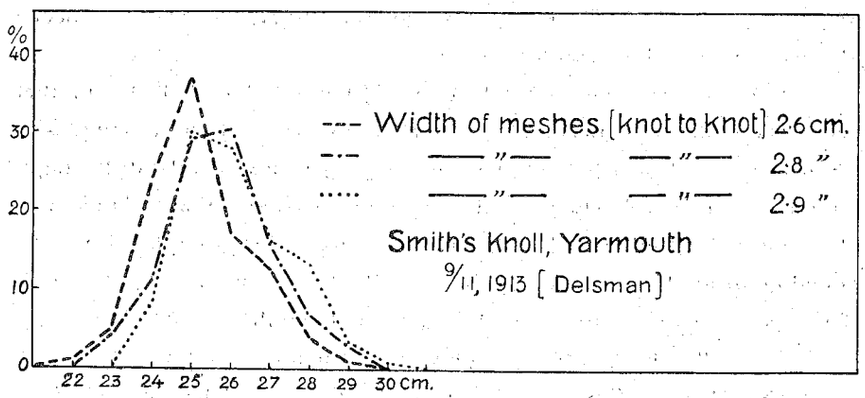

Fig 4. Length frequency curves of three samples from Smith's Knoll, caught by nets with different sized meshes.

Delsman (l. c. p. 180) gives the figures of length frequency of three samples taken by drift nets with different sized meshes, viz: 2.6, 2.8 and 2.9 cm. (from knot to knot) off Smith's Knoll, Yarmouth 9/11, 1913, and from these figures I have constructed the length frequency curves shown in fig. 4. It will be seen at once that the size of the mesh in the nets used affects the composition of the catches, but not to such an extent as might have been expected. The three length frequency curves denote that the true mode lies somewhere between 25 and 26 cm. In both of the samples from Lowestoft in the material taken in 1913 (coll. 7 & 8) the predominant yearclass (1909) has the average length of 25,6 cm., and it seems probable that the modes of the three frequency curves are determined by the average length of the herrings

of the predominant age group. From table Id. it will be seen that the average length of all the individuals in the two samples is 25.5 cm.

It is very interesting to compare the composition of trawl-caught and drift-caught herrings. The English Fishery Board has made extensive investigations and published some preliminary results as to the comparative length of the herrings caught. As stated above, the English herring trawl is very coarse in fabric and double threaded and will thus catch comparatively very small herrings. In the English Fishery Report for the year 1912 (Part I, p. 21) we find the following statement regarding these investigations: „The comparison of the drift-caught samples as a whole with the trawled herring is effected in Fig. 2 . . . . . it is clear that no material difference exists between the fish measured in respect of size."

Of Storrow's samples taken in 1913 more than half the number were taken in the trawl, and the age composition of these samples is shown in fig. 19, (see below). The age frequency curves of the drift-caught samples from off N. Shields indicate young herrings in accordance with the material from the three previous years. The samples from the trawling grounds towards the Dogger Bank consist of older herrings. The age frequency curves are bimodal, with modes for the yearclasses 1909 and 1906, the first being highly predominant. The trawled samples from the Dogger Bank mostly have the yearclass 1909 predominant, but two of the samples differ as to age composition, viz: W, with the young yearclass 1911 highly predominant and a slight mode in the frequency curve for the yearclass 1909, and X, with somewhat older animals.

The selective influence of the trawl is for the older and larger animals nil, and for the younger stages it is, on account of the coarse fabric, smaller than in most other implements used by herring fishers, Hjort (1914, p. 57). By comparison of the catches the trawl caught herring therefore is of great importance. We find that the trawled as well as the drift-caught herring indicate considerable variations in the composition of the herring schools in the sea. We find that drift-caught samples may point to the precence of rich yearclasses of very different ages, as shown by the Norwegian large herring and spring herring samples. We might then suppose that in most cases where

herrings of different sizes and ages are met with in drift-caught samples this denotes a difference in the composition of the herring shoals frequenting the fishing ground. As Delsman admits, the herring fishers adapt the size of the meshes of their nets to the average size of the herrings fished for, and the selection caused by the nets will then only affect the amount of extremely large or small herrings, the first being of minor importance in these investigations.

Regarding the younger stages of the herring, they might as stated by Hjort (1914, p. 60—), be supposed to keep to the shoaler areas nearer the coast. The O-group evidently occurs near the shore, the I-group about the 20 meter line, and the II-group hardly nearer the shore than the 40 meter line. They evidently thus congregate in shoals according to their size and development. It is difficult to account for this distribution; it might be due to the hydrographical conditions, the search for suitable food, the svimming capacity, or most probably a combination of all these factors. The important fact is that the individuals of approximately the same stage of development keep together in shoals in the North Sea, as found on the coast of Norway. The older immature herrings (fat herrings) along the Norwegian coast also congregate in separate shoals, now and then mixed with smaller herrings of minor quality, and the same seems to be the case in Shetland and English waters (see Coll. 18—22, 1912; Coll. 81, 1911). While along the Norwegian coast shoals of pure immature herrings (fat herrings) are met with, the samples from the North Sea include young herrings in the first stages of developing sexual organs. Some of the young-herring samples are found mixed up with spents and recovering spents (Coll. 76—80, 1911), the search for food being apparently the congregating agency. Later on the maturing herrings join the shoals of spawning herrings (see later). A sort of natural selection is supposed to keep the younger and smaller stages out from the shoals of grown up, maturing and spawning herrings, thus limiting the range of size in this direction. It seems certain that some of the smaller animals pass through the meshes of the drift nets, and we cannot know how much. The comparison of samples of trawled and drift-caught herring by the English investigators shows that the selection due to this cause cannot be very material.

III. Age Composition.

Smith in „Skandinaviens Fiskar" (1895, p. 957) seems to have been the first to have noticed the connection between the growth rings of the scale of the herring and the age of the fish. Broch (1908, p. 30) observed that the scales are excellent for the purpose of determining the age of the herring, and since then numerous papers on age determination have been published by Dahl, Hjort, Broch, Schneider, Lea, Lee, Meek, Storrow and Delsman. I will not here enter into the discussion of the reliability of the herring scale as an age indicator, as this is now acknowledged by most of the authors dealing with the question, the divergences of opinion now concerning rather the bearing of the growth investigations as based on calculation from measurements of the growth zones of the scales.

Lea (1910, p. 16—) has described the methods of age determination used in the herring investigation, to which I refer the reader. The methods may be modified according to the bearing of the investigations, as to whether they are connected with growth measurement or only involve age determination.

The age frequency has been calculated in percentages, and the results regarding each sample are given in table I. The years heading each column in the table denote those years in which the herrings had their first summer growth in accordance with the practice in vogue in the international herring investigations. The same is the case with all the figures of age frequency curves in this paper.

From these percentages I have calculated the average age of the herrings in each sample, which is entered in the next column. In using these figures it must be noticed that, according to the practice referred to above, they only denote the number of full summer zones and in order to ascertain the actual age of the herrings, as well as the

average age of all the individuals in a sample, the season in which the herrings were born must be taken into consideration. Thus with the same number of summer zones a herring born in the autumn must be about half a year older than one born in the spring, the first living through the first winter without assuming scales. To facilitate the use of the table I have as a footnote appended thereto a series of corrections. If a sample of spring herrings supposed to have been born approximately in March is caught in August it is only necessary to add the value found for five months in the series of corrections to the average age given in the table, and if it is a sample of autumn spawners, spawning say in September, we must add the value for eleven months to the average age. In the same way the ages of the different year-classes must be found by adding the number of months between the supposed birth season and the time of capture to the age indicated by the years heading the columns. In mixed samples this is naturally impossible.

In order to get a general view of the conditions found in a certain region I have mostly calculated the average age composition for the month, and according to these figures have constructed the average age frequency curve for each month. If the samples vary greatly in age composition, the components are shown separately in dotted lines, while the monthly averages are shown in continous lines. By this procedure I might be able to follow the variation of the stock as to age composition during the season, and to compare it with the maturity and quality as they change with the season.

IV. Maturity, Quality, Condition.

Maturity in this paper is mostly used as a short expression for degree of maturity, thus involving all stages of sexual development from immature herrings up to spents and recovering spents.

The sex is determined by eyesight or in case this is difficult (as in some young individuals) by the aid of a lens. Male is denoted by ♂, female by ♀.

The state of the sexual organs is classified into seven stages:

Stage I. Virgin individuals. Very small sexual organs close under vertebral column. ♀ wine coloured torpedoshaped ovaries about 2—3 cm. long and 2—3 mm. thick. Eggs invisible to the naked eye. ♂ whitish or greyish brown knife-shaped testes 2—3 cm. long and 2—3 mm. broad.

Stage II. Maturing virgins or recovering spents. Ovaries somewhat longer than half the length of ventral cavity, about 1 cm. in diam. Eggs small but visible to the naked eye. Milt whitish, somewhat bloodshot, same size as ovaries, but still thin and knife-shaped.

Stage III. Sexual organs more swollen, occupying about half the ventral cavity.

Stage IV. Ovaries and testes filling nearly two third of ventral cavity. Eggs not transparent. Milt whitish, swollen.

Stage V. Sexual organs filling ventral cavity. Ovaries with some large transparent eggs. Milt white, not yet running.

Stage VI. Roe and milt running (spawning).

Stage VII. Spents. Ovaries slack, with residual eggs. Testes baggy, bloodshot.

(Hjort and Dahl).

Doubtful cases were formerly indicated by giving two stages, e. g. I—II, II—III etc. but the practice now in the Norwegian herring investigations is to drop these double indications, in each case including them under the higher stage, and this practice is followed here.

Quality is here used in accordance with Hjort (114, p. 168) as denoting the chemical composition of the herring, i. e. whether the fish contains more or less fat, and the amount of intestinal fat (ister) is commonly used as an indicator of the quality in the herring investigations.

The amount of fat contained in the ventral cavity is denoted by four different signs:

m = fat in large quantities.
\+ = moderately fat.
I = a little fat
0 = practically no fat.

(Hjort and Dahl).

The sexual development has been found to be correlated with the amount of intestinal fat. The small herrings are devoid of intestinal fat, but having attained a certains length, they begin to accumulate fat in the ventral cavity, and approach the fat herring stage. When the sexual organs begin to develope, this fat is by and by absorbed, and used in the development, so that the amount of intestinal fat decreases with the increasing size of the sexual organs, and in the more advanced stages the herrings are mostly devoid of fat, as is the case with the spents. After the propagation the herrings again store intestinal fat and advance in quality.

In this manner we get practically five categories of herrings:

				Maturity stages
1)	Small herring		immature and lean	I
2)	Genuine fat herring		—„— „ fat	I
3)	Fat herring (Matjes)	maturing virgins	fat to moderately fat	II—III
		recovered spents, mature	fat to moderately fat	II—III
4)	Full herring	mature	moderately fat to lean	IV—VI
5)	Spents and recovering spents		mature and lean	VII, II

The first category is not represented in our material. Unmixed genuine fat herring are often met with along the Norwegian coast, especially in the North. Among the samples treated of here many immature herrings are found during the months of June and July, off North Shields, round Bressa Shoals and Shetland, but they are always mixed with a quantity of herrings farther advanced in sexual development. Spents and recovering spents are often found among the spawning herring, but they seem to segregate from the spawning shoals, and are often met with among the immature and maturing youngherrings, apparantly in search of food. Sometimes there is an admixture of herrings relatively much retarded, or much advanced, in development, and this might be ascribed to an intermixture of herrings of different spawning seasons.

This correlation between the sexual development and the amount of intestinal fat has enabled me to calculate in percentages the herrings belonging to each category of the combination of the maturity and quality stages, viz: Im, IIm, I+, II+, etc. To give a general view of the samples I have arranged them as shown in the three following tables:

1. North Eastern part, 61° 44′ N., 0° 25′ E.

Coll.: 17		Development of sexual organs %							Total
31/V, 11		I	II	III	IV	V	VI	VII	
Stages of fat %	m								
	+		11.8						11.8
	I		35.2						35.2
	0		53.0						53.0
Total			100.0						100.0
♂			50.0						50.0
♀			50.0						50.0

2. North Eastern part, 60° 51′ N., 2° 52′ E.

Coll.: 22		Development of sexual organs %							Total
6/VII, 11		I	II	III	IV	V	VI	VII	
Stages of fat %	m		5.8	1.9					7.7
	+		13.6	16.5					30.1
	I		20.4	25.3	1.0				46.7
	0		2.9	8.7	3.9				15.5
Total			42.7	52.4	4.9				100.0
♂			13.6	29.1	1.0				43.7
♀			29.1	23.3	3.9				56.3

3. Shetland, 60° 32′ N., 0° 08′ E.

Coll. 49		Development of sexual organs %							Total
29/VII, 11		I	II	III	IV	V	VI	VII	
Stages of fat %	m								
	+								
	I				0.8				0.8
	0		6.7	0.8	30.3	30.3	2.5	28.6	99.2
Total			6.7	0.8	31.1	30.3	2.5	28.6	100.0
♂			5.9	0.8	23.5	5.9	0.8	12.6	49.5
♀			0.8		7.6	24.4	1.7	16.0	50.5

The first sample (Coll. 17, 1911) consists of recovering spents from the „Revkant", all spring-spawning herrings from the last days of May. The second sample (Coll. 22, 1911) is a mixture of recovering spring spawners and developing Shetland summer spawners. The third sample (Coll. 49, 1911) consists of spawning Shetland herring with a few spring spawners intermixed.

The three tables are shown here as a proof of the method used to get a better judgement of the character of the samples as regards maturity and quality and only the totals of each maturity stage and quality stage, found as shown above, are entered in table I. Maturity stage II I have in the table found convenient to split up into two groups: fat (m, +) and lean (0,1), as explained below.

Dealing with the conditions in the different regions, I have usually taken the maturity and quality separately, as each is represented by a special graph showing the development from month to month, with the discernible components mostly shown separately. As these components coinside with those found by the age investigations it is very easy to make comparisons. In order to compare the samples as to quality I have found it convenient, in accordance with Hjort (1913, p. 47), to give the stages special values, viz: m = 3, + = 2, I = 1, 0 = 0, and from these I have calculated the average quality of each sample, the averages being entered in table I next to the fat stages. In the graphs they are shown separately, and when necessary in the course of the description I have added the corresponding figures in tables. As the coll. number has been added in every case the calculated figures may be controlled by the percentages found for maturity and quality in table I.

It has been found, as stated by Hjort (1914, p. 74), that the quality of the herrings belonging to stage II might in some cases be used as an indication as to whether the herrings in question are recovering spents (recently spawned), maturing young-herrings or herrings which had spawned months previously. The first are mostly very lean (0,1); the second mostly pass through the fatter stages (m, +) of stage II into stage III; and the third have in most cases again accumulated intestinal fat and might be classed as „recovered spents". As the quality of a whole sample of herrings might vary very much according to the

abundance of food, etc., care is necessary in judging each case, and if possible comparison with related samples is desirable. In the graphs representing the maturity the lean stages (0,1) of stage II are shown separately, mostly following stage VII in the columns.

The counting of the males and females belonging to each stage of maturity has given but slight results; the proportion may vary from 30.0 % males to 70.0 % females on one hand, to 68.8 % males to 31.2 % females on the other. The numbers seem to be more nearly equal towards the spawning time, but there seems to be no prevailing rule. As a whole the females are in the majority in more than half the samples at hand. Regarding the comparative development of males and females in the samples the males seem to be more advanced in samples of herrings in the first stages of sexual development, but in samples of herrings in the more advanced stages the females seem to have developed as fast as the males. This may be a real fact, or only a feature denoting that the stages as defined in the classification are not of the same value in both males and females.

In order to get a general means of comparing the condition of the herring in the different samples I have tried the equation of an inversion parabola of the form:

$$p = k.\, l^3$$

where p is the weight of the herring in grammes, l the length in centimetres, and k a coefficient depending upon the condition of the herring. k is high when the herring is fat and bulky, or when the sexual development is far advanced, and highest in fulls with much intestinal fat.

The weight is determined in grammes by means of an ordinary letter balance weighing objects up to 500 grammes.

The length is determined in centimetres, fractions being reduced to the nearest integer. Length is measured from point of lower jaw (when mouth shut) to middle part of vertical line drawn between the flukes of the tail, when these have their natural spread (Heincke).

In the following table (1 a) I have calculated the coefficient for the different length groups of one yearclass of a sample of small fat herring from the North of Norway, in which the length ranges between 16.0 cm. and 24.5 cm. Number of individuals 1169.

I a. **Small fat herring from the North of Norway**
(year-class 1907)
Number of individuals 1169.

Length, cm.	(16.0)	(16.5)	(17.0)	17.5	18.0	18.5	19.0	19,5	20.0	20.5	21.0	21.5	22.0	22.5	(23.0)	(23.5)	(24.0)	(24.5)
Number	1	—	3	34	61	136	172	192	145	121	109	75	52	45	18	2	2	1
Average weight gr.	30.0	—	31.6	31.7	34.2	37.2	40.1	44.6	49.1	52.7	57.9	65.0	68.1	73.9	79.7	80.0	85.0	95.0
$k = \frac{p}{l^3}$ mean: 0.0061	0.0073	—	0.0064	0.0059	0.0059	0.0059	0.0058	0.0060	0.0061	0.0061	0.0062	0.0065	0.0064	0.0065	0.0065	0.0061	0.0061	0.0064
Difference f. the mean (× 10 000)	+ 12	—	+ 3	÷ 2	÷ 2	÷ 2	÷ 3	÷ 1	0	0	+ 1	+ 4	+ 3	+ 4	+ 4	0	0	+ 3

All the herrings were immature and very fat (m). Leaving the lower and higher length groups with very few individuals out of the question, we find that though all the herrings have much intestinal fat the larger ones must be more bulky, the coefficient increasing with the length of the animals in the length groups 17.5 cm to 22.5 cm. The mean coefficient of these better represented length groups is about 0.0061.

In the next table (2) I have calculated the coefficient for the length groups of the yearclass 1904 of a sample of large fat herring from the North of Norway. Length 22 cm. to 30 cm., 282 individuals.

In order to get a short expression to denote the sexual development of the different length groups, I have given the stages values from 1—6 (stage VII valued as II = 2), and thus got an average as in the comparison of the sample as regards intestinal fat, see p. 26. Though all the herrings are on an average very fat, between 2.50 and 3, we find, especially among the higher length groups, herrings with more developed sexual organs. The coefficient is much higher in this sample than in the former, about 0.0080.

2. **Year-class 1904.**

Length cm.	(22)	(23)	24	25	26	27	28	(29)	(30)	
Number	1	—	23	92	87	52	17	7	3	282 indiv.
Average weight gr.	90.0	—	112.7	120.7	132.5	151.4	191.1	202.9	206.7	
$k = \frac{p}{l^3}$	0.0085	—	0.0081	0.0077	0.0076	0.0077	0.0087	0.0084	0.0076	Mean: 0.0080
Difference fr. the mean (×10000)	+ 5	—	+ 1	÷ 3	÷ 4	÷ 3	+ 7	+ 4	÷ 4	
Stage of sex, organs (mean)	1.00	—	1.07	1.22	1.32	1.65	2.91	2.36	2.33	from 1—6
Stage of fat (mean)	3.00		2.91	2.87	2.92	2:83	2.47	2.71	2.67	„ 3—0

In the following table the coefficient is found for the different length-groups of the yearclass 1908 of a sample taken off North Shields (Coll. 83. 1911), the length ranging between 21 cm. and 28 cm., 159 individuals:

3. **Yearclass 1908.**

Length cm.	(21)	22	23	24	25	26	27	(28)	
Number	1	7	27	58	37	10	8	1	159 indiv.
Average weight gr.	100.0	120.0	123.9	132.5	149.2	164.0	166.2	210.0	
$k = \frac{p}{l^3}$	0.0103	0.0112	0.0102	0.0096	0.0096	0.0095	0.0085	0.0096	mean: 0.0097
Difference fr. the mean.. ($\times$ 10 000)	+ 6	+ 15	+ 5	÷ 1	÷ 1	÷ 4	÷ 12	÷ 1	
Stage of sex. organs (mean)	4.00	3.57	3.70	4.05	4.38	4.70	4.37	5.00	from 1—6
„ - fat (mean)	2.00	1.29	1.65	1.41	1.08	0.40	0.50	0.00	„ 3—0

The averages of maturity (1—6) and quality (3—0) of the length groups are calculated and entered in the table. The herrings have highly developed sexual organs (average between 3.50 and 5.00, some of stage VII), and the smaller animals are slightly fat. The coefficient is thus higher than in the foregoing samples, and is higher than in any of the samples under consideration, the mean being about 0.0097. It mostly falls inversely to the length groups, following the decreasing quality but very unevenly, owing to the presence of individuals of stage VII.

By calculating the coefficient for the different length groups of the whole sample (Coll. 83, 1911) as found in the following table (4), we find the same decrease of the coefficient following the decrease of the quality, although the sexual development increases with the length. The mean coefficient is about 0.0096:

4. **All individuals (422).**

Length, cm...	(20)	(21)	22	23	24	25	26	27	28	(29)	(30)
Number.....	2	6	27	78	73	68	77	64	19	5	3
Average weight, gr...	80.0	96.7	112.2	122.7	132.7	147.8	161.1	180.2	200.8	206.0	226.7
$k = \frac{p}{l^3}$ (mean 0.0096).....	0.0100	0.0104	0.0105	0.0101	0.0096	0.0095	0.0092	0.0092	0.0092	0.0085	0.0084
Difference fr. the mean.... ($\times$ 10 000)	+ 4	+ 8	+ 9	+ 5	0	÷ 1	÷ 4	÷ 4	÷ 4	÷ 11	÷ 12
Stage of sex. organs (mean)	2.00	2.83	3.22	3.47	3.98	4.26	4.79	4.90	5.00	5.00	5.00
Stage of fat (mean).....	3.00	2.50	1.85	1.79	1.43	1.04	0.29	0.06	0.00	0.00	0.00

In the graph (fig 5) the figures shown in the tables have been plotted, and in each case compared with the parabola constructed on the mean coefficient according to the formula $p = k.\ l^3$. As an inset (1 b) I have given the result of a calculation on small herring from the West Coast of Norway.

By the calculation of the coefficient for the whole sample I have first calculated the average weight and the average length of the herrings in the sample, and from this I have found the coefficient according to the formula $k = \frac{p}{l^3}$, p being the average weight and l the average length. The coefficient thus found is however somewhat inconvenient and in the tables I have therefore entered it as:

$$i = 1000\ k.$$

and I can thus mostly write it in two figures viz: 6.1, 8.0, 9,6 etc.; i is in the following called the indicator.

In the samples treated of in this paper each herring has been scaled and measured, the investigation involving the examination of each individual as regards age, maturity and quality, The investigation might have been carried out more easily, if the investigation was only involving condition, by weighing the whole sample and then measuring

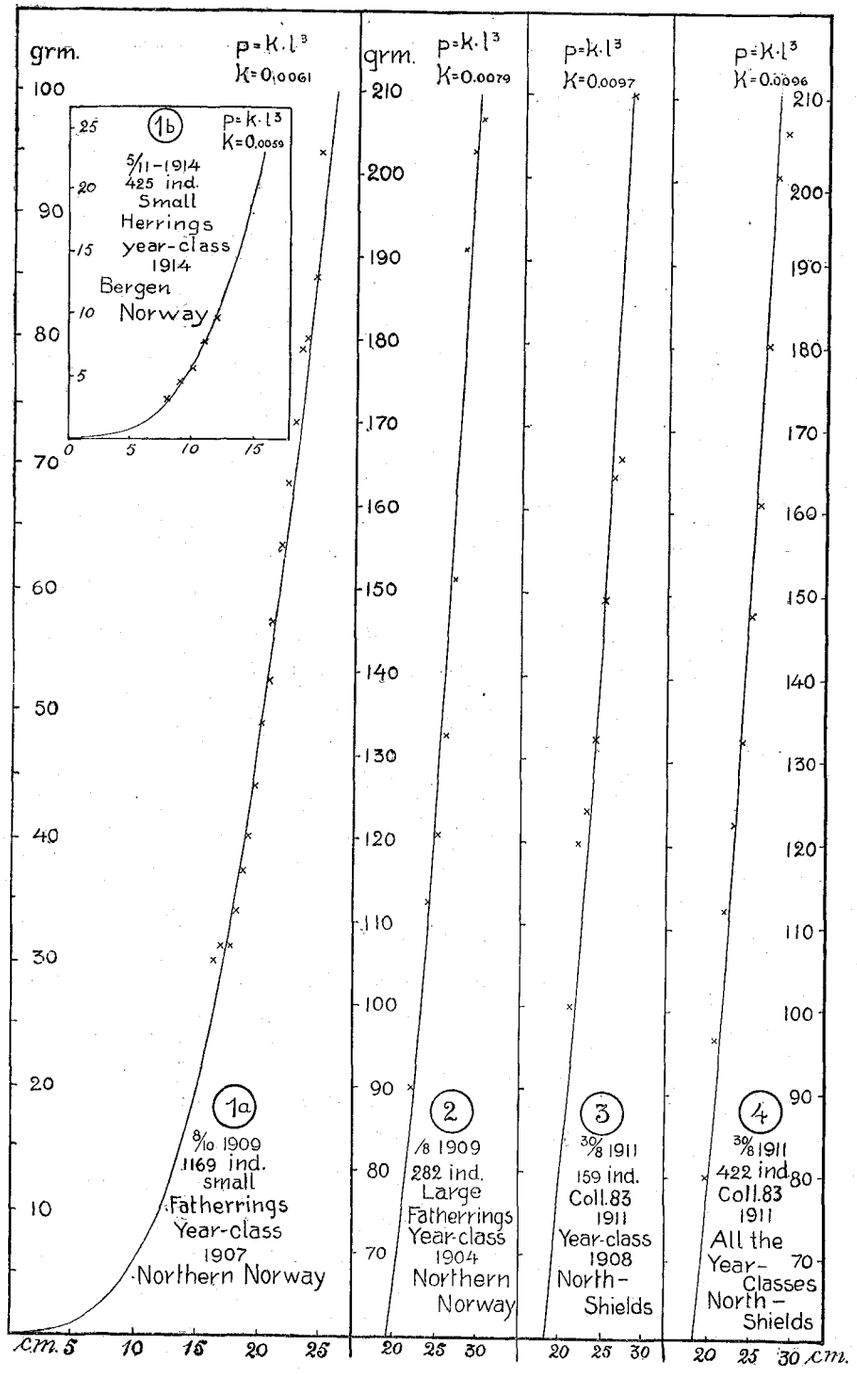

Fig. 5. Length-weight relation of samples of small herrings, small fat herrings, large fat herrings and relatively fat full herrings.

the herring, finding the frequency of each length group, then i is found by the formula:

$$i = \frac{1000\ g}{n\left[\frac{\sum f.\ l}{n}\right]^3}$$

where g is the weight of the whole sample, n the number of individuals in the sample, l the mean length of each length group and f the frequency of each length. The average weight of the herrings in the sample is then $\frac{g}{n}$ and the average length $\frac{\sum f.\ l}{n}$ [1]).

As already stated, in some of the samples the herrings were examined fresh or on ice, in others preserved in salt or formalin. The weight of the herrings from the different samples is therefore not quite comparable, as some of the samples were almost dry, while others were quite covered with liquid. The indicator entered in table I is the figure found directly by calculation from the weight of each sample as received, and in each case the manner of preservation must be taken into consideration.

When the samples consist of fresh herrings only I should think the indicator, thus found, might be of use as a means of comparing samples of small herrings, fat herrings, and fulls among themselves, in the latter case allowing for the stage of development. The limits of the indicator might be found for each kind of herring, and we might thus have a means of showing by figures whether the herrings in a catch are in a bad or good condition. These limits might differ slightly for the different races of herrings, the Shetland herring being, for instance, more bulky, but this could be ascertained by examining a sufficient number of samples of suitable material.

[1]) After having finished my manuscript I find in Report of the Lancashire Sea Fisheries Laboratory (1911), that Johnstone on the suggestion of Meek has used the length weight relation in the plaice measurements off the English coast. His formula for the calculation regarding the whole catch is however different from that given here and will in most instances give slightly different results. As „indicator" I find (l. c.) that D'Arcy Thomson has suggested a formula giving a figure a tenth smaller than that used here. As being written with only two figures the latter is however more convenient, and I therefore retain it.

V. North-eastern part of the North Sea.

As the samples are most numerous for the year 1911 I have taken these samples as a starting-point in the discussion of the biology and migrations of the North Sea herring. In most cases I have found it convenient to arrange the samples for each month, thus showing how the conditions concerning age-composition, maturity and quality change from month to month during the season represented.

1. Age-composition.

1911. It will be seen from table I, and from fig. 6 showing the average age-composition in percentages of individuals from month to month during the summer of 1911, that 1904 is by far the most frequent year-class in all the samples from the region. As shown by Hjort (1914, p. 24—) the year-class 1904 is quite predominant among the Norwegian large and spring herrings during the years 1910—1913, and the preponderance of the same year-class here indicates that the Norwegian herring stock frequents the fishing grounds in question at least during the months from May to September. In May the mean percentage for this year-class is 37,9, increasing from south to north from 27.8 % (Coll. 13) to 56.9 % (Coll. 17); the other year-classes group themselves very smoothly around the predominating year-class, the small collections 14 and 17 only exhibiting some exceptions. The average age (without correction) ranges from 6.80 to 8.02, 7 years being the age of the predominating year-class. The collections 13 and 15 contain some individuals of considerable age, the oldest reaching 18 years.

In June, July and August we find a continuous decrease in the percentage of the year-class 1904, thus denoting that we have an immigration of other herring stocks to take into consideration. I may

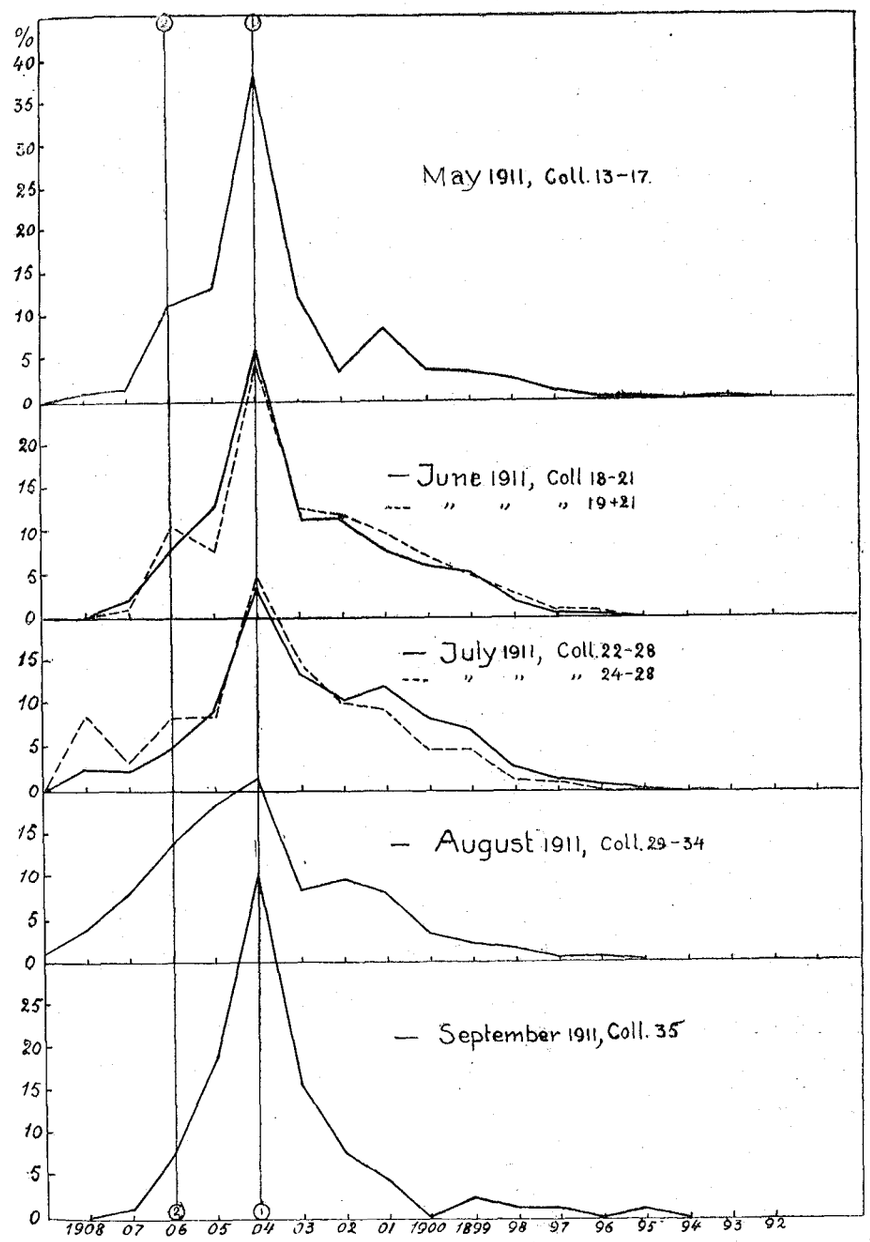

Fig. 6. Age composition of samples from the North-eastern part of the North Sea during the year 1911, compared monthly.

call attention to the year-classes 1906 and 1908 in June and July, which year-classes in some of the original collections (see table I b) make themselves very conspicuous. There is an immigration of older year-classes too, 1901 being of much interest, amounting in Coll. 24 (July) to 25.0 % and thus raising the average age in some of the samples to more than 9 years.

From August to September a segregation of a lot of the immigrants seems to have taken place, the predominant year-class again increasing to 40.2 % in September; though we have only one collection taken in September, we shall find that the above supposition is confirmed when we come to discuss the maturity.

1910. While the samples taken in 1911 might be said to have been secured at the „Revkant" i. e., the slopes from the North Sea platform down to the depths of the Norwegian Channel, where the Norwegian herring-fishery in the North Sea is largely carried on, the 1910 collections are more scattered, one station (Coll. 16) lying off Stadtland and others on the North Sea platform, miles from the slopes of the Norwegian Channel. The collections therefore vary more in age-composition than those taken in the following year (1911). The year-class 1904 is in some of the samples more predominant than in 1911, which corresponds with the Norwegian spring herring, the same year-class amounting to 77.3 % in 1910 as compared with 70.0 % in 1911. It is most abundant in the sample off Stadtland and the samples from the Revkant (Colls. 15, 17, 18) taken in July and September, ranging from 46.8 % to 54.0 %. But in some of the samples from the North Sea plateau taken in October and November the percentage of the year-class 1904 amounts to 36.6 to 48.9 (Colls. 23—24), thus making its influence felt throughout the whole region. We shall see that in the Shetland waters too this year-class takes a more prominent place in 1910 than in 1911. This feature in the composition of the herring stocks of the region in 1910 is explained by the fact that the individuals of the year-class 1904 had then come to maturity and joined the spring herring, so that among the Norwegian stock of mature herring the year-class 1904 was more numerous in individuals in 1910 than in any preceding or following year. Hjort (1914, p. 43) states that this one year-class in the years from 1907—1913 yielded more than half of the

Norwegian spring herring fishery. When a stock of herring receives such an immense augmentation through one year-class it is very likely to extend its usual range of distribution. This is confirmed by the sample from the Faroe Islands (Coll. 28, 1910), with a percentage of 51.0 of the 1904 year-class, and this though we have a component of young, mostly immature, herrings, that lowers the percentages of the other year-classes considerably. If the 1908 year-class were excluded, the percentage of the 1904 year-class would rise to 59.5, an amount approaching the percentage of that year-class among the genuin Norwegian spring herring in 1910. As shown by Hjort and Lea (1911, p. 18) 22 % of the 1904 year-class in the collection are „marked herrings", that is to say, in the third summer (1906) they exhibet a very bad growth, a phenomenon common to many of the herrings that year prevailing in the waters of Northern Norway. The migration of these „marked herrings" has been traced along the Norwegian coast since 1908, and as shown by Hjort and Lea (1912, p. 9) they have spread in several directions south and west of Norway. The authors therefore conclude that an immigration of Norwegian herrings into the fiords of the Faroe Islands has taken place between September 1909 and april 1910. This suggestion I find confirmed by the direction of the principal migration of the stock during the following summer 1911.

In the graph (fig. 7) I have compared the age composition of the herring stock prevailing in the region during the summers 1910 and 1911 for the months represented in both years, for April 1910 I have made use of the Faroe sample mentioned above. It will be seen at once that the year class 1904 is much more frequent in 1910 than in 1911. In September the average percentages are much alike in both years, but we must remember that the September collection of 1910 was secured on the North Sea plateau, miles from the Revkant and from the maximum development of the Norwegian herrings in those waters.

1912. The samples for the year 1912 are not all quite comparable with those for the preceding years, as some of them (Coll. 12—14) were taken by nets of much smaller mesh than commonly used by herring fishers in the North Sea. As may be seen from the map (fig. 2) these samples were taken further south than the others, and about 50

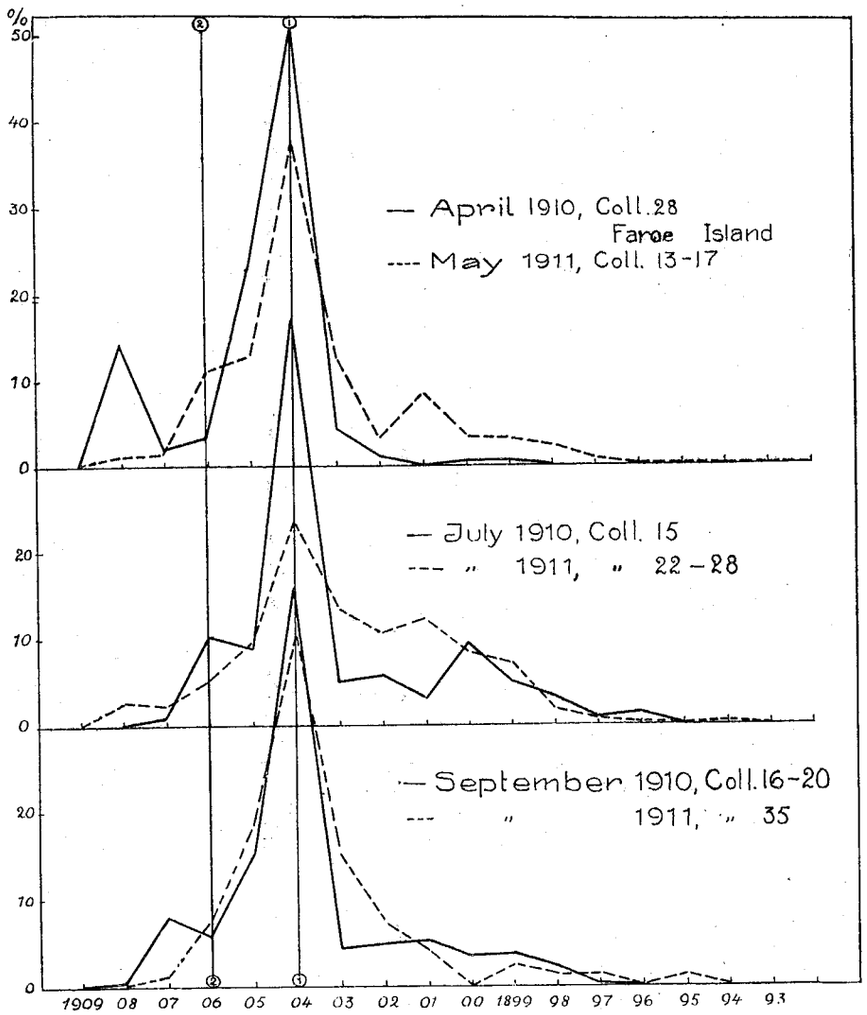

Fig. 7. Age composition of samples from the North-eastern part of the North Sea during the years 1910—1911, compared monthly.

miles distant from each other, which might explain the different age compositions (see table I c), though they consist of fairly young herring. The remaining samples were taken by nets varying in size of mesh up to the largest used. In these samples too we find a very marked difference in the age composition, the herrings being older the farther north we proceed. From these facts it follows that, though taking the

size of mesh into consideration, the difference in age composition is largely due to the composition of the herring shoals in the respective localities. That the predominance of the year-class 1904 decreases the farther south we proceed on the Revkant we have found in the year 1911 as well, and the presence of younger year-classes farther south and east we know from catches at Risør 1910 and Langesund 1911. The latter sample contained 75 % of the year-classes 1908, which in 1911 seems to be of importance in those waters and in 1912 is predominant in two samples (Coll. 15 and 16). As to the appearance of this year-class among the Norwegian spring herring see below. It thus seems as if the area off Jæderen and Lister on the Norwegian coast, south and west of the Norwegian Channel, is a young herring district, which might have considerable importance, especially for the herring fishery on the south-eastern coast af Norway. That the conditions in those waters at times might be influenced by invasions of herrings of more southerly origin is most probable.

2. Maturity.

The state of the sexual organs in the herrings from the region may to a certain extent be of importance in identifying the herring stocks frequenting the fishing grounds in question. The principal herring stocks that we might expect to find there are the Norwegian and the Shetland herring, the first being a late winter or spring spawner, the latter a summer spawner, spawning in August—September. In the first and the latter months of the summer we may therefore easily recognize the two principal components by their stages of maturity. During the intervening months this might be more difficult, the Norwegian herring then recovering and developing the sexual organs, while the Shetland herring are mostly highly developed, often with some individuals retarded in their development.

1911. In order to discuss the 1911 samples as regards state of maturity I have arranged and summed up the different year-classes for each available month, as shown in fig. 8.

As seen at a glance, the May collections include only stage II, thus denoting that we have to do with spring spawners, regenerating sexual organs. Only two samples (Coll. 16, 17) were examined as

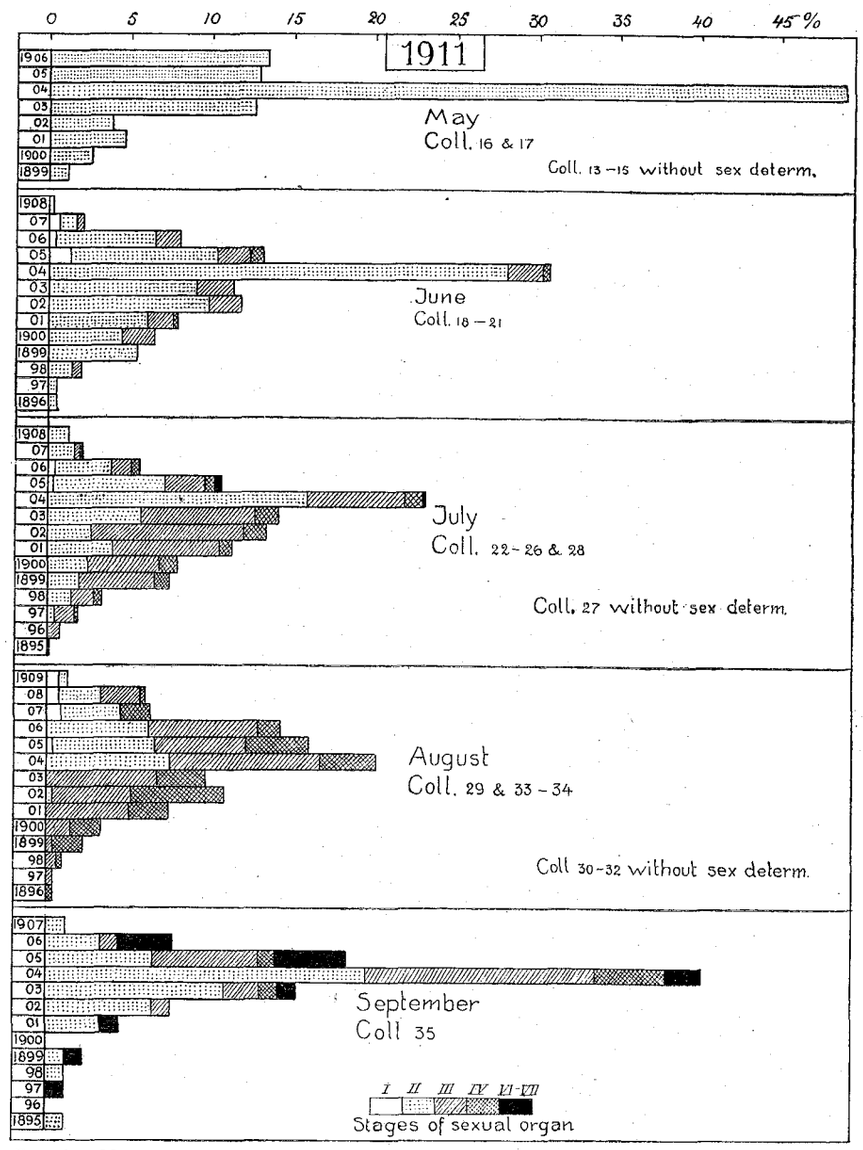

Fig. 8. Maturity stages of samples from the North-eastern part of the North Sea during the year 1911, compared monthly, year-classes separated.

regards maturity, the other three being in too bad condition for the purpose. Of the remaining samples, one (Coll. 15) is of considerable interest. Of this sample Captain Iversen says in the journal of the

„Michael Sars": „Caught 15 barrels of spents, mixed with individuals of fulls, partly spawning males and females, with full and commencing soft roe. The bulk were of a bad quality owing to the preponderance of spent herrings". I shall refer to Captain Iversen's statement later on, and here draw attention to it as of importance.

In June we find components of younger, immature herrings and some fulls (stages III—IV), showing an immigration of other herring stocks. In July and August the fulls have increased, and in July a few spawning and spents are to be found. It is difficult to say whether the bulk of the fulls belong to the primary stock of spring herring or to the immigrants. As mentioned above, some of the firstnamed might then have recovered and commenced the redevelopment of the sexual organs, and, on the other hand, some of the summer spawners are evidently retarded in their sexual development. By comparing the age composition and the state of maturity, I have come to the opinion that the bulk, if not all, of the individuals in stage III belong to the primary spring herring stock.

From August to September a segregation has taken place; the immature herrings and those in stage IV have disappeared and some spent herrings have joined the primary stock. As shown later on in the discussion of the Shetland herring (Coll. 51), spawning took place at that time a little to the west of the place where the September herring sample (Coll. 35) was secured.

1910. This year we find about the same sequence regarding the sexual development of the herring stocks of the region. The summer spawners, however, are not so numerous as in 1911, this being in conformity with the facts brought out in the discussion of the age composition during the two years.

1912. The bulk of the herrings captured this year are immature herrings (stage I) and herrings for the first time preparing for propagation. Most of the herrings with more highly developed sexual organs are found among the samples from the southernmost stations, where North Sea bank herrings of more southerly origin might come in.

3. Quality.

The meaning of the term quality as used here is given on p. 23. As samples are not available for the successive months both in 1910 and 1911, I have found it convenient to take the two years together, the samples then supplementing each other.

1910 and 1911. In order to give a general view of the conditions as regards amount of ister (intestinal fat) in the months from May to November I have arranged the average percentages of the individuals of the different fat stages for each month, as follows:

Month	1911					1910				
	(3) m	(2) +	1	0	Average (3—0)	(3) m	(2) +	1	0	Average (3—0)
May	1.2	5.0	25.4	68.4	0.39	—	—	—	—	—
June	1.1	9.5	36.5	52.9	0.59	—	—	—	—	—
July	11.9	27.4	42.4	18.3	1 33	14.7	58.1	25.8	1.4	1.86
August	17.0	20.7	31.8	30.5	1.24	—	—	—	—	—
September	3.3	14.1	29.3	53.3	0.67	40.1	25.9	4.0	30.0	1.76
October	—	—	—	—	—	25.1	27.8	21.5	25.6	1.52
November	—	—	—	—	—	5.2	29.0	36.7	29.1	1.10

As mentioned on p. 26 I have found it convenient, in accordance with Hjort (1913, p. 47), to get an average contents of ister for each month by giving the different fat stages values: m = 3, + = 2, 1 = 1 and 0 = 0..

These average values for each month show that the amount of ister differs much in the two years. Taking the year 1911 we find during the two months May and June very low amounts of ister, viz: 0.39 and 0.59, the bulk of the herring being in stages 0 and 1.

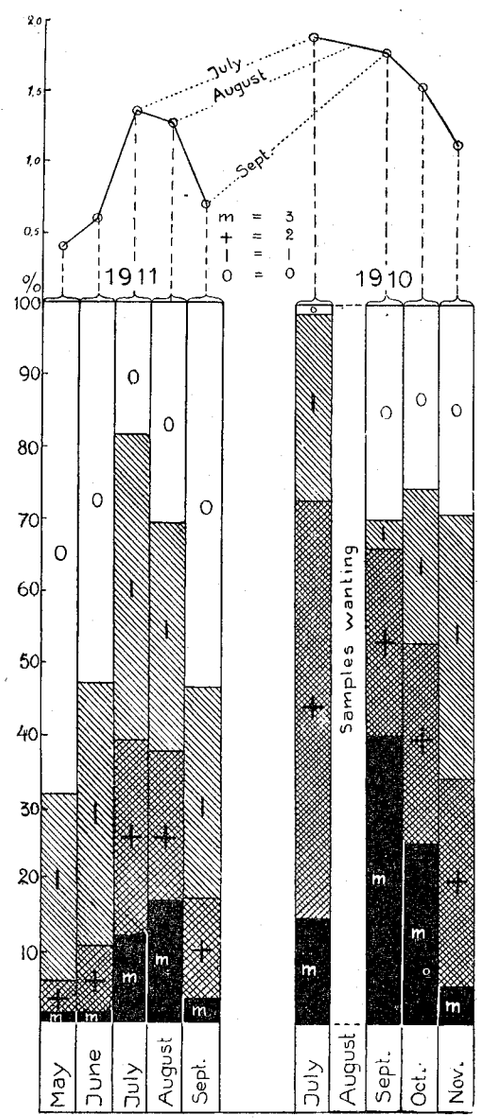

Fig. 9. Percentages of fat stages of samples from the North-eastern part of the North Sea during the years 1910 and 1911, compared monthly. Average (3—0) above.

In July and August we have an increase to respectively 1.33 and 1.24, many of the individuals having advanced to the stages + and m. In September again the amount falls to 0.67, the great majority belonging to the stages 0 and 1. When we compare these conditions with those indicated in the discussion of maturity, and remember that the bulk of the herring stock is made up of recovering spring spawners, we find the sequence of events in accordance with what has been said about the relation between maturity and quality p. 23. In 1910 we have no samples for May and June, but in July we find, as in the following year, the highest average value of ister. This value, 1.86, is, however, much higher than in 1911, the moderately fat herrings (stage +) being especially abundant. We have no August sample, but in September we see that the herrings have not only retained the high ister stages, but the highest stage (m) has risen to 40.1 % of all the individuals. The average however is lower than in July, owing to the high percentage of spawners and spents without ister.

During October and November we find relatively high averages of ister, viz: 1.52 and 1.10, but the amount of intestinal fat decreases, according to the development of the sexual organs, in inverse ratio. The average amount of fat thus falls as in 1911, but the increase is much more rapid and the decrease slower than in that year. This difference is partly due to the more marked preponderance of spring spawners in 1910, but other influences might come into play, such as: hydrographical conditions (temparature, salinity) working partly as direct, partly as secondary, agencies, changing the external biological conditions, food, etc, and we must also remember that in 1910 the main stock of herring were younger, many individuals of the predominating year-class having for the first time taken part in the propagation.

In fig 9 the quality of the samples for the years 1910 and 1911, discussed above is shown graphically. Below are shown the percentages of the fat stages represented by columns, and above the averages from month to month are represented.

1912. The samples for the year 1912 are more unequal as regards quality even during the same month, consisting of fat herrings or a very uneven mixture of recovered spents and young herrings. Collections 12 and 14 are very fat (average 2.09 and 2.50), and were taken in the most southerly positions. Farther north the quality decreases, though the average quality in no sample falls below 1.0. These facts agree very well with the sexual development of the samples.

4. Summary and discussion.

As shown above, the bulk of the herring frequenting during the summer the fishing grounds of this region, and especially the Revkant, are herrings belonging to the Norwegian stock, Norwegian spring herring, which, after having spawned on the banks near the West Coast of Norway in the months of February, March and April, emigrate to those regions to recover after propagation and to feed on the abundance of animal plankton occurring there. As mentioned by Hjort (1914, p. 176), I found, by an examination of the stomach-contents of fifty herrings caught on the Revkant during the spring, a total of 205 cm.^{3}, consisting of 338 *Meganyctiphanes norvegicus* (adults) and 8 *Thysanoëssa (Rhoda) raschii* (various sizes); Some of the stomachs being

empty, this gave an average of more than seven of these comparatively large crustaceans. It appears that the herring go there to feed, and during the spring months find food in abundance at that place. In the Norwegian Channel vertical hauls from the bottom to the surface (360—0 m.) showed, besides small crustaceans, *Copepoda (Calanus, Euchæta, Metridia* a. o.*)* also larger crustaceans, *Euphausida (Meganyctiphanes* and *Thysanoëssa*). Vertical hauls from lesser depths (75—0 m.) showed only *Copepoda*, and no *Euphausida*, which latter are therefore presumably restricted to the deeper water layers. Closer in, on the banks, only larval *Euphausida* were found, no adults; the adult crustaceans here consisted almost exclusively of *Copepoda.*

By closely examining the age composition of the herring stocks from both sides of the Norwegian Channel I have found that the conditions are not so simple as they appear at first sight. As already mentioned, the Norwegian spring herring in the year 1911 showed a percentage of the year-class 1904 amounting to 70.0. In the samples from the other side of the Norwegian Channel we find in May that year an average percentage of the same year-class of 37.9. We have seen when discussing maturity and quality that those May herrings are one and all spring spawners, belonging to stage II, recovering after propagation. Why this great difference in the percentage of the predominating year-class if the latter herrings were simply emigrants from the Norwegian spring herring districts? The available material does not answer the question directly, but I may be allowed to form a hypothesis, in trying to elucidate the composition of the herring stock of the region during the late spring and summer months.

We may recall Captain Iversen's statement regarding the interesting collection 15 (1911), to the effect that he caught spawning and spent herrings on the Revkant on the 8th of May that year. It has long been questioned whether spawning took place in the neighbourhood of the Viking Bank in spring. During the true spring spawning season no herring fishery actually exists in those regions of the North Sea, and unfortunately the sample in question, that might have helped to solve the problem was not scientifically examined as to maturity. The fact however remains, that men well trained in estimating the condition of herrings found spawning and spent herrings there in May.

If spawning to some extent is a common occurence every year on the banks there, then we may understand the difference in age composition of the spring herring from the Revkant and from the West Coast of Norway. The Norwegian spring herring, having at present a very characteristic age composition, may mix with the genuine spring herring from the Revkant, having a different age composition, with the result of lowering the percentages of the predominant year-class of the Norwegian herring. That the year-class 1904 still makes itself felt in all the samples from the Revkant is obviously due to its unique preponderance among the genuine Norwegian spring herring, and to the strength of the emigration of this herring to the Revkant.

We cannot explain the nonhomogeneity of the herring samples from the Revkant in May by an estimation of the stage of maturity, both components being presumably spring spawners. We must therefore see whether other peculiarities in the age composition of the herring of the Revkant point in the same direction and whether the hydrographical conditions in the region might favour a spring spawning.

I have drawn attention to the year-classes 1901 and 1908 among the herrings on the Revkant. In the percentage curves of the age composition these year-classes give only small modes compared with the year-class 1904. We must however bear in mind that the year-class 1901 is very old, on the verge of extinction, and that the year-class 1908 is in 1910 and 1911 very young. In 1912 we find the year-class 1908 of much importance in many of the samples, especially from the southernmost stations. Among the Norwegian spring herring the year-class 1901 is only slightly represented in 1910—12 and the year-class 1908 is for the first time of importance in some of the samples taken in January 1914. The appearance of the year-class 1908 among the spring herring of 1914 is of much interest; According to Hjort (1914, p. 219—) all the samples but one taken in the month of January gave only slight percentages of the class. In one sample secured off Kristiansand the year-class 1908 was represented by 28.7 %, compared with 29.8 % of the year-class 1904. In some other February samples, also collected off the south-western coast of Norway, the said age group was more than usually frequent. As shown by closer examination, counting of vertebrae, etc., this high frequency was not due

to invasion of true North Sea herring. The herrings had the number of vertebrae characteristic of the Norwegian herring, as shown by Heincke (1898), and the development of the sexual organs showed that they were true spring spawners. The invasion of this comparatively young year-class however only served to confirm the predominance of the year-class 1904; when the invaders had been thoroughly mixed up with the spring herring shoals, the year-class 1904 again took the lead by virtue of its immense preponderance of individuals.

From what has been stated I have ventured to assume that the two year-classes 1901 and 1908 are characteristic age groups of the presumed spring spawning herring from the Revkant, parallels to the year-class 1904 among the Norwegian spring spawners, but not nearly so important. The sudden appearance of the year-class 1908 among the Norwegian spring herring off Kristiansand was probably due to accidental invasion of spring spawners from the Revkant.

The hydrographical conditions in the North-eastern part of the North Sea, and especially at the Revkant and adjacent banks, are very variable. Helland-Hansen and Nansen (1909, p. 143—) state that: „the bottom-water of the northern North Sea is Atlantic water that has come round Shetland southward in autumn and winter. It has got temperatures below 7 ° C., partly by vertical convection currents in winter and partly by a slow transmission of low temperatures (by conduction) from above," and further: „There are obviously rather great variations in this influx, seasonal as well as annual." The latter part of the quotation is confirmed by plates IX—XII in the same work, showing the hydrographical condition in different years and seasons. Especially at the north-eastern border of the North Sea plateau we find that the variations in the hydrographical conditions are very great. The great seasonal and annual variations in the north-eastern part are due to the varying strength of the Norwegian coast current running northward bringing Baltic water and coast water of a low degree of salinity (27—33 ‰). This current is strongest in the spring and early summer months owing to the melting snow in the adjacent countries.

As shown by Hjort (1897, p. 6) the herring will not go near land on the coast of Norway, when this water of low salinity sets in, the fishery than being limited to the deeper water, where bank-water

and water of higher salinities are found, — or the herring may disappear almost entirely.

On the Viking Bank and adjacent regions the prevailing currents run in a southerly direction, but eddies are obviously very common here, the banks being situated, especially during the spring, in a border region, where the southerly running Atlantic water and the Norwegian coast current come into contact. During the spring the salinity of the water on the banks may lie between 34 and 35 ‰, but the conditions will vary much according to the varying strength of the opposing currents. The temperature of the water on the banks will however during the spring be lower than 7° C. in either case, the Atlantic water being cooled down to that degrce as stated by Helland-Hansen and Nansen (see above). In the late spring months, April and May, therefore the hydrographical conditions on the Revkant may to some extent resemble those on the banks of the West Coast of Norway some two months earlier, only the salinity may be a little higher. From the above discussion I think the herring might very likely spawn on the western side of the Norwegian Channel in the spring, perhaps somewhat later than on the coast of Norway. The interesting collection 15 (1911) was taken on the 8th of May, long after the time of the herring spawning off the West Coast of Norway. The intensity of the spring spawning of the western banks is likely to vary much according to the annual variations of the hydrographical conditions, and this may occasionaly bring about an exchange between the neighbouring spring spawning regions.

The prevailing currents on the eastern and western sides of the Norwegian Channel are, as shown above, opposed to each other, and therefore when the hatching has taken place, the fry is likely to be carried off in opposite directions from the two spawning regions. As shown by several authors, and recently most plainly by Hjort (1914, p. 35), the young herrings from the Norwegian spring herring districts are mostly carried northward by the coast current, fishing for immature herrings mostly taking place in the fiords of Northern Norway. Respecting the western banks we have not such precise and extensive investigations to rely upon, but as shown by the cruise of the s/s „Michael Sars“ in 1912 young herrings were met with on the North Sea plateau

west and south of Jæderen. The young, mostly immature, herrings were 1—4 years old, and especially the year-classes 1908 and 1909 were frequent. Some of the older herrings were preparing for propagation, and these must from the development of the sexual organs mostly be spring spawners (see table I c, Colls. 12—15).

The hydrographical conditions thus seem to indicate not only, that a spring spawning might take place on the banks west of the Norwegian Channel but also that a certain age composition different from that of the spring spawners of the West Coast of Norway might very well be found there. If this be the case, then the comparatively low percentage of the year-class 1904 among the spring spawners on the Revkant in May 1911 is explicable.

Several authors state that the herrings are very capricious in their spawning habits, suddenly abandoning spawning grounds habitually frequented for generations. Fulton (1891, p. 178) says this is true as regards the spawning grounds off the west coast of Scotland. During the lapse of years similar indications have been recognised in the Norwegian spring herring fishery, which has been transferred north and south along the coast from Lindesnes to Trondhjemsfiord, and at times the herring would not come near land to spawn on any of the usually frequented spawning grounds (Sars, 1879, p. 107). Sars presumes that in the latter case the herring may spawn on the banks farther out, indications of the precence of herring shoals having been observed in the open sea. As shown above this might be the case in so far that the herring is then to be found in the deeper water, the upper waters being too fresh to allow the herring to come near land. Then the coast current during the months, when spring herring fishery ought to take place on the West Coast of Norway, may be so strong that the herring can not spawn on the Norwegian side of the channel. Hjort (1897, p. 5—) has shown that this was probably the case in the year 1895, combined with a common disturbance in the hydrographical conditions of the northern waters. He has found that such disturbances in the hydrographical conditions have occurred during several periods in the 19th century, and always caused a fluctuation of the fishery from the North Sea region to the Norwegian Sea. During such periods the spawning of the Norwegian stock of herring

takes place farther north, but the hydrographical conditions on the Revkant may allow of an increased spring spawning, being in such periods more like the conditions on the banks of the west coast of Norway. As already mentioned fishing on the Revkant has not taken place during the months when spring spawning takes place, and we have accordingly no knowledge whether such fluctuations are caused by a tranfer of spawning of genuine Norwegian spring herring. Boeck (1871, p. 128) has indicated transfer of the spawning of the Norwegian spring herring to the western banks in the years, when spawning does not take place near the West Coast of Norway.

This discussion shows that the presumed spring spawners on the Revkant may have a certain independence in their relation to the large spring spawning stock of the West Coast of Norway, but exchange of spawning grounds might occur with changing hydrographical conditions. Through such a combination many of the salient points in the fluctuations of the spring herring fisheries of Norway might be explained.

Apart from this, we find in these fluctuations features that indicate variations in the total number of individuals belonging to the stock, as discussed by Hjort in his „Fluctuations in the great Fisheries of Northern Europe." Such variations are characterised by annual increase of the average length and weight of the individuals caught, as mentioned by Jensen (1881, p. 9), and are obviously due to the preponderance of certain year-classes comparable to the year-class 1904 at present.

As shown by the age composition of the different samples the preponderance of the year-class 1904 increases from the south to the north, as shown by Coll. 17 (1911) and the Faroe sample (Coll. 28, 1910), when compared with the southern samples. We must therefore presume that the Norwegian spring herring occurs with less intermixture in those northern regions during the summer. The spring herring are recorded by Sars (1879, p. 121—) to leave the Norwegian coast in a north-westerly direction. The left wing of the shoals then touches the Revkant and adjacent banks, finding abundance of food, and remaining there are mixed first with the presumed spring spawners of these banks, and later on with outposts of

the Shetland herring. The bulk of the shoals however proceeds northwestward to Tampen and farther north, reaching in the heat of the summer the vast feeding grounds of the main North-Atlantic current. The shoals might be led farther north according to the hydrographical and biological (food) conditions, but in the course of the summer they approach nearer and nearer to the coast, following the development of the Atlantic current. In the autumn we know that Atlantic water reaches the Norwegian coast carrying with it Atlantic organismes like salpæ etc. The salpæ are recorded by Boeck and Sars under the name of „silderæk", a term at least in former times used in the large herring districts because these plankton-organismes were supposed to indicate the approach of the herring.

In the present herring period the returning herring shoals first come near land at the mouth of Trondhjemsfiord as „large herrings" (fulls) in the latter days of November or in December, and later on the large herring fisheries proceed farther south to about the coast of Aalesund and Stadtland. In former periods large herring fisheries are recorded even farther north to Lofoten etc. Nordgaard mentions (1910, p. 9) that in 1909 vast quanties of salpæ were found off Hitteren at the mouth of Trondhjemsfiord in late autumn, and at times they may be found still further north. This indicates that the Norwegian herring stock during the summer and autumn in those regions has a connection with the North-Atlantic current, and to some extent follows the water-layers of Atlantic origin.

The fishery for spawning herring („vaarsild") however does not begin in these northern districts, but farther south, off the coast near Stavanger and Haugesund. At precent the first touches with the spawning herring are usually recorded in the middle of January off Utsire, and later on the fishery proceeds northward to about Stadtland. This somewhat puzzling fact may be understood by bearing in mind that the shoals of Norwegian herring that remained at the Revkant take the shortest route back to their habitual spawning places, and the development of the sexual organs may be more advanced in these herrings which have prevailed in southern latitudes, thus forcing them to be the first to seek their spawning grounds. Later on the herrings which

during the summer have sought father north proceeds southward to the spring herring districts from the large herring districts, or directly from the open sea in a direction opposite to that in which they disappeared in the spring.

The development of the herring fisheries in the latter years has shown that the above named discontinuity of the two herring fisheries is mostly apparent. As mentioned the large herring fisheries are carried on by drift-nets farther out at sea, while the spring herring is caught nearer land by gill-nets, seines and purse seines. Before good sea-going boats were common the herring fishers were therefore confined to fish the large herring when it came comparatively near the coast. This has been the case periodically at certain places along the coast between Lofoten and Stadtland (the large herring districts). Later on the fishers has found the large herring many places off the spring herring districts (south of Stadtland) too. Iversen (1915, p. 95) states about the coast district Bømmelen—Jæderen: „This drift net fishery is as the drift net fishery off Solsvik—Feie (near Bergen) and off Kristiansand a large herring fishery, the herring being taken early in the season and being of the same quality as the large herring. In the official reports this drift-caught herring is erroneously confounded with the spring herring." Off Moldøen and Kinn large herring is taken in quantities with drift nets, but the more lucrative cod fisheries take place at the same time and occupy the population in January and February when the large herring is mostly found there. The general impression is that shoals of large herrings might be found off the Norwegian coast from Lofoten south to Kristiansand, and that the discontinuity of the fishery is mostly due to fishery-tecnical and fishery-oeconomical conditions along the coast. The difference between large herrings (slosild, sloefulls) and genuine spring herrings (vaarsild) is thus qualitative; the first named are fulls with hard roe, the latter (mostly) fulls with soft roe, about to spawn or spawning and therefore often mixed with spawned herring (tomsild, blodsild).

VI. Shetland.

The Shetland samples are most numerous for the year 1911, twenty samples being available, while for the years 1910 and 1912 we have only two and five samples respectively. Most of the samples were collected by the s/s „Michael Sars", others were bought at Shetland, some of them without exact locality, but knowing the landing places and dates of capture we may determine the positions by comparision with samples from known localities.

1. Age composition.

1911. We have samples taken in 1911 ranging from the middle of May to the first days of September. Of the 20 samples available, collections 52 and 60 must be omitted in the following discussion, because the herrings seem to have been assorted, but these samples will be referred to in the summary.

In the graph (fig. 10) the age composition shown by the average percentage curves is represented from month to month by continuous lines. When different components are discernible the average percentage curves of these are represented by dotted lines. The positions of the samples are given in the map (fig. 1).

For May this year we have three samples (Colls. 42, 53 and 59). The exact locality for Coll. 59 is not recorded, but having been landed at Lerwick it was probably taken to the south-east of that place near Coll. 53. As will be seen the year-class 1906 predominates, being in two of the samples (Colls. 53 and 59) very marked. In the remaining sample (Coll. 42) the herrings are older, the year-class 1905 being preponderant, and the frequencies of the year-classes 1898—1904 falling between 5 and 15 per cent.

In June we find a component with about the same age composition as that of May to the north of Bressa Shoals (Colls. 54, 55 and 58). On Bressa Shoals however a very marked component with the

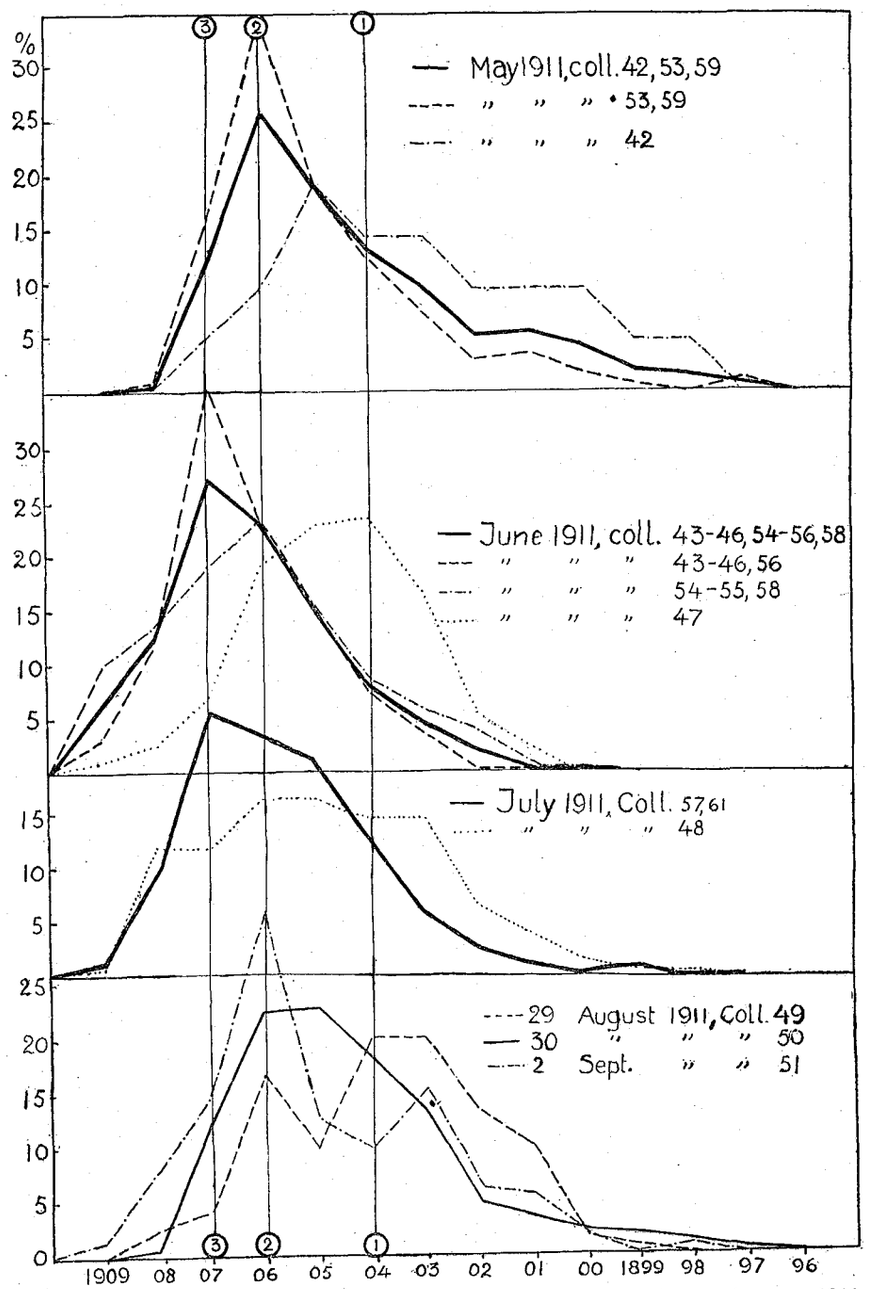

Fig. 10. Age composition of samples from Shetland waters during the year 1911, compared monthly.

year-class 1907 as the preponderant age-group is found (Colls. 43—46, 56). Collection 47, secured in the north-eastern part of the region towards the Revkant, I have not taken into consideration in the average age curve for June, represented by the continuous line, the age-composition of that sample indicating a very strong admixture of Norwegian herrings. The average age composition of the samples for June, thus arrived at, shows very distinctly the preponderance of the year-class 1907 in the waters on and about Bressa Shoals. It may be mentioned that in collection 52, the year-class 1907 is represented with about 58 %, thus confirming the results shown by the remaining samples.

In July the percentage curves show the predominance of the year-class 1907 as in June, but not so marked, one of the samples (Coll. 48) consisting of comparatively old herrings. This sample was taken more to the north-east, as will be seen from the map, thus confirming the general impression that in this part of the Shetland waters the herring might be somewhat older than in the south-east, in the neigbourhood of Bressa Shoals. The two remaining samples (Colls. 57 and 61) show an age composition with 1907 as the preponderant age-group, but the percentages for the year-classes 1906 and 1905 are also high, as might be expected from the age composition in May and June.

From the last days of August and the first days of September we have three samples from the northern part of the region, the August samples (Colls. 49 and 50) being taken to the south-east of Unst Bank and the September sample (Coll. 51) to the south-west of Viking Bank. These samples vary so much in age composition that no attempt has been made to draw an average curve, but this great variation of the year-classes will be referred to later on in the general discussion.

1910. For 1910 we have only two samples (Colls. 19 and 29), but the age composition is very interesting seen in combination with the conditions discussed in dealing with the North-eastern part of the North Sea. Collection 29 secured near to Bressa Shoals in July contains up to 19.5 % of the year-class 1904, which is the preponderant age-group, the year-classes 1903, 1905 and 1906 being also well represented. Collection 19 was taken more to the east, south-west of Viking Bank, and gives 26.2 % of the predominant year-class 1904. Both samples confirm the conclusion that the Norwegian stock of her-

ring this year had a tendency to extend beyond the habitual range of distribution. I have already stated that this may be due to the augmentation of the stock, caused by the immense number of individuals belonging to the predominant age-group 1904, which this year must have been more numerous than ever among the mature stock.

1912. Five samples are available for 1912, three for June (Colls. 20—22) and two for July (Colls. 18—19). In both months we find that the year-class 1907, the predominant age-group in the preceding year is of much importance. The dominant year-class is however 1909, while the intervening year-class, 1908, is of minor importance. The average age-curves for each month, and most of the separate samples, thus display two sharply defined modes for the years 1907 and 1909. This shows very distinctly that in Shetland waters too the propagation may fall very different in successive years, as may be proved by investigation of the age composition of the stock on the fishing grounds later on. The discrepancies between the various samples may be understood, when we remember that at least one age-group is comparatively young, and that immigration from the young-fish grounds is going on. The various shoals are not thoroughly mixed up, and the samples secured may represent different degrees of congregation. As it is the samples agree very well, considering the distances between the localities where the samples were taken.

2. Maturity.

In order to get a general view of the stages of maturity of the herring stock in Shetland waters during the summer time, I have tried graphically to show the conditions in the years 1910—1912 as indicated by the available samples, in fig. 11, which should be studied in connection with the two maps (p. 11 and 12) showing the position of each sample.

1911. The May samples were collected in the south-western part of the region, and display a comparatively low degree of sexual development most of the individuals belonging to stage II. Some immature herrings (0.6 %) and spents (1.9 %) are present. The majority of the herring thus seem to have spawned in early spring

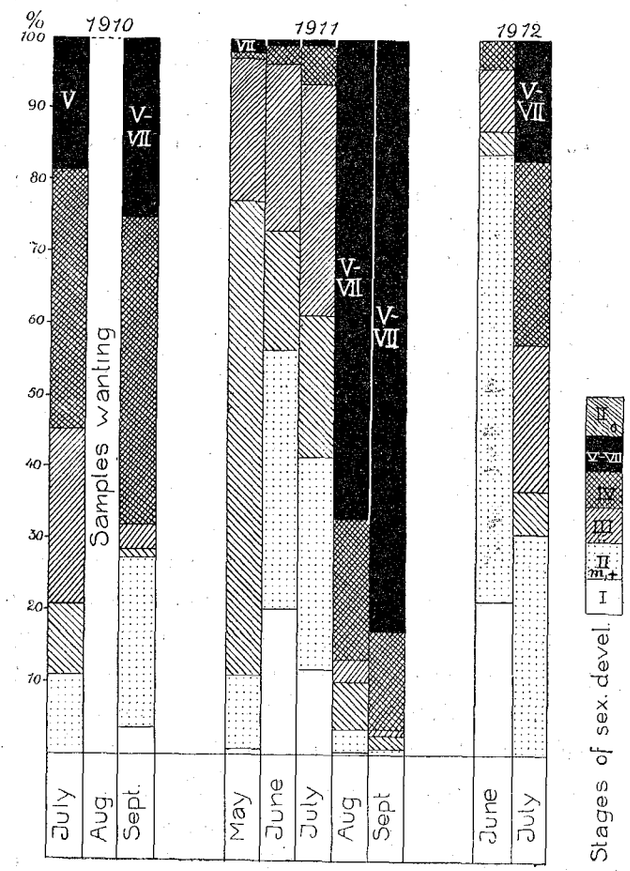

Fig. 11. Maturity stages of samples from Shetland waters during the years 1910—1912, compared monthly.

and are now regenerating the sexual organs, but about 26 % are in stages III—IV and might thus be summer- or autumn-spawners.

The conditions during June and July confirm the impression that a great part of the herrings are winter- or spring- spawners, the percentage of stage II being 52 9 and 49.6 respectively, while 10—20 % are immature herrings, and we must bear in mind that part of the herrings of stage II might be maturing young-herrings and not regenerating herrings. The exact proportion of spring- and summer-spawners in the samples cannot be determined, but later on I shall show that many of the herrings must be spring spawners, by taking

into consideration the condition of maturity and quality combined, as shown below.

Except Coll. 47 all the samples taken in May—July are from the south-western part of the region, on and about Bressa Shoals. The samples for August (Colls. 49—50) and September (Coll. 51), however, were taken far to the north, the former south-east of Unst Bank and the latter south-west of Viking Bank, and the graph shows at a glance that here spawning and spent herrings were in the majority. The difference in the conditions of maturity in the two parts of the region is thus too great to be brought into accordance as successive stages of the same stock. We must therefore take the features displayed by the samples as an indication that differences really exist in the stocks of herring frequenting the northern and southern parts of the region. To the south-west we find that the stock consist of winter- or spring-spawners and summer-spawners, both being well represented, the northern samples include summer spawners almost exclusively, spring spawners being very scarce. Whether this is a result of the congregation of the mature herrings on the spawning grounds at the time of propagation, or really a feature characteristic of those waters throughout the year, can only be determined by closer examination of the various conditions relating to the stock and the question is therefore postponed to the general discussion later on.

1910. In the July sample, we find spring-spawners and summer-spawners in about equal proportion. We have no August sample, but in September we find the July conditions still in progress, with up to 25 % spawning and spents, and a large number that must be supposed to spawn during the autumn. The July sample is from Bressa Shoals and the September sample from the north-eastern border-region. As already shown both samples, and especially the September sample must be supposed to include many Norwegian spring spawners.

1912. The five samples for 1912 confirm the impression of the presence of both spring- and summer- spawners in the south-western part of the region in the early summer-months. The samples were taken farther west than those of the preceding year, and this might explain why the spring-spawners are more numerous than in the samples for 1911.

3. Quality.

I have tried to show in the graph (fig. 12) the amount of the different stages of ister (intestinal fat) during the summer in the years 1910—1912.

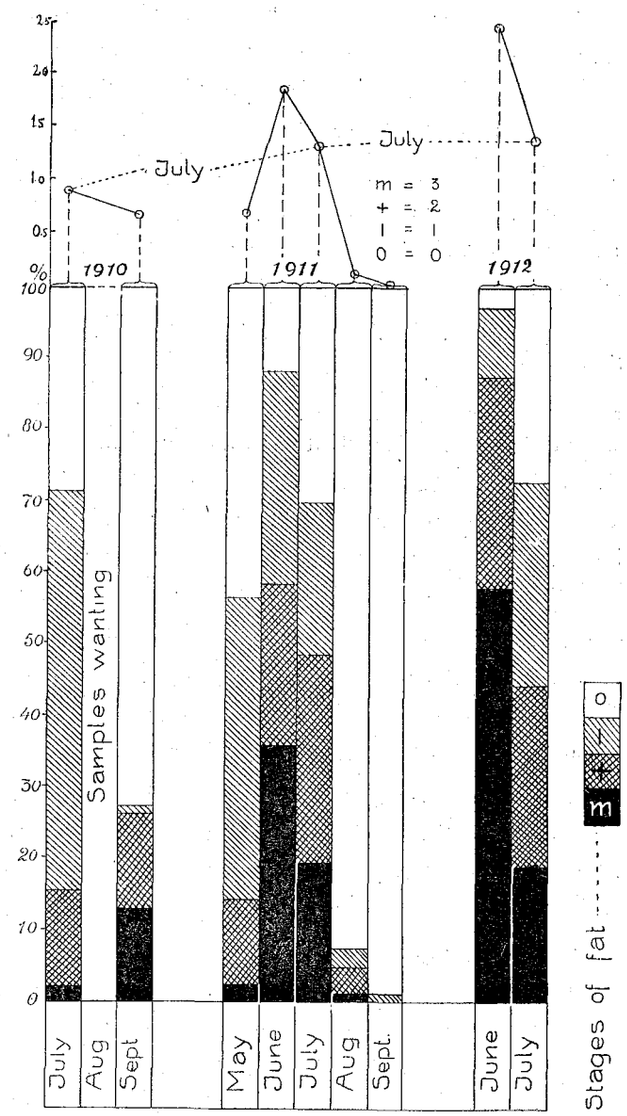

Fig 12. Fat stages of samples from Shetland waters during the years 1910—1912, compared monthly. Average (3—0) above.

1911. The amount of ister is seen to increase very much from May to June, partly due to invasion of immature and maturing young-herrings as indicated by the rise of stage *m* from 2.5 % to 36.2 %. But the simultaneous expansion of the intermediate stages (1, +) at the expence of stage 0 in the May samples indicates that a considerable part of the increase is due to the recovering of herrings which have spawned during the spring. By a study of the maturity and ister conditions combined we may arrive at more definite results on this point and this we shall do in the general discussion later on.

In July we find that the amount of ister has decreased, as the general development of the sexual organs proceeds. The spring-spawners are to a certain degree still storing intestinal fat, but they do not seem to be present in such numbers as in May and June, and the summer spawners rapidly consuming their intestinal fat thus dominate the result.

The ister conditions displayed by the August and September samples confirm the result arrived at from an examination of the sexual development of the herrings from the northern part of the region, for we find that 92.5 and 99.1 % respectively are without intestinal fat, as might be expected for herrings in the act of spawning. The non-conformity of the May—July and the August—September samples is thus confirmed by the investigation of the fat conditions.

1910. In the two 1910 samples we find a strong decrease of intestinal fat from July to September, affecting especially the lower stages, stage I falling from 55.9 % to 1.2 %; stage + remains about 13 % and stage *m* increases from 2.3 % to 13.1 %. These changes in the fat conditions indicate that the summer spawners are at first in a majority, and that in September immature and maturing young-herrings have joined the shoals preparing for spawning.

1912. The fat conditions in 1912 are very like those in the preceding year, though the amount of fat is considerably higher and the decrease from June to July more rapid. Both these features are obviously due to a stronger component of immature and maturing young-herrings, as will be seen at once by comparison with the age composition and maturity of the same samples.

As supplementing the graph I add the following table showing the exact figures:

Years	Month	Colls.	(3) *m*	(2) +	1	0	Average (3—0)
1910	July	29	2.3	13.3	55.9	28.5	0.89
„	August	wanting	—	—	—	—	—
„	September	19	13.1	13.1	1.2	72.6	0.67
1911	May	12, 53, 59	2.5	11.9	38.2	47.4	0.70
„	June	43—47, 54—56	36.2	22.3	29.8	11.9	1.83
„	July	48, 57, 61	19.4	29.2	31.2	30.2	1.48
„	August	49—50	1.1	3.7	2.7	92.5	0.13
„	September	51	—	0.9	—	99.1	0.01
1912	June	20—22	57.6	29.9	9.6	2.7	2.42
„	July	18—19	18.7	25.6	28.4	27.3	1.36

4. Summary and discussion.

As might be expected, the conditions in the Shetland waters are more complex and therefore more difficult to understand than those in the north-eastern part of the North Sea. The changes in the stock are more pronounced from locality to locality and from month to month. This seems to be due to the presence of strong components of both spring-spawning and summer-spawning herrings. Among the spring-spawning herrings we must distinguish between the component of Norwegian herring in the eastern part of the region and a component of spring-spawners belonging to the western part, round the Shetland Islands.

According to the available samples there seems to be a striking difference between the north-eastern area and the south-western area,

round Bressa Shoals as regards age composition. In the former the herrings are much older, and when without immigrants from the adjacent waters they are true summer-spawners. Spawning takes places in this part in August and September on the slopes of Unst Bank and south of a line drawn between this bank and Viking Bank. In the south-west the herrings caught are younger, and spring-spawners and summer-spawners are found together. Especially in the spring and early summer months the spring-spawning component is very strong on the fishing grounds of Bressa Shoals and adjacent waters. Unfortunately we have no samples of spawning herrings from this part, and therefore we cannot tell where the two components spawn. Broch (1908 p. 52) examined a sample taken by the s/s „Michael Sars", September 10th, 1904, and found about 58 % of Heincke's stage VII[1]), just spawned. This sample was taken a few miles S. W. of Bressa Shoals, and we find the same two components viz: summer-spawners 58 % (stage VII) and spring-spawners 36 % (stages II—III), both according to Broch (1908, p. 26) Shetland herrings. From this we might conclude that the summer-spawners we have traced on Bressa Shoals in the earlier summer months, spawn somewhere near this bank in August-September. The spring-spawners are apparently more nearly related to the Shetland coast, at least they seem to be of a more westerly origin, than the other herrings of the Shetland waters.

In the Shetland waters we have thus found two summer-spawning grounds, viz: (1) Unst Bank to Viking Bank in the north, with decidedly older herrings and (2) round Bressa Shoals to the south, with younger herrings; there are also two spring-spawning elements; the Norwegian herring in the north-east and the spring-spawners of Bressa Shoals, which latter might be a coast herring from the Shetland coast.

That this complex character of the herrings fished east of Shetland has persisted for ages we might conclude from the statements of Mitchell (1864, p. 55) in 1864: „The greatest quantities are caught in July, August and September. The herrings taken on the east side are generally two-thirds 'full fish' and one-third 'spent fish', while fully more than one-half of those caught in September are spent fish."

[1]) Called by Broch „stage VI".

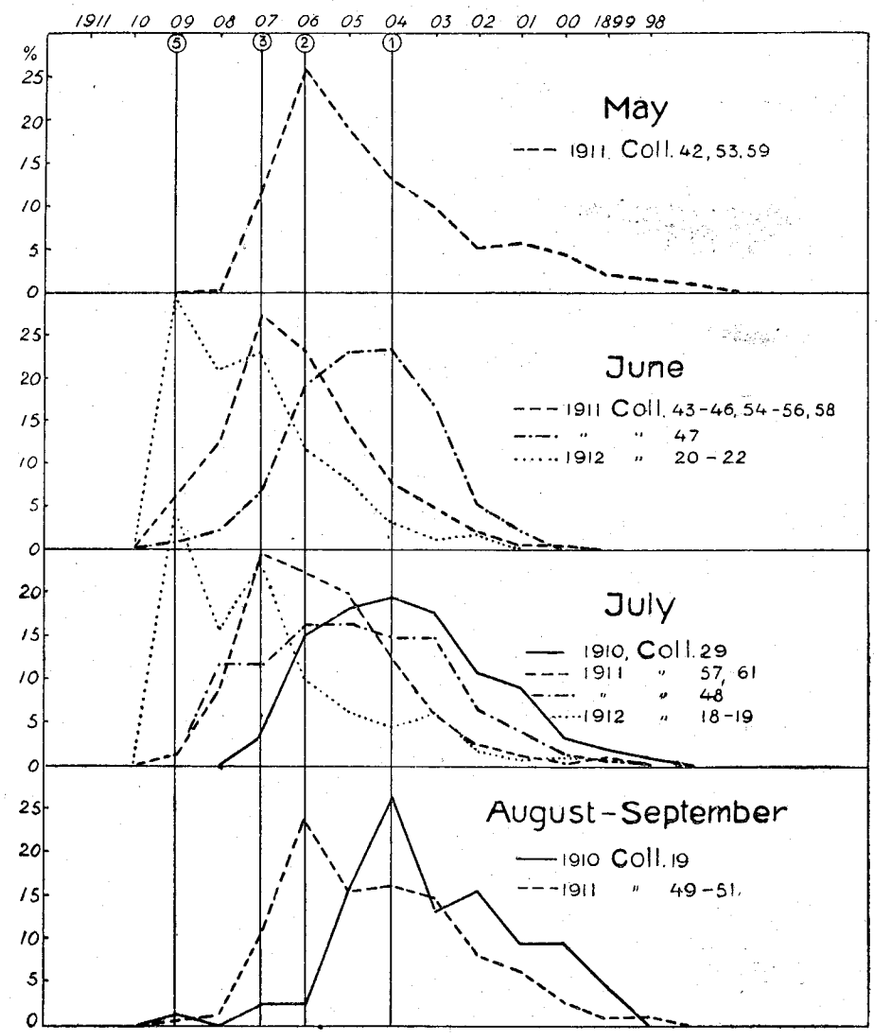

Fig. 13. Age composition of samples from the Shetland waters during the years 1910—1912, compared monthly.

Mitchell (l. c.) states too that the herrings from the west side are quite different from those fished on the east side, three-fifths of them (fished July—September?) are spent herrings, „or rather have not ovaries developed, but do not appear to have recently deposited their spawn". From this last somewhat vague statement it might be concluded that the herrings in question are not summer-spawners, but probably herrings af more westerly origin, spawning in the spring.

In order to get a general view of the samples taken in Shetland waters during the years 1910, 1911, and 1912 I have constructed the graph (fig. 13), showing the averages from month to month. The samples from the eastern border are shown separately, but have been excluded from the averages of June and July 1911, as in fig. 10.

Fig. 13 only gives the percentage curves of age, so I have drawn up the following table, where the monthly averages are taken chronologically, beginning with 1910, and the characteristic facts as to age, maturity, quality and locality shortly indicated. By studying the graph and table together, I hope the main features of the herrings from this region may be understood.

Year	Month and Colls.	Character	Average age	Locality
1910	July 29	1904 slightly predom. Fat: 0.89 Spring and summer spawners	6.29	Near Bressa Shoals
	Sept. 19	1904 much predom. Fat: 0.67 Spring and summer spawners	7.00	East border
1911	May 42, 53, 59	1906 predom. Fat: 0.70 Spring and summer spawners	6.13	Near Bressa Shoals
	June 43-46, 54-56, 58	1907 predom. Fat: 1.86 Spring and summer spawners	4.76	Near Bressa Shoals
	(June) 47	1904 slightly predom. Fat: 1.82 Spring and summer spawners	6.40	East border
	July 57, 61	1907 predom. Fat: 1.42 Spring and summer spawners	5.45	Near Bressa Shoals
	(July) 48	1905/06 slightly predom. Fat: 160. Spring and summer spawners	6.17	East border
	Aug.-Sept. 49—51	1906 predom. many older. Fat: 0.09 Summer spawners	6.70	North-East
1912	June 20—22	1909 predom. 1907 next. Fat: 2.42 Spring and summer spawners	4.72	South-West
	July 18—19	1909 predom. 1907 next. Fat: 1.36 Spring and summer spawners	5.04	South-West

Following the chronological order, we find that in 1910 the year-class 1904 predominates, slightly near Bressa Shoals, more decidedly

towards the east. That Norwegian spring-spawners are represented in the catches, is very likely, especially in the September sample (Coll. 19). The Shetland herrings represented in the July sample from Bressa Shoals must however be comparatively older than those taken in the two following years, more like the herring in Coll. 42 (1911).

If more samples had been available for 1910 we might, at least west of Bressa Shoals, have traced the strong year-class 1906, predominant in May 1911. The year-class 1907, predominating near Bressa Shoals in June and July 1911, is however so young that its importance is likely to be felt for the first time among the shoals out there in 1911. It is an immigrating year-class with immature and maturing herrings, and this might, together with the recovering of the spring-spawners of the samples, be responsible for the rise of the quality from May to June. In the two samples from the eastern border taken in June and July (Colls. 47, 48) we find older herrings in the more easterly sample (Coll. 47), with 1904 predominating. Among the spring-spawners of these samples the Norwegian herring is likely to be represented. The August—September samples (Colls. 49—51) from the north-east consist decidedly of summer-spawners, being mostly spawning and spents without intestinal fat; though the year-class 1906 is predominant, the herrings are on the average much older than the herrings from the south-western waters.

The samples taken in 1912 are all from the south-western part, and though the year-class 1907 is again very prominent the year-class 1909 is predominant, with many immature and maturing fat herrings invading the shoals. Though we find some recovering spents, the maturing young-herrings lower the average of intestinal fat from June to July considerably. The low degree of maturity of many of the herrings of the July samples seems to indicate that they are not spawning this summer.

In order to show more plainly the relation between the spring- and summer-spawners from the western part, I have drawn up the following percentage table for the years 1911 and 1912:

Year	Month, Colls.	I	II (m +)	III	IV	V	VI	VII	II (1, 0)
1911	May, 42 & 53 [1])	0.7	10.1	20.0	0.7				66.7
"	June, 43—45, 54—56, 58 [2])	22.5	32.6	22.3	2.7			0.7	19.0
"	July, 57 & 61	11.2	31.6	33.0	4.8			0.7	18.8
1912	June, 20—22	13.6	61.6	12.1	3.8				3.1
"	July, 18 & 19		30.7	15.5	25.7	11.4		5.5	6.3

In this table the critical stage II is divided into (1) herrings with much and moderate fat (m, +) and (2) herrings with little or no fat (1, 0). The latter are placed after stage VII (spents), and are thus regarded as recovering spents. In May we have samples only in 1911 and in those samples we find 66.7 % recovering spents, showing that a lot of the herrings must have spawned in the winter or spring. In Coll. 59, which has not been examined as to maturity, the herrings again are „mostly spents". In the two following months the conditions are made more complex through the fact that the recovering spents are storing fat, and thus partly passing into the higher fat stages; at the same time we have an invasion of immature and maturing young-herrings, the latter rapidly consuming their intestinal fat in preparing for propagation. And in July a few of the summer spawning herrings might be spawning; in fact in 1912 a small proportion seemed to show very distinctly that spawning had taken place. As a whole the summer spawners in that year seemed to be more advanced than in the preceding year. The comparatively high percentage of stage II in July tells against the supposition that all the herrings are summer spawners, especially when we take the conditions of the preceding year into consideration.

As we have seen, the herrings from the northern part of the Shetland waters were older than those from the south-western part, and it is a question whether the same kind of summer spawning herring is

[1]) Coll. 59 „mostly spents". [2]) Coll. 46 without sex. determ.

represented in both places. From the beginning of the herring fishery in Shetland waters the fishing grounds round Bressa Shoals have been regarded as the special fat herring grounds. In the two years when sufficient samples were taken in that part we find a lot of very fat maturing young-herrings. In 1912 we find a small percentage of this herring spawning in July, and Broch (1908, p. 52) has shown that spawning takes place near Bressa Shoals in September. Now the nursery grounds of the Shetland herrings must principally be in the shallower waters near the Shetland Islands, and we can thus understand why we find more maturing young-herrings out near Bressa Shoals. Later on the same herring might migrate as far as the northern banks, and this is confirmed by the fact that the yearclass 1906, predominant in the spring on the southern banks, but later on displaced by the young year-class 1907 is the most prominent year-class among the spawning herrings from Unst Bank to Viking Bank in August—September 1911.

VII. Scotland.

From Scottish waters samples are available only for the year 1911. Thirteen samples are available, but of these only two (Colls. 62 & 63), one taken by the s/s „Michael Sars" and the other bought in Hamburg, have the exact locality of capture recorded. Of the other eleven samples we only know that they were landed at certain Scottish ports, viz: Grangemouth, Aberdeen, Fraserburgh and Wick. This of course lowers the value of the samples considerably, for the fishing grounds frequented by the fishermen from these ports during the herring season are very extended.

As regards age composition, maturity and quality I have arrived at certain conclusions that permit me to split up the samples into certain groups, and by comparing these groups with the conditions in the adjoining regions some light may be thrown on the relations of those groups.

1. Age composition.

As in the investigation of the herrings from Shetland and the „Revkant", I have found it conveniant to group the samples chronologically from month to month. As the herring fishery tends to move from place to place in the course of the season, I may be able to see whether those movements can be traced in the composition of the samples, and I can more easily compare the age composition with the results as to maturity and quality. In fig. 14 I have shown the average age composition in percentage of individuals from June to September by a continuous line. The dotted curves represent the different components for each month. As may be seen at a glance, the year-class 1907 is predominant in all the months from June to September, as was the case for the same months in the Shetland waters.

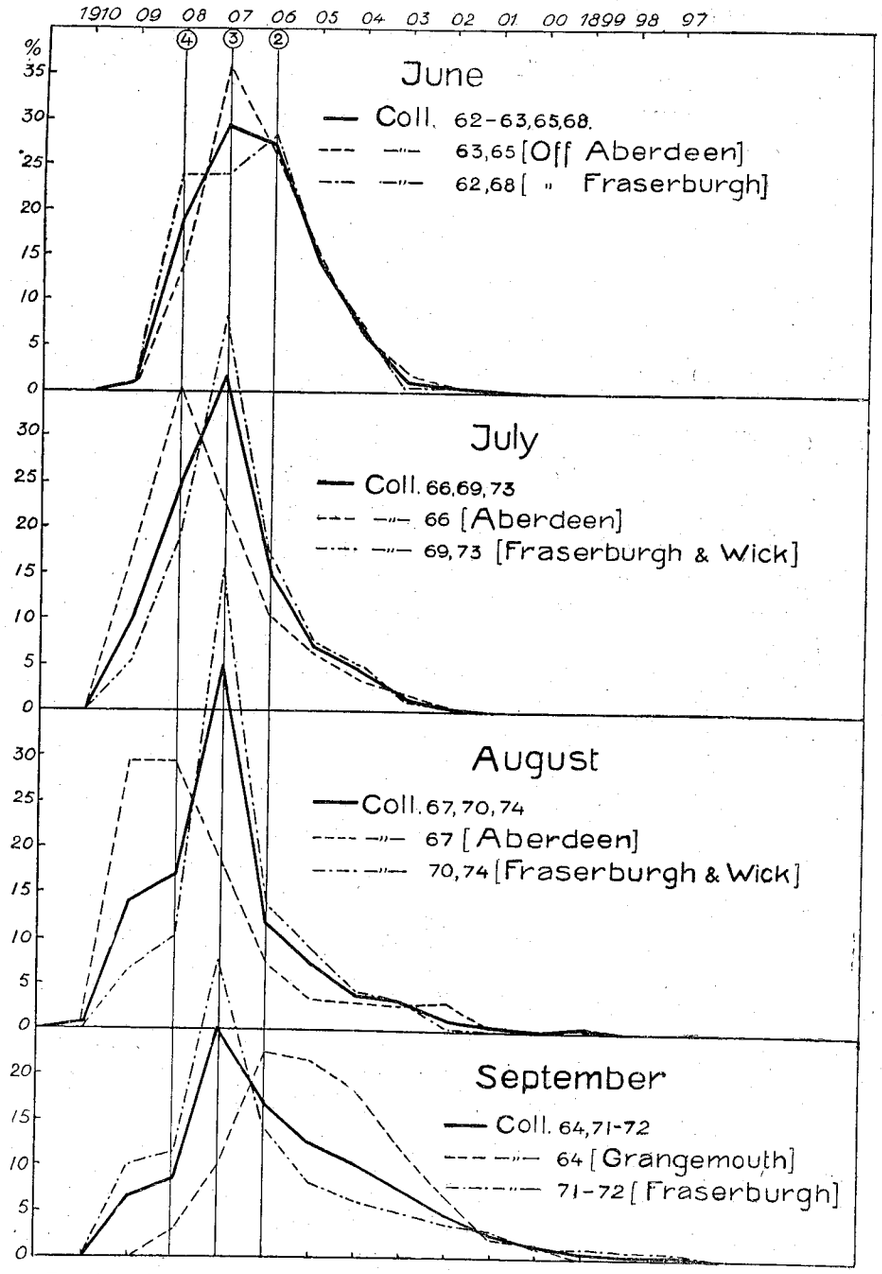

Fig. 14. Age composition of samples landed in Scotland during the year 1911, compared monthly.

In June we have four samples, the two with locality of capture (Colls. 62 & 63) and samples from Aberdeen and Fraserburgh. The age composition of the Aberdeen sample is very like that of the Coll. 63, with 1907 as the predominant year-class, while the Fraserburgh sample resembles Coll. 62, with a preponderance of the year-classes 1906, 1907 and 1908. From the map fig. 1 we find that this coincides with the localities, Coll. 63 being taken off Aberdeen and Coll. 62 off Fraserburgh.

In July the Fraserburgh and Wick samples display a predominance of the year-class 1907, while in the Aberdeen sample the year-class 1908 takes the lead. In August the year-class 1907 again dominates the samples from Fraserburgh and Wick, but in the Aberdeen sample we find a large proportion of young-herrings of the year-classes 1908 and 1909 (about 60 %).

In September the year-class 1907 is again predominant in the Fraserburgh samples, while the sample from Grangemouth consists of much older animals, with the year-class 1906 predominating. The age composition of the latter sample resembles very much that of the samples from the Dogger Bank taken during the same month (see below). A conspicuous feature in the samples from Fraserburgh and Wick is a small amount of young-herrings of the year-class 1909, increasing steadily from June to September.

2. Maturity.

In most of the June samples we find a large amount of virgin fish. In the samples landed at Aberdeen (Coll. 65) and Fraserburgh (Coll. 68) we have a lot of spent herrings (stage VII), but as most of them have more fat than should be the case with spent herrings, I should think they are recovering spents and properly belong to stage II. In the graph (fig. 15) representing the average maturity of the groups in percentages from month to month, I have omitted these two samples.

The June samples seem to consist of summer- and autumn- spawners, and considering the many recovering spents in Colls. 65 and 68 also many spring spawners. From July onwards we find that the

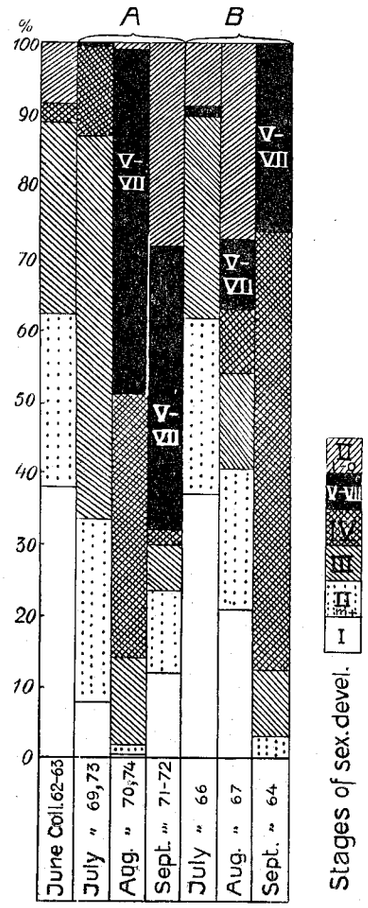

Fig. 15. Maturity stages of samples landed in Scotland during the year 1911, compared monthly.

Fraserburgh—Wick herrings are far more developed than the Aberdeen—Grangemouth herrings. For the first (A) we can follow the development of maturity until they become spawning and spents in September, when we find that some virgin fish have congregated among the mostly spent schools of herring. The Aberdeen—Grangemouth herrings (B) seem to be retarded in their sexual development, and though we may find a few spawning and spents in August—September, the bulk of the Grangemouth September sample is in the same stage of maturity as the herrings from the Dogger Bank caught during the same month. This coincides with the age compositions of the same samples.

Taken as a whole we find in the Scottish samples summer-spawners, spawning in August—September, autumn-spawners, spawning in September—October and, especially in the June samples, a lot of spring-spawners.

3. Quality.

As regards the amount of intestinal fat I have made a comparison between the groups found by the age investigation, the result being shown in fig. 16, where the June samples are slumped together. In June we find the herrings to be very fat (average 2.0), especially in the samples with many virgin fish. In July and August the fat decreases very rapidly in group A. (Fraserburgh, Wick), but in Septem-

ber we find the quality much improved owing to the invasion of virgin young-herrings. In group B we find the quality still very high in July (average 1.80), but decreasing very rapidly in August-September, as the herrings are developing for propagation.

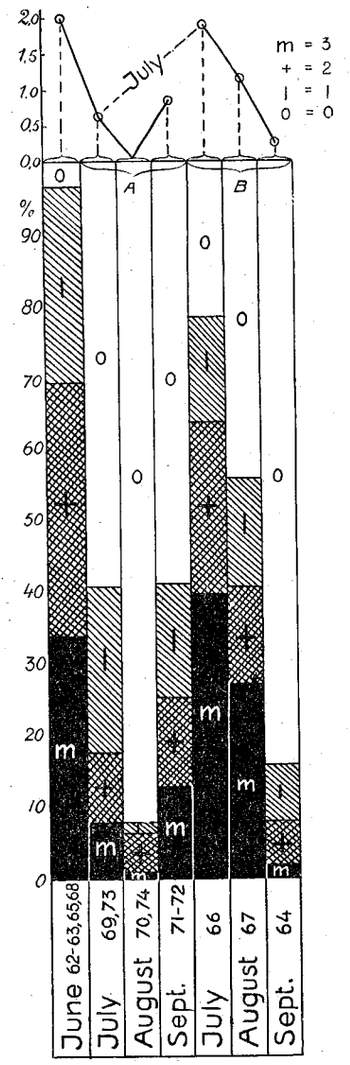

Fig. 16. Fat stages of samples landed in Scotland during the year 1911, compared monthly. Average (3—0) above.

4. Summary and discussion.

Owing to the lack of information as to the habitat of the larger part of the Scottish samples, it is very difficult to draw any general conclusions from the study of the age composition, maturity and quality. The investigations of maturity and quality seem to show that the two groups defined according to the age composition are very well founded. The Fraserburgh and Wick samples taken in July-September seem to consist largely of herrings resembling in age composition maturity and quality the summer spawners from Shetland waters. Now Fraserburgh and Wick are the northernmost of the ports in question, and everything seems to indicate that these samples were taken farther north than the other samples. The summer spawners in the June samples I am inclined to place mostly in the same group. If I might venture to make any further suggestions as to locality, I think the samples taken in the latter part of the season were secured nearer to the coast than those in the earlier part. This is indicated by the appearance especially

in the September samples of many young-herrings of the year-class 1909, known to inhabit the shoaler water up to the coast.

The second group is more difficult to explain, and I find that very likely we have to do with two kinds of herring. I have already referred to the resemblance in all essential particulars between the Grangemouth herrings and the herrings caught during the same year on the Dogger Bank. The herring of the Aberdeen samples taken in July and August are as a whole much younger than the other herring among the Scottish samples, the year-classes 1908 and 1909 being most abundant. The average length for each age-group is smaller than for Dogger Bank herring and the herring from Fraserburgh and Wick. This and the seasonal development seem to indicate a more southerly origin. They are more like the herrings caught off the English coast about North Shields.

VIII. Dogger Bank.

From the Dogger Bank we have three samples in 1910 and six samples in 1911. Of the 1911 samples two, viz: Colls. 39 and 40, are assorted herrings, which are no use for age-investigation, but might be of interrest in the study of maturity and quality. All the samples from the Dogger Bank were taken in the latter part of the season: in 1911 September and in 1910 September and October and this will limit the scope of the investigations to some extent.

1. Age composition.

The graph (fig. 17) shows at once that the herrings from the Dogger Bank are considerably older than the herrings from the adjacent waters. In 1910 the yearclass 1905 is predominant, and in 1911

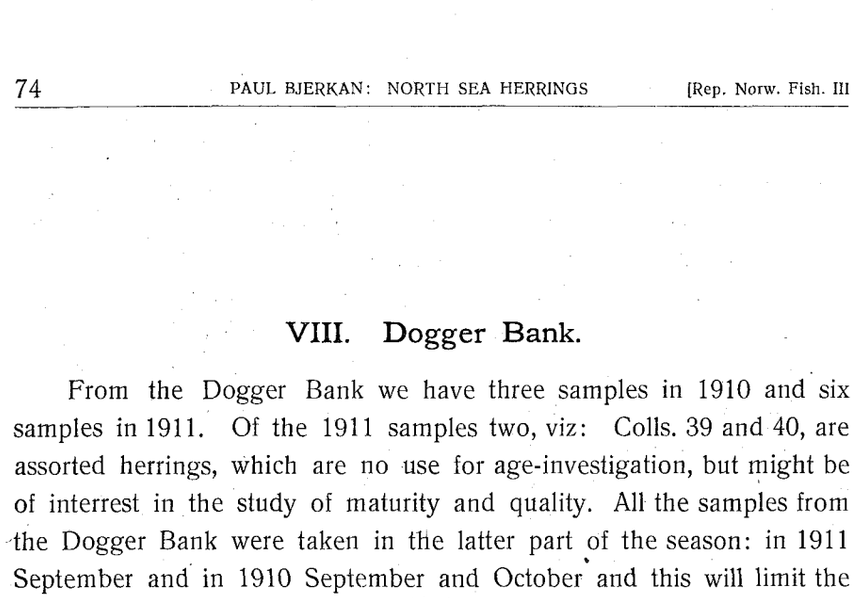

Fig. 17. Age composition of samples from the Dogger Bank during the years 1910 and 1911.

the yearclass 1906, the stock of herrings in both years being thus about the same average age. The age-curves for both years are fairly smooth and similar in character, the only irregularity being in the case of the yearclass 1900, which seems to be more abundantly represented than might be expected for a yearclass of that age. Now the curves include only seven samples, and it might be regarded as merely an accidental coincidence, but when a parallel irregularity is met with in the Grangemouth sample (Coll. 65, 1911, see above), and in a sample from off Spurn Point on the English coast (Coll. 75, 1911, see below), it seems worthy of attension.

2. Maturity and quality.

There is very little to be said about the maturity and quality, the samples being all of about the same seasonal development, as shown in the following table, giving the percentages of individuals of each stage of development:

Month	Coll.	I	II_{m+}	III	IV	V	VI	VII	$II_{1,0}$	m	+	1	0	Average 3—0
1910														
September	25—26	—	0.4	8.0	64.6	26.0	0.7	—	—	0.2	0.4	0.2	99.2	0.006
October....	27	—	3.9	54.2	23.8	3.9	—	—	14.2	—	3.9	10.2	85.8	0.18
1911														
September	36—41	—	—	11.0	71.8	16.5	0.1	0.4	0.3	—	0.2	0.2	96.9	0.03

In this table I have included all the 1911 samples, as giving the most reliable result; by omitting the assorted samples very small differences would be introduced.

In both years the September samples include mostly individuals in stage IV, and with very little intestinal fat; a few are spawning or spent. It is remarkable that the October sample in 1910 is far less developed than the September samples, showing that a very marked difference in development may be found among the different schools about the same locality, and that the spawning season of the Dogger Bank herring covers a long time, very likely from September to December with the maximum of spawning in October—November.

Storrow's samples taken in 1913 are dealt with at p. 79 and in fig. 19. Of these, five samples, viz: Q, U—X, are from the Dogger Bank, all taken by trawl. The predominant year-class in the average age-curve is 1909, but two of the samples, W and X, differ in this respect, W consisting mostly of young herrings of the year-class 1910, while in X the herrings are older than the rest. The youngherring-catch is very interesting, as being the only sample showing separate schools of youngherrings out there. The sexual development of the samples confirms the idea that spawning may take place as late as November-December.

IX. England.

From the English North Sea coast twenty-four samples were taken in the years 1910—1913, for 1913 there are also twenty-four samples described by Storrow (see p. 79—81), of which five, as will be seen by the map (fig 2), are from the area designated Dogger Bank. I have found it convenient to combine them all, especially as about half the samples were taken by trawl. Many of the English samples are very large, occasionally numbering more than 700 individuals, thus giving a fairly good representation of the shoals.

1. Age composition.

The samples for the year 1911 are most numerous and cover most of the season, so I start with this year in order to get a general view of the conditions existing in the English waters.

1911. Eleven samples are available from many parts of the East coast of England, from N. Sunderland to Lowestoft. The yearclass 1908 is predominant in the average age-curves almost every month from May to November, as will be seen from the graph (fig. 18). Where different components are discernible during the same month I have shown these by dotted lines, while the monthly averages are represented by continuous lines.

In the samples taken off North Shields during the months May to August the yearclass 1908 predominates, with a fairly large proportion of older animals; coll. 80 (June) has a large amount of younger herrings of the yearclass 1909. The May sample from off Scarborough consists of somewhat older animals, the yearclasses 1906 and 1907 being most prominent. The July sample (Coll. 84) taken far out off N. Sunderland is more like the samples from Shetland and Scotland as regards age composition, the predominant yearclass being that of 1907. The November sample from off Lowestoft has up to

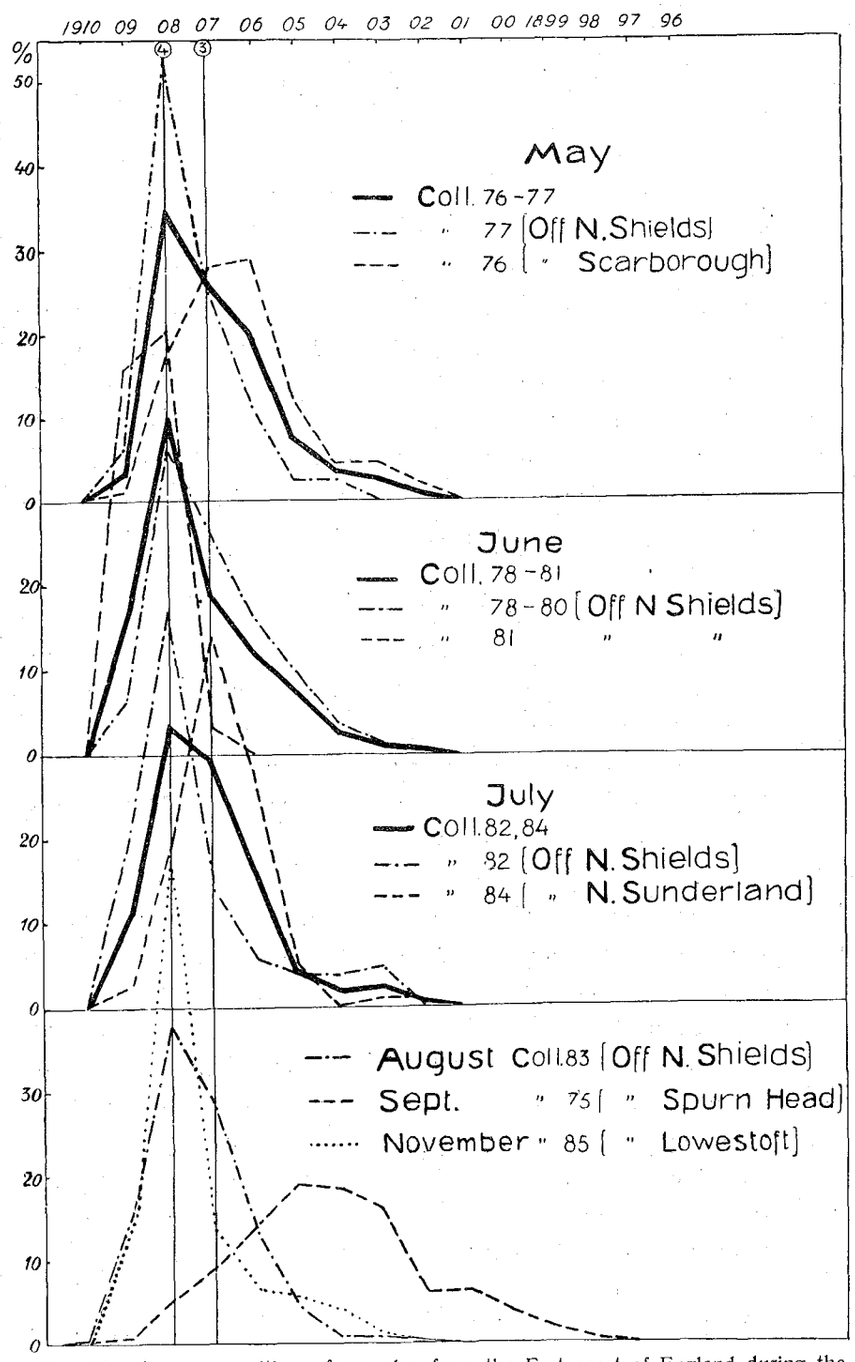

Fig. 18. Age composition of samples from the East coast of England during the year 1911, compared monthly.

58 % of the yearclass 1908, and shows an extreme predominance of that yearclass. The September sample from off Spurn Head consists of much older herrings than the rest of the English samples; the predominant yearclass is 1905, and the age-curve resembles that of the Dogger Bank samples of the preceding year.

1910. Four samples were taken in 1910. As in 1911 the North Shields sample (July) consists of fairly young herrings, the predominant yearclass being 1907. The Spurn Head sample consists of older herrings mixed with the yearclass 1907; the age curve otherwise recalls the Dogger Bank samples. In the October-November samples from off Lowestoft the yearclasses 1905, 1906 and 1907 are most prominent, and the average age is thus this year higher than in any of the following years.

1912. There are five samples, in most of which, especially off Lowestoft, the yearclass 1908 predominates, as during the preceding year. The August-September samples from off N. Shields and Spurn Head consist of younger herrings, with the yearclass 1909 highly predominant, mixed up with a small amount of older herrings. In July the yearclasses 1908 and 1909 are most prominent in the North Shields sample.

1913. Exclusive of Storrow's samples, three samples are available this year; the yearclass 1909 is most prominent, though the yearclass 1910 is slightly predominant in one of the Lowestoft samples.

Of Storrow's twenty-four samples thirteen are from the coast off North Shields to North Sunderland, six from the sea towards the Dogger Bank, and five from the area in the map fig. 2 designated Dogger Bank.

As the herrings from the firstnamed area were taken by driftnet, and the others by trawl, I have found it convenient to treat them all together in order to get some idea of the importance of the gear used. The graph (fig. 19) represents the age composition in percentage of individuals in the three groups. In all the N. Shields—N. Sunderland samples the yearclass 1910 is highly predominant, while in the other two groups the yearclass 1909 dominates the averages. Storrow states (1914, p. 60) that the herrings in samples N and O are Dogger Bank herring, so in the graph I have compared samples N-O with samples

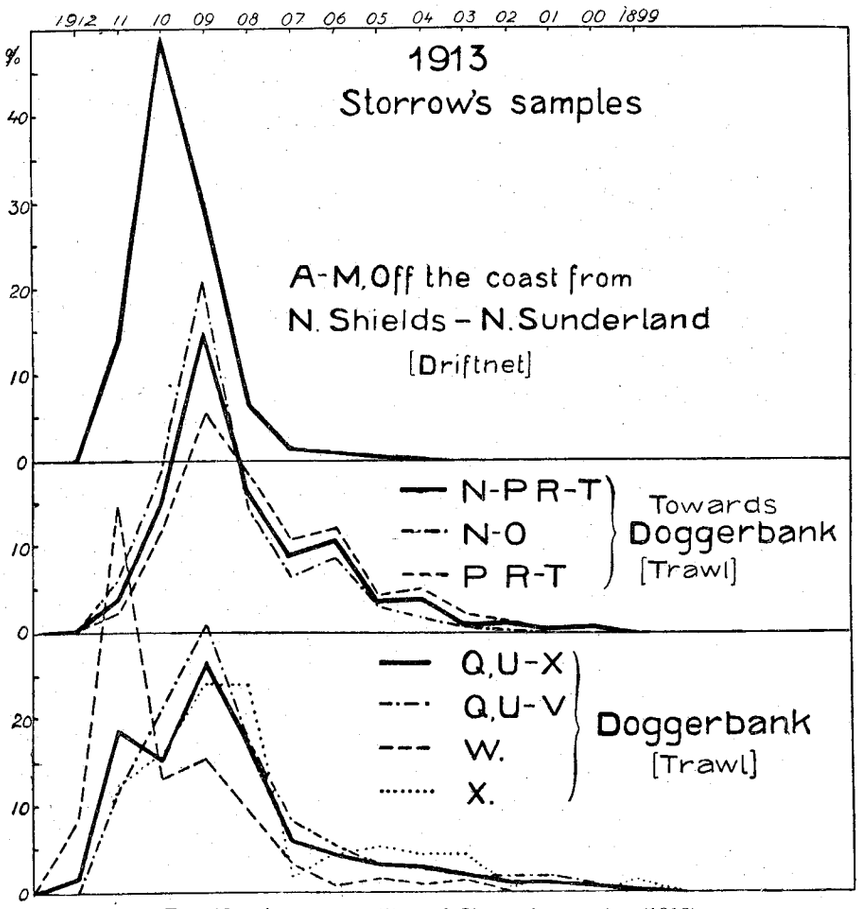

Fig. 19. Age composition of Storrow's samples (1913).

P, R-T, but the age composition gives no clue to the solution of the question, which could only be decided by minute growth measurements, as tried by Storrow. It seems however that he was not quite successfull. He states (p. 63): „For the Dogger Bank and Yorkshire coast trawled herrings the 1913 growth increments, for those with 2, 3 and 4 winter rings, show too much variation to allow of a distinction being drawn between them". Thus the difference in size between the two groups, N-O and P, R-T, which he only bases on the percentages of individuals belonging to each length group (p. 60), may be due to the fact that the herrings are somewhat older on the average in the latter, as shown by the age-curves. I have myself from the samples

at hand found that the Dogger Bank herring may be a trifle larger at the same age than the herrings nearer the coast.

Regarding the importance of the fishing gear, (driftnet and trawl), and the selective influence of the former, the samples give some interesting results, as indicated on p. 18. The comparative age of the herrings caught by driftnet as well as by trawl seems principally to depend on the composition of the schools frequenting the fishing grounds. On the coast off N. Shields and N. Sunderland the herrings are younger (smaller), farther out they are older (larger), and any selection due to the nets used can only be of slight importance.

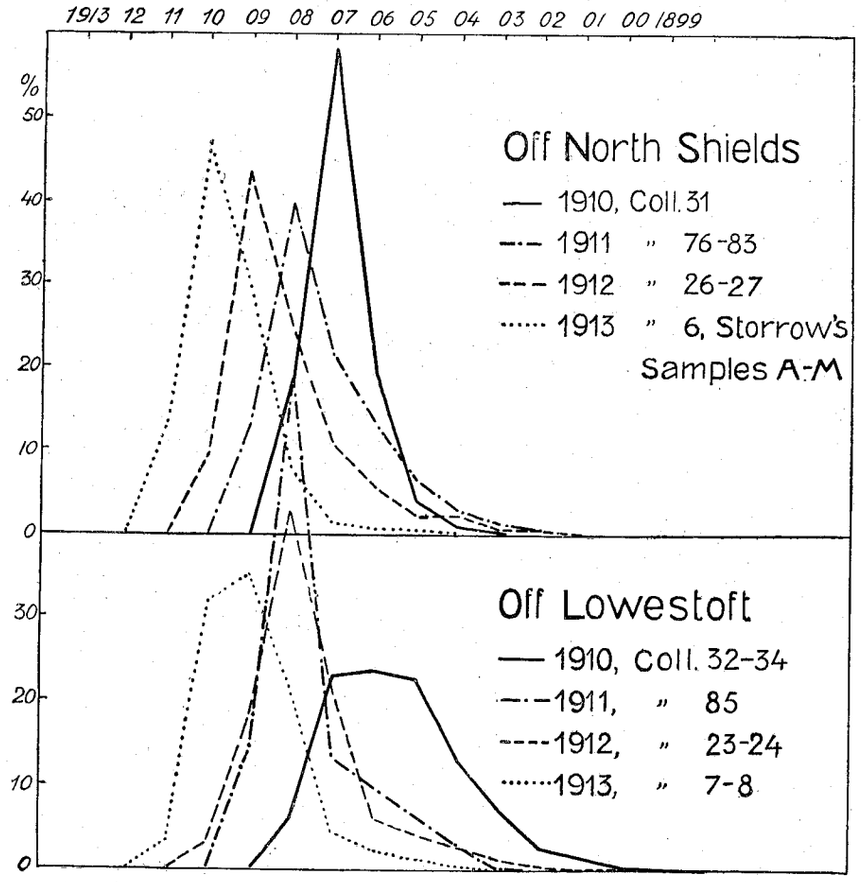

Fig. 20. Age composition of all the samples from the North Shields and Lowestoft areas, taken during the years 1910—1913, compared yearly.

In the graph (fig. 20) I have made a collective comparison of the age composition of the samples taken in 1910—1913 at the two principal fishing grounds off the English North Sea coast, viz: Off North Shields during the summer and off Lowestoft during the months October-December. There is a well defined difference, for while the N. Shields fishery is each year principally made up of herrings of the same age, 3-4 years old, the Lowestoft fishery shows greater variations, having years with stronger or weaker yearclasses. Thus while in 1910 the three yearclasses 1905, 1906 and 1907 are prominent in the Lowestoft samples, in 1911 and 1912 the rich yearclass 1908 is highly pre-

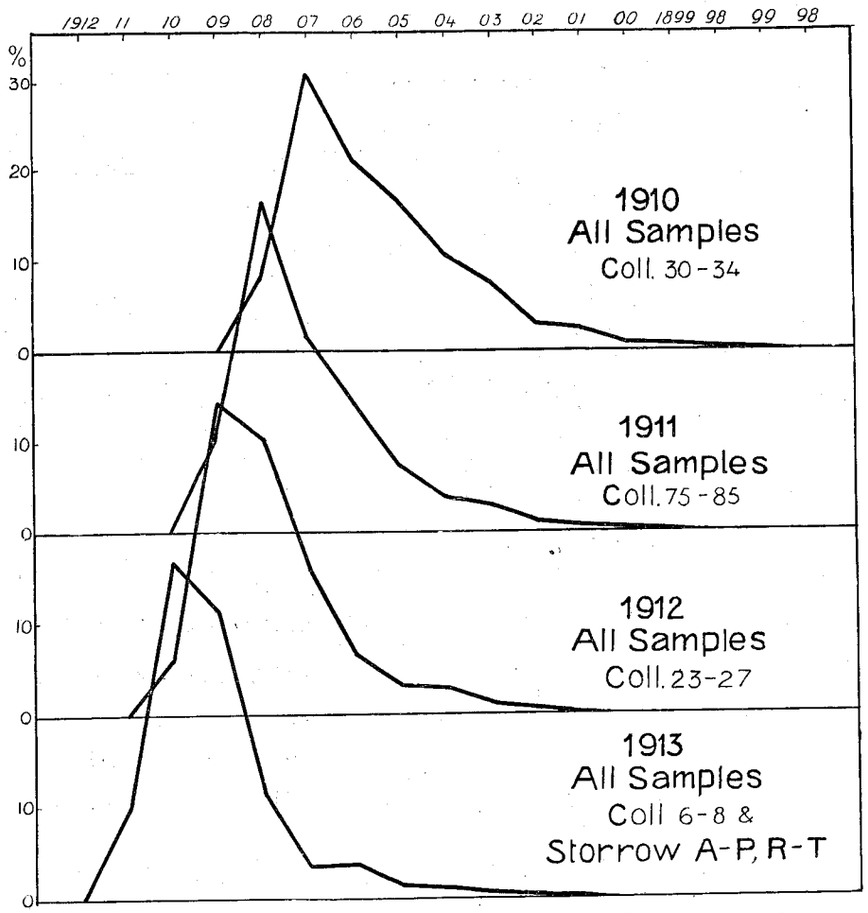

Fig. 21. Age composition of all the samples from the East coast of England during the years 1910—1913, compared yearly.

dominant, but in 1913 it has been displaced by the younger yearclasses 1909 and 1910, though still comparatively well represented.

Comparing the two districts there seems to be little connection between them. The yearclass 1908, so prominent among the Lowestoft samples, is of minor importance in the N. Shields district. If from the available samples we were asked to name a prominent yearclass off N. Shields it would be the yearclass 1907, highly predominant in 1910. This is more in accordance with the age composition in Scottish and Shetland waters, where during the following year this yearclass is very important.

In the graph (fig. 21) I have compared the average age composition of all the samples from the East coast of England during the years 1910—1913. We find a striking difference in the conditions here and farther to the north. In the north-eastern part of the North Sea we might for years fish principally on one yearclass while off the English coast the yearclasses are more evenly distributed. Strong yearclasses may be found on some fishing-grounds, but as a whole the renewal of the stock goes on very steadily.

2. Maturity.

In order to get a general view of the sexual development of the herrings from the East coast of England I have constructed the graph (fig. 22), representing the percentages of individuals of the different stages from month to month in the years 1910—1913.

1911. The May and June samples from off North Shields consist of immature herrings with many spents and recovering spents, evidently spring-spawners. In June one sample (Coll. 81) consists of about 80 % immature herrings, corresponding to the facts brought out by the age investigation. Of the two July samples, one (Coll. 82) was taken off N. Shields, and the other (Coll. 84) far out at sea off N. Sunderland. The firstnamed consists of many immature herrings and herrings developing sexual organs up to stage III, while the presence of a few spents (stage VII) seems to connect it with the May-June samples from the same area. Coll. 84 resembles the Scottish samples as to sexual development, and the herrings thus seem to be summer spawners. The August samples from off N. Shields consist mostly of herrings belonging

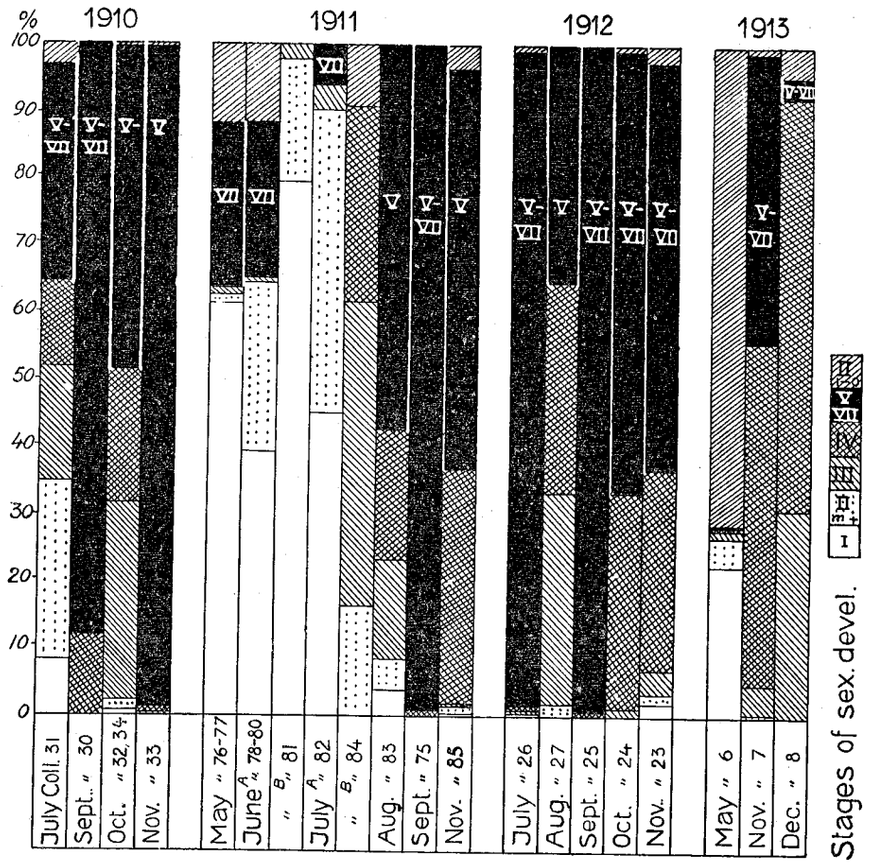

Fig. 22. Maturity stages of samples from the East coast of England during the years 1910—1913, compared monthly.

to stages III—V, more than 50 % of the latter, and thus seem to be autumn spawners. The September sample from off Spurn Head consists mostly of spawners and spents, and the November sample from off Lowestoft has up to 60 % belonging to stage V, and a few spawners and spents.

1910. The July sample from off N. Shields is peculiar, consisting of a mixture of all stages from immature herrings up to spawners and spents and a few recovering spents; this will be referred to in the discussion of the 1912 samples. The September sample from Spurn Head has about 88 % belonging to stages V—VII, mostly stage V, thus calling to mind the sample from the same place in September

1911 and the autumn spawners of the Dogger Bank. The October-November samples from off Lowestoft consist of winter spawners, more than 97 % belonging to stage V.

1912. The July sample from off N. Shields consists of more than 90 % of stage V, and some spawners and spents (stages VI—VII). There are thus apparently schools of spawning herrings present here at midsummer, as was indicated by Coll. 31, 1910, — the only mid-summer spawners met with during these investigations. The August sample from off N. Shields consists of maturing herrings up to stage V, being thus far less developed than in the July sample. The September sample from off Spurn Head includes a lot of spawning herring (stage VI), and thus confirms the results obtained in the preceding years, autumn spawners being found regularly there during this month. The October-November samples from off Lowestoft display the same seasonal development as in 1910 and 1911.

1913. The May sample from off N. Shields consists of immature herrings with many apparently recovering spents. Exclusive of Storrow's samples, no samples are available for the summer months, but for November-December we have samples from off Lowestoft. The sexual development of the December sample (taken $^{16}/_{12}$) seems to indicate that spawning takes place in some cases after midvinter, stages III—IV being by far the most common in the sample.

Storrow's samples were taken in 1913: a) off North Shields to North Sunderland, b) towards the Dogger Bank, and c) on the Dogger Bank. In the table below a monthly record of the sexual development in these samples is shown, taken from Storrow's table, but omitting the intermediate stages I—II, II—III etc., which are in each case included in the higher stage. This I have done to make the table uniform with the other tables in this paper in conformity with the practice in vogue in the herring investigation (see p. 23). As no statement regarding quality is given, no distinction can be made between fat and meagre herrings belonging to stage II.

Month	Coll.	I	II	III	IV	V	VI	VII		
June.....	A-B	55.0	41.0	2.5	—	1.5	—	—	Off North Sunderland	(drift-net)
July	C-D	33.5	37,1	18.0	8.5	1.0	—	—	„ —„—	
August	E-G	3.0	13.7	31.7	20.4	18.3	1.0	—	„ North Shields	
September ..	H-M	7.8	15.3	31.7	22.2	17.5	2.5	2.8	„ —„—	
„	N-P, R-T	2.3	4.8	22.7	19.7	31.8	0.7	18.0	Towards the Dogger Bank	(trawl)
„	Q, U-V	7.0	10.0	31.3	23.3	25.3	0.7	1.3	Dogger Bank	
October.....	W-X	24.0	16.0	29.5	24,0	4.5	—	2.0	—„—	

From this table we can follow the development from June to October. In the first months we find many immature herrings off N. Sunderland and North Shields, but in September the herrings seem to be fairly well developed. Farther out they seem to be a trifle more advanced. The maturity displayed by the Dogger Bank herring confirms the idea that they might spawn as late as November-December. The average of the October samples shows many immature herrings principally belonging to the youngherring sample from that month (W).

This examination of the available samples shows that the herrings caught off the coast near N. Shields in the earlier summer months might spawn as early as July, but most of the herrings are autumn and early winter spawners. Spring-spawners are found especially in the May-June samples. Off Spurn Head herrings are found spawning principally in Septemper, like the Dogger Bank herring. The herrings from off Lowestoft spawn from October perhaps on till January, with the height of the spawning in November-December. From the latter fishing grounds we have no samples in the earlier part of the year, and thus know very little about the earlier stages and the immature herrings.

3. Quality.

To show the average amount of intestinal fat from month to month during the years 1910—1913 I have constructed the graph (fig. 23).

1911. From May to June this year the quality increases slightly owing to the recovering spents in the samples. The youngherring sample in June (Coll. 81) consists almost exclusively of stage m. and the average (3—0) is as high as 2.97. The July sample (Coll. 82) also

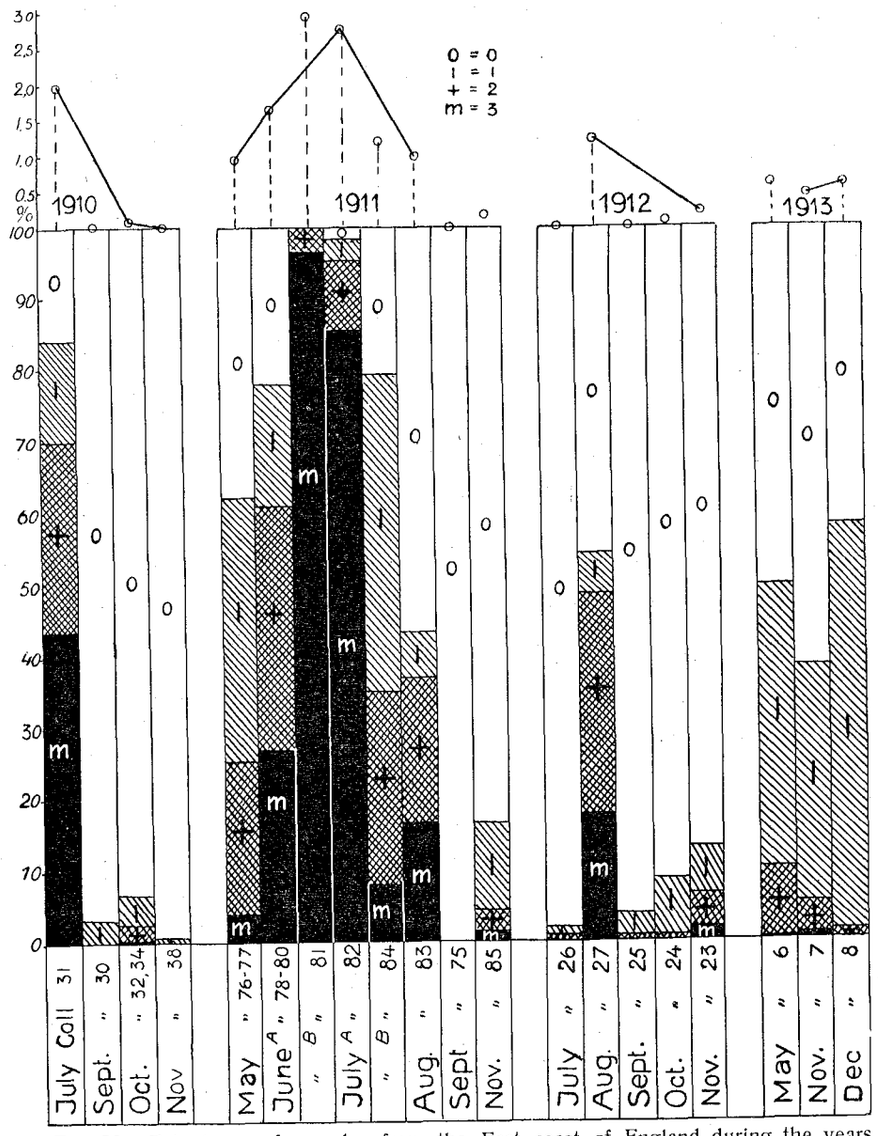

Fig. 23. Fat stages of samples from the East coast of England during the years 1910—1913, compared monthly. Average (3—0) above.

consists mostly of very fat maturing youngherrings with a few spents. The July sample far out at sea off N. Sunderland (Coll. 84) consists of moderately fat herring, and thus resembles the Scottish samples taken the same month, spawning in August-September. The August sample

from off N. Shields is moderately fat and is a contrast to the Spurn Head September sample, which is quite devoid of intestinal fat, as is the case too with the November sample from off Lowestoft.

1910. The North Shields July sample is moderately fat, consisting of young herrings of all stages. The September sample from off Spurn Head, and the November-December samples from off Lowestoft, are almost devoid of intestinal fat, being about spawning time.

1912. The quality of the July sample from off N. Shields confirms the idea of the midsummer spawning of some schools frequenting the fishing grounds there, the herrings being devoid of intestinal fat, in contrast to the August sample from the same area, which is moderately fat, as usual. The September sample from off Spurn Head and the Lowestoft samples for October-November correspond in quality with the samples taken in preceding years at those places.

1913. The May sample from off N. Shields is slightly fat, consisting apparently mostly of recovering spents. The Lowestoft samples for November-December are fatter than the corresponding samples for the three previous years, and especially the relatively high quality of the December sample is astonishing, though agreeing very well with the stages of maturity.

4. Summary and discussion.

In these investigations regarding the age composition, maturity and quality of the herrings from the East coast of England, we have found the conditions to differ considerably in the different fishing districts along the coast.

The fishery along the coast from N. Sunderland to N. Shields from May to July-August depends principally on young herrings, 3—4 years old: in 1910 they were mostly of the yearclass 1907, in 1911 the yearclass 1908, etc. In the spring and early summer we may find samples with herrings one year older. Some of these samples consist more or less of spents, and recovering spents, and are thus comparatively poor; they show that spring spawners are present in some schools. Most of the samples, however, especially about midsummer, include many immature herrings, apparently maturing in the course of the summer. Those herrings are mostly very fat, decreasing in quality

as the sexual organs develop. They seem to spawn in the autumn or early winter, but from that period we have no samples, the fishery being then more important farther south. In two samples (Coll. 31, 1910, 26, 1912) the herrings were July spawners, and as already stated, they are the only herrings met with during these investigations that spawn in the height of summer. These spawning herrings are very poor. In one July sample (Coll. 81, 1911) still younger herrings are found in large amount, less advanced in sexual development than the other herrings taken the same month, more than three-fourths being still immature. It thus seems as if the fishing grounds in question are principally frequented by maturing youngherrings and recovering spring spawners which find their feeding ground there, while only occasionally are spawning schools met with during the summer.

Farther out at sea, towards til Dogger Bank, wee see from Storrow's samples (1913) that the herring are older and somewhat more advanced in sexual development, the predominant yearclass being 1909. Storrow (p. 63) states that the herring out there „of three and four winter rings have a smaller increase than have the drift-net herrings of the same age." According to Lea (1913, p. 29) this might mean that those herrings have segregated from the youngherring schools and spawned for the first time the preceding year.

According to Mitchell (1864, p. 68) the herring fishery of Northumberland in those days was carried on during the months of August and September, the herrings caught being of large size and about to spawn. It thus seems as if the fishery had changed since those days both in season and character. Now it is a youngherring fishery carried on in the months of June and July; then it was a fishery for spawning herrings coincident in time with the fishery as carried on now farther south, off Spurn Head.

Farther south along the coast, especially among the samples from off Spurn Head, we have older herrings. The Spurn Head samples for 1910 and 1911 coincide in age composition and seasonal development with the Dogger Bank herring spawning in September. The 1912 sample consists of herrings spawning in September, but the yearclass 1909 is predominant, as in the North Shields samples for the same year. A slight intermixture of older herrings however seems to

indicate that they are partly at least different from the North Shields herrings. Whether the Spurn Head herrings really are Dogger Bank herrings, immigrating at times into this area, is difficult to say, but the average length of the different age groups is more in accordance with that of the Dogger Bank herring than with that of the North Shields herring.

During the months from October to December a large herring fishery takes place of Lowestoft and Yarmouth. As we have seen already, this fishery principally depends on schools of fulls about to spawn, and they seem to spawn in November and December. This herring I will in accordance with Delsman call the *Channel herring*, very strikingly different from the Dogger Bank herring, and occurring in this area only in the late autumn and early winter. The spring spawning herrings from this area, mentioned by Dahl (1907, p. 29), are not represented among my material, the samples having been exclusively collected during the winter. Now and then schools might be found with herrings whose sexual development indicates spawning after mid-winter (Coll. 8, 1913). Whether this indicates a fixed difference in the spawning time, or only a retarded spawning, is difficult to say. It is however interesting to note that the herrings of this sample seem to be smaller than those of the same age in the other samples from the area. Delsman (1914, p. 153) who has investigated the question of the Lowestoft spring herring more fully, states that the fishery is only of minor importance, and that the herrings are mostly spent in March. He also mentions that he has found herrings spawning in January and February. In this connection it is interesting to note that my material from the Cornwall coast (St. Ives Bay) and from the west and south coast of England as a whole shows samples of herring which seems to spawn after midwinter.

X. Holland.

From Holland waters only one sample for June 1910 is available, taken in „Zegen“ (Seine) near Helder, at the mouth of the Zuiderzee. The herrings are comparatively young, (see table I a) on an average 3.5 years (without correction), the yearclass 1907 being predominant with about 58 %. As about 70 % of the herrings are in stage III and about 20 % in the stages IV and V, they must be summer or autumn spawners. Dahl (1907, p. 28) and Delsman (1914, p. 138) state that the genuine Zuiderzee herrings, like most coast races, are spring spawners, spawning in March and April. The above sample thus seems rather to belong to the North Sea than to the Zuiderzee.

In June 1911 a sample without locality was obtained in Holland (Coll. A), having an age composition similar to that of June 1910, the yearclass 1908 being predominant, and the sexual development is about the same so that I should think both samples were taken off the coast of Holland.

The age composition of these two samples is most like that of the samples collected during the young-herring fishery in the same month off the coast near North Shields. It is thus most probable that we have to do with the same phenomenon, viz: maturing young-herrings congregating into separate shoals before joining the spawning schools of older herrings.

XI. Review and general results.

In the discussion of the age composition of North Sea herrings we have found that certain year-classes are of more importance in the catches than others. These more prominent year-classes may differ in the various regions, and may alter with the different kinds of fishery. Thus the fishery off the coast near North Shields in June and July is a young-herring fishery; and the herrings caught are usually younger than the herrings caught off the East coast of England later in the season.

The preponderance of certain year-classes in the different regions is most plainly shown by the 1911 samples, of which we have 76. To get a general view of the conditions I have constructed the graph (fig. 24), to show how the samples from the different regions group themselves about four preponderant year-classes, viz: 1904, 1906, 1907 and 1908. Of the samples represented in the graph I subsequently found that Colls. 40 and 60 are not quite reliable, consisting most probably of assorted herrings.

In the North-eastern part the predominant year-class 1904 coincides with that of the Norwegian spring and large herring for the same year, and this is plainly due to invasion into the region of Norwegian herring during the spring and summer months. In the Shetland waters the year-class 1906 is predominant in May and later on farther out at sea. In June, however, the year-class 1907 is predominant in most samples from Bressa Shoals and is spreading fast. The samples landed at the northern Scottish ports, Wick and Fraserburgh, coincide with the Shetland samples, 1907 being the predominant year-class. The samples from the Dogger Bank, on the other hand coincide with the Shetland samples, with 1906 as the predominant year-class. On the East coast of England, off North Shields and farther south at Yarmouth and Lowestoft, the still younger year-class 1908 is predominant. In the

graphs of age composition in the different regions the four year-classes prominent in the year 1911 are shown by vertical lines numbered 1 to 4, 1 meaning the year-class 1904, 2 the year class 1906, etc.

By comparing the age composition of the herring samples for 1911 with the other years we find that the year-class 1904 is of importance through more years on the Revkant than elsewhere. In 1910 it is still more predominant than in 1911, and if it is not so much felt in the samples for 1912, it is because most of those samples were taken farther south, where the preponderance of the year-class was not so pronounced even in the years 1910 and 1911. According to the Norwegian fishery investigations, we know that the year-class 1904 was the leading one among the Norwegian stock of herring from 1910 up to 1915.

The year-class 1906 must have been of importance in the Shetland waters during the year 1910, but the samples that year are too few and were taken too far east to give evidence of the fact. It is of interest that in 1911 we find this year-class especially in the middle part of the North Sea, from Unst Bank in the north to the Dogger Bank in the south.

The year-class 1907 is predominant on Bressa Shoals and neighbourhood during the month of June 1911, and in the samples landed at the northern ports of Scotland. In 1912 this year-class and that of 1909 are of importance on Bressa Shoals and nearly up to the Shetland coast. The intervening year-class, 1908, is of minor importance in those waters.

Off the coast of North Shields the year-class 1903 is predominant among the young herring only during the fishing season of 1911; off Lowestoft and Yarmouth, however, it is predominant during the years 1911 and 1912, and is still of importance in the catches for 1913.

As stated by Hjort (1914, p. 22—), the fishery statistics of Norway show that the year-class 1904 has been of much importance for the yield of the Norwegian herring fishery from 1907 up to 1914. During the years 1907—1913 it has yielded more than half the quantity of the spring herring fishery, and is still (January 1916) the most important year-class in the catches. Off the coast of Lowestoft and Yarmouth the year-class 1908 seems to play the same important part among the

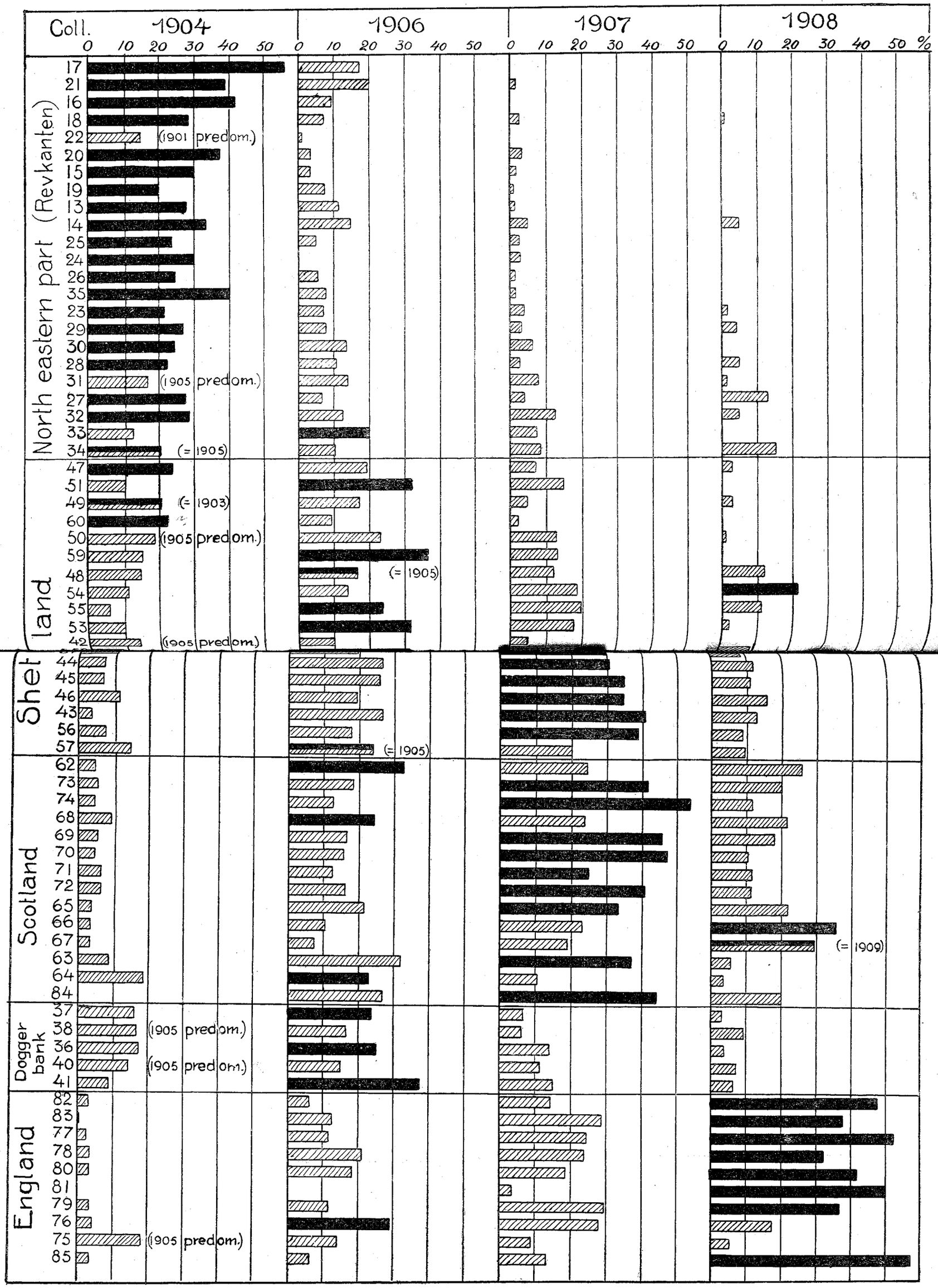

Fig. 24. Predominant year-classes (black columns) among the samples from the North Sea during the year 1911, arranged from north-east to south-west.

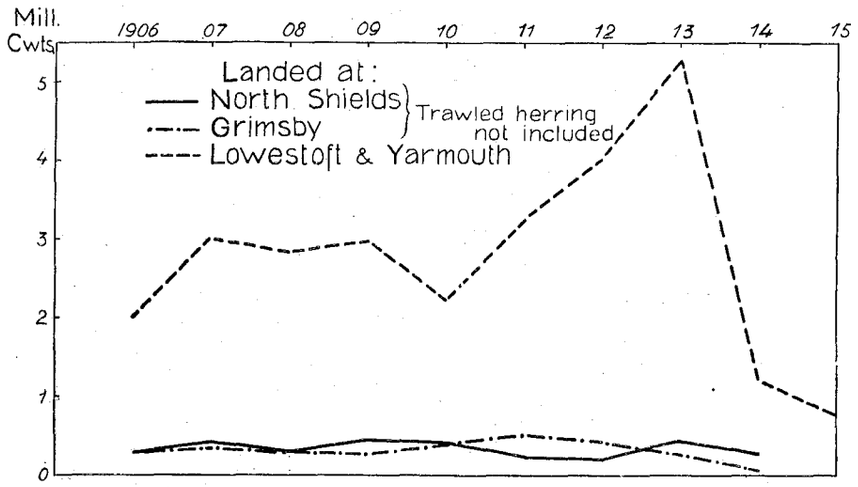

Fig. 25. Yield of herring fishery off Lowestoft and Yarmouth, North Shields and Grimsby, during the years 1906—1915.

Channel herring during the years 1911—1913. The graph (fig. 25) shows the yield of the herring fishery at Lowestoft and Yarmouth, North Shields and Grimsby from 1906 to 1915 according to the English fishery statistics. In 1910 the yield of the herring fishery at Lowestoft and Yarmouth is comparatively small, but increases during the years 1911—1913, when the year-class 1908 is well represented in the catches. In 1913 the yield was more than double that for 1910. The abrupt decline in the yield for 1914 must be principally attributed to the conditions prevailing during the war. In contrast to this the yield of the herring fishery at North Shields and Grimsby is more even from year to year, and this coincides with the more regular occurrence of the year-classes.

The changes in the predominant year-classes in the Shetland waters during the years 1910—1912 do not give any anticipation of marked fluctuation in the yield of the herring fishery from year to year, and this is borne out by the Scottish fishery statistics as well.

In the discussion of age composition in the different regions of the North Sea we found that the renewal of the stock by propagation seems to be more regular every year in the southern and western parts than in the north-eastern part. Especially on the young-herring grounds off North Shields and on Bressa Shoals the predominant year-class

seems to be about the same age every season. But even among the spawning herring the conditions seem to be more regular in the south, though we have seen that relatively rich year-classes may occur, as was the case with the year-class 1908 among the Channel herring off Lowestoft. New year-classes may appear and very soon distance the older year-class, which may have shown itself rich enough to take the lead during a couple of years. As regards the Shetland waters the samples for the years 1910—1912 only show that the year-class 1908 was of minor importance in comparition with the year-classes 1906, 1907 and 1909. As to the herring on the Revkant and its principal mother stock the Norwegian herring, we find other conditions in vogue during the years 1910—1914, for here a certain year-class, viz: 1904, is during many successive years quite predominant among the mature herring. Previous to that it had during three years been predominant among the immature fat herring in Northern Norway. Younger, relatively rich, year-classes have appeared now and then at some places along the Norway coast, but they have been completely outdistanced by the immense numerical predominance of the older year-class,

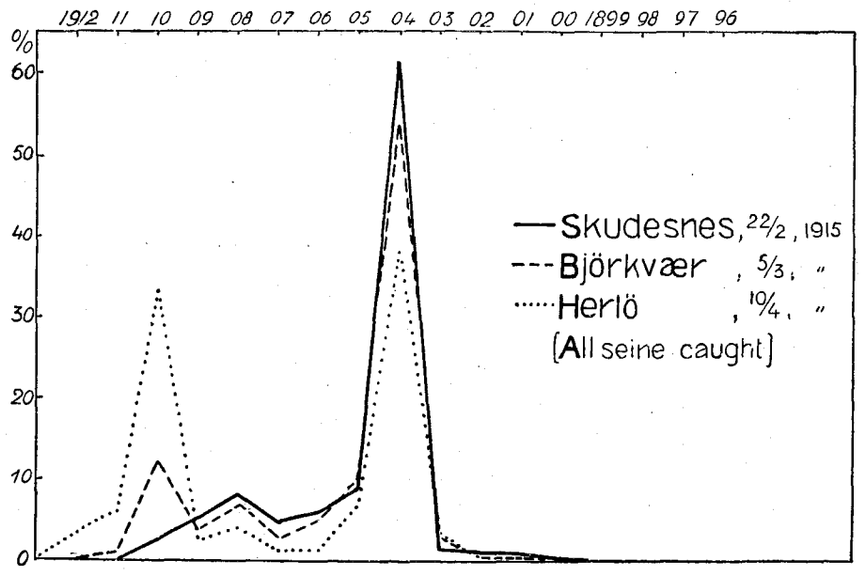

Fig. 26. Age composition of three samples of Norwegian spring herring, showing the invasion of a young year-class among the spawning herring.

when the shoals have become thoroughly mixed. To indicate how the renewal of the mature stock is effected among the Norwegian herrings, I have constructed the graph (fig. 26), showing the invasion of a young rich year-class during the spring of 1915. The figures have been taken from Lea (Fiskets Gang 1915, no. 39), and represent the age composition of three samples of seine-caught herring from the West Coast of Norway. The three curves show that in the February sample the year-class 1910 is only slightly represented, in the March sample it is next to year-class 1904 in number of individuals with 12 %, and in the April sample it has 33.3 % against 38.4 % for the year-class 1904. The curves are all multimodal, the first showing distinct modes for the years 1908 and 1904, and the two latter for the years 1910, 1908 and 1904. In quite the same way the year-class 1908 made itself felt in some of the samples taken in the spring of 1914. The invasion of the year-class 1910 has been found in the drift-caught as well in the seine-caught samples as shown by fig. 3, p. 16. Such invasions of new rich year-classes with up to four years intervals between them, give the age curves of the herring samples from the coast of Norway quite a different appearance from those of the herring taken in the southern North Sea, which latter led Delsman to make the statement quoted on page 15.

By looking at the average age of the herring of the different samples, we find that the herrings in the catches from the northern North Sea are considerably older than those caught in the southern areas. We must, however, remember that most of the herrings from the southern and western North Sea are autumn spawners, and as nearly all the samples were taken during the summer season, these autumn spawners are more than half a year older than shown by the averages and as compared with spring spawners taken during the same months. On the other hand, the young herring caught off the coast near North Shields and on Bressa Shoals are younger than the average stock of mature spawning herrings from the same regions. Taking both these factors into consideration we still find that the average age of the herrings from the southern areas is considerably lower than that of those from the northern.

The explanation of this fact might be found in the more regular renewal of the stock by propagation, together with a more intensive fishery in the southern part of the North Sea. These two conditions combined will naturally tend to lower the average age of the herring stock to a certain extent. But another agency may come into play in in lowering the average age of the herring in the south. In the Norwegian herring investigation Lea (1913, p. 34—) has found indications that herrings, which attain sexual maturity at an earlier age die earlier than those, which are older when propagating for the first time. The number of spawnings in the life cycle of the herring thus seems to be more important than the actual number of years.

Hjort (1914, p. 175) states that „the North Sea herring has probably only one, the Norwegian West Coast herring two, and the North Coast herring as many as four ister stages before reaching maturity." Among my material I have no sample of genuine fat herring, and as the young herring samples from the coast off North Shields are mostly mixed up with older herrings, especially spring herrings, it is difficult to state the exact limits of the age of the herring. The number of relatively young animals among the spawning herring from the southern areas shows however very plainly that the bulk of the herring from there attain sexual maturity at an earlier age than farther north. This being so, it will tend constantly to lower the average age of the herring in the southern North Sea. In the salmon of the Norwegian coast we have a parallel pointing in the same direction. Dahl (1910, p. 43—) has shown that the salmon in the southern rivers of Norway emigrate to the sea at an earlier age, and become mature earlier, than those in the northern rivers, and to this he attributes the fact that the salmon caught in the northern rivers are mostly much larger and older than those from the southern rivers. The same difference he has found, as stated verbally, between the trout from the lowlands of the West Coast and those from the mountain lakes and from eastern Norway. The relation between the number of spawnings in the life cycle of the fish, and the average age of the stock in the different areas, thus seems to be a constant feature for northern waters.

If we try to get a general view of the spawning of the herring in the North Sea, we find that the month of June is perhaps the only

month in the year that spawning does not take place anywhere. It is thus very difficult to recognise the general features, but from what we know, and from the different statements found in literature (Heincke a. o.), we may as regards spawning time, divide the North Sea herings into three groups, viz: (1) Spring spawners, (2) Summer and autumn spawners, and (3) Winter spawners.

1. As spring spawners I have ranged the Norwegian herring on the Revkant, and the different coast herrings from Shetland, Scotland, England and the Zuiderzee. The coast herrings I have only found occasionally among the samples, especially from Shetland and North England, and from this it seems as if they spawned about March and April, as is stated by Dahl and Delsman of the Lowestoft and Zuiderzee spring spawners. As this spawning time coincides with that of the Norwegian herring I have ranged them together. Respecting all these herrings the spawning season seems to bear some relation to the coast water currents.

2. Summer and autumn spawners are Heincke's Northern bank herring, which form the object of the Shetland, Scottish, North England and Dogger Bank fisheries. If we follow the spawning of these herrings from the northern border on Unst Bank to the Dogger Bank in the south we find that the spawning takes place later and later in the season. In Shetland waters we find the herring spawning in August-September; off the coast of North England an on the Dogger Bank in September-October, perhaps November. Off North Shields we have found herrings spawning in July, but this seems to be only occasional, and the bulk spawn much later. If we compare the range of this herring stock, taken as a whole, with the North Sea currents, as shown by Dr. Fulton's drift bottle experiments (fig. 27), there seems to be a striking coincidence, though these experiments were not extended to the waters east of Shetland. To the course of these currents may possibly be attributed the retardation of the spawning time in the southern part of the area.

3. As winter spawners I have ranged the Channel herring of Lowestoft and Yarmouth, spawning in November-December, perhaps January. This stock seems to be influenced by the currents entering the North Sea from the English Channel.

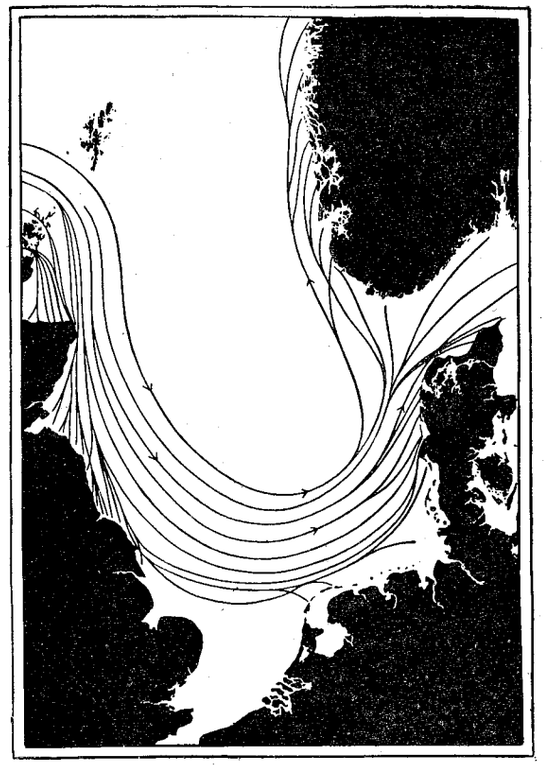

Fig. 27. Results of Dr. Fulton's drift bottle experiments in the North Sea.

As already mentioned (p. 19) we must presume that the young herrings up to a certain age and size remain in the shallower waters of the North Sea all the year round. On approaching maturity these young herrings congregate into shoals at certain areas, viz: Off the coast near North Shields and on Bressa Shoals. Later on they must be supposed to join the spawning shoals. After the spawning we may find some spents scattered among other herring schools, as we have found spent spring herrings among the young herrings off North Shields. The majority, however, are presumed to migrate from the North Sea towards the Atlantic. As regards the Norwegian herring, this migration towards the open sea has been referred to by severel authors (Boeck, G. O. Sars, a. o.), and is confirmed by these investigations. A similar migration towards the salter water of the Channel is sure to take place in the case of the Channel herring, spawning in November-December off Lowestoft, which after spawning are not to be found in this area nor in the North Sea at all. In the central and north-western North Sea it is more difficult to trace the migration, but such a migration is presumed by most writers on the subject (Storrow, a. o.) and by analogy with the other areas, I can only

support the migration theory as regards the mature herring, which have spawned on the banks in the North Sea.

This migration of the herring has a parallel in the migration of the salmon from the fresh water of the rivers to the sea off the coast, though the limits of salinity are different in the two cases, the lower limit as regards the salmon being the fresh water. The young herring seem to thrive everywhere in the coast water, moving farther out as they grow older while the mature spawning herring of the West Coast of Norway, according to Hjort (1897, p. 7), recoils from water having a lower salinity than 33 ‰. The lower limit may vary for the different races of herrings, and this might be one of the agencies keeping the herring races apart. The upper limit of salinity we don't know, either for the salmon or the herring, as we don't know how far out they migrate after spawning. It seems however as if the herrings immediately after spawning are more indifferent to salinity, the majority of the spent herrings migrating seawards, while we may find stragglers or even shoals of spents nearer to the coast than the spawning grounds. Regarding the Channel herring off Lowestoft we have some information pointing in the same direction as Hjort's observations off the Norwegian West Coast. According to the Annual Report of the English Sea Fisheries (1913, part I, p. 51) the salinity off Smith's Knoll near Yarmouth in October-December that year lay between 34.1 and 34.4 ‰, while the salinity in the English Channel was above 35.0 ‰. There is apparently a migration towards the lower salinities as the spawning time approaches, and the same must be the case with the herrings in the remaining areas of the North Sea, if we accept the Atlantic migration theory and the return of the herring to the banks of the North Sea towards the spawning time.

Though the most striking feature in the migrations of the herring is the difference in salinity in the localities passed through, the temperature might have as much, if not more, influence, at least in the maturing of the gonads. In the development of the gonads we might distinguish between the growth of the eggs and the maturation, viz: the absorbtion of water by which the eggs cease to be opaque and become transparent. The increase in water contents during maturation

must be considerable[1]), and it is possible that the salinity and temperature of the surrounding sea water are of some importance in the process. I have not found any records in literature of investigations on the physical conditions under which this process takes place, but I am inclined to think that experiments in this direction might be of much interest.

Dr. Hjort has called my attention to the fact that the temperature of the sea off the West Coast of Norway towards the spawning time of the herring is considerably lower than some months earlier. As shown by Hjort's observations off the West Coast in the nineties of last century (1912, p. 709), the temperature may go down considerably below 6 ° C. during January-April, while in November at the same place it is above 8 ° C. The maturing herrings were not actually in that locality during November, but farther north or farther out at sea, where the temperature was comparatively high during the month of November, and we may conclude that the herring migrated from a higher to a lower temperature. As to the Channel herring off Lowestoft we find (Fishery Report, 1913, part I, p. 51) that the temperature off Smith's Knoll during the months of October-December went down from 16 ° C. to about 9 ° C. In the English Channel the temperature was high even in November (13 ° C.), but fell later (March-May 9—10 ° C.). According to Hjort (1905, p. 125-127), and confirmed by later investigations (Bulletin hydrographique, 1908—1912), the temperature of the North Sea below 30 metres is fairly constant summer and winter, about 6—7 ° C. or even lower. As we find a temperature about 10 ° C. between the Orkney and Shetland Islands and to the north east in September, the herring must in their migration from the Atlantic towards the North Sea banks during the summer months pass from water of a higher to water of a lower temperature. It thus seems as if the

[1]) Dr. Hjort informs me verbally of some analyses of the eggs of *gadus callarias* made by him in the year 1893 but not yet published. The analyses gave the following figures:

	Ovarial eggs			Unfertilized, mature eggs	
	a	b	c	a	b
Water contents....	71.703 %	72.78 %	81.22 %	93.854 %	95.02 %

ovaries grow, and the eggs store yolk matter, during the stay of the herring in the warmer and salter Atlantic water, while the maturation of the eggs, or the absorption of water by the eggs, takes place in fresher and colder water, when the herring proceeds towards the habitual spawning grounds. As already stated, the question as to the actual importance of the agencies referred to can only be solved by direct experiments, and I have tried, as far as the material allows, to arrange the facts as they strike me.

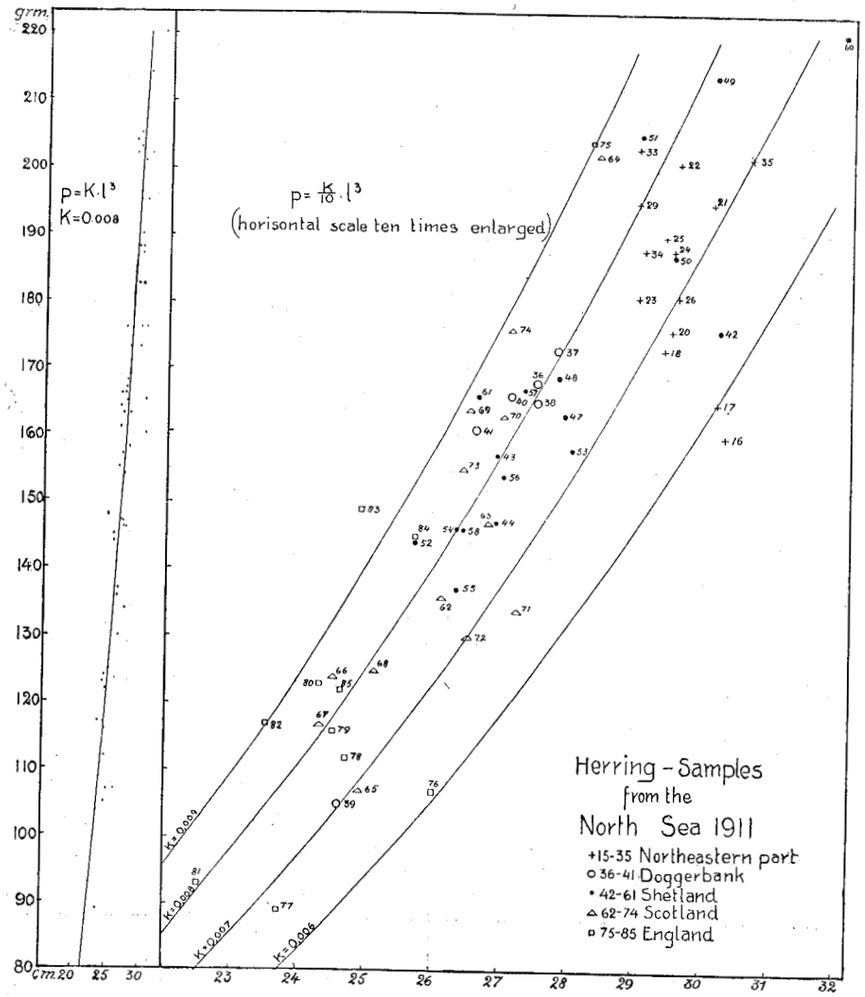

Fig. 28. Length-weight relation of the herring samples taken in the North Sea during the year 1911.

In order to get a general view of the condition (see p. 27) of herring samples from the different areas of the North Sea I have constructed the graph (fig. 28). As already mentioned (p. 33) the material is not very well suited for the purpose, the preservation of the samples varying to such an extent that the length-weight relation is changed considerably, but nevertheless it may be of interest to compare the samples for the year 1911 in this way. In the graph the length-weight relation of the different samples is compared with the parabolas constructed from the formula $p = k.\ l^3$, with k. ranging from 0.006 to 0.009, so as to show how the samples with lean herrings gather towards the parabola of the lower k, and those with fatter and bulkier herrings towards that of the higher. From table I b we find that the „indicator" ($i = 1000\ k$) of the samples for 1911 ranges between 5.8 (Coll. 16, and 9.6 (Coll. 83). The lowest figures are found in the spent herrings caught on the Revkant in the month of May, and the highest in the sample of relatively fat and fairly mature herrings caught off North Shields in the latter days of August. Comparing these figures from the table with the graph we find that between these samples the others range themselves especially about the indicator 8.0, where we find most of the samples from Shetland, Scotland and the Dogger Bank caught during the summer, and then in different stages of sexual development. The young herring samples caught off North Shields mostly lie above this indicator, but some samples fall below, which fact I attribute to the different method of preservation (salt). As a rule when the indicator falls quite out of place, we may find the explanation in the manner of preservation (see the list p. 6—9).

In these investigations it has been questions which I have been obliged to leave in abeyance, either because they fell out of the lines of this work or because the material at hand did not allow of a thorough investigation. In most cases I have then however given an indication of the lines in which I have found that the future investigations might fall.

Thus the question of herring races which I have only occationally touched may find its proximate solution through the investigations of growth of the herrings which go on steadily in Norway, England and other countries. In this publication I have mostly stuck to the stocks

of herrings habitating the different areas where herring fishery takes place. From the age, maturity and quality of the herrings belonging to these stocks I have tried to elucidate the relations of the herrings in the different areas without taking any standpoint to the question of races. As shown this has been sufficient to show that: the Revkant-herring proper has a certain relation to the Norwegian herring stock, the Yarmouth and Lowestoft herring to the herring found in the English Channel, the summer spawning herring of the northern banks of the North Sea plateau to the herring closer up to the Shetland coast (Bressa Shoals, etc.) and the Dogger Bank herring to the mature herring fished in August-September off the coast of Middle and North England, and finally: that the two latter groups together with the Scotland herring form a unity corresponding to Heincke's Northern bank herrings. The more particular shades of the relation between the different herring stocks must however be left to be solved on other lines.

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Tables.

Table I a, 1910.

Coll. no.	Date	No. of indiv.	Year-classes Number of individuals % 1909	1908	1907	1906	1905	1904	1903	1902	1901	1900	1899	1898	1897	1896	1895	1894	Aver. age[1]
15	28/7	372	—	—	0.8	10.2	3.8	46.8	4.8	5.6	3.0	9.4	4.8	3.2	0.8	1.3	—	0.3	6.94
16	8/9	21	—	—	4.8	4.8	9.5	47.6	9.5	—	14.2	4.8	4.8	—	—	—	—	—	6.62
17	14/9	63	—	—	1.6	7.9	22,2	54.0	6.3	3.2	4.8	—	—	—	—	—	—	—	5.84
18	15/9	104	—	1.0	4.8	6.7	21.1	53.8	1.9	1.9	1.0	1.9	2.9	1.9	1.0	—	—	—	5.95
19	16/9	84	1.2	—	2.4	2.4	15.5	26.2	13.1	15.5	9.5	9.5	4.7	—	—	—	—	—	7.00
20	17/9	15	—	—	20.0	13.3	6.7	26.6	—	13.3	—	6.7	6.7	6.7	—	—	—	—	6.33
21	13/10	272	—	—	0.7	2.9	8.5	13.6	11.4	14.7	17.3	11.4	11.8	5.1	1.5	1.1	—	—	8.27
22	27/10	75	—	—	1.3	10.7	8.0	29.3	12.0	13.3	4.0	8.0	10.7	2.7	—	—	—	—	7.19
23	28/10	145	—	—	0.7	7.6	17.2	48.9	8.3	6.2	5.5	2.7	1.4	0.7	0.7	—	—	—	6.30
24	11/11	134	—	—	2.2	13.4	22.4	36.6	8.9	6.7	6.0	3.0	0.7	—	—	—	—	—	6.00
25	18/9	286	—	—	11.2	18.2	22.0	18.9	15.0	7.0	3.8	2.8	0.7	0,4	—	—	—	—	5.65
26	21/9	194	—	0.5	6.7	12.4	19.1	19.1	13.4	14.4	8.2	4.6	1.0	0.5	—	—	—	—	6.28
27	24/10	155	—	—	5.2	9.0	22.6	18.1	14.2	7.7	5.8	11.6	2.6	1.9	1.3	—	—	—	6.72
28	/4	204	—	14.2	2.0	3.4	23.0	51.0	4.4	1.0	—	0.5	0.5	—	—	—	—	—	5.22
29	19/7	220	—	—	3.6	15.0	18.2	19.5	17.7	10.9	9.1	3.2	1.8	0.9	—	—	—	—	6.29
30	8/9	485	—	1.0	20.0	13.0	12.2	16.3	15.7	7.6	7.4	2.7	2.5	0.8	0.8	—	—	—	5.84
31	/7	528	—	18.6	57.6	19.3	3.8	0.6	—	0.2	—	—	—	—	—	—	—	—	3.11
32	17/10	534	—	6.0	21.6	28.7	25.7	11.4	6.2	0.4	0.6	—	—	—	—	—	—	—	4.38
33	14/11	432	—	2.2	17.9	23.4	25.4	16.3	8.5	3.5	1.8	0.6	0.6	0.4	—	—	—	—	4.90
34	23/10	193	—	13.5	34.7	19.2	14.0	7.8	5.7	3.6	1.5	—	—	—	—	—	—	—	4.57
67	/6	190	—	8.4	57.9	20.5	5.3	4.8	2.1	1.1	—	—	—	—	—	—	—	—	3.50

[1]) Table of correction of average age.

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Year	0.08	0.16	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.16	1.25

Table I a, 1910.

Stages of sex. organs No. of indiv. % I	II m +	II o 1	III	IV	V	VI	VII	Stages of fat No. of indiv. % m	+	1	0	Average fat (3—0)	length cm.	weight gr.	$i = 1000\ k$	Remarks
—	59.7	11.3	25.5	3.2	0.3	—	—	14.7	58.1	25.8	1.4	1.86	28.6	180	7.7	
4.8	38.1	—	33.3	14.3	9.5	—	—	42.9	19.0	—	38.1	1.68	30.8	206	7.1	
1.6	60.3	4.8	22.3	9.5	1.6	—	—	33.3	39.7	6.4	20.6	1.86	30.6	206	7.2	
7.7	55.8	1.9	19.2	5.8	—	2.9	6.7	44.2	31.7	2.9	21.2	1.99	29.8	179	6.8	
3.6	23.8	1.2	3.6	42.9	9.5	7.1	8.3	13.1	13.1	1.2	72.6	0.67	29.8	190	7.2	Shetland.
13.3	40.0	—	6.7	26.7	6.7	6.7	—	40.0	13.3	6.7	40.0	1.53	28.4	161	7.1	
—	71.0	11.4	11.7	2.9	—	0.4	2.6	51.5	30.1	9.9	8.5	2.25	31.0	204	6.9	
2.7	29.3	54.7	13 3	—	—	—	—	9.3	29.3	38.7	22.7	1.25	31.2	190	6.3	
5.5	22.7	6.9	58.6	6.3	—	—	—	14.5	24.1	15.9	45.5	1.08	31.0	210	7.1	
—	9.7	5.2	35.8	37.4	11.9	—	—	5.2	29.0	36.7	9.1	1.10	31.1	240	8.0	
—	0.3	—	7.3	61.6	29.4	1.4	—	—	0.3	0.3	99.4	0.01	27.6	161	7.7	
—	0.5	—	8.8	67.5	22.7	—	0.5	0.5	0.5	—	99.0	0.03	27.6	169	8.0	
—	3.9	14.2	54.2	23.8	3.9	—	—	—	3.9	10.3	85.8	0.18	28.5	171	7.4	
14.2	—	2.5	3.9	4.9	44.6	28.4	1.5	—	5.4	13.7	80.9	0.25	28.0	—	—	Faeroe Islands.
—	11.4	9.5	24.6	36.3	18.2	—	—	2.3	13.3	55.9	28.5	0.89	27.8	187	8.7	Shetland.
—	—	—	—	11.9	87.7	—	0.4	—	—	3.1	96.9	0.03	27.3	190	9.3	
8.3	36.5	3.1	17.1	12.5	14.6	0.6	7.3	43.4	26.4	14.0	16.2	1.97	24.3	136	9.5	
—	—	—	—	3.9	96.1	—	—	—	—	1.2	98.8	0.01	25.7	146	8.6	
—	0.2	0.4	—	1.2	98.2	—	—	—	0.4	—	99.6	0.01	26.3	154	8.5	
1.5	3.1	0.5	58.6	35.3	1.0	—	—	0.5	4.1	7.3	88.1	0.17	25.0	117	7.5	
1.1	5.3	4.2	70.0	14.7	4.7	—	—	3.2	7.9	32.6	55.3	0.58	22.2	90	8.2	

Table I b, 1911. (Continued).

Coll. no.	Date	No. of indiv.	Year-classes Number of individuals % 1910	1909	1908	1907	1906	1905	1904	1903	1902	1901	1900	1899	1898	1897	1896	1895	Aver. age
13	5/5	90	—	—	—	1.1	11.1	15.6	27.8	13.5	5.6	8.9	4.4	4.4	3.3	2.2	1.1	1.1	8.02
14	6/5	21	—	—	4.8	4.8	14.3	4.8	33.3	4.8	—	19.1	—	4.8	9.5	—	—	—	7.76
15	8/5	59	—	—	—	1.7	3.4	18.6	30.5	20.3	3.4	5.1	8.5	5.1	—	1.7	—	—[1]	8.01
16	15/5	43	—	—	—	—	9.3	14.0	41.9	16.3	4.7	9.3	2.3	2.3	—	—	—	—	7.41
17	31/5	34	—	—	—	—	17.6	11.8	55.9	8.8	2.9	—	2.9	—	—	—	—	—	6.80
18	17/6	112	—	—	0.9	2.7	7.1	14.3	28.6	13.4	8.9	8.9	8.9	5.4	0.9	—	—	—	7.86
19	22/6	110	—	—	—	0.9	7.3	6.4	20.0	17.2	19.1	11.8	6.4	6.4	0.9	1.8	1.8	—	8.57
20	23/6	59	—	—	—	3.4	3.4	22.0	37.3	6.8	13.6	3.4	1.7	6.8	1.7	—	—	—	7.56
21	29/6	64	—	—	—	1.6	14.1	9.4	39.1	7.8	4.7	7.8	7.8	3.1	4.7	—	—	—	7.73
22	6/7	103	—	—	—	—	1.0	5.8	14.6	14.6	16.5	17.5	11.7	8.7	4.8	4.8	—	—	9.45
23	7/7	88	—	—	1.1	3.4	6.8	5.7	21.6	13.6	15.9	8.0	14.8	8.0	—	1.1	—	—	8.42
24	20/7	36	—	—	—	2.8	—	11.1	30.6	11.1	8.3	25.0	5.6	2.8	2.8	—	—	—	8.36
25	21/7	223	—	—	—	2.2	4.9	9.4	23.8	13.5	9.4	10.8	6.7	10.3	4.0	2.7	1.8	0.4	9.11
26	22/7	97	—	—	—	1.0	5.2	16.5	24.7	12.4	4.1	5.2	10.3	10.3	6.2	2.1	2.1	—	8.67
27	25/7	77	—	—	13.0	3.9	6.5	5.2	27.3	13.0	7.8	11.7	5.2	5.2	—	1.3	—	—	7.37
28	26/7	262	—	—	4.6	2.7	10.3	12.2	22.1	16.8	12.6	6.9	4.2	4.2	2.3	0.8	0.8	—	7.63
29	3/8	104	—	—	3.8	2.9	7.7	10.6	26.9	9.6	11.5	10.6	4.8	7.7	1.9	1.0	1.0	—	7.98
30	4/8	83	—	—	—	6.0	13.3	21.7	24.1	8.4	12.0	4.8	4.8	1.2	1.2	1.2	1.2	—	7.85
31	7/8	102	—	1.0	1.0	7.8	13.7	22.4	16.5	10.8	9.8	10.8	1.0	3.0	1.0	—	1.0	—	7.05
32	8/8	49	—	2.0	4.1	12.2	12.2	20.4	28.6	2.0	2.0	8.3	4.1	—	4.1	—	—	—	6.64
33	9/8	57	—	—	—	7.0	19.3	17.5	12.3	15.8	15.8	8.8	3.5	—	—	—	—	—	7.10
34	10/8	134	—	3.7	14.9	8.2	16.4	20.2	20.2	3.7	6.7	3.0	1.5	0.7	0.7	—	—	—	5.60
35	30/9	92	—	—	—	1.1	7.6	18.5	40.2	15.2	7.6	4.3	—	2.2	1.1	1.1	—	1.1	7.41
36	18/9	164	—	—	3.7	14.0	25.0	17.1	17.1	9.7	4.9	3.7	1.8	2.4	—	—	—	—	6.25
37	19/9	136	—	0.7	2.9	6.6	23.5	19.9	16.2	12.5	8.1	4.4	3.7	0.7	0.7	—	—	—	6.63
38	20/9	65	—	—	9.2	6.2	16.9	21.5	16.9	16.9	7.7	—	3.1	—	1.5	—	—	—	6.43
39	22/9	110	—	11.0	43.6	32.7	8.2	3.6	—	—	0.9	—	—	—	—	—	—	—	3.55
40	23/9	157	—	—	7.0	11.5	14.7	15.9	14.7	10.8	11.5	5.7	5.1	0.6	1.3	0.6	0.6	—	6.84
41	11/9	390	—	1.0	6.2	15.1	37.2	23.3	9.0	4.6	2.5	0.3	0.8	—	—	—	—	—	5.40
42	13/5	21	—	—	—	4.8	9.5	19.0	14.3	14.3	9.5	9.5	9.5	4.8	4.8	—	—	—	8.00
43	8/6	174	—	1.7	12.6	40,8	26.4	12.6	3.6	2.3	—	—	—	—	—	—	—	—	4.55
44	9/6	184	—	2.2	11.4	30.4	26.1	19.6	7.1	2.2	0.5	0.5	—	—	—	—	—	—	4.85
45	19/6	101	—	3.0	10.9	34.6	25.7	11.9	6.9	5.0	—	—	2.0	—	—	—	—	—	4.87
46	20/6	26	—	3.8	15.4	34.0	19.2	11.5	11.5	3.8	—	—	—	—	—	—	—	—	4.70
47	21/6	131	—	0.8	2.3	6.9	19.1	22.9	23.6	16.8	5.3	2.3	—	—	—	—	—	—	6.40
48	27/7	177	—	0.6	11.9	11.9	16.4	16.4	14.7	14.7	6.7	4.0	1.7	0.6	0.6	—	—	—	6.17
49	29/8	119	—	—	2.5	4.2	16 8	10.1	20.2	20.2	13.4	10.1	1.7	0.8	—	—	—	—	7.24
50	30/8	303	—	—	0.6	12.3	22.7	23.6	18.4	8.7	4.9	3.6	2.2	1.9	1.3	0.3	—	—	6.52

[1]) 1893: 1.7 %.

Table I b, 1911.

Stages of sex. organs No. of indiv. % I	II m+	II o 1	III	IV	V	VI	VII	Stages of fat No. of indiv. % m	+	1	0	Average fat (3—0)	length cm.	weight gr.	$i = 1000\ k$	Remarks
—	—	+	—	—	—	—	+	—	—	—	+	—	30.1	—	—	Spents.
—	—	+	—	—	—	—	+	—	—	—	+	—	29.6	—	—	„
—	—	—	—	—	+	+	+	—	—	—	+	—	29.3	—	—	Spawners and spents.
—	4.6	95.4	—	—	—	—	—	2.3	2.3	7.0	88.4	0.19	30.3	160	5.8	
—	11.8	88.2	—	—	—	—	—	—	11.8	35.2	53.0	0.59	30.2	165	6.0	
—	19.7	58.0	21.4	0.9	—	—	—	2.7	18.8	66.0	12.5	1.12	29.4	173	6.7	
2.7	4.5	82.8	10.0	—	—	—	—	1.8	2.7	20.9	74.6	0.32	29.5	—	—	
5.1	8.5	69.4	15.3	1.7	—	—	—	—	8.5	15.3	76.2	0.17	29.5	176	6.9	
1.6	7.8	76.6	10.9	3.1	—	—	—	—	7.8	43.8	48.4	0.59	30.1	195	7.2	
—	19.4	23.3	52.4	4.9	—	—	—	7.7	30.1	46.7	15.5	1.30	29.6	201	7.8	
5.6	42.0	27.3	23.9	1.1	—	—	—	22.7	30.7	30.7	15.9	1.60	29.0	181	7.4	
—	19.4	36.2	44.4	—	—	—	—	—	25.0	58.4	16.6	1.08	29.5	188	7.3	
0.4	27.4	10.7	51.2	8.1	—	0.4	1.8	11.7	31.4	36.8	20.1	1.35	29.4	190	7.5	
1.1	25.8	45.3	23.7	4.1	—	—	—	11.3	19.6	46.4	22.7	1.20	29.6	181	7.0	
—	—	—	—	—	—	—	—	—	—	—	—	—	29.0	—	—	
0.4	24.4	4.6	47.0	22.5	—	—	1.1	17.9	27.1	35.6	19.4	1.44	28.9	—	—	
1.9	9.6	5.8	45.2	37.5	—	—	—	7.7	17.3	33 6	41.4	0.91	29.0	195	8.0	
—	—	—	—	—	—	—	—	—	—	—	—	—	29.2	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	28.8	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	28.5	—	—	
—	12.3	8.8	47.3	31.6	—	—	—	3.5	15.8	29.8	50.9	0.72	29.0	203	8.3	
6.0	39.7	8.9	42.4	3.0	—	—	—	38.9	22.5	28.2	10.4	1.90	29.1	188	7.6	
—	8.7	45.7	25.0	6.5	—	1.1	13.0	3.3	14.1	29.3	53.3	0.67	30.7	202	7.0	
—	—	0.6	2.4	75.0	22.0	—	—	—	—	—	100.0	0.00	27.5	168	8.1	
—	—	—	1.5	69.1	29.4	—	—	—	—	—	100.0	0.00	27.8	173	8.1	
—	—	1.5	3.1	86.2	9.2	—	—	—	—	—	100.0	0.00	27.5	165	7.9	
—	—	—	22.7	75.5	0.9	0.9	—	—	0.9	14.6	84.5	0.16	24.6	115	7.7	Assorted sm. herrings
—	—	—	1.9	59.9	36.9	—	1.3	—	0.6	2.6	96.8	0.04	27.1	166	8.3	—„— herrings.
—	—	—	32.6	65.9	0.5	—	1.0	—	—	—	100.0	0.00	26.6	161	8.6	
—	—	90.4	9.6	—	—	—	—	—	4.8	14.3	80.9	0.24	30.2	176	6.4	
18.4	51.1	6.4	21.8	2.3	—	—	—	65.0	16.6	12.7	5.7	2.41	26.9	157	8.1	
39.2	40.7	9.8	9.3	1.0	—	—	—	62.5	20.7	15.2	1.6	2.42	26.9	147	7.6	
9.9	20.7	25.7	38.6	5.0	—	—	—	10.9	27.7	54.5	6.9	1.43	27.4	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	27.0	—	—	
6.1	42.0	19.8	29.8	2.3	—	—	—	32.8	27.5	28.2	11.5	1.82	27.9	163	7.5	
13.0	26.6	21.4	31.0	7.4	0.6	—	—	25.5	22.6	38.3	13.6	1.60	27.8	169	7.9	
—	—	6.7	0.8	31.0	30.3	2.5	28.6	—	—	0.8	99.2	0.01	30.2	214	7.8	
0.3	6.1	7.2	4.5	6.8	8.1	—	66.0	2.3	7.4	4.5	85.8	0.26	29.5	187	7.3	

Table 1 b, 1911. (Continuation).

Coll. no.	Date	No. of indiv.	Year-classes Number of individuals % 1910	1909	1908	1907	1906	1905	1904	1903	1902	1901	1900	1899	1898	1897	1896	1895	Aver. age
51	2/9	110	—	0.9	—	14.5	31.8	12.7	10.0	15.5	6.4	5.5	1.8	—	1.9	—	—	—	6.33
52	26/6	33	—	—	24.2	57.6	12.1	6.1	—	—	—	—	—	—	—	—	—	—	4.00
53	30/5	79	—	—	1.3	17.7	31.6	12.7	10.1	8.9	3.8	6.3	3.8	1.3	—	2.5	—	—	6.23
54	13/6	81	—	8.6	21.0	18.5	13.6	14.8	11.1	4.9	7.4	—	—	—	—	—	—	—	4.96
55	20/6	86	—	17.4	10.5	19.8	23.3	10.5	5.8	8.1	2.3	2.3	—	—	—	—	—	—	4.75
56	27/6	81	—	4.9	8.6	38.3	17.3	18.5	7.4	4.9	—	—	—	—	—	—	—	—	4.83
57	3/7	76	—	1.3	9.2	19.7	23.7	23.7	14.5	3.9	3.9	—	—	—	—	—	—	—	5.38
58	6/6	91	—	3.3	8.8	18.7	30.8	22.0	8.8	4.4	2.2	—	1.1	—	—	—	—	—	5.22
59	13/5	93	—	—	—	12.9	36.6	25.8	15.1	6.4	2.1	1.1	—	—	—	—	—	—	5.77
60	?	474	—	—	—	1.9	8.9	20.2	22.1	20.3	12.0	7.8	3.6	2.1	0.6	0.2	—	—	7.54
61	/7	242	—	1.2	8.3	29.3	19.4	16.1	10.7	7.9	1.2	2.5	0.8	2.5	—	—	—	—	5.51
62	10/6	124	—	1.6	25.8	24.2	32.3	11.3	4.8	—	—	—	—	—	—	—	—	—	4.41
63	14/6	92	—	—	5.4	37.0	31.5	14.1	8.7	2.2	1.1	—	—	—	—	—	—	—	4.95
64	20/9	128	—	—	3.1	10.2	22.7	21.9	18.7	12.5	7.0	2.3	1.6	—	—	—	—	—	6.30
65	6/6	238	—	2.1	21.9	33.2	21.4	16.0	3.8	1.7	—	—	—	—	—	—	—	—	4.45
66	/7	200	—	18.5	35.5	23.0	10.5	6.5	3.5	2.0	—	0.5	—	—	—	—	—	—	3.72
67	30/8	217	0.9	29.5	29.5	18.9	7.4	3.7	3.2	2.8	3.2	0.5	—	0.5	—	—	—	—	3.67
68	6/6	266	—	0.8	21.4	23.7	24.1	17.3	9.1	1.1	1.5	0.4	0.4	—	—	—	—	—	4.80
69	/7	205	—	6.3	18.0	45.4	16.6	6.8	5.4	1.5	—	—	—	—	—	—	—	—	4.16
70	/8	227	—	6.2	10.1	47.1	15.8	10.6	4.4	4.4	0.4	0.9	0.4	—	—	—	—	—	4.54
71	23/9	253	—	9.9	11.5	24.9	12.6	7.9	6.3	6.3	6.7	5.9	2.4	2.8	0.8	1.6	—	0.4	5.30
72	/9	305	—	10.2	11.2	40.3	16.1	9.2	6.2	4.6	1.3	0.3	0.3	—	0.3	—	—	—	4.54
73	/7	236	—	5.1	19.9	41.5	18.2	8.1	5.1	1.3	0.8	—	—	—	—	—	—	—	4.32
74	/8	246	—	7.0	11.4	53.7	12.6	8.1	4.4	2.4	0.4	—	—	—	—	—	—	—	4.29
75	20/9	394	—	0.5	5.1	8.9	14.2	18.8	18.3	16.0	5.8	6.3	3.8	1.8	0.5	—	—	—	6.76
76	22/5	86	—	1.2	17.4	27.9	29.0	12.8	4.7	4.7	2.3	—	—	—	—	—	—	—	4.79
77	27/5	78	—	6.4	52.6	24.3	11.5	2.6	2.6	—	—	—	—	—	—	—	—	—	3.84
78	5/6	84	—	3.6	32.1	23.8	19.1	13.6	3.6	2.4	1.2	—	—	1.2	—	—	—	—	4.42
79	12/6	84	—	2.4	36.9	29.7	11.1	11.9	3.6	2.4	1.2	—	—	—	—	—	—	—	4.20
80	19/6	86	—	13.9	41.9	18.6	18.6	3.5	3.5	—	—	—	—	—	—	—	—	—	3.66
81	26/6	87	—	46.0	50.6	3.4	—	—	—	—	—	—	—	—	—	—	—	—	2.58
82	3/7	82	—	19.5	47.6	14.4	6.1	3.7	3.7	4.9	—	—	—	—	—	—	—	—	3.57
83	30/8	422	0.2	14.9	37.7	28.7	12.8	4.3	0.7	0.7	—	—	—	—	—	—	—	—	3.58
84	18/7	86	—	2.3	19.8	44.1	26.7	4.7	—	1.2	1.2	—	—	—	—	—	—	—	4.22
85	13/11	504	—	13.9	57.3	13.3	6.5	3.8	3.8	1.0	0.2	—	—	0.2	—	—	—	—	3.46
A	20/6	148	—	—	36.5	27.7	21.6	5.4	2.0	4.7	1.4	0.7	—	—	—	—	—	—	4.32
B	27/9	233	—	—	8.2	6.4	11.2	16.7	12.4	12.9	13.3	11.6	1.7	3.0	1.3	1.3	—	—	7.22
C	20/10	266	—	—	3.0	7.5	22.9	19.5	14.3	12.0	5.6	6.8	4.1	3.4	0.4	0.4	—	—	6.82

Table 1 b, 1911.

Stages of sex. organs No. of indiv. % I	II_{m+}	II_{01}	III	IV	V	VI	VII	Stages of fat No. of indiv. % m	+	1	0	Average fat (3—0)	length cm.	weight gr.	$i = 1000\,k$	Remarks
—	0.9	1.8	0.9	13.6	59.1	22.8	0.9	—	0.9	—	99.1	0.02	29.0	205	8.4	
—	36.4	15.1	42.5	6.0	—	—	—	21.3	42.4	30.3	6.0	1.79	25.7	144	8.5	Assorted herrings.
1.3	20.2	43.0	30.4	1.3	—	—	3.8	5.1	19.0	62.0	13.9	1.16	28.0	158	7.2	
30.8	26.4	22.3	14.8	2.5	—	—	1.2	37.0	24.7	32.1	6.1	1.93	26.3	146	8.0	
32.6	17.5	27.8	17.5	4.7	—	—	—	29.2	19.7	30.2	21.0	1.57	26.3	137	7.5	
12.4	13.6	23.5	44.4	3.7	—	—	2.5	13.6	8.6	39.6	38.3	0.98	27.0	154	7.8	
5.3	6.6	30.2	50.0	6.6	—	—	1.3	2.6	6.6	44.6	46.1	0.66	27.3	167	8.2	
14.3	58.2	16.5	9.9	—	—	—	1.1	38.4	33.0	46.4	2.2	2.28	26.4	146	7.9	
—	—	+	—	—	—	—	+	—	—	—	+	—	27.8	—	—	Mostly spents.
—	—	0.8	0.6	2.5	39.1	56.6	0.2	—	0.8	0.2	99.0	0.02	32.2	220	6.7	Assorted herrings.
17.0	56.6	7.4	16.1	2.9	—	—	—	30.0	58.3	10.7	0.8	2.17	26.6	166	8.8	
70.2	19.3	7.3	3.2	—	—	—	—	79.9	8.0	9.7	2.4	2.65	26.1	136	7.7	
5.4	29.3	9.8	50.0	5.4	—	—	—	27.2	35.8	31.6	5.4	1.85	26.8	147	7.6	
—	3.1	—	9.3	61.0	4.7	9.4	12.5	1.6	6.2	7.9	84.3	0.25	28.4	202	8.2	
37.3	26.6	8.7	2.5	—	—	—	24.9	12.6	48.4	34.8	4.2	1.69	24.9	107	6.9	
37.0	24.5	9.0	28.0	—	—	—	1.5	39.5	23.5	15.0	22.0	1.81	24.5	124	8.4	
20.7	19.8	27.6	13.4	8.8	—	0.9	9.2	27.2	13.3	15.2	44.3	1.23	24.3	117	8.2	
15.8	22.5	1.1	0.8	—	—	0.4	59.3	15.8	49.2	33.1	1.9	1.59	25.2	125	7.8	
4.9	12.6	10.7	55.7	15.1	—	—	1.0	9.2	10.3	16.6	63.9	0.65	26.5	164	8.8	
—	0.4	0.4	3.5	2.2	0.4	78.0	15.1	—	3.5	0.8	95.7	0.08	27.6	163	8.3	
14.2	5.2	22.9	8.2	4.0	—	—	45.4	15.4	6.3	9.2	69.1	0.68	27.4	134	6.5	
9.8	17.7	34.4	4.3	0.6	—	0.3	32.9	10.1	18.4	22.6	48.9	0.90	26.5	130	7.0	
11.1	8.4	21.1	51.2	8.0	—	—	—	6.4	9.3	29.5	54.7	0.66	26.4	155	8.5	
0.4	2.4	1.2	21.6	71.2	1.6	—	1.6	1.6	6.9	2.4	89.1	0.21	27.1	176	8.8	
—	—	—	—	1.0	60.8	32.9	5.3	—	—	—	100.0	0.00	28.3	204	9.0	
67.5	1.2	12.8	—	—	—	—	18.5	—	4.7	55.9	39.4	0.64	26.0	107	6.1	
55.1	1.3	6.1	1.3	—	—	—	36.0	7.7	38.5	17.8	36.0	1.18	23.7	89	6.7	
27.4	9.5	16.6	—	—	—	—	46.5	6.0	25.0	17.8	51.2	0.86	24.7	112	7.5	
53.6	16.7	33.5	—	—	—	—	14.3	19.0	46.4	22.7	11.9	1.73	24.5	116	7.9	
37.2	48.8	5.9	1.2	—	—	—	7.0	55.7	30.2	10.6	3.5	2.38	24.3	123	8.6	
79.3	18.4	—	2.3	—	—	—	—	96.5	3.5	—	—	2.97	22.5	93	8.2	
45.1	45.2	—	3.7	—	—	—	6.0	85.4	10.0	2.4	1.2	2.79	23.5	117	9.0	
4.0	4.5	—	14.9	19.2	57.4	—	—	17.3	19.7	6.3	56.7	0.98	24.9	148	9.6	
—	16.3	9.3	45.4	29.0	—	—	—	8.1	26.9	44.2	20.8	1.22	25.7	145	8.6	
0.4	1.0	3.6	0.2	35.6	59.4	—	—	1.2	3.2	7.0	88.8	0.17	24.6	122	8.2	
—	—	—	69.5	27.8	2.7	—	—	—	—	—	100.0	0.00	23.5	98	7.6	
—	0.4	3.0	3.0	72.5	12.0	3.5	5.6	—	0.4	0.4	99.2	0.01	26.3	153	8.4	
—	—	3.0	2.3	42.1	18.4	15.4	18.8	—	—	0.4	99.6	0.00	27.6	155	7.4	

Table I c, 1912.

Table I c, 1912.

Coll. no.	Date	No. of indiv.	Year-classes Number of individuals %																Aver. age	Stages of sex. organs No. of indiv. %								Stages of fat No. of indiv. %				Average			$i = 1000\ k$	Remarks
			1911	1910	1909	1908	1907	1906	1905	1904	1903	1902	1901	1900	1899	1898	1897	1896		I	II m +	II 0 1	III	IV	V	VI	VII	m	+	1	0	fat (3—0)	length cm.	weight gr.		
11	10/6	161	—	—	12.4	5.0	3.1	8.1	12.4	11.2	19.9	14.3	6.2	4.3	2.5	0.6	—	—	7.80	8.1	52.7	31.1	8.1	—	—	—	—	21.7	41.6	29.9	6.8	1.78	29.7	—	—	
12	20/7	32	18.8	37.5	25.0	6.2	9.4	3.1	—	—	—	—	—	—	—	—	—	—	2.59	37.6	31.2	9.4	18.7	3.1	—	—	—	46.9	18.7	31.3	3.1	2.09	22.6	84	7.3	
13	22/7	98	—	10.2	34.7	29.6	11.2	9.2	1.0	4.1	—	—	—	—	—	—	—	—	3.78	29.6	17.3	25.5	27.6	—	—	—	—	16.3	15.3	51.1	17.3	1.31	25.1	106	6.7	
14	23/7	12	—	41.7	41.7	16.6	—	—	—	—	—	—	—	—	—	—	—	—	2.69	50.0	33.4	—	16.7	—	—	—	—	58.3	33.3	8.3	—	2.50	23.2	92	7.4	
15	24/7	184	—	1.1	23.4	31.5	16.9	10.9	5.4	4.9	4.4	0.5	0.5	0.5	—	—	—	—	4.82	2.7	28.8	20.6	43.0	4.9	—	—	—	1.0	36.5	55.5	7.0	1.30	25.7	116	6.8	
16	20/7	314	—	1.3	16.6	17.8	15.9	15.3	7.3	10.8	7.6	4.5	1.3	1.0	0.6	—	—	—	5.18	3.5	20.4	10.2	53.8	12.1	—	—	—	13.1	17.9	48.1	20.4	1.24	26.5	133	7.2	
17	26/7	206	—	—	4.9	5.3	4.9	3.9	7.8	16.5	15.0	16.5	13.1	6.7	2.9	1.5	1.0	—	8.70	0.5	18.9	19.9	52.4	8.3	—	—	—	3.9	22.3	52.0	21.8	1.08	27.6	154	7.3	
18	/7	92	—	—	43.5	13.0	18.5	8.7	2.2	3.2	7.6	1.1	—	2.2	—	—	—	—	4.61	—	39.1	4.3	15.2	19.6	14.2	—	7.6	31.5	20.7	22.8	25.0	1.59	26.9	178	9.2	
19	/7	85	—	—	15.3	18.8	28.2	11.3	10.6	5.9	4.7	2.3	1.2	1.2	—	—	—	—	5.47	—	22.3	8.3	25.9	31.7	8.7	—	3.5	5.9	30.6	34.0	29.5	1.13	27.2	170	8.5	
20	20/6	88	—	—	33.0	29.5	20.4	12.5	2.3	2.3	—	—	—	—	—	—	—	—	4.28	22.7	65.9	5.7	3.4	2.3	—	—	—	64.7	26.2	9.1	—	2.56	27.3	—	—	
21	12/6	105	—	—	31.4	12.4	20.0	10.4	12.4	6.7	2.9	3.8	—	—	—	—	—	—	5.11	11.2	60.9	6.7	8.6	7.6	—	—	—	52.4	27.6	13.3	6.7	2.26	28.4	—	—	
22	12/6	70	—	—	24.3	21.4	28.6	12.9	10.0	—	1.4	1.4	—	—	—	—	—	—	4.76	5.7	57.9	—	14.3	1.4	—	—	—	55.7	35.8	7.1	1.4	2.52	27.5	—	—	
23	14/11	521	0.2	6.2	32.2	38.6	9.2	5.2	4.0	3.3	0.6	0.2	0.2	—	0.2	—	—	—	4.06	2.0	1.4	2.3	3.7	29.8	52.2	0.4	8.2	1.5	4.9	6.5	87.1	0.20	25.6	137	8.2	
24	14/10	613	—	—	4.6	46.8	32.9	6.8	4.4	2.3	1.5	0.5	—	—	0.2	—	—	—	4.76	—	—	0.2	1.3	32.2	65.6	0.3	0.5	—	0.5	7.9	91.7	0.09	24.8	126	8.3	
25	18/9	378	—	3.7	47.4	15.3	13.5	9.5	2.7	3.4	1.6	0.8	1.6	—	—	0.5	—	—	4.28	—	—	—	—	0.3	57.7	42.0	—	—	0.5	3.2	96.3	0.04	26.2	151	8.4	
26	16/7	495	—	8.7	29.5	31.5	15.6	7.1	3.4	2.6	0.6	0.8	—	—	—	—	—	0.2	4.14	0.4	0.4	0.6	—	0.6	93.8	3.2	1.0	—	0.6	0.6	98.8	0.02	26.6	149	7.9	
27	13/8	442	—	10.4	57.3	19.0	6.1	3.8	1.1	1.8	0.5	—	—	—	—	—	—	—	3.49	—	2.0	—	31.4	31.2	35.3	—	—	22.6	25.9	5.6	45.7	1.25	24.9	145	9.4	

Table I d, 1913.

Table I d, 1913.

Coll. no.	Date	No. of indiv.	Year-classes Number of individuals % 1912	1911	1910	1909	1908	1907	1906	1905	1904	1903	1902	1901	1900	1899	Aver. age
6	15/5	714	—	3.4	26.3	45.4	18.9	4.2	1.1	0.4	—	0.3	—	—	—	—	4.00
7	20/11	429	—	2.3	33.8	28.4	27.0	4.4	2.3	1.2	—	0.2	0.2	—	—	—	5.11
8	16/12	419	—	4.3	30.1	41.3	16.4	4.3	1.9	1.2	0.5	—	—	—	—	—	4.99
A	6/6	69	—	10.2	47.8	36.2	5.2	—	—	—	—	—	—	—	—	—	3.10
B	19/6	66	—	6.1	42.4	30.3	21.2	—	—	—	—	—	—	—	—	—	3.6
C	16/7	107	—	26.2	56.1	16.8	1.9	—	—	—	—	—	—	—	—	—	3.0
D	17/7	83	—	16.8	50.6	26.4	6.2	—	—	—	—	—	—	—	—	—	3.2
E	19/8	78	—	16.7	50.0	25.6	7.7	—	—	—	—	—	—	—	—	—	3.2
F	28/8	97	—	7.2	44.3	36.1	11.3	1.0	—	—	—	—	—	—	—	—	3.5
G	29/8	100	—	9.0	40.0	44.0	6.0	—	1.0	—	—	—	—	—	—	—	3.5
H	1/9	100	—	6.0	50.0	27.0	3.0	9.0	3.0	2.0	—	—	—	—	—	—	3.7
I	2/9	100	—	6.0	53.0	30.0	3.0	1.0	2.0	1.0	1.0	1.0	—	1.0	—	—	3.7
J	6/9	198	—	6.5	47.0	33.0	8.0	1.5	2.5	0.5	—	—	—	—	—	—	3.6
K	8/9	198	—	14.0	56.0	23.5	3.0	1.5	0.5	—	—	—	—	—	0.5	—	3.2
L	12/9	203	—	15.3	46.8	32.0	4.5	0.5	—	0.5	—	—	0.5	—	—	—	3.3
M	13/9	105	—	41.9	46.7	9.5	1.0	—	1.0	—	—	—	—	—	—	—	2.7
N	15/9	195	—	—	12.6	50.3	20.0	6.7	5.7	2.1	2.1	0.5	—	—	—	—	5.0
O	16/9	164	—	12.2	25.6	31.7	7.9	6.1	10.3	3.7	1.2	0.6	0.6	—	—	—	4.1
P	17/9	188	—	—	9.1	32.1	20.0	9.1	13.4	7.0	4.3	0.5	1.6	0.5	2.7	—	5.6
Q	18/9	160	—	12.6	22.6	30.8	17.6	3.1	5.7	1.9	1.3	—	1.3	2.5	0.6	—	4.4
R	19/9	95	—	2.1	8.4	33.7	15.8	14.7	10.5	4.2	7.4	2.1	—	—	1.1	—	5.4
S	22/9	160	0.6	7.5	17.5	24.4	18.8	6.3	14.3	3.1	2.5	3.1	0.6	0.6	—	—	4.9
T	23/9	151	—	1.3	12.6	30.5	15.9	12.6	9.9	2.7	6.0	3.3	4.0	1.3	—	—	5.7
U	25/9	158	—	10.1	14.6	22.2	12.7	8.2	10.1	5.7	4.4	5.1	3.2	2.5	0.6	0.6	5.7
V	29/9	160	—	13.8	8.8	39.4	20.6	7.5	1.3	1.9	4.4	0.6	—	0.6	1.3	—	4.0
W	3/10	116	7.8	44.8	13.8	15.5	9.5	3.4	0.9	1.7	0.9	0.9	—	—	0.9	—	3.1
X	6/10	159	—	12.6	16.4	24.1	24.1	1.9	4.4	5.1	4.4	4.4	0.6	1.3	—	1.3	5.0

Stages of sex. organs No. of indiv. % I	II m +	II 0 1	III	IV	V	VI	VII	Stages of fat No. of indiv. % m	+	1	0	Average fat (3—0)	length cm.	weight gr.	$i = 1000\ k$	Remarks
22.7	4.2	71.5	1.2	0.3	0.1	—	—	0.1	9.8	39.7	50.4	0.60	24.6	100	6.7	
—	0.5	0.7	4.4	51.0	42.2	—	1.2	0.5	4.4	33.3	61.8	0.44	25.5	137	8.3	
—	—	4.7	31.3	61.1	2.2	—	0.7	—	1.2	56.9	41.9	0.59	25.5	140	8.5	
65	33		—	—	1	—	—	—	—	—	—	—	23.5	—	—	(Storrow).
45	49		5	—	2	—	—	—	—	—	—	—	23.6	—	—	„
39	31		22	7	2	—	—	—	—	—	—	—	23.0	—	—	„
28	44		14	10	—	—	—	—	—	—	—	—	23.6	—	—	„
6	11		52	16	14	—	—	—	—	—	—	—	24.3	—	—	„
1	16		20	17	41	2	—	—	—	—	—	—	25.1	—	—	„
2	14		23	38	22	1	—	—	—	—	—	—	24.7	—	—	„
7	9		22	23	34	5	—	—	—	—	—	—	25.3	—	—	„
—	10		33	26	25	3	—	—	—	—	—	—	24.8	—	—	„
—	10		28	34	24	4	—	—	—	—	—	—	25.0	—	—	„
5	26		39	19	10	3	—	—	—	—	—	—	24.4	—	—	„
8	15		39	18	11	2	7	—	—	—	—	—	24.8	—	—	„
27	22		29	13	1	—	8	—	—	—	—	—	23.6	—	—	„
—	4		23	30	36	—	8	—	—	—	—	—	25.6	—	—	„
8	10		19	13	20	—	30	—	—	—	—	—	25.0	—	—	„
—	2		26	22	37	—	13	—	—	—	—	—	26.8	—	—	„
6	12		35	27	16	—	4	—	—	—	—	—	24.9	—	—	„
—	4		27	20	42	1	5	—	—	—	—	—	26.5	—	—	„
6	8		19	17	14	—	35	—	—	—	—	—	26.2	—	—	„
—	1		22	16	42	3	17	—	—	—	—	—	26.6	—	—	„
4	8		18	25	43	—	2	—	—	—	—	—	26.2	—	—	„
11	10		41	18	17	2	2	—	—	—	—	—	26.0	—	—	„
40	19		23	14	4	—	—	—	—	—	—	—	23.7	—	—	„
8	13		36	34	5	—	4	—	—	—	—	—	25.4	—	—	„