

MEDDELELSER

FRA

KOMMISSIONEN FOR HAVUNDERSØGELSER

SERIE: FISKERI · BIND VII

Nr. 5. A. C. JOHANSEN: ON THE SUMMER- AND AUTUMN-SPAWNING HERRINGS OF THE
NORTH SEA

KØBENHAVN
C. A. REITZEL, BOGHANDEL

BIANCO LUNOS BOGTRYKKERI

1924

MEDDELELSER FRA KOMMISSIONEN FOR HAVUNDERSØGELSER

SERIE: FISKERI · BIND VII · NR. 5 · 1924

ON THE SUMMER- AND AUTUMN-SPAWNING
HERRINGS OF THE NORTH SEA

BY

DR. A. C. JOHANSEN

KØBENHAVN
C. A. REITZEL, BOGHANDEL

BIANCO LUNOS BOGTRYKKERI

1924

I. Introduction.

IN the present treatise I have tried to contribute to the knowledge concerning the racial characteristics of the summer- and autumn-spawning herrings of the North Sea and of the relation between these herrings and other sea herrings of the North Sea and adjacent waters.

Two classes of characters have been used by various authors to characterise the various races of fishes: those which, when once formed, remain constant during the whole life of the specimen (number of vertebrae, fin rays and keeled scales etc.), and those which are relative measures, as, for example, the length of head in proportion to the total length, the distance from the point of the snout to the anus in proportion to the total length, etc.

There is no doubt that the first mentioned group of characters present considerable advantages compared with the second group. The second group of characters may vary according to the different stages of development and are moreover influenced by the environment and perhaps by the state of preservation. Thus a considerable amount of uncertainty arises, the extent of which can not be determined without special investigations.

The experiences encountered in hatcheries etc. with young of the trout and other fishes placed under different environments induce us to be cautious in using the second group of characters as race characters. The same is the case with the experiences gained in the race studies of the common eel (*Anguilla vulgaris* Turton). Dr. JOHNS. SCHMIDT has shown (1914, 1916) that all eels from the whole of Europe belong to the same race, and yet it is a well-known fact that their appearance may be very different. The grown up eels vary not only in colour but also in shape, and even the skull is subject to great variations (TÖRLITZ 1922). I have preferred therefore at the present stage of the investigations to employ only characters of the first mentioned group.

The following individual constant characters are taken up for statistical treatment in the present paper:

- 1) Number of vertebrae
 - a. Total number of vertebrae (named *Vert. S.* = *Vertebrarum Summa*).
 - b. precaudal vertebrae (the vertebrae in front of the first closed haemal arch).
 - c. caudal vertebrae (*Vert. S. minus Vert. præc.*)
- 2) Number of keeled scales between the ventral fins and anus (K_2).
- 3) Number of fin rays in both ventral fins together.
- 4) Number of fin rays in dorsal fin. Only the branched rays are counted.
- 5) Number of fin rays in anal fin
 - a. total number of fin rays
 - b. number of branched fin rays
 - c. number of unbranched fin rays.

Concerning the description of these characters I refer to two of my previous papers (A. C. JOHANSEN 1919, 1921). Abnormal and defective specimens are omitted. When this is the case mistakes in the counting of any consequence can easily be avoided for the following characters:

- Total number of vertebrae
- Number of fin rays in ventral fins
- Number of branched dorsal fin rays

Number of branched and unbranched anal fin rays.

If the skeletonising is not carried out with caution the foremost haemal arches may be damaged, and this can lead to mistakes in distinguishing between the caudal and precaudal vertebrae.

It is sometimes difficult to find the limit between the foremost and the hindmost keeled scales (K_1 and K_2), especially in small specimens. It will therefore be safest to reckon with the possibility of a few mistakes in case of small specimens. The foremost dorsal fin ray is sometimes rudimentary, and this offers a great difficulty in the counting of the unbranched rays. For this reason I have usually omitted the unbranched dorsal rays and counted only the branched ones.

For the calculation of σ the formula:

$$\sigma = \pm \sqrt{\frac{\sum p \alpha^2}{n-1}} = \pm \sqrt{\frac{1}{n(n-1)}} \sqrt{n \sum p \alpha^2 - (\sum p \alpha)^2}$$

is used throughout the work.

For the calculation of the correlation between two different characters we have employed PEARSON'S formula $= \frac{\sum p \alpha_x \cdot \alpha_y}{\sum p' \alpha_x^2 \cdot \sum p'' \alpha_y^2} = \frac{\sum p a_x \cdot a_y - n b_x \cdot b_y}{(n-1) \sigma_x \cdot \sigma_y}$; α_x and α_y indicate the deviation from the mean values for the two series; p is the number of variants for each separate class; a_x and a_y are the deviations from the chosen starting point for the calculation of the mean value; b_x and b_y indicate for each of the two series the distance between the true mean value, and the starting point for the calculation of the mean value. The total number of variants is indicated by n .

The characteristics used here of the different stages of maturity of the herring are in near agreement with HEINCKE'S (1898). They are shown in the survey below.

Stage of Maturity	Female	Male
I. (Young virgin herrings) . . .	The height of the ovary is below 4 mm and the eggs can only be distinguished by help of the microscope. The colour of the ovary is whitish, greyish, or faintly reddish.	The height of testes is below 4 mm. The colour is whitish or greyish.
II. (Maturing herrings)	The height of the ovary is ca. 4—8 mm the eggs can be distinguished by help of a magnifying glass. The ovary is as a rule of a reddish colour.	The height of testes is 4—8 mm. The colour greyish or reddish grey.
III. (Maturing herrings)	The height of the ovary is ca. 8—15 mm. The eggs may be distinguished with naked eye. Their diameter is 0.2—0.5 mm. The ovary is as a rule of a reddish or yellowish colour.	The height of testes is 8—15 mm. The colour is greyish or reddish grey.
IV. (Full herrings)	The ovary takes up a predominant part of the abdominal cavity. The eggs are 0.5—0.8 mm in diameter.	The height of testes is more than 15 mm. The colour is greyish white.
V. (Full herrings)	The whole abdominal cavity is taken up by the ovary. The eggs about 0.8—1 mm in diameter or more.	Testes almost fill up the whole abdominal cavity. The colour is pure milky white.
VI. (Spawning herrings)	The roe running.	Sperma running. The colour is milky white.
VII. (Spents or Blood-Herrings)	The ovary is empty or contains only a few residual eggs.	Testes baggy, bloodshot. Small remains of sperma may be present.
VIII. (Recovering Spents)	The specimen has passed spawning some time ago. The eggs as in stage I—II, but the ovary is usually of greater dimensions.	The specimen has passed spawning some time ago. Testes bloodshot, no running sperma.

The stage VIII passes into the stage II or II—III. A stage which almost agrees with my stage VIII is indicated by HEINCKE as stage II a.

II. The Shetland Summer Herrings.

During the months from June to September a very considerable herring fishery based on summer-spawning herrings takes place in the waters surrounding the Shetland Isles. From June to the end of August the Shetland Herring is captured mostly as full herrings, and in September mostly as spent herrings. According to FULTON (1891) the spawning takes place during the months July to September in the environs of the Shetland Isles, for instance, at the south eastern part of Mainland. According to BJERKAN (1917) the spawning takes place in August—September on Unst Bank to Viking Bank in the North, and round Bressay Shoals in the South.

The Shetland Herring was made the subject of special race studies by the Norwegian zoologist HJ. BROCH who published his results in the treatise: "Norwegische Heringsuntersuchungen während der Jahre 1904—1906" (1908). Broch's material was collected partly from the Norwegian research steamer "Michael Sars", partly from the steamer "Kinn", and partly from the cutter "Frithjof". It originates from the northern part of the North Sea and adjacent parts of the Norwegian Sea between 59°—62° N. and 1° W. —3° E.

As a result of his investigations BROCH arrives at the conclusion that the Shetland Summer Herring belongs to a peculiar race, which, in certain respects, occupies an intermediate position between the Dogger Bank Herring and the Norwegian Spring Herring. As mean values for the number of vertebrae and keeled scales, Broch gives the following figures:

	Total number of Vertebrae	Number of keeled scales (K ₂)
The Dogger Bank Herring.....	56.45	14.63
The Shetland Summer Herring.....	56.70	14.44
The Norwegian Spring Herring	57.60	c. 14.11

Broch makes the following remarks concerning his determinations of the maturity of the herring (l. c. p. 13—14):

"In den unsern Observateuren mitgeteilten Instruktionen werden die Entwicklungsstufen der Geschlechtsorgane auf folgende Weise eingeteilt:

- I. Hering der nie gelaicht hat. Bei diesem liegen die Geschlechtsorgane, die in der Regel in Fett begraben sind, dicht unter der Wirbelsäule; es ist unmöglich mit dem blossen Auge zu entscheiden, welchem Geschlecht sie angehören. Die Höhe der Geschlechtsorgane überschreitet nicht 2—3 mm.
- II. Höhe der Geschlechtsorgane 3 bis 9 mm (3 mm bis $\frac{1}{3}$ Zoll.).
- III. Höhe der Geschlechtsorgane 9 bis 18 mm ($\frac{1}{3}$ bis $\frac{2}{3}$ Zoll.).
Die einzelnen Eier in den Ovarien sind klein und eckig; keine klaren Eier.
- IV. Höhe der Geschlechtsorgane über 18 mm ($\frac{2}{3}$ Zoll.). Testes ganz milchweiss, Sperma nicht fliessend, die Ovarien mit einzelnen, zerstreuten, hellen Eiern.
- V. Sperma und Eier fliessend.
- VI. Ausgelaicht (Bluthering wird mit einem hinzugefügten b. bezeichnet).

In zweifelhaften Fällen werden Zwischenstadien angegeben (z. B. II—III).

Wenn man diese Tabelle mit HEINCKE'S [l. c. 1898] vergleicht, fällt sogleich eine Grundverschiedenheit auf; seine Einteilung erfordert, dass dem Untersucher eine Lupe zur Verfügung steht und es ist notwendig, dass er grosse Übung besitzt wenn er mit einiger Schnelligkeit die Einteilung von HEINCKES Entwicklungsstadien anwenden können soll. Gerade dieser Umstand erforderte für uns eine Änderung der Einteilung. Unsere Observateure waren Fischer, und es war unmöglich ihnen auf einem Laboratorium Gelegenheit zu längeren Übungen zu geben; dazu kommt, dass die Zeit die auf einem Heringsfischerboot

für diese Art Arbeiten angewendet werden kann, sehr knapp bemessen ist, und es war nötig, innerhalb kürzester Zeit möglichst viele Individuen untersuchen zu können. Aus diesem Grunde war es nötig die Höhenmessungen der Geschlechtsorgane bei der Einteilung ihrer Entwicklungsstufen einzuführen..."

The herrings investigated by Broch, which, according to his opinion, belonged to the Shetland Summer Herring, were captured in the months September, October and November, and they are nearly all indicated as being of maturity VI (Broch's scale). Other herrings were captured at the same time of maturity II and III which, according to Broch's opinion, belonged to the Norwegian Spring Herring.

A survey will be found below showing the results of Broch's analyses with regard to the characters constant for the individual:

Analyses, according to Broch, of Shetland Herrings.

Date	Place of capture	No. of spec.	Average length	Vert. S.	Vert. præc.	K ₂	Rays in both ventr. fins	Maturity (Broch's scale)
13/IX 1904	ca. 61° 51' N., 0° 45' E.	32	30.66	56.94	23.59	14.41	..	(V) VI, (II—III)
14/X 1904	Viking Bank	60	30.65	56.62	23.73	14.39	..	VI
27/X 1904	—	16	30.21	56.63	23.31	14.25	17.62	VI
1/XI 1904	—	20	29.36	56.65	23.60	14.60	17.95	VI
2/XI 1904	—	2	30.95	58.00	24.00	14.50	17.50	VI
Total		130	30.40	56.73	23.63	14.41	17.76	

For the three latter samples the material is given in detail and the following table shows the extent of the variation.

	Vert. S.		Vert. præc.		K ₂		Rays in both ventr. fins	
	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	1		22	4	13	3	15	1
56	15		23	14	14	18	16	3
57	18		24	17	15	15	17	1
58	3		25	3	16	1	18	32
..	..		..	..	17	1	19	1
60	1		..	..	..	..	..	..
<i>n</i>	38			38		38		38
<i>m</i>	56.71			23.50		14.45		17.76
σ	0.87			0.80		0.85		0.75
σ_m	0.14			0.13		0.13		0.12
σ_σ	0.10			0.09		0.09		0.09

We shall consider here another of Broch's analyses of summer-spawning herrings from the northern part of the North Sea (l. c. 1908).

BROCH examined 29 herrings of maturity VII (Broch's stage VI) of a length of 26—32 cm, aver. 28.8 cm captured from "Michael Sars", on September 10, 1904 at Station VII ca. 40 miles S. E. of Fair Isle at 59° 14' N. and 0° 38' W. The analysis gave the following result:

	Vert. S.		Vert. præc.		K ₂		Rays in ventr. fins	
	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	14		23	11	13	2	15	1
57	15		24	14	14	10	16	..
..	..		25	3	15	15	17	4
..	..		26	0	16	2	18	24
..	..		27	1	..	..	..	..
<i>n</i>	29			29		29		29
<i>m</i>	56.52			23.83		14.59		17.76
σ	0.51			0.89		0.73		0.64
σ_m	0.09			0.16		0.14		0.12
σ_σ	0.07			0.12		0.10		0.08

Broch also referred this herring to the Shetland Summer Herring. It will be seen that in this group the mean figure for Vert. S. is somewhat lower and the mean figure for keeled scales somewhat higher than for Broch's other Shetland Herrings.

HEINCKE (l. c. 1898) investigated a sample of summer-spawning herrings which were captured at Fair Isle from an Emdener Logger on June 27. and 29. 1887. The herrings had a size from 24.6—30.8 cm, average 26.4 cm. Nearly all the specimens were of maturity III—VI, and the sample in its entirety was named Voll Heringe by HEINCKE. A few specimens were of maturity I—II, and quite a few had spawned (maturity VII). Heincke's analysis gave the following result for the individually constant characters:

Summer Herrings from Fair Isle, 27. and 29. June 1887 (Heincke):

Vert. S.		Vert. præc.		Vert. caud.		K ₂		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	5	22	1	31	1	13	5	16	1
56	35	23	11	32	13	14	19	17	6
57	31	24	16	33	12	15	39	18	67
58	4	25	2	34	4	16	10	19	1
..	..	..	..	..	..	17	2	..	..
<i>n</i>	75		30		30		75		75
<i>m</i>	56.45		23.63		32.63		14.80		17.91
σ	0.70		0.67		0.76		0.85		0.37
σ_m	0.08		0.12		0.14		0.099		0.043
σ_σ	0.057		0.09		0.10		0.070		0.031

REDEKE (1918) has investigated a sample of herrings which was captured on the plateau East of the Shetland Isles at 60° 37.5' N. 0° 41' E. on June 23. 1906. The sample consisted of 50 specimens of a length from 24—27 cm. Redeke assigns to most specimens a maturity of II and for a smaller number that of I—II, II—III and III—IV. We may assume that the specimens of maturity II—III and III—IV are summer or autumn spawning herrings, and Redeke was of the opinion that the whole sample consisted of such herrings. The analysis gave for the individually constant characters the following result:

Vert. S.		Vert. præc.		Vert. caud.		K ₂		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	1	23	10	30	2	12	1	16	3
56	20	24	24	31	4	13	2	17	1
57	22	25	13	32	15	14	18	18	46
58	7	26	2	33	25	15	21	..	..
..	..	27	1	34	4	16	4	..	..
..	..	..	..	..	..	17	4	..	..
<i>n</i>	50		50		50		50		50
<i>m</i>	56.70		24.20		32.50		14.74		17.86
σ	0.74		0.88		0.91		1.03		0.50
σ_m	0.10		0.12		0.13		0.15		0.07
σ_σ	0.074		0.088		0.091		0.103		0.050

As the samples of herrings from the area around the Shetland Isles which were investigated by HEINCKE and REDEKE, seemed to differ from the samples investigated by BROCH, the racial characteristics of the Shetland Summer Herring were exceedingly doubtful. For this reason I asked the Chairman of the Fishery Board for Scotland, Mr. D. T. JONES, to forward a sample of typical summer- or autumn-spawning Shetland Herrings for investigation, and Mr. Jones kindly complied with my wishes.

The Shetland Herrings which I have examined, were taken from a catch of 72 crans, which, according to information kindly supplied by Mr. JONES, was caught in drift nets 20 miles S. E. of Balta Sound (at abt. 60° 35' N. 0° 13' W.) on September 1st 1921. The sample consisted of 363 specimens of the following lengths:

cm	♂	♀	Total
25	1	1	2
26	13	12	25
27	40	37	77
28	47	86	133
29	22	60	82
30	10	25	35
31	3	6	9
Total	136	227	363
Average length ¹	28.37	28.78	28.63

¹ Corrected by adding 0.5.

Arranged according to maturity the herring fell into the following groups:

Maturity:	♂	♀	Total
III ¹	..	27	27
IV	..	70	70
IV—VI	135	..	135
V—VI	..	129	129
VII	1	1	2
Total	136	227	363

The results of the detailed analysis of the herring are given in the survey below:

Vert. S.	Vert. præc.		Vert. caud.		K ₂		
	No.	Freq.	No.	Freq.	No.	Freq.	
51	1	20	1	29	1	13	17
..	..	..	..	30	6	14	104
54	1	22	14	31	21	15	175
55	10	23	106	32	129	16	54
56	170	24	179	33	137	17	12
57	163	25	48	34	66	18	..
58	17	26	14	35	3	19	1
59	1	27	1	..	..	..	..
<i>n</i>	363		363		363		363
<i>m</i>	56.504		23.837		32.667		14.846
σ	0.718		0.882		0.941		0.882
σ_m	0.0377		0.0463		0.0494		0.0463
σ_σ	0.0267		0.0327		0.0349		0.0327

Rays in ventral fins (Both fins together)		Rays in dorsal fin. branched		Total		Rays in anal fin. branched		unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
15	1	14	58	14	1	11	1	2	23
16	33	15	211	15	15	12	12	3	288
17	36	16	87	16	68	13	87	4	43
18	283	17	3	17	154	14	142	..	..
19	6	..	..	18	95	15	99	..	..
20	1	..	..	19	20	16	14	..	..
..	..	..	..	20	1	17	1	..	..
<i>n</i>	360		359		354		356		354
<i>m</i>	17.731		15.097		17.105		14.045		3.056
σ	0.669		0.655		0.948		0.930		0.429
σ_m	0.0353		0.0346		0.0504		0.0493		0.0228
σ_σ	0.0249		0.0244		0.0356		0.0349		0.0161

¹ The spawning of the specimens of maturity III would probably not take place earlier than October.

In order to investigate whether the specimens of different maturity and sex showed the same racial characteristics I have divided the material in the following way:

	27 females of maturity III
70	— - — IV
130	— - — V—VII
136 males	- - - IV—VII

The analysis for the individually constant characters gives for these groups the following results:

27 Females of Maturity III. S. E. of Balta Sound. Septbr. 1. 1921.

	Vert. S.	Vert. præc.	Vert. caud.	K ₂
55	1	23	5	31
56	13	24	19	32
57	10	25	3	33
58	3	..	..	34
<i>n</i>	27	27	27	27
<i>m</i>	56.56	23.93	32.63	14.70
σ	0.75	0.55	0.74	0.72
σ_m	0.14	0.11	0.14	0.14
σ_G	0.10	0.07	0.10	0.10

Rays in ventral fins	Rays in dorsal fin branched	Total	Rays in anal fin branched	unbranched
17	1	14	5	15
18	26	15	15	16
..	..	16	7	17
..	..	..	..	18
..	..	..	..	19
<i>n</i>	27	27	27	27
<i>m</i>	17.96	15.07	17.15	14.00
σ	0.19	0.68	0.91	0.83
σ_m	0.04	0.130	0.17	0.16
σ_G	0.03	0.092	0.12	0.11

70 Females of Maturity IV. S. E. of Balta Sound. Septbr. 1. 1921.

	Vert. S.	Vert. præc.	Vert. caud.	K ₂
54	1	23	20	30
55	..	24	40	31
56	32	25	8	32
57	35	26	2	33
58	2	..	..	34
<i>n</i>	70	70	70	70
<i>m</i>	56.53	23.89	32.64	14.74
σ	0.63	0.71	0.92	0.79
σ_m	0.075	0.085	0.110	0.095
σ_G	0.053	0.060	0.078	0.067

Rays in ventral fins	Rays in dorsal fin branched	Total	Rays in anal fin branched	unbranched
16	6	14	7	14
17	7	15	49	15
18	57	16	13	16
..	..	..	..	17
..	..	..	..	18
..	..	..	..	19
<i>n</i>	70	69	69	69

m	17.73	15.09	17.00	13.94	3.058
σ	0.61	0.54	1.03	1.01	0.42
σ_m	0.073	0.064	0.124	0.122	0.050
σ_σ	0.052	0.046	0.088	0.086	0.035

130 Females of Maturity V—VII. S. E. of Balta Sound. Septbr. 1. 1921.

	Vert. S.	Vert. præc.	Vert. caud.	K ₂	
55	4	22	9	29	13
56	64	23	39	30	14
57	56	24	54	31	15
58	5	25	18	32	16
59	1	26	9	33	17
..	..	27	1	34	18
..	..	..	..	35	19
n	130	130	130	130	130
m	56.50	23.86	32.64	14.91	
σ	0.66	1.02	1.09	0.94	
σ_m	0.058	0.090	0.095	0.083	
σ_σ	0.041	0.064	0.067	0.059	

Rays in ventral fins	Rays in dorsal fin			Total	Rays in anal fin		unbranched	
	branched				branched			
15	1	14	23	15	5	12	3	2
16	17	15	74	16	24	13	27	3
17	16	16	32	17	49	14	47	4
18	90	17	1	18	39	15	39	..
19	2	..	..	19	6	16	7	..
20	1	..	..	20	1	17	1	..
n	127	130	124	124	124	124	124	124
m	17.61	15.08	17.16	14.19	2.98			
σ	0.80	0.67	0.96	0.95	0.41			
σ_m	0.071	0.059	0.086	0.085	0.037			
σ_σ	0.050	0.042	0.061	0.060	0.026			

136 Males of Maturity IV—VII. S. E. of Balta Sound. Sept. 1. 1921.

	Vert. S.	Vert. præc.	Vert. caud.	K ₂	
51	1	20	1	30	13
..	..	22	5	31	14
55	5	23	42	32	15
56	61	24	66	33	16
57	62	25	19	34	17
58	7	26	3	35	..
..
n	136	136	136	136	136
m	56.49	23.77	32.71	14.87	
σ	0.81	0.87	0.84	0.89	
σ_m	0.069	0.075	0.072	0.077	
σ_σ	0.049	0.053	0.051	0.054	

Rays in ventral fins	Rays in dorsal fin			Total	Rays in anal fin		unbranched	
	branched				branched			
16	10	14	23	15	5	12	5	2
17	12	15	73	16	26	13	35	3
18	110	16	35	17	62	14	58	4
19	4	17	2	18	33	15	34	..
..	..	..	..	19	8	16	4	..
n	136	133	134	134	136	136	134	134

m	17.79	15.12	17.10	13.98	3.11
σ	0.61	0.70	0.91	0.88	0.45
σ_m	0.052	0.060	0.078	0.076	0.039
σ_σ	0.037	0.043	0.055	0.053	0.028

It will be seen that the females of maturity III have a higher number of ventral fin rays, a somewhat higher number of vertebrae and a little lower number of keeled scales than the females of maturity V—VII. The material investigated is, however, not large enough for us to decide whether there is a difference of real importance or not. The females of maturity IV do not show any striking deviations from the females of maturity V—VII, and it will be noticed that there is no marked difference between males and females of the same maturity stage.

A comparison with the older material shows that the result of my analysis agrees with Heincke's but differs a little from Redeke's and essentially from Broch's analysis.

For one particular character the sample from Fair Isle differs a little from the sample which I have investigated. There is a difference in the number of ventral fin rays of 0.20 while the standard deviation of the difference is 0.057. Here, however, it must be remembered, that the standard deviation of the mean figure for the sample from Fair Isle is calculated on the basis of a proportionately small number of specimens ($\sigma_\sigma = 0.031$), so there is very little reason for laying much stress upon this difference.

Though the sample investigated by REDEKE is rather small, and though the deviations from my analysis need not to be of real importance, it is, however, peculiar, that his sample shows a higher number of vertebrae (Vert. S. and Vert. præc.) and a lower number of keeled scales than the samples investigated by Heincke and me. The explanation of the difference is probably that Redeke's samples contained a few young specimens of Spring Herrings. It is by no means certain that specimens which, at the end of June, show the maturity stage I—II or II are summer- or autumn-spawning herrings.

Redeke supposed that the sample investigated by him belonged to the same race as the Dogger Bank Herring.

The differences, however, between the results of Broch's analysis on the one side and Heincke's and mine on the other are essential. In Broch's samples the herrings have a perceptibly higher number of vertebrae and a lower number of keeled scales than the samples investigated by Heincke and me. If we suppose that the standard deviation of Broch's mean figure for the 130 specimens from Vikingbank etc. is abt. 0.07, a comparison between Broch's analysis and mine gives the following result:

Difference between results of BROCH's analysis of Shetland Herring 1904 (130 specimens) and JOHANSEN's of Shetland Herring 1921 (363 specimens):

Diff. Vert. S.	0.23	St. Dev.	Diff.	0.08
— Vert. præc.	-0.21	-	-	0.08
— K_2	-0.44	-	-	0.08

The question is now: Has Broch dealt with a summer spawning herring belonging to a race different from that examined by Heincke and me, or has he dealt with the same race mixed with winter or spring herrings. It seems that BROCH has dealt with a herring race differing from that examined by HEINCKE and me. A mixture of specimens of this last race with specimens of the Norwegian Spring Herring or the Shetland Spring Herring could show a similar number of Vert S. and of K_2 as that found by BROCH, but it would show a higher number of precaudal vertebrae, as both the components of the mixture have a higher number of such vertebrae than that found by BROCH (comp. Chap. XI). As there is evidence to hand that the herring race established by BROCH is bound mainly to deep water in the northern part of the North Sea, I propose to name it: The North Sea Deep Water Herring, and to apply the name of Scotch Summer Herring to the race examined by HEINCKE and me (comp. Chap. III). The specimens from "Michael Sars" St. VII (59° 14' N., 0° 38' W. September 10, 1904) which are mentioned on p. 6—7, may belong to the Deep Water Herring.

III. The Scotch Summer Herring.

It is a well known fact that the great herring fisheries in the North Sea in summer and autumn off the eastern coasts of Scotland and England from the Orkneys to Flamborough Head are mainly based on a summer- or autumn-spawning herring. As KYLE has pointed out in his treatise: "Monthly Data and Charts over the Herring Fishery in 1903" (1906), the fishery for this herring commences in the month of June at the Orkneys and the northern coasts of Scotland after which it extends southwards. In July it is carried on in the area east of Scotland up to about 100 miles from shore, and in August it extends southwards past Flamborough Head. In September the fishery is greatly diminished off the coasts of Scotland, and north east England.

The spawning period for the Scotch Summer Herring is, according to FULTON (1891), MASTERMAN (1896), and BOWMAN (1923), mainly the months July, August and September, in the same months therefore during which the great fisheries take place. The mature specimens of the Scotch Summer Herring vary as a rule in length from about 22—32 cm, and the average length is in most catches about 25—28 cm.

We shall now examine the most important of the samples of the Scotch Summer Herring investigated by HEINCKE, BROCH, and REDEKE.

HEINCKE (1898) investigated 24 full herrings of a length 24—30 cm and of maturity IV—VI captured on the east coast of Scotland off Peterhead in August of 1871. The investigation showed the following distribution of the variants for keeled scales and rays in the ventral fins:

K ₂		Rays in ventral fins	
No.	Freq.	No.	Freq.
13	2	17	5
14	1	18	17
15	20	19	1
16	1	..	..
<i>n</i>	24		23
<i>m</i>	14.83		17.83
σ	0.63		0.49
σ_m	0.13		0.10
σ_σ	0.09		0.07

BROCH investigated 31 herrings captured off the Firth of Forth on "Michael Sars" St. VI at about 56°08' N. and 0°05' E. on September 8, 1904. The lengths of the herrings varied from 231 to 307 mm (aver. 254 mm) and BROCH indicates the stage of maturity for most specimens as II—III or III. Broch's analysis gave the following result: (l. c. 1908)

Vert. S.		Vert. præc.		K ₂		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	2	22	2	13	2	13	1
56	15	23	7	14	7	..	..
57	12	24	17	15	19	15	1
58	2	25	5	16	3	..	..
..	..	..	..	..	..	17	5
..	..	..	..	..	..	18	23
..	..	..	..	..	..	19	1
<i>n</i>	31		31		31		31

m	56.45	23.81	14.74	17.61
σ	0.72	0.79	0.73	1.09
σ_m	0.13	0.14	0.13	0.20
σ_σ	0.09	0.10	0.09	0.14

BROCH referred this herring to the Dogger Bank Herring.

REDEKE (l. c. 1918) investigated 50 herrings captured in Moray Firth on July 18th and 19th, 1906. The average length of the herrings was 24.7 cm and the stage of maturity varied from II—IV. The analysis gave, for the individually constant characters, the following results:

Vert. S.		Vert. præc.		Vert. caud.		K ₂		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	2	23	17	31	1	13	1	16	3
56	21	24	29	32	17	14	15	17	2
57	24	25	4	33	24	15	29	18	45
58	3	..	..	34	6	16	5	..	..
..	..	..	..	35	2	..	..	..	..
n	50		50		50		50		50
m	56.56		23.74		32.82		14.76		17.84
σ	0.67		0.60		0.83		0.66		0.51
σ_m	0.10		0.08		0.12		0.09		0.07
σ_σ	0.07		0.06		0.08		0.07		0.05

REDEKE referred this herring to the Dogger Bank Herring.

It will be noticed that all the samples of herring represented here, are in close agreement with the Summer Herring from Balta Sound investigated by me (comp. Chap. II).

IV. The Dogger Bank Herring.

In the middle part of the North Sea, especially around the southern and western part of the Dogger Bank, and between the Dogger Bank and the English coast, a great fishery takes place in September, October and November. It is based on an autumn spawning herring which has its spawning places in the neighbourhood of the areas where the greatest fisheries occur, and its spawning time in the period during which the main catch takes place.

REDEKE (1918) has investigated the stage of maturity of herrings from the Dogger Bank at different times during the spawning period, and he found that it is not till about the middle of October that the majority of the specimens have spawned¹.

HEINCKE (1898) has investigated a small sample of herrings captured on the eastern part of the Dogger Bank at 55° 10' N. 3° 40' E. on September 9. 1890. The sample consisted of 5 specimens of a length of 24—27 cm and of the maturity stage V—VI. The distribution of the variants was as follows:

Vert. S.		Vert. præc.		K ₂		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	1	23	2	15	5	18	5
57	4	24	2	..	..	..	..
..	..	25	1	..	..	..	..
n	5		5		5		5
m	56.80		23.80		15.0		18.0

BROCH (1908) investigated 31 specimens of an autumn-spawning herring captured between the Great Fisher Bank and Dogger Bank on September 5. 1904 ("Michael Sars" St. IV. 56° 16' N. 5° 16' E.). The average length of the herrings was 25.2 cm, and the stage of maturity III, rarely IV. From his analyses he

¹ In October 1904 REDEKE investigated 64 haddocks captured on the Dogger Bank and found that in 60 of these the stomach contained herring eggs.

obtained the following mean figures: Vert. S. = 56.32, Vert. præc. = 23.90, K_2 = 14.31. BROCH does not give the analyses in detail, but the standard deviation of his mean figures may be estimated to be about 0.14.

BROCH referred this sample to the Dogger Bank Herring, but its low number of keeled scales makes it very improbable that it should belong to that race. It seems more probable that the sample belongs to the Jutland Bank Herring (comp. Chap. V).

BROCH examined 31 herrings captured on September 6, 1904 on the western part of the Dogger Bank at "Michael Sars" St. V. at $54^{\circ} 47' N.$ and $1^{\circ} 18' E.$ Their average length was 256 mm and the maturity stage was as a rule II—III, more rarely IV. The analysis of the data is not given in detail, but the means are as follows:

Vert. S.	56.58
Vert. præc.	23.74
K_2	14.84

The standard deviation for these means may be estimated to be about 0.14.

DELSMAN (1914) investigated the number of vertebrae of 156 autumn spawning herrings captured on the Dogger Bank on October 3, 1911 and on September 14, 1912. The result of his analyses was as follows:

Dogger Bank, $54^{\circ} 30' N.$ $1^{\circ} 25' E.$ Oct. 3, 1911.

Length 22—30 cm (aver. 27.0). Maturity (Heincke's scale) III, IV (V, VI).

Vert. S.			
No.	Freq.		
55	4	m	56.43
56	55	σ	0.62
57	44	σ_m	0.060
58	3	σ_σ	0.042
n	106		

Dogger Bank, $54^{\circ} 35' N.$ $1^{\circ} 32' E.$ Septbr. 14, 1912.

Length 23—30 cm (aver. 27.2). Maturity (III), IV, V (VI).

Vert. S.			
No.	Freq.		
55	1	m	56.54
56	23	σ	0.61
57	24	σ_m	0.087
58	2	σ_σ	0.061
n	50		

REDEKE investigated 40 herrings captured north west of the Dogger Bank at $55^{\circ} 36' N.$ and $0^{\circ} 10' E.$ on August 19, and September 3, 1906. The specimens were of an average length of 25.2 cm. The maturity stage was for most specimens III and IV. The analysis gave the following result:

Vert. S.		Vert. præc.		Vert. caud.		K_2		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	1	23	13	29	3	14	10	16	2
56	19	24	14	30	1	15	24	17	3
57	19	25	7	31	6	16	6	18	35
58	1	26	2	32	10	..	..	..	..
..	..	27	3	33	14	..	..	..	..
..	..	28	1	34	6	..	..	..	..
n	40		40		40		40		40
m	56.50		24.28		32.23		14.90		17.83
σ	0.60		1.32		1.37		0.63		0.50
σ_m	0.09		0.21		0.22		0.10		0.08
σ_σ	0.07		0.15		0.15		0.07		0.06

REDEKE investigated 25 herrings captured on the Dogger Bank at 54°30' N. 2°40' E. on October 11, 1906. The average length of the specimens was 26.4 cm and the stage of maturity of the majority of the specimens varied from III to V—VI. The analysis of the specimens gave, for the characters which I consider, the following result:

Vert. S.		Vert. præc.		Vert. caud.		K ₂		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	1	23	7	30	2	12	1	15	1
56	13	24	12	31	3	13	..	16	..
57	10	25	4	32	9	14	2	17	1
58	1	26	2	33	6	15	10	18	22
..	..	..	..	34	4	16	11	19	1
..	..	..	..	35	1	..	..	..	..
<i>n</i>	25		25		25		24		25
<i>m</i>	56.44		24.04		32.40		15.25		17.88
σ	0.65		0.89		1.26		0.94		0.67
σ_m	0.13		0.19		0.25		0.19		0.13
σ_σ	0.09		0.13		0.18		0.14		0.09

Both samples taken together give the following result:
Dogger Bank Herring investigated by REDEKE.

Vert. S.		Vert. præc.		Vert. caud.		K ₂		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	2	23	20	29	3	12	1	15	1
56	32	24	26	30	3	..	..	16	2
57	29	25	11	31	9	14	12	17	4
58	2	26	4	32	19	15	34	18	57
..	..	27	3	33	20	16	17	19	1
..	..	28	1	34	10	..	..	..	..
..	..	..	..	35	1	..	..	..	..
<i>n</i>	65		65		65		64		65
<i>m</i>	56.48		24.18		32.29		15.03		17.85
σ	0.62		1.17		1.32		0.78		0.57
σ_m	0.08		0.15		0.16		0.10		0.07
σ_σ	0.054		0.103		0.116		0.069		0.050

It is probable that the herrings mentioned here have their spawning places on the very Dogger Bank or in the area between the Dogger Bank and the English coast.

The herrings mentioned here from the area around the Dogger Bank are evidently nearly related to the Scotch Summer Herring. As stated in Chapter VII the Dogger Bank Herring has usually a little higher number of keeled scales (K₂) than the Herrings from the north western areas of the North Sea.

REDEKE (l. c. 1918) considered the samples which he had investigated from the Shetland Isles and Moray Firth to belong to the same race as the Dogger Bank Herring.

The "Yarmouth-Lowestoft Herring" which is caught in the south-western part of the North Sea (especially between 52—53° N. and 2—3° E.) in October, November and December, consists mainly of winter spawning herrings, which belong to the Channel Sea Herring (see Chap. XI). The autumn spawning herrings are of little importance in the area where the "Yarmouth-Lowestoft Herring" is mainly caught. REDEKE (1918) has investigated 3 autumn spawners of maturity VII caught at 53°06' N. 3° E. on November 7, 1906 and has found the following numbers of vertebrae etc.:

No.	Total length mm	Vert. S.	Vert. præc.	K ₂	Rays in both ventral fins
1	270	57	24	15	18
2	245	57	24	15	18
3	242	55	23	14	18
Average	25.2	56.33	23.67	14.67	18.00

The number of specimens investigated by Redeke is too small to allow us to decide to which race they belong, but they harmonize very well with the Dogger Bank Herring.

From analyses carried out by Heincke and me it appears that in the eastern part of the North Sea young herrings occur which are in very close accordance with the Dogger Bank Herring, and as the prevalent currents will tend to transport a great deal of the small larvae from the spawning places of the Dogger towards the waters west of Jutland (comp. Fig. 5) it is also probable that many of the Dogger Herrings grow up there.

The results of some analyses of young herrings from these waters are given below.

HEINCKE examined a sample of young herrings of a length of 13—17 cm and of maturity I captured west of Sylt at 54° 55' N. 6° 34' E. on August 4th 1889. The analysis gave the following result:

Vert. S.		Vert. præc.		K ₂		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
54	1	22	2	14	10	16	2
55	0	23	3	15	13	17	4
56	12	24	11	16	7	18	22
57	16	25	7	..	..	19	1
58	1	26	5	..	..	20	1
<i>n</i>	30		28		30		30
<i>m</i>	56.53		24.36		14.90		17.83
σ	0.73		1.13		0.76		0.75
σ_m	0.13		0.21		0.14		0.14
σ_σ	0.09		0.15		0.10		0.10

This sample agrees in every respect with the typical Dogger Bank Herring.

From the west coast of Jutland off Thyborön I have had for investigation a large sample of young herrings which were captured on July 16, 1918. The number of vertebrae and of keeled scales were investigated in 200 specimens of a length of 5—9 cm. Moreover the number of vertebrae was counted in 140 specimens of 6—11 cm length.

The analysis gave the following result:

200 specimens 5—9 cm.				
Vert. S.		K ₂		
No.	Freq.	No.	Freq.	Freq.
54	2	13	4	4
55	13	14	51	51
56	95	15	83	83
57	83	16	53	53
58	7	17	7	7
..	..	18	1	1
..	..	19	1	1
<i>n</i>	200		200	200
<i>m</i>	56.40		15.08	15.08
σ	0.71		0.93	0.93
σ_m	0.050		0.066	0.066
σ_σ	0.035		0.046	0.046

The length and the number of vertebrae of the 140 specimens were as follows:

Length cm		Vert. S.	
6	5	55	4
7	41	56	68
8	53	57	64
9	22	58	3
10	15	59	1
11	4	..	..
<i>n</i>	140		140

m	8.09 + 0.5	56.49
σ	1.13	0.63
σ_m	0.096	0.053
σ_σ	0.068	0.038

Taking the vertebrae of the two groups together we get the following result:

Vert. S.			
No.	Freq.	m	
54	2		56.44
55	17	σ	0.68
56	163	σ_m	0.037
57	147	σ_σ	0.026
58	10		
59	1		
n	340		

It appears that this herring with regard to the keeled scales and vertebrae is probably in full accordance with the Dogger Bank Herring.

V. The Jutland Bank Herring.

The Jutland Bank Herring has its spawning places on the Little Fisher Bank, the Jutland Bank, and adjacent parts of the Skagerak, and the spawning period is September—October.

HEINCKE (1898) proved the occurrence of ripe autumn spawning herrings N. E. of Jutland Bank at 57° 20' N, and 7° 56' E. on September 12. 1889, and in 1903 DUGE stated that the stomach of the haddock and the frogfish (*Lophius piscatorius*) captured on the Little Fisher Bank and the Jutland Bank between September 30. and October 4. 1903 contained herring eggs. — In September and October 1922, I found that young herring fry occurred in the neighbourhood of the Little Fisher Bank, the Jutland Bank and the south western Skagerak (see Figs. 1 and 2).

HEINCKE examined a sample of herrings captured on September 12. 1889 N. E. of the Jutland Bank at 57° 20' N. 7° 56' E. (1898 p. 72), and he ascribed the following stages of maturity to 30 specimens:

Length cm	I	V	VI	VI—VII
24	..	..	2	..
25	1	..	2	..
26	..	..	..	..
27	..	1	6	..
28	..	..	5	..
29	..	1	4	..
30	..	..	6	..
31	..	..	1	1
	1	2	26	1

The mature specimens had an average size of 28.6 cm. The immature specimen of 25 cm (maturity I) had 58 vertebrae, 14 keeled scales and 18 ventral fin rays. In all probability it belonged to the Norwegian Spring Herring. The frequency distribution of the 29 specimens of maturity V—VII for the number of vertebrae, keeled scales and ventral rays was as follows:

Vert. S.		K ₂		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.
55	1	13	3	16	3
56	11	14	11	17	3
57	17	15	11	18	22
..	..	16	4	19	1
n	29		29		29

m	56.55	14.55	17.72
σ	0.58	0.87	0.70
σ_m	0.11	0.16	0.13
σ_G	0.075	0.11	0.092

HEINCKE investigated 26 young herrings of maturity I—II and of 14—24 cm length captured 28 miles N. by W. of Hanstholm on August 12, 1889. He found the following numbers of vertebrae etc.: Vert. S. = 56.31 ± 0.14 ; Vert. præc. = 23.81 ± 0.21 ; vert. caud. = 32.50 ± 0.17 ; K_2 = 14.73 ± 0.17 ; Rays in ventral fins = 17.81 ± 0.17 .

The Jutland Bank Herring is not sufficiently characterized by the investigations carried out hitherto, but it seems probable that it is closely related to the Scotch Summer Herring.

VI. Autumn Herrings from the German Bight.

In the German Bight autumn herrings occur which usually are of little importance but sometimes may be numerous. HEINCKE writes as follows about these herrings (1898 I¹ p. LXII—LXIII): "während die Herbstheringe der nördlichen Nordsee in ungeheuren Schwärmen auftreten und den Gegenstand einer grossartigen Fischerei bilden, sind die Schwärme der Herbstheringe der südlichen Nordsee klein und individuenarm. Namentlich gilt dies von der südöstlichen Nordsee oder der deutschen Bucht. Es ist jedoch wahrscheinlich, dass dem nicht immer so gewesen ist, dass es vielmehr Zeiten gegeben hat, z. B. der Anfang dieses Jahrhunderts, wo grössere fangwürdige Mengen von Herbstheringen in der deutschen Bucht vorhanden waren. Es ist auch wahrscheinlich dass eine solche Zeit einmal wiederkehren wird".

A sample of mature herrings described by HEINCKE was captured south of Horns Reef at $55^{\circ} 26' N.$ $6^{\circ} 50' E.$ on September 13, 1890. The specimens were of maturity V—VI and their lengths were as follows:

cm	♂	♀
22	1	..
23	..	..
24	3	1
25	4	2
n	8	3
m	24.2 ± 0.5	24.7 ± 0.5

It will be seen that the average length of the specimens was smaller than is usually the case in the mature Dogger Bank Herring.

The analysis gave for the individually constant characters the following result:

Vert. S.		Vert. præc.		Vert. caud.		K_2		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	6	23	4	29	1	14	5	16	2
57	5	24	3	30	2	15	4	17	..
..	..	25	1	31	0	16	2	18	9
..	..	26	2	32	2	..	..	..	..
..	..	27	1	33	4	..	..	..	..
..	..	..	..	34	2	..	..	..	..
n	11	11	11	11	11	11	11	11	11
m	56.45	24.36	24.36	32.09	32.09	14.73	14.73	17.64	17.64

From this small sample we are not able to judge whether the German Bight Herring differs from the Dogger Bank Herring or not, but some analyses of young herrings caught in the German Bight suggest that we have here to do with an autumn spawning herring which differs from the Dogger Herring by a somewhat smaller number of Vertebrae (Vert. S.).

We will here consider some analyses of such young herrings.

A sample investigated by me, consisting of young herrings of a length of 8—10 cm, maturity I, captured from the "Dana" by otter-trawl south of Horns Reef at $55^{\circ} 20' N.$ $7^{\circ} 20' E.$ on September 19th 1922, showed the following distribution of the variants:

	Vert. S.		Vert. præc.		Vert. caud.	
	No.	Freq.	No.	Freq.	No.	Freq.
55	5		22	2	30	3
56	37		23	21	31	9
57	20		24	28	32	19
58	3		25	10	33	27
..	..		26	3	34	7
..	..		27	0	..	..
..	..		28	1	..	..
<i>n</i>	65			65		65
<i>m</i>	56.32			23.92		32.40
σ	0.69			1.02		0.01
σ_m	0.085			0.13		0.13
σ_σ	0.060			0.09		0.09

The survey below shows the distribution of the variants for the vertebrae etc. of 50 young herrings of lengths of 9—11 cm caught by herring trawl from the "Dana" southwest of Graadeep at 55° 23' N. 8° 12' E. on November 30, 1922:

	Vert. S.		Vert. præc.		Vert. caud.		K ₂		Rays in ventr. fins	
	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	2		22	1	30	1	14	12	16	4
56	29		23	13	31	5	15	17	17	9
57	16		24	24	32	22	16	19	18	36
58	3		25	10	33	18	17	2	19	1
..	..		26	2	34	2	..	..	..	..
..	..		..	..	35	2	..	..	..	..
<i>n</i>	50			50		50		50		50
<i>m</i>	56.40			23.98		32.42		15.22		17.68
σ	0.67			0.84		0.95		0.86		0.65
σ_m	0.09			0.12		0.13		0.12		0.09
σ_σ	0.07			0.08		0.09		0.09		0.07

The scales proved to be without winter ring. We are evidently concerned here with autumn herrings of the year class 1921.

HEINCKE has investigated some samples of young herrings captured at the mouth of Elbe, where there is a possibility of an intermixture with spring spawners. The high number of keeled scales suggests, however, that the possible intermixture of spring spawners cannot be of much importance. The analysis of 105 specimens of a length of 8—23 cm and maturity I—II, captured on November 30th 1877, November 17, 1886, December 1891, February 2, 1887, March 22, 1889 and March 11, 1891 has given the following results for the individual constant characters:

	Vert. S.		Vert. præc.		K ₂		Rays in ventr. fins	
	No.	Freq.	No.	Freq.	No. ¹	Freq.	No. ²	Freq.
55	7		22	4	13	3	16	5
56	38		23	12	14	20	17	8
57	29		24	18	15	57	18	91
58	2		25	7	16	22	19	1
..	..		..	..	17	1	..	..
..	..		28	1	..	..	..	..
<i>n</i>	76			42		103		105
<i>m</i>	56.34			23.79		14.98		17.84
σ	0.68			1.09		0.75		0.50
σ_m	0.08			0.17		0.07		0.05
σ_σ	0.06			0.12		0.05		0.03

¹ One specimen with 20 K₂ omitted as abnormal.

² - - - 11 Ventr. fin rays omitted as abnormal.

A sample investigated by HEINCKE consisted of young herrings of 9—14 cm length captured off Helgoland on October 3, 1894. The distribution of the variants was as follows:

Vert. S.		Vert. præc.		K ₂		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	13	23	4	13	2	13	1
57	11	24	15	14	8	14	1
58	1	25	5	15	9	15	1
..	..	..	..	16	5	16	2
..	..	..	..	17	1	17	3
..	..	..	..	..	..	18	16
<i>n</i>	25		24		25		24
<i>m</i>	56.52		24.04		14.80		17.21
σ	0.59		0.62		1.00		1.41
σ_m	0.12		0.13		0.20		0.29
σ_σ	0.08		0.09		0.14		0.20

It will be noticed that the average number of rays in the ventral fins is here unusually low.

HEINCKE investigated 17 young herrings captured North of Terschelling at 53° 45' N. 4° 47' E. on September 4th 1890. The specimens were of length from 13—16 cm and of maturity I. The analysis gave the following result:

Vert. S.		Vert. præc.		K ₂		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
54	1	23	8	14	3	17	3
55	1	24	7	15	11	18	14
56	9	25	2	16	2	..	..
57	5	..	..	17	1	..	..
58	1	..	..	..	..	..	..
<i>n</i>	17		17		17		17
<i>m</i>	56.29		23.64		15.06		17.82

The high number of keeled scales makes it improbable that these herrings should belong to the Channel Sea Herring or local races of spring herrings from the Zuider Zee or the southern part of the North Sea.

It will be seen that in all these samples, except one, the number of vertebrae is somewhat lower than in the Dogger Bank Herring and the Scotch Summer Herring. It might be suggested that the low number of vertebrae in the case of the young herrings examined could originate from an intermixture with local spring spawners, but that such an intermixture is of any consequence is improbable on account of the high number of keeled scales found in the samples.

It is possible that some of the samples of the young herrings investigated may be Dogger Bank Herrings, but it is improbable that all the samples should belong thereto.

From the analyses to hand we gain the impression that the autumn spawning herrings of the German Bight have a similar high number of keeled scales as the Dogger Bank Herring but a somewhat lower number of vertebrae. The average number of vertebrae in 244 specimens was 56.36 against 56.49 in the Dogger Bank Herring. (257 spec.)

The spawning places for the autumn herrings from the German Bight are not known as yet.

VII. General Survey of the Racial Characteristics of the Summer- and Autumn-Spawning Herrings of the North Sea.

It appears from the analyses mentioned in Chap. II—IV that a part of the Shetland summer herrings belongs to the same race as the Scotch Summer Herring, and that we have only been able to point out very small — and perhaps not constant — differences, in the individual constant characters between the Scotch Summer Herring and the Dogger Bank Herring. The Jutland Bank Herring is not yet sufficiently known, but it seems probable that this herring is in close agreement with the Scotch Summer Herring. We will therefore refer all these herrings to one single race and use a common name for them all: The Bank Herring of the North Sea. This herring may be characterized provisionally by the following average numbers of vertebrae, keeled scales, rays in ventral fins and rays in dorsal and anal fins (Comp. Table 9, p. 84):

Total number of Vertebrae	56.50 ± 0.05
Number of precaudal Vertebrae	23.90 ± 0.07
— - caudal Vertebrae	32.60 ± 0.07
— - keeled scales (K_2)	14.85 ± 0.07
— - fin rays in both ventral fins	17.75 ± 0.05
— - branched dorsal fin rays	15.20 ± 0.10
Total number of anal fin rays	17.20 ± 0.10

The Bank Herrings from various parts of the North Sea are evidently in close agreement with each other as to the morphological characters. It appears, however, from the survey below, that the Bank Herrings from the north western part of the North Sea have usually a little lower number of keeled scales than the Bank Herrings from the Dogger Bank and adjacent areas to the East.

Number of Keeled Scales (K_2) and Precaudal Vertebrae in Herrings from the North Western Area and the Dogger Bank etc.

Locality	Date	No. of specimens	Maturity	K_2	Vert. præc.	Investigator
North western Area.						
S. E. of Balta Sound	1—IX—1921	363	III—VII	14.85	23.84	Johansen
Fair Isle	27/29—VI—1887	75 (30)	III—VI	14.80	23.63	Heincke
Moray Firth	18/19—VII—1906	50	II—IV	14.76	23.74	Redeke
Off Peterhead	VIII—1871	24	IV—VI	14.83	..	Heincke
Off Firth of Forth	8—IX—1904	31	II—III	14.74	23.81	Broch
Dogger Bank etc.						
N. W. of Dogger Bank 19—VIII & 3—IX—1906		40	III—IV	14.90	24.28	Redeke
Dogger Bank	6—IX—1904	31	II—IV	14.84	23.74	Broch
— —	11—X—1906	25	III—VI	15.25	24.04	Redeke
West of Sylt	4—VIII—1889	30	I	14.90	24.36	Heincke

It is not known whether the relatively high number of keeled scales is characteristic to all herrings spawning on the Dogger Bank and in the area between the Dogger Bank and the English coast (comp. Fig. 6) or only to a part of them. There is some evidence to hand that the herrings which have a relatively high number of keeled scales, have usually a higher number of precaudal vertebrae and a lower number of caudal vertebrae than the other Bank Herrings of the North Sea.

There is a possibility that the sample from the Dogger Bank investigated by BROCH has contained some specimens belonging to the Channel Sea Herring (specimens of maturity II).

The morphological differences between the Scotch Summer Herring and the Dogger Bank Herring (or a part of those) are indeed very small, but they indicate a certain degree of independence for each

of the groups. Future investigations may show whether the differences are so constant that we can use them as a distinguishing mark between two different races of Bank Herrings.

In connection with the small morphological differences pointed out here, it should be noted that herrings of the same age are larger in the north western part of the North Sea than off the East Coast of England (see Chap. VIII).

The Autumn Herrings of the German Bight have probably a somewhat smaller number of vertebrae than the Bank Herring of the North Sea, as will appear from the survey below:

Number of vertebrae etc. in the Bank Herring of the North Sea and the Autumn Herrings of the German Bight.

A. The Bank Herring of the North Sea.

Locality	Date	No. of spec. examined	Average length cm	Maturity	Vert. S.	Investigator
S. E. of Balta Sound	1-IX-1921	363	28.5	III-VII	56.50	Johansen
Fair Isle	²⁷ / ₂₉ -VI-1887	75	26.4	III-VI	56.45	Heincke
Moray Firth	¹⁸ / ₁₉ -VII-1906	50	24.7	II-IV	56.56	Redeke
Off Firth of Forth	8-IX-1904	31	25.4	II-III	56.45	Broch
N.W. of Dogger Bank 19-VIII & 3-IX-1906	3-IX-1906	40	25.2	III-IV	56.50	Redeke
Dogger Bank	6-IX-1904	31	25.6	II-IV	56.58	Broch
— —	9-IX-1890	5	25.7	V-VI	56.80	Heincke
— —	3-X-1911	106	27.0	III-VI	56.43	Delsman
— —	14-IX-1912	50	27.2	III-VI	56.54	—
— —	11-X-1906	25	26.4	III-VI	56.44	Redeke
[Jutland Bank	12-IX-1889	29	28.6	V-VII	56.55	Heincke]

B. The Autumn Herrings of the German Bight.

Locality	Date	No. of spec. examined	Average length	Maturity	Vert. S.	Investigator
S. of Horns Reef	13-IX-1890	11	24.9	V-VI	56.45	Heincke
— — —	19-IX-1922	65	..	I	56.32	Johansen
S. W. of Graadeep	30-XI-1922	50	..	I	56.40	—
Mouth of Elbe	1877-1891	76	..	I-II	56.34	Heincke
Off Helgoland	3-X-1894	25	..	I	56.52	—
N. of Terschelling	4-IX-1890	29	..	I	56.29	—

In connection with the small difference in the number of vertebrae it should be noted that the Autumn Herrings of the German Bight are probably spawning in water of less salinity than the Bank Herring of the North Sea (see Chap. X).

The North Sea Deep Water Herring, which is known from BROCH's investigations, has a little higher number of vertebrae (Vert. S.) than the Bank Herring of the North Sea, viz. 56.70 ± 0.05 , and a somewhat lower number of keeled scales, about 14.40 to 14.50 in mean value (comp. p. 6). The spawning places for this herring are probably situated on rough grounds on rather deep water on the northern plateau of the North Sea (see Chap. IX and X) where the temperature in the spawning period is somewhat lower than in the area where the Bank Herring is spawning.

VIII. Age and Size of mature Summer- and Autumn-Spawning Herrings from different parts of the North Sea.

Some doubt has been expressed in later years as to the validity of the results arrived at by the new method of age determinations, by means of rings in the scales (D'ARCY W. THOMPSON & CATHERINE SHERRIFF 1922). In my opinion the "ring method" signifies a great progress in comparison with the me-

thods previously used for age determinations, but it is quite clear that the method is far from being exact. Erroneous determinations are probably frequent, and mainly on account of the fact that the winter rings are often not more distinct than the "secondary rings" which have nothing to do with the winter rings. Each naturalist forms here his own praxis in his distinction between the two sorts of rings. He may be able to count the number of "winter rings" approximately in the same way at different times, but this is not a sufficient proof that the counting is correct. There is some evidence at hand that the first winter ring is often feeble or wanting, and in old specimens it is usually the case that there is an outer zone with more or less indistinct rings which are lying very close to each other. In this zone the distinction between winter rings and secondary rings becomes highly arbitrary.

It is beyond the purpose of this paper to give a general view of the age determinations hitherto carried out of the autumn herrings of the North Sea. I shall here represent only the results of the age determinations of the samples of Shetland Herrings and Bohuslän Herrings¹ examined by me and my collaborators (see Tables 1, 2 and 4), and for the sake of comparison I shall state the result of some of the age determinations of mature autumn spawning herrings from other parts of the North Sea investigated by HJORT & LEA (1910) and by STORROW & DOROTHY COWAN (1920).

This comparison (Table 3) shows, that herrings with the same number of winter rings (4—9) were practically of the same average length at Balta Sound and at Peterhead. On the other hand the autumn herring on the stretch from North Shields to Haighsborough Float are, on an average, 1—2 cm shorter at the same age than the herrings from the Shetland Isles and Peterhead, and finally, the Bohuslän Herring has on an average the same size as herrings of the same age from North Shields to Haighsborough Float.

DOROTHY COWAN has found previously that herrings in the northern parts of the North Sea are larger at the same age than herrings from the more southerly fishing grounds off the English east-coast.

Table 1. Age and Length of mature Herrings caught S. E. of Balta Sound on Sept. 1. 1921.

(Age indicated by number of winter rings in the scales).

Length cm.		25	26	27	28	29	30	31	Total no. of specimens	Average length cm	Corrected by 0.5
Year class	No. of winter rings										
1917	3	..	1	..	..	..	..	..	1	26.0	26.5
1916	4	..	2	8	9	2	2	..	23	27.74	28.24
1915	5	1	9	20	24	13	2	..	69	27.65	28.15
1914	6	..	3	18	20	13	3	1	58	27.97	28.47
1913	7	1	6	18	22	23	5	1	76	28.04	28.54
1912	8	..	1	3	22	16	9	3	54	28.70	29.20
1911	9	..	..	2	10	4	5	1	22	28.68	29.18
1910	10	..	..	..	1	3	1	..	5	29.0	29.5
1909	11	..	..	..	..	..	1	..	1	30.0	30.5
..	3—4	..	..	1	..	..	..	..	1	27.0	27.5
..	4—5	..	..	..	1	..	..	1	2	29.5	30.0
..	5—6	..	..	1	6	1	..	..	8	28.0	28.5
..	6—7	..	..	1	4	1	1	..	7	28.29	28.79
..	6—9	..	..	..	..	..	1	..	1	30.0	30.5
..	7—8	..	..	..	1	1	1	1	4	29.5	30.0
..	8—9	..	..	..	1	1	2	..	4	29.25	29.75
..	8—12	..	..	..	1	..	..	..	1	28.0	28.5
..	9—10	..	..	..	..	2	1	..	3	29.33	29.83
..	?	..	3	5	11	2	1	1	23	27.83	28.33
Total number of spec. .		2	25	77	133	82	35	9	363	..	..

¹ See also p. 72—73.

Table 2. Age and Length of Herrings of Maturity VIII caught in purse seine N. W. of Hirshals. March 6. 1923.

Length cm		20	21	22	23	24	25	26	27	28	29	Total no. of spec.	Average length cm	Corrected by 0.5
Year class	No. of winter rings													
1919	3	..	2	2	5	2	1	1	1	..	..	14	23.36	23.86
1918	4	2	4	14	8	7	4	1	..	1	..	41	22.88	23.38
1917	5	..	2	3	7	6	8	7	2	..	..	35	24.26	24.76
1916	6	..	..	..	2	1	1	6	4	..	1	15	25.87	26.37
1915	7	..	..	..	..	..	..	1	..	..	..	1	26.00	26.50
1914	8	..	..	..	..	..	..	..	2	..	1	3	27.67	28.17
1913	9	..	..	..	..	..	..	..	..	..	..	..	..	..
1912	10	..	..	..	..	..	..	..	..	..	..	..	..	..
1911	11	..	..	..	..	..	..	..	..	1	..	1	28.00	28.50
..	4-5	..	..	1	..	2	..	..	..	..	..	3	23.33	23.83
..	4-6	..	..	..	..	..	..	..	..	1	..	1	28.00	28.50
..	4+	..	..	..	..	..	1	..	..	..	..	1	25.00	25.50
..	4?	..	1	..	..	1	..	..	1	..	..	3	24.00	24.50
..	6?	..	..	..	..	..	..	2	..	..	..	2	26.00	26.50
Total no. of specimens .		2	9	20	22	19	15	18	10	3	2	120	..	..

Table 3. Age and Average Length of mature Autumn Herrings from various parts of the North Sea.

Locality	20 miles S. E. of Balta Sound (Johansen & Poulsen)	14 miles E. of Peterhead (Storrow & Cowan)	Off North Shields (Hjort & Lea)	10 miles E. N. E. of Scarborough (Storrow & Cowan)	[Grimsby] (Hjort & Lea)	3 miles N. of North Haisborough Float (Storrow & Cowan)	N. W. of Hirshals (Johansen & Poulsen)	3 miles N. W. of Skagen (Johansen & Bruun)
Date	1-9-1921	9-9-1919	22-10-1909	29-9-1919	30-9-1909	20-11-1919	6-3-1923	5-1-1924
State of Maturity ...	III-VII	IV-VII	IV-VII	IV-VII	V-VII	III-VII	VIII	VII-VIII
No. of winter rings	Average length cm							
2 .....	..	25.0	23.0	23.32	23.3	23.42	..	..
3	26.5	26.61	26.9	25.55	24.1	24.33	23.86	23.87
4	28.24	27.47	26.3	26.48	25.0	25.57	23.38	25.34
5	28.15	28.41	26.6	26.98	26.1	26.37	24.76	26.47
6	28.47	29.19	26.8	27.74	26.7	27.08	26.37	27.65
7	28.54	29.25	26.8	28.09	26.9	27.34	26.50	26.50
8	29.20	29.67	27.2	28.50	27.8	28.0	28.17	29.00
9	29.18	29.80	27.2	28.50	27.0	28.67	..	28.50
10	29.5	30.30	27.7	..	25.7	28.67	..	..
11	30.5	30.5	28.0	27.0	..	..	28.50	..
12 .....	..	31.0	..	..	..	..	..	..
No. of winter rings	Number of specimens							
2 .....	..	3	1	19	16	12	..	..
3	1	31	7	42	141	85	14	27
4	23	38	6	60	206	30	41	31
5	69	17	24	56	67	60	35	31
6	58	27	13	19	25	48	15	13
7	76	12	13	32	9	32	1	2
8	54	18	12	12	6	10	3	2
9	22	5	11	4	9	6	..	1
10	5	3	12	..	3	3	..	..
11	1	2	3	1	..	..	1	..
12 .....	..	1	..	..	..	..	..	..
Total no. of spec....	309	157	102	245	482	286	110	107

Table 4. Age and Length of Herrings of Maturity VII—VIII caught in purse seine 3 miles N. W. of Skagen. January 5. 1924.

Length cm.		20	21	22	23	24	25	26	27	28	29	Total No. of specimens	Average length cm.	Corrected by 0.5
Year class	No. of winter rings													
1920.....	3	2	2	5	7	5	2	1	2	1	..	27	23.37	23.87
1919.....	4	..	..	1	7	6	5	6	6	..	..	31	24.84	25.34
1918.....	5	..	..	..	3	2	8	5	8	3	2	31	25.97	26.47
1917.....	6	..	..	..	..	..	2	1	5	3	2	13	27.15	27.65
1916.....	7	..	..	..	..	..	..	2	..	..	..	2	26.0	26.5
1915.....	8	..	..	..	..	..	..	..	..	1	1	2	28.5	29.0
1914.....	9	..	..	..	..	..	..	..	..	1	..	1	28.0	28.5
Total no. of specimens		2	2	6	17	13	17	15	21	9	5	107	..	..

IX. On the positions of the Spawning Grounds of the Summer- and Autumn-Spawning Herrings of the North Sea.

We are still far from knowing the extent and location of the main spawning grounds of the summer and autumn spawning herrings of the North Sea, but a series of new facts throwing light upon this difficult problem, has been brought forth in the last decennaries, and it will be worth while to consider, how far our present knowledge extends.

FULTON has, in his important work on "The Chief Fishing Grounds on the East Coast of Scotland" (1891) given detailed information about the situation of the spawning places both as regards winter (or spring) spawners and summer spawners. Very little is stated about the way in which the spawning places have been located, but it seems probable that FULTON for the preparation of his charts has collected all the material then available concerning:

- 1) actual finds of the herring spawn on the sea bottom.
- 2) observations about the occurrence of newly hatched herring larvae.
- 3) observations about the localities where fishes with herring spawn in the stomach have been caught.
- 4) observations about the places where great quantities of ripe herrings (of maturity VI) are caught.

The position of the spawning places for the summer spawning herring on the stretch from the Shetland Isles to Northumberland, as located by FULTON, is represented in this paper on Fig. 8 p. 41. The spawning places are almost all situated at depths from about 25 to 80 meters.

The charts of FULTON are, of course, of a provisional nature.

From a consideration of the state of maturity of the herrings in different catches taken east of the Shetland Isles, BJERKAN (1917) draws the conclusion that spawning takes place on the slopes of Unst Bank and south of a line drawn between this Bank and Viking Bank, including Bressay Shoals. If this conclusion is right it would seem that spawning takes place here at depths from 80 to 120 meters or even more.

RUSSELL (1914) draws attention to the fact that during the autumn fishing off the coast of Northumberland considerable quantities of haddock are caught whose stomachs are crammed with herring spawn. Some records of the place of capture of such "spawny" haddocks have been collected at North Shields during 1911. The places of capture were situated off the English coast between 55° 30' and 56° 0' N. lat., and it appears that they occurred not far from the spawning places located by FULTON. Four of the catches were taken at depths of about 60 meters, 15 catches came from depths between 60 and 80 meters, and 4

catches from depths between 80 and 90 meters. The landings occurred between August 8th and September 26th 1911.

MEEK records (1919) that the summer herring in 1918 was spawning North of the Farnes off the Northumberland coast.

WOOD (1922) tried to locate the spawning grounds east of Scotland and the Shetland Isles by recording the localities of occurrence of shoals of ripe herrings. He finds in this way that spawning places were situated near Out Sherries, east and southeast of Sumburgh Head, on the Fair Bank, east of Lewis, and on several places near the east coast of Scotland, where they were known from previous investigations by FULTON, MITCHELL, etc. WOOD was aware that an accurate determination of the spawning grounds can not be reached by a study of the state of maturity of the herrings in the catches, and he summarises his experiences in the following manner: "Although fish full of milt and roe may be found at least 100 miles from land, as may be seen in samples of trawled herring, it is fairly obvious that the most favoured areas lie close to or within the immediate coastal zone".

WOOD gives also some information about the occurrence of "spawny" haddocks in the Scotch waters in the summer of 1922, but this subject is more fully dealt with by A. BOWMAN (1923), who gives a series of valuable records regarding date and locality for catches of "spawny" haddocks in spring and summer of the two years 1921 and 1922. Among the interesting results arrived at by BOWMAN the following should be quoted: "In the first place, it is obvious from the accompanying chart that the spawning grounds chosen by the herring for the two years in question were approximately the same, the variations on the whole not suggesting any considerable change from one year to another in the localities chosen..."

"In the second place, the chart shows that the greater number of 'spawny' haddocks caught by trawlers in spring come from grounds to the north-west of Scotland, extending from the Butt of Lewis to Muckle Flugga, whilst the greater number of catches in autumn come from the East Coast of Scotland..."

"The third point brought out by the data is that, although the spawning grounds extend over considerable areas, the distribution of the spawn itself does not appear to be uniform, but occurs rather in more or less extensive patches..."

"The fourth and probably the most interesting point elucidated is that spring and autumn spawning may take place on approximately the same grounds.... The selection of the same grounds by spring and autumn spawners suggests that two of the most potent factors determinating the positions of the herring spawning grounds are depth and nature of bottom".

"Finally, the data suggest that, at least on the more extensive spawning grounds both during summer and winter successive waves of spawning shoals visit the spawning grounds to deposit their eggs, and that haddock drawn from the surrounding area segregate on these grounds in turn throughout the incubation periods".

The localities from which "spawny" haddocks have been recorded by BOWMAN in August, September and October 1921 and 1922 are represented on Fig. 7 p. 40 without keeping the two years apart.

From the Dutch investigations of BOEKE (1906), REDEKE and VAN BREEMEN (1907—1908), it is quite clear that spawning places for autumn herrings occur on the Dogger Bank itself and in the area off the east coast of England between 53° and 55° N. lat. REDEKE found that almost all haddock in a sample caught north of the South West Patch of the Dogger in October 1904 contained herring eggs, and at many of the Dutch seasonal stations newly hatched herring larvae were found. It will here be worth while to recall the localities where such small herring larvae were found.

The positions of the Dutch Seasonal Stations were as follows:

H 1	N. W. of Texel	53° 14' N. 4° 15' E. ca. 30 m
H 2	S. of Cleaver Bank	53° 45' N. 3° 27' E. - 40 -
H 3	S. of Dogger Bank	54° 06' N. 2° 55' E. - 40 -

H 4 Dogger Bank	54° 33' N. 2° 05' E. ca. 20 m
H 5 W. of Dogger Bank	54° 06' N. 1° 26' E. - 50—70 m
H 6 Off Spurn	53° 40' N. 0° 32' E. - 25 m
H 7 N. W. of Cromer	53° 06' N. 1° 11' E. - 20 -
H 8 Deep Water Channel	52° 40' N. 2° 28' E. - 40—50 m
H 8 A — — —	52° 30' N. 3° 00' E. - 40 m
H 9 E. of Deep Water Channel	52° 15' N. 3° 28' E. - 30 -

On the Dutch seasonal cruise in November 1902 some herring larvae were taken at the surface with plankton net at St. H 6. On the cruise in November 1903 no herring larvae were observed, but in November 1904 great masses of larvae were caught at several stations, and mainly at H 3, H 5, H 6 and H 7. At the two last stations the Hensen Net was used for vertical hauls, and at H 6 were taken 43 larvae (of 8—17 mm length) pr. m², and at H 9 13 larvae (of 9—10 mm length) pr. m². At station H 8 no larvae were taken by the Hensen Net and only a single larva with the Helgoland Young Fish Trawl (Scherbrutnetz), and at St. H 1, H 8 a, and H 9 no larvae were captured either with Hensen Net or with Young Fish Trawl.

On the Dutch seasonal cruise in November 1906 numerous herring larvae were taken with young fish trawl and egg nets on the Stations H 3, H 4, and H 7, and at all these stations newly hatched larvae of less than 10 mm length occurred. Newly hatched larvae were also taken on St. H 2 and St. H 8, but the number caught here was much smaller. At St. H 4 several larvae of 11—20 mm length were taken. At St. H 8 a and H 9 no herring larvae occurred.

Having regard to the direction of the prevalent currents I consider it probable that the numerous young herring larvae from St. H 3 taken in November 1904 and 1906 originate from spawning places on the south western part of the Dogger Bank. The larvae taken at H 6 and H 7 come without doubt from spawning places situated between the Dogger Bank and the English coast.

REDEKE and VAN BREEMEN are of opinion that the few herring larvae caught at the Dutch Stations south of 53° N. lat. in November originate from spawning grounds situated between the Dogger Bank and the English coast and not from herrings which have spawned in the actual area where the larvae have been taken. They lay stress upon the fact that the herring of the Deep Water Channel is a winter spawning herring, and they believe that the spawning places for this herring are situated near the entrance of the English Channel.

HJORT (1905) gives much valuable information about time and place for the catches of full herrings and spent herrings in various parts of the North Sea. It appears from HJORT's observations that almost all herrings caught in November in the important herring fishing area between 52 and 53° N. lat. and 2 and 3° E. long. are full herrings and only very few spent herrings.

BORLEY and RUSSELL state (1922) that spawn of herring was taken on the Inner Trawling Ground (West of Dogger Bank) in September 1913, but a more exact location is not given.

The same authors are of opinion that a great spawning ground probably occurs in the neighbourhood of Smith's Knoll. They write about this question as follows (p. 48): "In view of the enormous concentration of the herring off the Norfolk coast in the region of Smith's Knoll in the later part of the season, the existence of a great spawning ground in the vicinity can hardly be doubted. There is, however, no direct information on this point".

The herrings which are caught in great quantities in the region of Smith's Knoll in October—November are mainly winter spawners (see Chap. XI), but as no great herring fishing takes place in this region at the time when these herrings are spawning (about December—January), it seems doubtful whether BORLEY and RUSSELL are right in their view.

Very little has been published about the situation of the spawning places in the eastern part of the North Sea.

DUGE (1903) and EHRENBAUM (1904) state that the stomach of the haddock and the frogfish captured on the Little Fisher Bank and the Jutland Bank from September 30. till October 4. 1903 contained herring eggs. DUGE (1903) writes as follows about this observation:

“In der Zeit vom 30. September bis 4. Oktober 1903 fischten die Fischdampfer EVA, Kapitän KÜLPER und JADE, Kapitän M. MODERSITZKI aus Geestemünde auf der Kleinen Fischerbank auf etwa 57° N-Breite

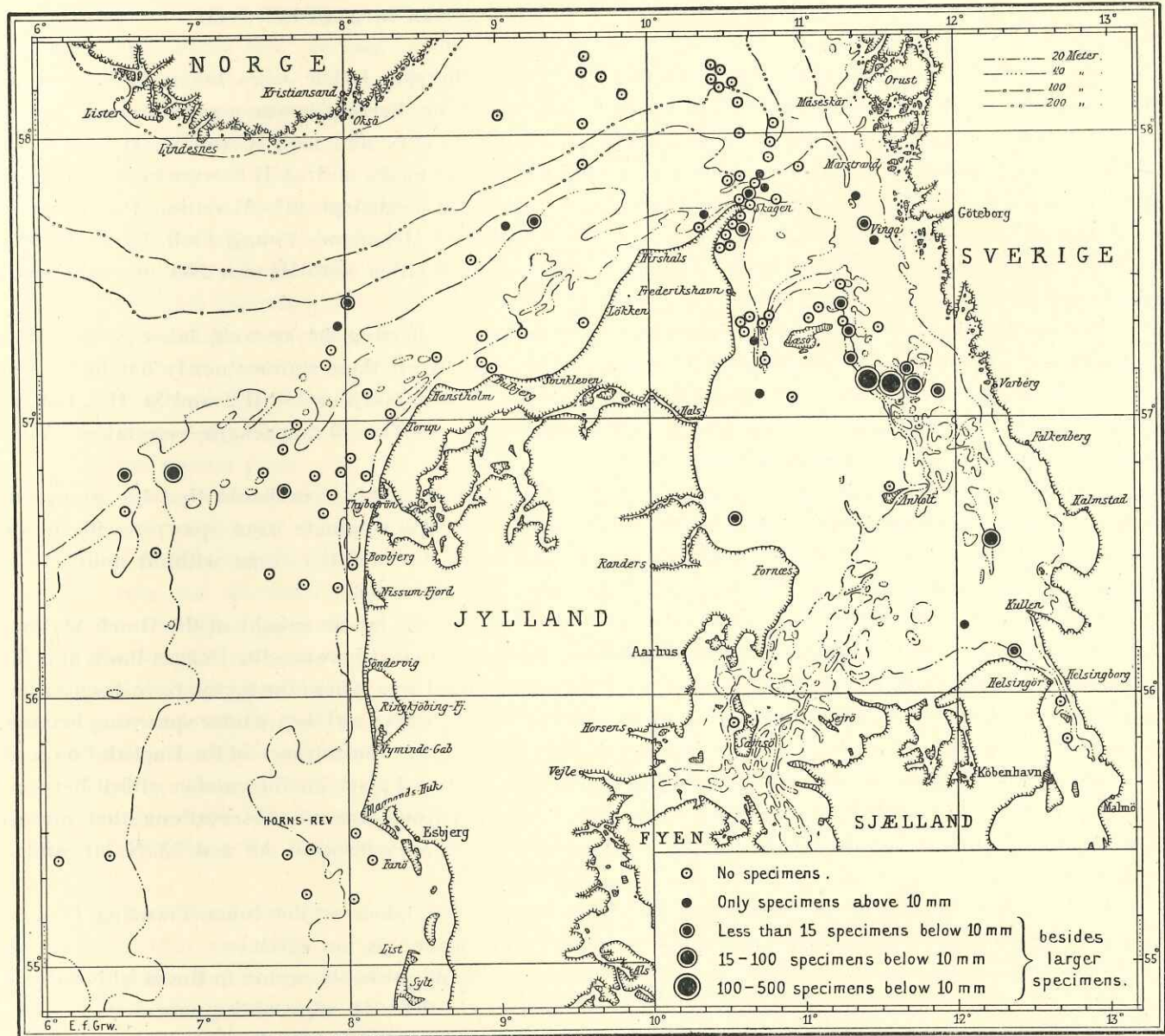


Fig. 1. Catch of herring larvae per 30 minutes haul with Petersen's Young Fish Trawl in September—November 1903—06 and September—October 1922.

und 7° O-Länge, wo sie einen recht guten Fang an grossen und mittel Schellfischen erzielten. Beim Ausweiden der Fische fiel es auf, dass ihre Magen stark und theilweise zum Platzen gefüllt waren. Der Inhalt bestand aus kleinen Fischeiern. Alle in dieser Gegend gefangenen Fische und auch die auf der Jütlandbank angetroffenen hatten ausschliesslich solche Eier im Magen. Auffällig war ferner die grosse Menge todtter Fische, die mit dem Netz heraufgebracht wurde. Ausser ganz frischen, offenbar eben eingegangenen

Fischen, die noch ganz klare Augen hatten, kamen zentnerweise Fische vor, die schon länger tot waren. Unter den toten Fischen waren Seeteufel (*Lophius*) ziemlich häufig, die ebenfalls den Magen voller Rogen hatten. An einigen Stellen, nahe dem steinigen Grunde, kamen grosse Mengen Fischeier mit dem Netze herauf, die sich in den Maschen festgesetzt hatten.

Den Fischern war diese Erscheinung sehr auffällig, da es sich um ganz enorme Mengen von Fischeiern handelte, die nach dem Inhalt der Magen und den im Netze haftenden Quantitäten am Grunde vorhanden

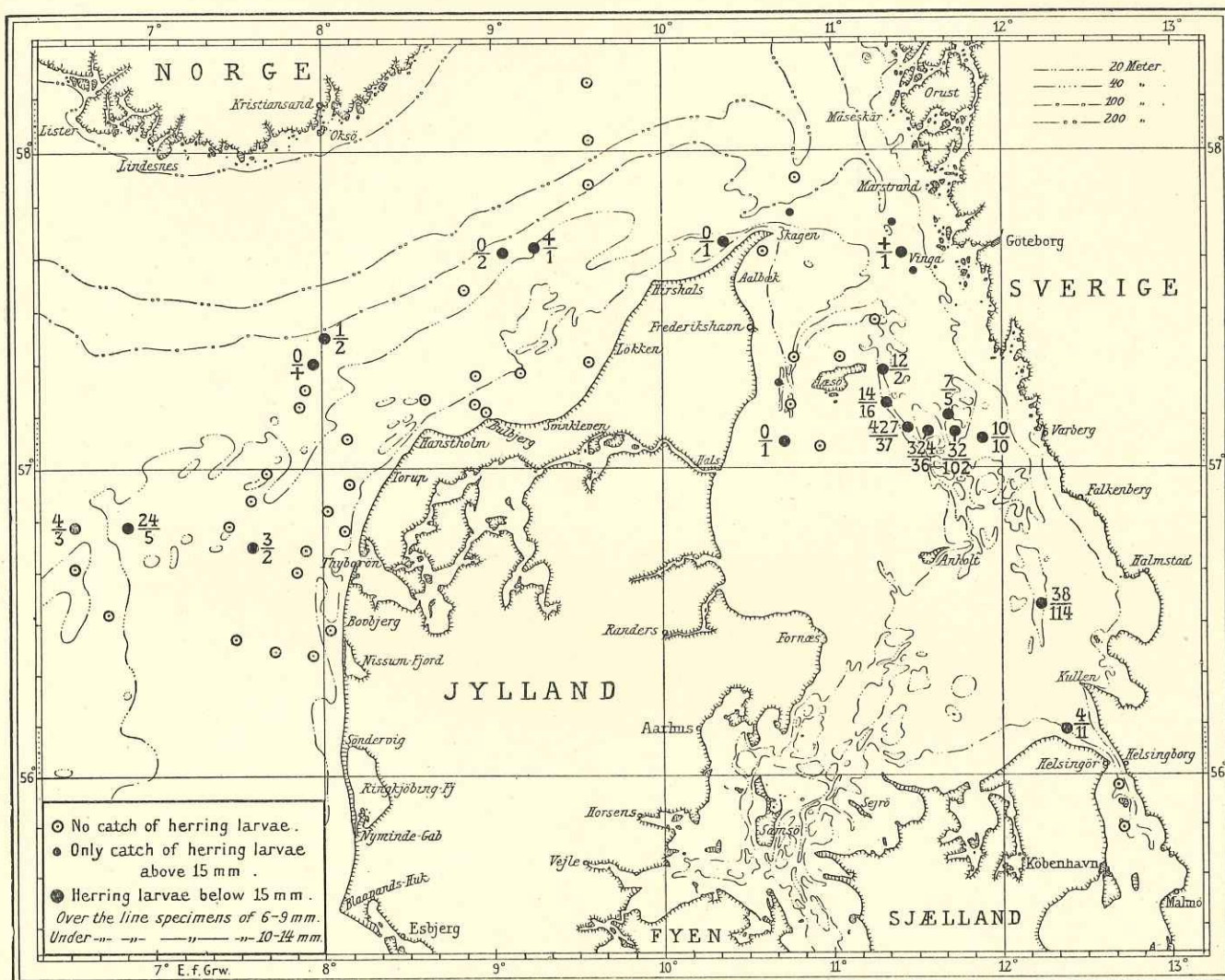


Fig. 2. Catch of herring larvae per 30 minutes haul with Petersen's Young Fish Trawl in September—October 1922.

sein mussten und da sie annahmen, die Fische hätten soviel Eier gefressen, dass sie eingegangen seien, bzw. wie behauptet wurde, dass ihr Magen geplatzt sei”.

A series of new facts is, however, to hand concerning herring larvae caught in the Danish fishing experiments with Young Fish Trawl and Plankton Nets in the North Sea and the Skagerak in the years 1903—07 and 1922—24.

In Figs. 1 and 2 the catches of herring larvae taken by the Danish research steamer with Petersen's Young Fish Trawl¹⁾ during the autumn season have been represented. In Fig. 1 the catch is represented graphically, and the Chart comprises stations from the years 1903—06 and 1922. In Fig. 2

¹⁾ The opening of Petersen's Young Fish Trawl in front was 2—2.5 m × 1.3 m. In some cases a ring trawl of stramin of 2 m in diameter was used.

the number of herring larvae taken in September—October 1922 is put down with statements about number of larvae of different size.

Fig. 3 illustrates the number of larvae taken with vertical hauls with Hensen Net per m².

It appears from these charts that no herring larvae have been caught in the Horns Reef area (between 55 and 56° N. and east of 6° E.) during the Danish fishing experiments with young fish

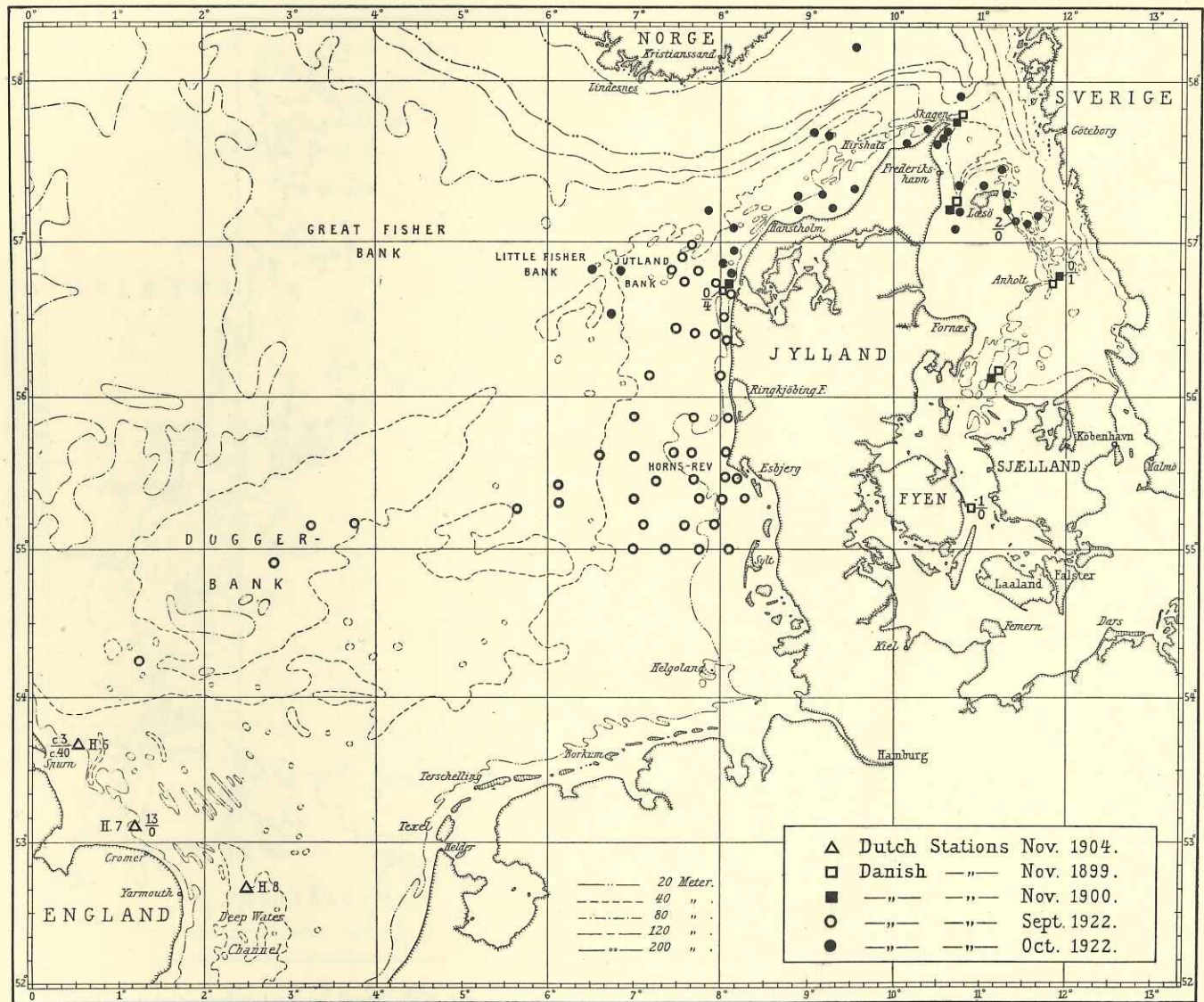


Fig. 3. Catch of herring larvae with vertical hauls by Hensen Net, per m².

Over the line: number of larvae of less than 10 mm length.

Below the line: number of larvae of 10—17 mm length.

If no figures at the stations, no larvae were caught.

The Danish records from 1899 and 1900 originates from C. G. Joh. Petersen (1903).

trawl and Hensen Net during the autumn. Experiments with Hensen Net were undertaken in September 1922 (13 Stations). Experiments with Young Fish Trawl were carried out in September 1903 (1 Station), and in September 1904 (7 Stations).

Later experiments with Young Fish Trawl in the waters close west of Graadeep have given negative results during the following months:

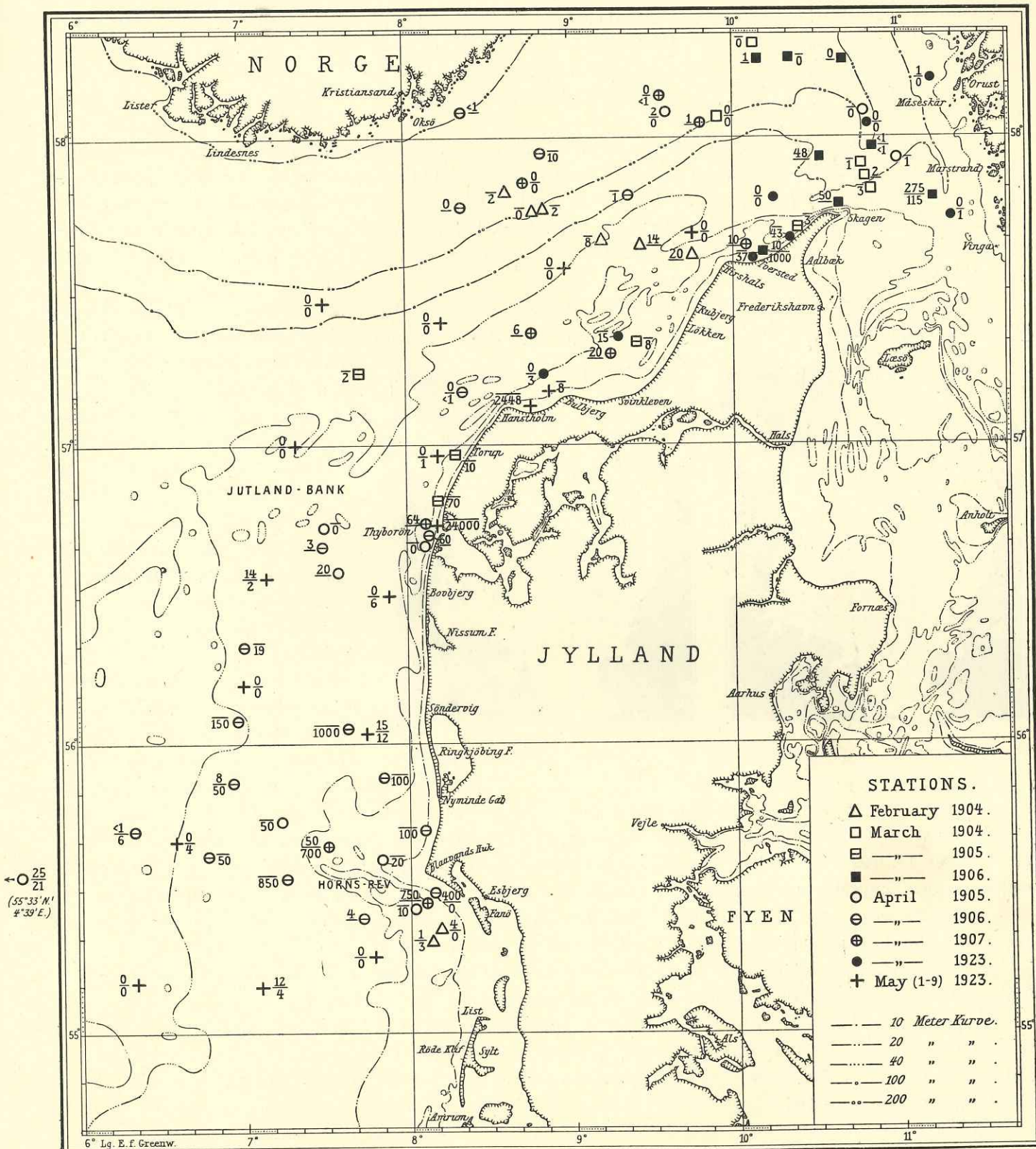


Fig. 4. No. of herring larvae of autumn spawners caught in the spring months per 30 minutes during the Danish fishing experiments by Petersen's Young Fish Trawl.
 Over the line: number of specimens caught in the upper layers.
 Below the line: number of specimens caught in the lower layers.

November	1922	(2 Stations)
December	—	(1 Station)
January	1923	(1 Station)
—	1924	(2 Stations)

From these experiments we gain the impression that if spawning places for an autumn herring occur in the Horns Reef Area or adjacent parts of the German Bight, they must be of very little importance.

In February of 1904 a few herring larvae of 24—41 mm length were caught with Young Fish Trawl south of Horns Reef, and in April of the years 1904, 1905, 1906, 1907 and 1923 several larvae of 13—45 mm length were taken in the Horns Reef Area. These large larvae may have come from the southern part of the German Bight or even from more distant areas.

In the area around the Little Fisher Bank and the Jutland Bank some newly hatched larvae were taken with Young Fish Trawl at the end of September and the beginning of October 1922, (Fig. 1,

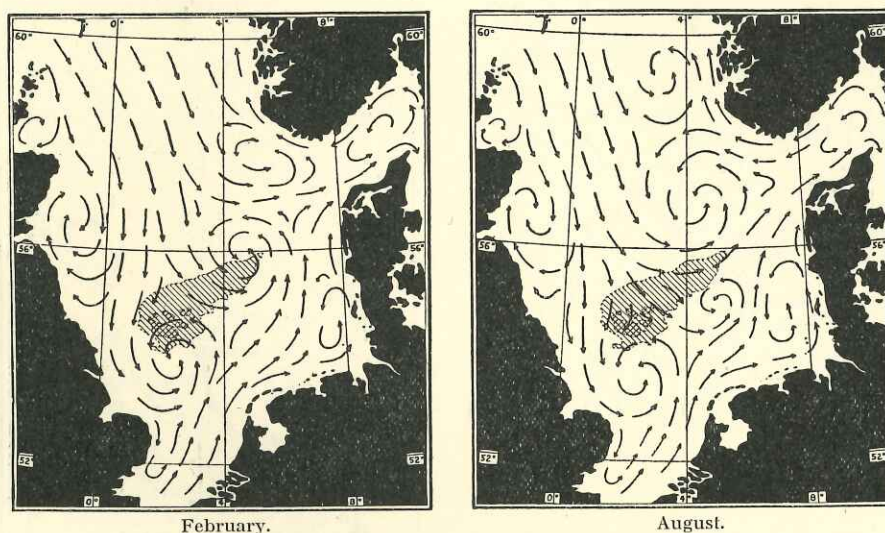


Fig. 5. View of the mean surface currents of the North Sea. After Böhneche. 1922.

2 and Tables 5 and 6), but most of the stations gave negative catches, and the same was the case with a few stations taken in October 1904. In vertical hauls with Hensen Net a few larvae of 15—16 mm length were taken off Thyborøn in November 1899 and December 1900 (Petersen 1903). A coast herring is spawning in autumn (September—November) in the western part of the Lim Fiord, and we do not know whether the larvae taken off Thyborøn originate from this herring or from the Jutland Bank Herring.

In the south western Skagerak a few herring larvae have been caught in autumn. Two larvae of 9—11 mm and 6 larvae of 14—15 mm length were taken N. W. of Rubjerg Knude Light on October 4, 1922, and 8 larvae of 11—17 mm length were taken at about the same place on October 14, 1922 (see Tables 5 and 6). It is probable that spawning places occur here and there in the south western Skagerak, but there is no evidence that these spawning places are of much importance.

Altogether we gain the impression that the spawning places situated in the area of the Little Fisher Bank and the Jutland Bank are usually not of very great importance.

From Fig. 4 it will be seen that many very large catches of larvae of autumn spawners have been taken off the west coast of Jutland in the spring months.

As all the large catches of larvae of autumn spawners have been taken in the spring months and none in autumn, it seems probable that most of the larvae occurring in the spring months at the west coast of Jutland have been transported by the currents from the Dogger Bank or the East Anglian Area. In this connection it should be remembered that the analysis of a large sample of young herrings, originating from autumn spawners, and taken at Thyborøn on the 16. July, 1918, showed the same racial characteristics as the Dogger Bank Herring (comp. p. 16—17).

If we regard the situation of the spawning grounds in the western part of the North Sea between 53° and 55° N. (see Fig. 6) and the direction of the prevalent currents (Fig. 5) we should expect that

greater quantities of herring larvae should be caught off the northern coasts of Jutland than in the Horns Reef Area. If we look at the chart Fig. 4, we notice, however, that more larvae have usually been taken in the Horns Reef Area than off the more northern parts of Jutland. This fact seems to show that the active migrations of the herring larvae plays a great rôle when they have reached a certain length.

Great shoals of young herrings occur often at the western entrance to the Lim Fiord, and it will be noted that a very large catch of larvae has been taken there.

From Fig. 4 it will be seen that almost all the great catches of larvae of autumn spawners are taken in the coastal areas in the spring months. This fact harmonizes with the view of A. T. MASTERMAN (1896): that the older stages of the herring larvae and the youngest stages of the herring after the transformation occur mostly in the litoral Zone¹).

It will be seen from Fig. 1 and Fig. 2 that many young herring larvae have been taken in the eastern Kattegat in autumn, but these larvae originate from spawning places actually in the Kattegat, and the herrings spawning there are different in their racial stamp from those spawning in the North Sea (see Chap. XI). In the neighbourhood of Skagen a few young herring larvae have been caught. It is not known whether these have come from the Skagerak or from the spawning places of the northern Kattegat. During the autumn of 1899 and of 1900 a series of vertical hauls with Hensen Net were taken from the light vessel of Skagen in such periods when the current was coming from West, but no larvae were caught in such hauls (C. G. JOH. PETERSEN, 1903).

If we look at the chart Fig. 3 it is a striking feature that very few larvae have been taken in the Danish waters in comparison with those taken at the Dutch Stations H 6 and H 7 off the East Coast of England. The greatest catches per m² in the Danish waters are 4 and 2, but on the two named Dutch Stations, 43 and 13 larvae were caught respectively.

In Table 6 the size of the larvae taken in the Jutland Bank Area in September and October 1922 is represented. It will be seen that most of the larvae taken between September 28. and October 2. were very small. They were probably hatched in the last half of September. Their average length was only 9.4 mm, while the average length of the specimens taken on the 14. and 15. October was 14.5 mm. This may indicate a growth of about 5 mm in the first half of October. It appears from Table 7 that the growth in the winter months must be much slower, about 4 to 5 mm per month. In the period from March 21. to May 4. the increase in length may be estimated to be about 13 mm or about 9 mm per month.

Table 5. List of Stations where Herring Larvae were caught in the Jutland Bank Area including the Southern Skagerak North of Jutland. Sept. Oct. 1922.

Fishing experiments from the "Dana" with Petersen's Young Fish Trawl.

Station No.	Date	Place	Central Position		Depth in m	Temperature		Salinity		Depth of fishing	Duration of fishing		No. of Larvae caught
			N. Lat.	E. Long		Surface	Bottom	Surface	Bottom		Hours	Min.	
	1922												
2839	Sept. 28	17 miles W. $\frac{3}{4}$ N. of Lodbjerg Light ...	56°49'	7°45'	36	12.0	12.3	33.7	34.5	Near bottom	..	30	12
2843	— 29	22 miles W. of Lodbjerg Light	56°45'	7°36'	41	12.4	12.5	34.1	34.5	Near bottom 85 m wire	..	30	5
2852	Oct. 1	55 miles NW. by W. $\frac{1}{2}$ W. of Bovbjerg L.	56°49'	6°32'	48	12.6	10.6	34.5	34.7	Near bottom 80 m wire	..	30	7
2853	— 1	45 miles W. by N. of Lodbjerg Light...	56°49'	6°51'	34	12.8	11.8	34.8	35.0	Near bottom 75 m wire	..	30	29
2861	— 2	NW. of Hanstholm	57°25'	8°01'	80	..	..	..	..	Intermediate 130 m wire	2	..	14
2862	— 3	26 miles NW. $\frac{1}{4}$ W. of Hanstholm	57°20'	7°57'	60	..	..	..	..	Intermediate 70 m wire	2	..	1
2869	— 4	22 miles NW. $\frac{1}{2}$ N. of Rubjerg Knude Light	57°42'	9°15'	47	11.8	12.0	34.3	34.8	Near bottom 100 m wire	2	..	8
2892	— 11	2.5 miles NE. by N. of Skagen Light-Vessel	57°48'.5	10°45'.5	90	10.2	8.2	24.6	35.2	Near bottom 250 m wire	..	30	1
2906	— 14	26 miles NW. $\frac{1}{4}$ W. of Rubjerg Knude Light	57°41'	9°04'	70	10.82	9.0	32.09	34.97	Intermediate	4	..	8
2912	— 15	5.5 miles W. $\frac{1}{2}$ S. of Højen Light	57°43'	10°22'	25	10.8	11.2	..	..	Near bottom	..	30	5

¹ MASTERMAN (1896 p. 295) writes as follows about this matter: "By a length of some 20—25 millimetres, the young herrings have reached the surface water, or are near the surface, and they then migrate shorewards, taking up a littoral habit, commonly at the mouths of rivers, where they usually move about in small shoals."

Table 6. Lengths of Herring Larvae caught in the Jutland Bank Area including the Southern Skagerak North of Jutland in September—October 1922.

Fishing experiments from the "Dana" with Petersen's Young Fish Trawl.

Month.....	September		October							
	28.	29.	1.	1.	2.	3.	4.	11.	14.	15.
Date.....	1922	1922	1922	1922	1922	1922	1922	1922	1922	1922
Year.....	2839	2843	2852	2853	2861	2862	2869	2892	2906	2912
Station No.										
Length mm.										
6.....	..	..	..	..	..	..	..	..	..	..
7.....	3	..	..	2	..	..	..	..	..	..
8.....	4	1	2	7	..	..	..	..	..	..
9.....	3	2	2	15	3	..	1	..	..	..
10.....	1	2	3	4	5	..	..	..	..	..
11.....	..	..	..	1	1	..	1	..	1	..
12.....	1	..	..	..	..	..	..	..	1	..
13.....	..	..	..	..	2	1	..	..	2	..
14.....	..	..	..	..	1	..	4	..	3	1
15.....	..	..	..	..	1	..	2	..	..	1
16.....	..	..	..	..	1	..	..	..	..	1
17.....	..	..	..	..	..	..	..	..	1	1
18.....	..	..	..	..	..	..	..	..	..	..
19.....	..	..	..	..	..	..	..	1	..	1
20.....	..	..	..	..	..	..	..	..	..	..
	12	5	7	29	14	1	8	1	8	5

We can now summarise the results arrived at concerning the extent and location of the spawning places for the summer and autumn spawning herrings of the North Sea in the following way:

The main spawning places are situated near the British coasts, from the Shetland Isles to Norfolk, at depths from about 20 to about 90 meters, including the Dogger Bank. Spawning places of some importance are situated on the Little Fisher Bank and the Jutland Bank, including the adjacent parts of the Skagerak. The Herrings spawning on these grounds seem to belong to one single race: the Bank Herring of the North Sea (see Chap. VII).

Spawning grounds are also situated here and there far from the shore on the banks of the northern plateau of the North Sea at depths from about 70 to 120 meters, or even more. The racial characteristics of the herrings spawning there are but little known, but according to the results of investigations carried out by BROCH, it must be supposed that these herrings belong to another race than the Bank Herring, viz.: The North Sea Deep Water Herring (see Chap. VII).

The position of the spawning places of the Autumn Herrings of the German Bight is not known as yet. They are usually of very little importance.

X. On the Temperature and Salinity at the spawning places of the Summer- and Autumn-Spawning Herrings of the North Sea.

After Bulletin Trimestriel 1906—07, Partie Supplémentaire, the maximum temperature for the year at the sea bottom is represented on the chart Fig. 6, p. 39, and on the same chart the approximate situation of the spawning places of the summer- and autumn-spawning herrings is shown according to the information referred to in Chap. IX. It appears from this chart that most of the spawning places occur

Table 7. Lengths of Herring Larvae¹⁾ caught in various months from September to May in the Jutland Bank Area.
Danish Fishing Experiments with Petersen's Young Fish Trawl.

Month.....	September	October	November	February	March	April	May	
Date.....	28.—29.	1.—15.	14.—19.	17.	11.—30.	30.	1.—9.	
Year.....	1922	1922	1903	1904	1903, 1904 1906	1923	1923	
Length mm.								Length mm.
7.....	3	2	..	..	..	..	..	..... 7
8.....	5	9	1	..	• 1	..	..	..... 8
9.....	5	21	2	..	• ..	1	..	..... 9
10.....	3	12	1	..	• ..	27	..	.....10
11.....	..	4	..	..	• ..	60	1	.....11
12.....	1	1	..	1	• ..	75	3	.....12
13.....	..	5	..	..	• ..	57	2	.....13
14.....	..	9	..	..	• ..	25	2	.....14
15.....	..	4	..	1	• ..	10	5	.....15
16.....	..	2	..	..	• ..	9	6	.....16
17.....	..	2	..	..	• ..	3	8	.....17
18.....	3	1	• 1	4	1	.....18
19.....	..	1	..	1	• ..	2	3	.....19
20.....	1	1	• ..	..	..	.....20
21.....	1	• ..	..	1	.....21
22.....	•	2	.....22
23.....	4	• 2	..	..	.....23
24.....	• 2	..	3	.....24
25.....	1	• ..	..	..	.....25
26.....	4	• 1	1	3	.....26
27.....	1	• ..	1	2	.....27
28.....	2	• 2	..	4	.....28
29.....	1	• ..	1	3	.....29
30.....	• 2	2	4	.....30
31.....	2	• ..	1	3	.....31
32.....	1	• ..	3	3	.....32
33.....	1	• 2	1	5	.....33
34.....	• ..	4	4	.....34
35.....	• 1	3	3	.....35
36.....	• ..	3	6	.....36
37.....	• 2	5	6	.....37
38.....	• 1	1	10	.....38
39.....	• ..	2	30	.....39
40.....	• 1	..	52	.....40
41.....	• ..	2	61	.....41
42.....	• ..	9	68	.....42
43.....	• ..	7	68	.....43
44.....	• ..	8	67	.....44
45.....	• ..	13	69	.....45
46.....	• ..	12	59	.....46
47.....	• ..	5	48	.....47
48.....	• ..	2	35	.....48
49.....	• ..	2	15	.....49
50.....	• ..	4	7	.....50
51.....	• ..	3	5	.....51
52.....	• ..	1	1	.....52
53.....	• ..	2	..	.....53
No. of larvae of autumn herrings .	17	72	8	23	17	98	ca. 644	
Aver. length mm. . .	8.7	10.9	13.75	23.7	29.8	42.3	42.8	
No. of larvae of spring herrings	1	273	ca. 34	

¹ The largest specimens taken between April 30. and May 9. were in the transitional stage, but none of these were covered by scales.

Table 8. List of Stations where Herring Larvae of Autumn-Spawners were caught off the West Coast of Jutland and in the Southern Skagerak in the spring months 1904-07 and 1923.

(Petersen's Young Fish Trawl).

Station No.	Date	Locality	Central Position		Depth in m	Temp. °C.		Salinity ‰		Depth of fishing	Duration of fishing hours	No. of larvae caught	Length in mm			
			N.	E.		Surface	Bottom	Surface	Bottom				mini- mum	maxi- mum	aver- age	
185	1904 Febr. 17	6.5 miles WNW of Hirshals	57°37'	9°45'	30	2.7	..	34.0	..	Surface	1/4	10	23	33	29	
186	— — —	18 miles WNW of Hirshals	57°39'	9°26'	26	3.3	..	34.3	..	Surface	1/4	7	15	28	23	
187	— — —	25 miles WbyN of Hirshals	57°40'	9°12'	42	3.7	..	34.5	..	Intermediate	1/4	4	12	21	18	
188	— — —	1 mile SE ¹ / ₂ S of Oxø	57°46'	8°49'	210	3.3	..	33.0	..	Intermediate	5/6	2	23	36	30	
190	— — —	23 miles SE ¹ / ₂ S of Oxø	57°49.5'	8°37'	425	..	..	..	..	Intermediate	1/2	2	..	26	..
202	— — 26	8 miles SW ¹ / ₂ S of Graadeep Buoy	55°19'	8°08'	14	1.1	..	..	..	{ Surface Near bottom	1/3 1/3	1 2	.. 39	.. 41	24 40
203	— — —	5 miles SW ³ / ₄ S of Graadeep	55°21.5'	8°10.5'	13	1.5	..	31.8	..	{ Surface Near bottom	1/4 1/6	2 0	.. ..	24 ..	..
220	— March 16	5 miles NE by E of Skagen L.V.	57°49.5'	10°50'	88	0.3	..	..	..	Intermediate	1/2	3	..	..	..
221	— — —	7 miles NE by E of Skagen L.V.	57°52.5'	10°48'	135	1.1	5.4	25.9	33.3	Surface	1/2	2	24	28	26	
222	— — —	9 miles NNE ¹ / ₂ E of Skagen L.V.	57°55'	10°47.5'	170	0.1	5.6	24.6	34.9	Near bottom	1/2	1	..	..	..
349	1905 March 20/22	2 miles W of Spirbakken Bro	57°42'	10°23'	17	3.3	3.5	32.2	32.3	{ Intermediate Near bottom	1 1/3	4 3	.. ..	.. ..	..
351	— — 22/23	9 miles WNW of Kjettrup Bro	57°20'	9°24'	9	2.3	..	32.1	..	Intermediate	8	130	..	..	..
352	— — 23	29 miles WNW of Hanstholm	57°14'	7°43'	50	4.9	5.0	35.0	35.1	Intermediate	6	20	..	..	..
353	— — 24	2.5 miles W of Lodbjerg Light	56°49'	8°12'	17	3.6	4.0	32.1	34.0	Intermediate	8	1100	24	43	..	
354	— — —	3 miles W of Torup Bro	56°58'	8°18'	18	3.9	4.0	33.5	33.9	Near bottom	1	20	20	30	..	
367	— April 7	13.5 miles NE by E of Skagen L.V.	57°56'	11°00'	105	4.2	5.0	34.0	34.8	Near bottom	1/2	1	..	..	..
369	— — 8	32 miles N ³ / ₄ W of Hirshals	58°05'	9°36'	414	3.9	..	32.3	..	{ Surface Intermediate	2 2	9 0	25 ..	37 ..	..
372	— — 9	18 miles NW by W ¹ / ₂ W of Bovbjerg Light	56°35'	7°35'	27	4.8	5.3	34.7	34.7	Surface	1/2	20	20	35	..	
373	— — —	10 miles N by W of Horns Reef L.V.	55°44'	7°13'	27	4.5	4.8	33.5	33.6	Near bottom	2	200	22	40	..	
380	— — 14	Dogger Bank, Tail End	55°33'	4°39'	32	5.5	5.5	34.8	34.8	{ Surface Intermediate	2 3	100 125	32 33	38 38	..	
381	— — 15	8 miles SSW of Blaavand Point	55°26'	8°02'	14	4.4	4.5	30.5	30.6	Near bottom	1/2	10	35	45	..	
382	— — 15	Slugen, North	55°36'	7°50'	15	4.2	4.5	31.1	31.3	{ Intermediate Near bottom	1/2 1/4	25 8	22 25	46 41	..	
741	1906 March 19	16 miles E ¹ / ₂ S of Skagen L.V.	57°48'	11°13'	65	2.9	3.8	32.4	34.4	{ Surface Near bottom	3 5	1650 1150	.. ..	32 33	..
751	— — 23	15 miles NE by N of Skagen L.V.	57°58'	10°50'	140— 188	2.6	5.1	32.9	35.0	{ Surface Intermediate Near bottom	1 2 4	1 2 0	.. .. ..	.. 25 ..	35
754	— — 23	32 miles N by W of Højen Light	58°15'	10°09'	550	3.5	5.3	33.1	34.9	Surface	2	5	24	37	..	
758	— — 24	11 miles N ¹ / ₂ W of Skagen L.V.	57°56'	10°32'	97	3.7	..	33.8	..	Surface	1	96	12	35	..	
759	— — 24	3 miles N by E of Skagen L.V.	57°47'	10°38'	85	2.5	..	31.5	..	Surface	1	142	..	32	..	
770	— — 30	7 miles E ¹ / ₂ N of Hirshals Light	57°37'	10°09'	13	2.6	4.1	30.2	33.1	{ Surface Intermediate	3 3	61 6000	18 ..	38 40	..	
782	— April 3/4	23 miles NW ¹ / ₄ N of Hirshals Light	57°49'	9°22'	105	4.3	5.6	..	..	Intermediate	1/2	1	..	..	27
783	— — 3/4	42 miles NW ¹ / ₄ W of Hirshals Light	57°57'	8°50'	510	3.5	5.7	..	..	Intermediate	1	21	18	34	..
784	— — 4	9 miles E by S of Oxø Light	58°05'	8°21'	108	3.2	5.3	33.4	34.9	Surface	1	1	..	..	35
787	— — —	9 miles NW ¹ / ₂ W of Hanstholm	57°11'	8°21'	25	5.0	4.6	35.0	34.9	{ Surface Intermediate	1 1	0 1	.. ..	.. ..	22
788	— — —	2.5 miles W by N ¹ / ₂ N of Thyborøn Bro	56°42'	8°08'	15	4.7	3.5	33.8	34.7	Surface	1	120	15	42	..	
789	— — 5	23 miles NW ¹ / ₂ W of Bovbjerg	56°40'	7°29'	31	4.5	5.0	34.8	35.0	Surface	1	5	21	35	..	
791	— — —	38 miles W ¹ / ₄ S of Bovbjerg Light	56°20'	7°00'	37	4.2	4.5	34.4	34.6	Intermediate	1	38	20	32	..	
792	— — —	34 miles N ¹ / ₂ W of Horns Reef L.V.	56°06'	6°58'	36	4.2	3.8	34.3	34.4	Intermediate	1	300	15	30	..	
793	— — 5/6	22 miles NNW of Horns Reef L.V.	55°52'	6°56'	37	4.0	3.7	34.5	34.8	{ Surface Intermediate	1 1	15 100	20 14	42 40	..	

Station No.	Date	Locality	Central Position		Depth in m	Temp. °C.		Salinity ‰		Depth of fishing	Duration of fishing hours	No. of larvae caught	Length in mm		
			N.	E.		Surface	Bottom	Surface	Bottom				mini- mum	maxi- mum	aver- age
794	1906 April 6	36 miles WNW of Horns Reef L.V.	55°42'	6°19'	47	4.5	3.9	34.9	34.9	Surface	1	1	..	..	19
795	— — —	19 miles NW by W ³ / ₄ W of Horns Reef L.V.	55°37'	6°46'	38	4.1	3.8	34.1	34.8	Near bottom	1	11	16	26	..
796	— — —	3 miles SW by W ¹ / ₂ W of Horns Reef L.V.	55°32'	7°15'	28	3.6	3.6	33.5	33.5	Intermediate	2	200	13	37	..
798	— — —	1 mile NW of Vyl L.V.	55°24'	7°43'	20	3.9	3.8	33.5	33.4	Intermediate	1	7	12	22	..
802	— — —	3 miles WNW of Kærgaarde Bn.	55°42'	8°04'	15	4.1	5.8	33.6	33.7	Surface	1	200	..	..	..
803	— — —	11 miles W of Haurvig Bn.	55°53'	7°51'	24	4.7	3.9	33.7	33.9	Intermediate	1	200	18	35	..
804	— — 9/10	17 miles W ¹ / ₄ S of Søndervig.	56°03'	7°38'	30	4.4	3.9	34.2	34.4	Intermediate	2	4000	15	42	..
806	— — 10	5 miles S by E of Blaavand Point.	55°29'	8°09'	9	4.9	4.4	33.8	33.7	Surface	1	800	20	43	..
939	1907 April 11	35 miles N ³ / ₄ W of Hirshals.	58°08'	9°34'	500	4.4	5.8	32.9	35.0	Near bottom	1/2	0	..	..	..
940	— — 12	28 miles N ¹ / ₂ E of Hirshals.	58°03'	9°49'	220	4.4	5.8	32.7	34.9	Surface	1	2	22	26	24
949	— — 15	6 miles NE by E ¹ / ₂ E of Hirshals.	57°39'	10°05'	16	5.0	5.8	34.9	35.0	Intermediate	8	1	..	..	27
950	— — 16	19 miles W by S of Rubjerg Knude ...	57°18'	9°15'	17	5.2	4.8	34.3	34.3	Near bottom	2	0	..	..	..
955	— — —	17 miles NE by N of Hanstholm.	57°22'	8°46'	28	5.3	5.4	34.3	34.9	Surface	1	21	..	..	..
956	— — 17	Off Thyborøn.	56°46'	8°09'	19	5.5	5.6	32.6	33.6	Surface	2	77	18	38	..
960	— — 18	7 miles S by W of Blaavand Point.	56°42'	8°07'	16	5.5	5.6	31.5	31.5	Surface	3	38	21	41	..
982	— — 29	c. 5 miles NE ¹ / ₂ N of Horns Reef L.V. ...	55°27'	8°05'	17	5.4	5.9	32.8	32.8	Surface	3	384	26	41	..
983	— — 30	5 miles NE ¹ / ₂ N of Horns Reef L.V.	55°39'	7°30'	17	5.9	5.8	32.8	32.8	Surface	3	300	24	44	..
2991	1923 April 29	9.5 miles SW by S of Paternoster Light	57°45'	11°20'	85	6.1	6.2	23.0	35.0	Intermediate	3	4200	..	..	..
2992	— — —	7 miles NNW ¹ / ₄ W of Måseskär Light. ...	57°45'	11°20'	85	6.1	6.2	23.0	35.0	Surface	1/2	0	..	..	..
2995	— — 30	Tannis Bay.	58°11.5'	11°13'	62	6.0	6.1	23.0	34.1	Intermediate	1/2	1	..	..	40
2996	— — —	6 miles E ¹ / ₂ N of Hirshals Light.	57°40.5'	10°21'	10	6.6	6.7	34.5	34.4	Surface	1/2	1	..	..	35
2997	— — —	17 miles W by S og Rubjerg Knude Light	57°36.5'	10°08'	7	6.9	6.9	34.3	34.3	Near bottom	1/2	0	..	..	..
2998	— — —	11 miles NE by E ¹ / ₄ E of Hanstholm Light	57°21'	9°18'	15	6.0	5.7	33.7	33.8	Near bottom	1/2	43	43	53	46
2999	— May 1	10 miles E by N ¹ / ₄ N of Hanstholm Light	57°14'	8°51'	23	5.5	5.4	33.8	33.8	Surface	1/2	37	26	48	41
3000	— — —	1.5 mile N by E ¹ / ₂ E of Vigsø Bn.	57°10.5'	8°53'	15	6.0	5.7	33.7	33.8	Near bottom	1/2	15	29	43	36
3001	— — 2	9 miles N ¹ / ₂ W of Lodbjerg Light.	57°07'	8°46'	7	6.1	5.7	33.6	33.8	Surface	1/2	0	..	..	..
3002	— — —	2 miles SW by W of Agger Bn.	56°58'	8°12'	24	5.4	5.3	33.4	33.6	Near bottom	1/2	3	27	30	29
3003	— — —	7 miles W ¹ / ₂ N of Bovbjerg Light.	56°54'	8°11'	9	6.1	5.8	33.1	33.1	Intermediate	1/2	8	28	42	34
3004	— — —	12 miles W ¹ / ₂ N of N. Lyngvig Light ...	56°50'	7°54'	24	6.5	5.5	32.7	33.0	Near bottom	1/2	2448	21	48	41
3007	— — 5	23 miles SW ¹ / ₄ W of Vyl L.V.	56°44'	8°11'	9	6.1	5.8	33.1	33.1	Surface	1/2	0	..	..	..
3009	— — 6	25 miles NW by W ³ / ₄ W of Horns Reef L.V.	56°30'	7°54'	24	6.5	5.5	32.7	33.0	Near bottom	1/2	6	20	36	31
3012	— — 7	32 miles W by N ¹ / ₂ N of Bovbjerg Light	56°02'	7°45'	26	5.8	5.3	32.7	32.8	Surface	1/2	15	29	35	32
			55°10'	7°05'	33	7.3	5.1	32.2	33.2	Near bottom	1/2	12	25	37	34
			55°40'	6°35'	40	7.1	5.1	32.2	33.9	Surface	1/4	6	28	34	31
			56°34'	7°09'	31	6.1	4.7	32.8	33.9	Near bottom	1/4	2	34	39	37
										Surface	1/4	0	..	..	..
										Near bottom	1/4	2	36	40	38
										Surface	1/4	7	34	41	37
										Near bottom	1/4	1	..	..	43

in the warm area where the maximum temperature is above 9° C, and that only a few spawning places are known in the cold area, where the maximum temperature is only 6—9° C.

It appears from Chap. II and Chap. IX that two different races of summer herrings are spawning in the northern part of the North Sea, and in all probability the Bank Herring is spawning in the warm area and the North Sea Deep Water Herring in the cold area. The samples of mature Bank Herrings

investigated were all taken in the warm area or on the boundary between the two areas. The samples of the North Sea Deep Water Herring investigated by BROCH (1906), originated from the following localities:

Tampen.....	61° 51' N. 0° 45' E.	13. Sept. 1904
Viking Bank (several samples).....		October—November 1904
40 miles S. E. of Fair Isle	59° 14' N. 0° 38' W.	10. Sept. 1904. (comp. p. 6—11).

These localities are all situated in the cold area.

The Bank Herring in the northern part of the North Sea is spawning in the period when the water is warmest: viz. August—September, but the Bank Herring on the Dogger Bank and off the English East Coast between 53° and 55° N. lat. is spawning later in autumn viz. September—November, with maximum in October, when the cooling of the water has begun. In this way the temperature on the spawning places for the Bank Herring becomes rather similar on the northern and the southern spawning places at the time when the main spawning actually takes place.

Fig. 7 represents the spawning places of the summer herrings (of different races) in the northern part of the North Sea, according to BOWMAN, BJERKAN and WOOD, and the mean temperature at the sea bottom in August¹). Fig. 8 shows the situation of the spawning places of the Bank Herring in the north western coastal area, according to FULTON (1891), and the mean temperature for August at 40 meters depth. Fig. 9 represents the approximate situation of the main spawning places of the Bank Herring in the southern area and the mean temperature at 40 meters depth in November.

If we consider the mean temperature at 40 meters depth in the north western spawning area in August, it will be seen that it is about 10—12° C. (Fig. 8). In the southern area the temperature is, on the whole, higher during this season (Fig. 7 and 8) and the spawning has not yet begun. In 20 meters depth the mean temperature for August is about 11° C at the Shetland Isles and between 12 and 13° C in the area east of Scotland, but from 14 to 16° C on the Dogger Bank, and 13 to 15° C in the area between Flamborough Head and Cromer. At 60 meters depth the mean temperature is about 10° C at the Shetland Isles and in the area east of Scotland, and at 80 m about 9—10° C. Thus it appears that the spawning in the northern area at depths from about 20 to 80 meters takes place in August at a temperature of ca. 9—13° C, and the same temperature is prevailing in that area during September.

Turning now to the chart for November (Fig. 9) we find that the mean temperature at 40 m in the southern spawning areas is the same as that which we found in the north western spawning area in August, viz. 10—12° C. In the north western area the temperature is in November a little lower, about 9 or 10° C.²) In 20 meters depth and on the whole in the upper 40 meters layer the temperature is about the same as at 40 meters. During the main spawning period in October the temperature is somewhat higher on the southern spawning places, namely about 11—13° C.

According to REDEKE (1918) no spawning of herrings takes place in autumn in the south western part of the North Sea south of 53° 0' N. lat. The temperature here in September—October is more than 13° C. on the sea bottom.

The spawning in the eastern area around the Little Fisher Bank and Jutland Bank occurs in September—October. The temperature here is, in August, at 40 meters depth, about 8—10° C, but if we look at the chart showing the maximum temperature at the bottom of the North Sea, we see that a higher temperature of 10—12° C (Fig. 6) prevails there in the warmest period of the year, and that coincides with the spawning period in September—October.

¹) The isotherms are taken from Bulletin Trimestriel 1906—07, Partie Supplémentaire, and the means are calculated for the period from August 1902 to May 1905. The isotherms and isohalines represented on Fig. 8—11 cover the same period.

²) In Bulletin Trimestriel, Partie Supplémentaire 1906—07, an isotherm of 11° C. giving the mean temperature on the sea bottom for November is drawn on the stretch Aberdeen-Tynemouth. It seems to be a mistake for 10° C.

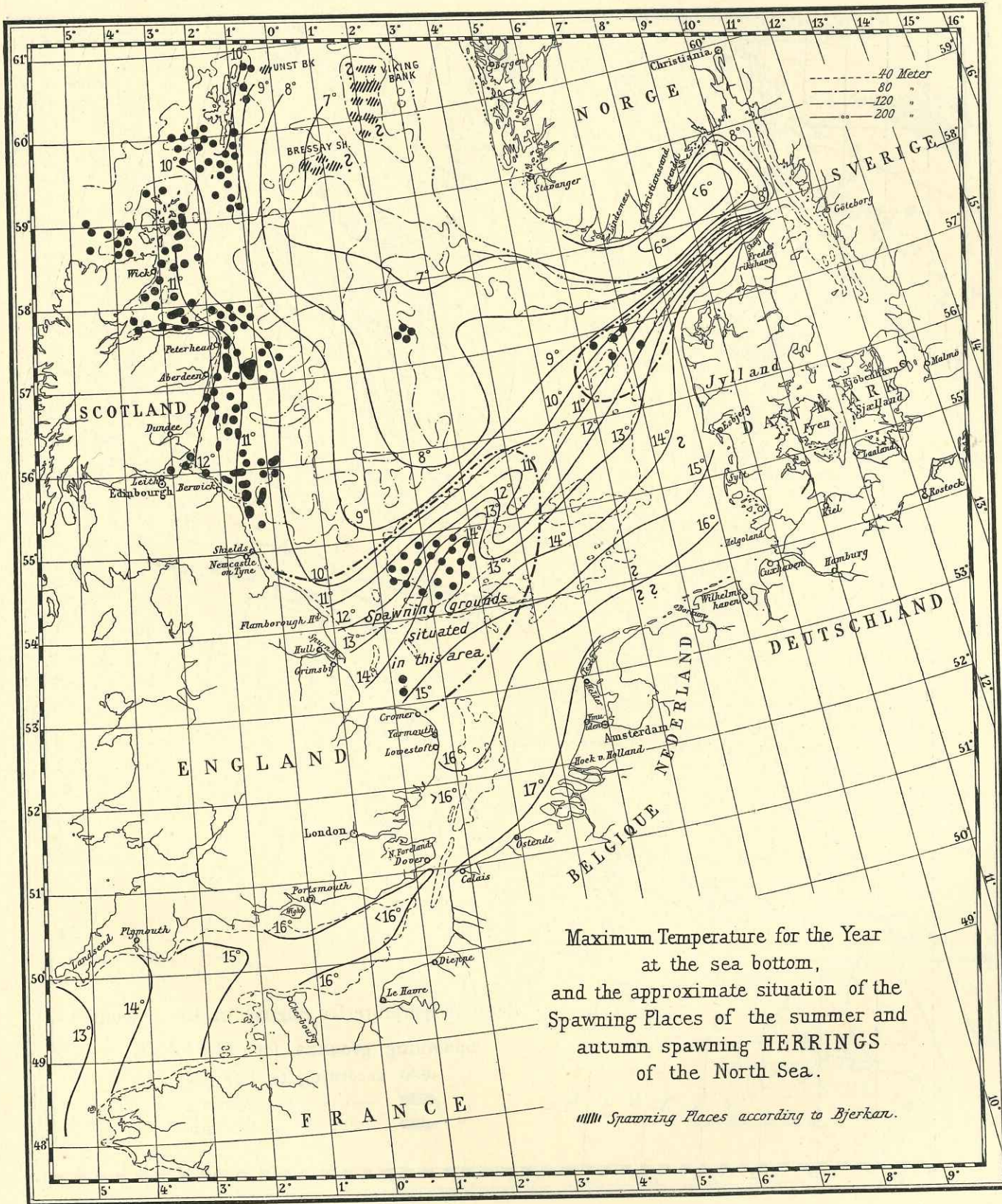


Fig. 6. Maximum temperature for the year at the sea bottom and the approximate situation of the spawning places of the summer and autumn spawning herrings of the North Sea, according to the information available (comp. Chap. IX).

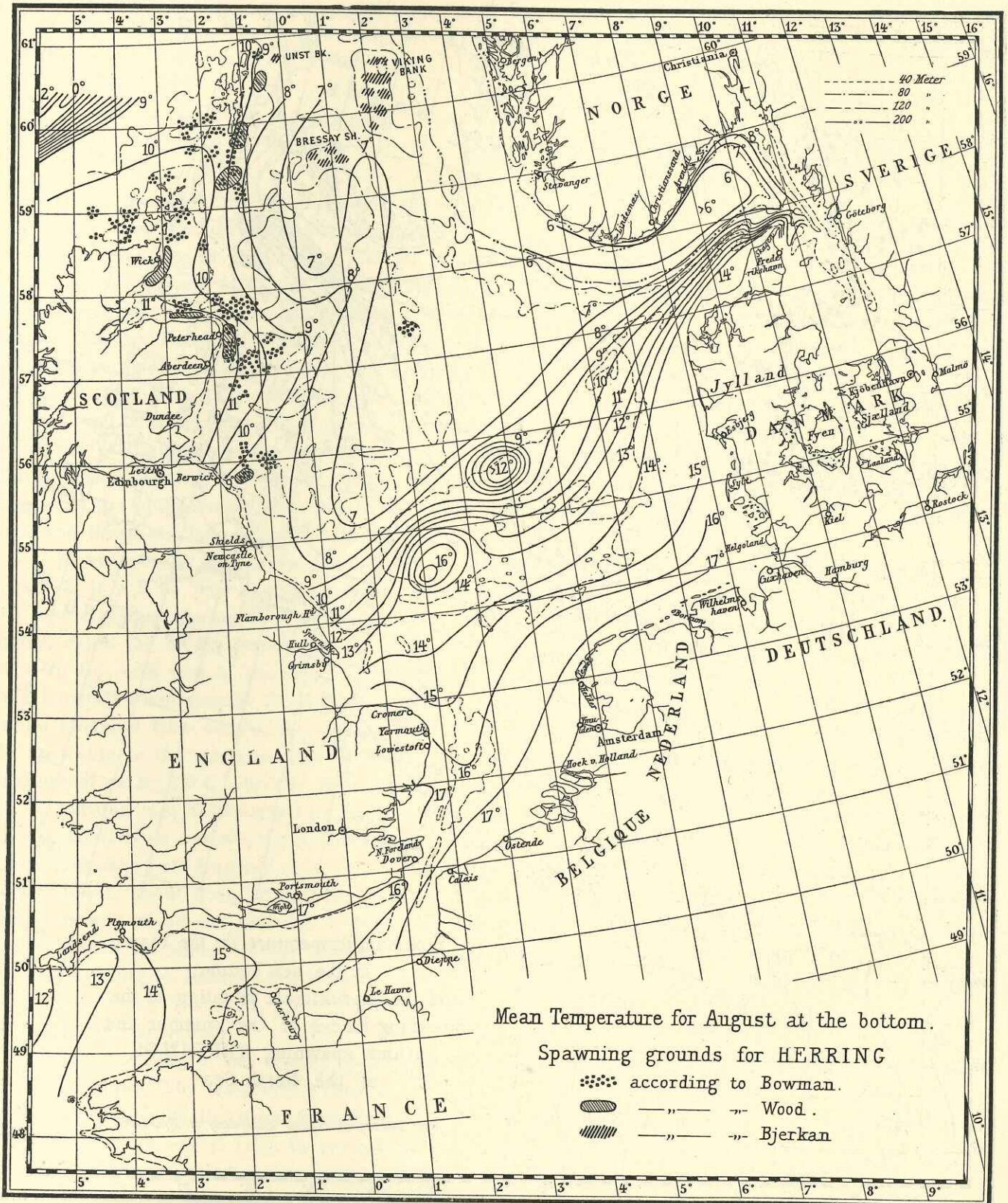
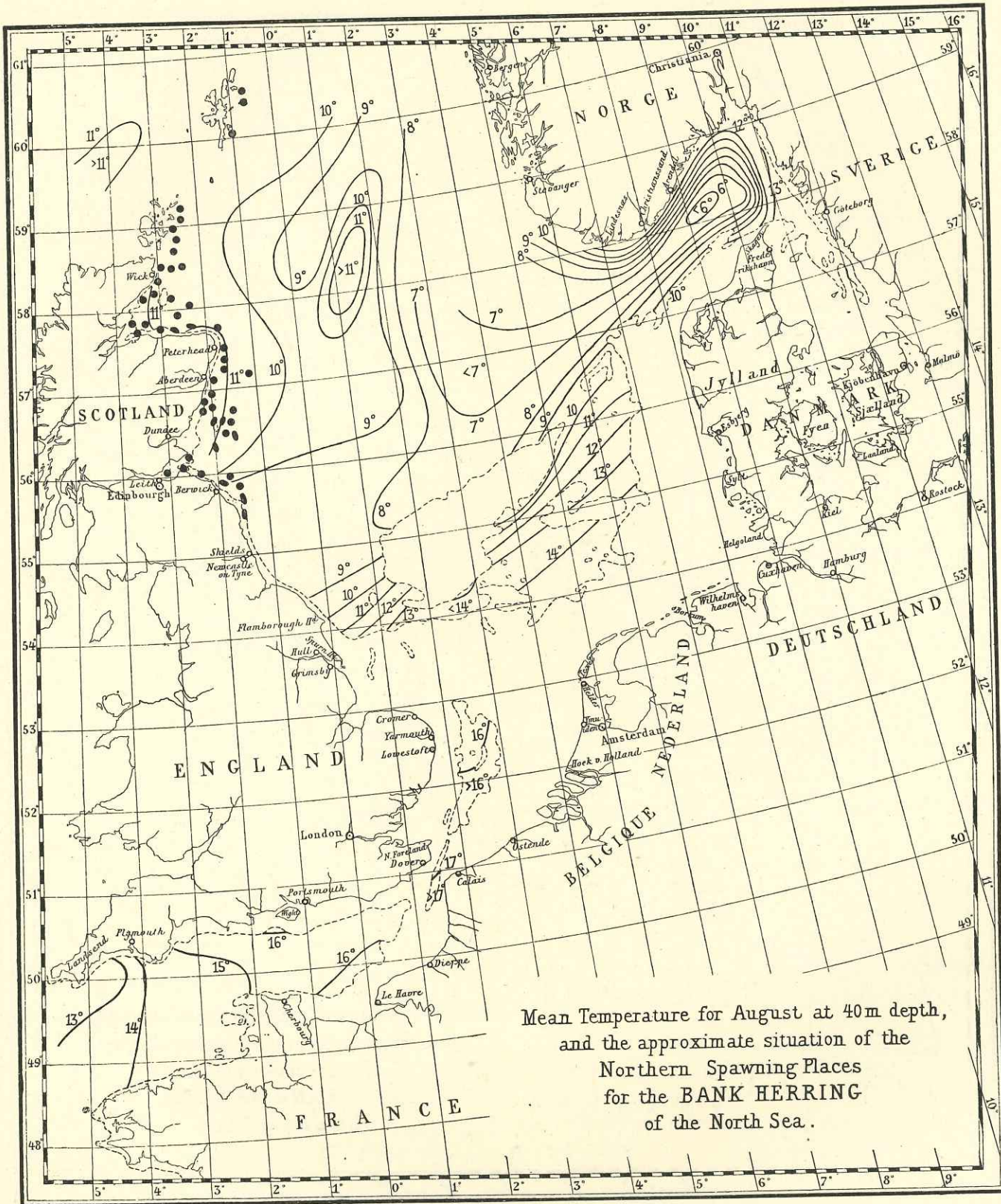


Fig. 7. Mean temperature for August at the sea bottom and the approximate situation of spawning grounds of the summer spawning herrings in the northern part of the North Sea, after BOWMAN, WOOD and BJERKAN (Comp. Chap. IX).



Mean Temperature for August at 40m depth,
and the approximate situation of the
Northern Spawning Places
for the BANK HERRING
of the North Sea .

Fig. 8. Mean temperature for August at 40m depth, and the approximate situation of the principal north-western spawning places for the Bank Herring, after FULTON.

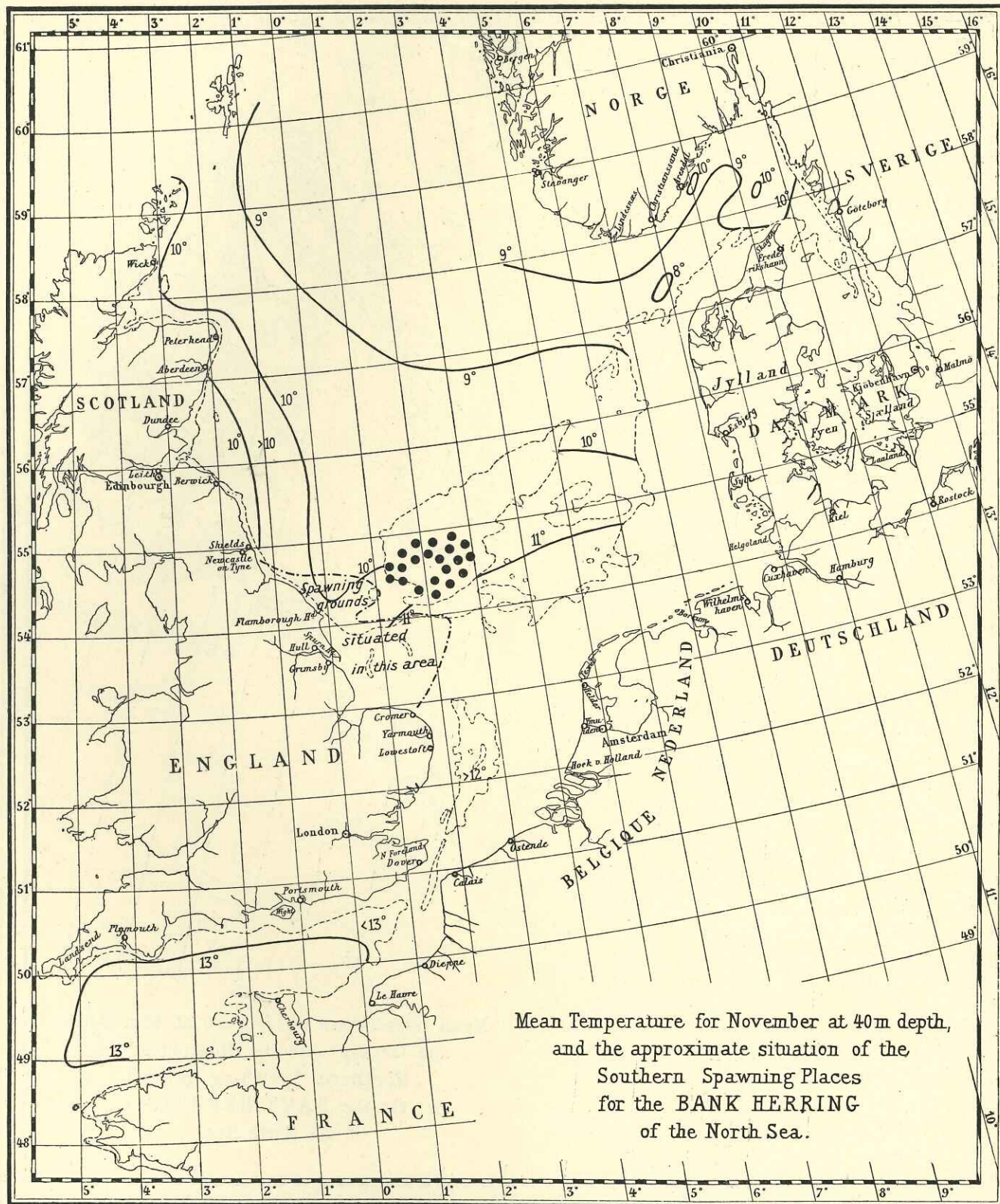


Fig. 9. Mean temperature for November at 40 m and the approximate situation of important spawning grounds for the Bank Herring on the Dogger Bank and the area between the Dogger Bank and the English coast.

Thus it will be seen that the mean temperature at the spawning places for the Bank Herring during the period when spawning actually takes place probably lies between 9° and 13° C, and the main spawning probably occurs at a temperature of about 10—12° C. The temperature varies at a certain depth from one year to another, but it is not known whether this variation causes a change in the depth or locality of the spawning places.

Fig. 10 represents the mean salinity for the year at the bottom of the sea, together with a sketch of the approximate position of the known spawning places of the summer and autumn spawning herrings of the North Sea.

As shown by D'ARCY THOMPSON (1909) the yearly variation in the salinity is, on the whole, slight at the bottom of the North Sea. Its mean value amounts only to about 0.1 to 0.5 pro mille in the places where the Bank Herrings have their spawning grounds. It will be seen therefore, that the mean salinity of the water in the different places in the North Sea where the Bank Herring has its spawning places, lies between 34.0 and 35.2‰. The salinity on the different spawning places for the North Sea Deep Water Herring differs very little from 35.2‰.

The situation of the spawning places of the Autumn Herrings of the German Bight is not known, but as on the whole there is muddy bottom in the small area of the German Bight where the depths are above 40 meters, we must conclude that the spawning places occur at depths below 40 meters. The spawning probably takes place in the period September—October, and perhaps mainly in October. The mean temperature on the sea-bottom at depths from 20—40 meters is in September about 14—16° C, in October 12—13° C. The mean salinity at the same depths is in September—October about 32—34‰. Thus it appears that the temperature is a little higher and the salinity somewhat lower than the values we observed on the spawning places for the Bank Herring of the North Sea.¹⁾

We can now give the following provisional survey of the temperature and salinity at the spawning places for the summer and autumn spawning herrings of the North Sea during the spawning period.

	Temp.° C.	Salinity ‰
The North Sea Deep Water Herring.....	6—9	ca. 35.2
The Bank Herring of the North Sea.....	9—13	34.0—35.2
The Autumn Herrings of the German Bight.....	12—14	32.0—34.0

Thus we see that the morphological differences observed are accompanied by differences regarding temperature and salinity at the spawning places.

XI. On the Differences between the Bank Herring of the North Sea and various other Herring Races in the North Sea and adjacent waters.

It has been shown in the present paper that small differences occur between the Bank Herring of the North Sea and two other groups of summer or autumn spawning herrings occurring in the North Sea, viz. the North Sea Deep Water Herrings, and the Autumn Herrings of the German Bight. In the following will be mentioned some differences observed between the Bank Herring of the North Sea and various other sea herrings occurring in the North Sea or adjacent waters, viz.

¹⁾ An autumn spawning coast herring, of little importance, which has a lower number of vertebrae than the Bank Herring of the North Sea, occurs in the western part of the Lim Fiord, where the mean salinity is about 30—31‰. It would be worth while to investigate whether such autumn spawning coast herrings occur also in other fiords or coastal waters of the North Sea e. g. in The Wash and adjacent waters.

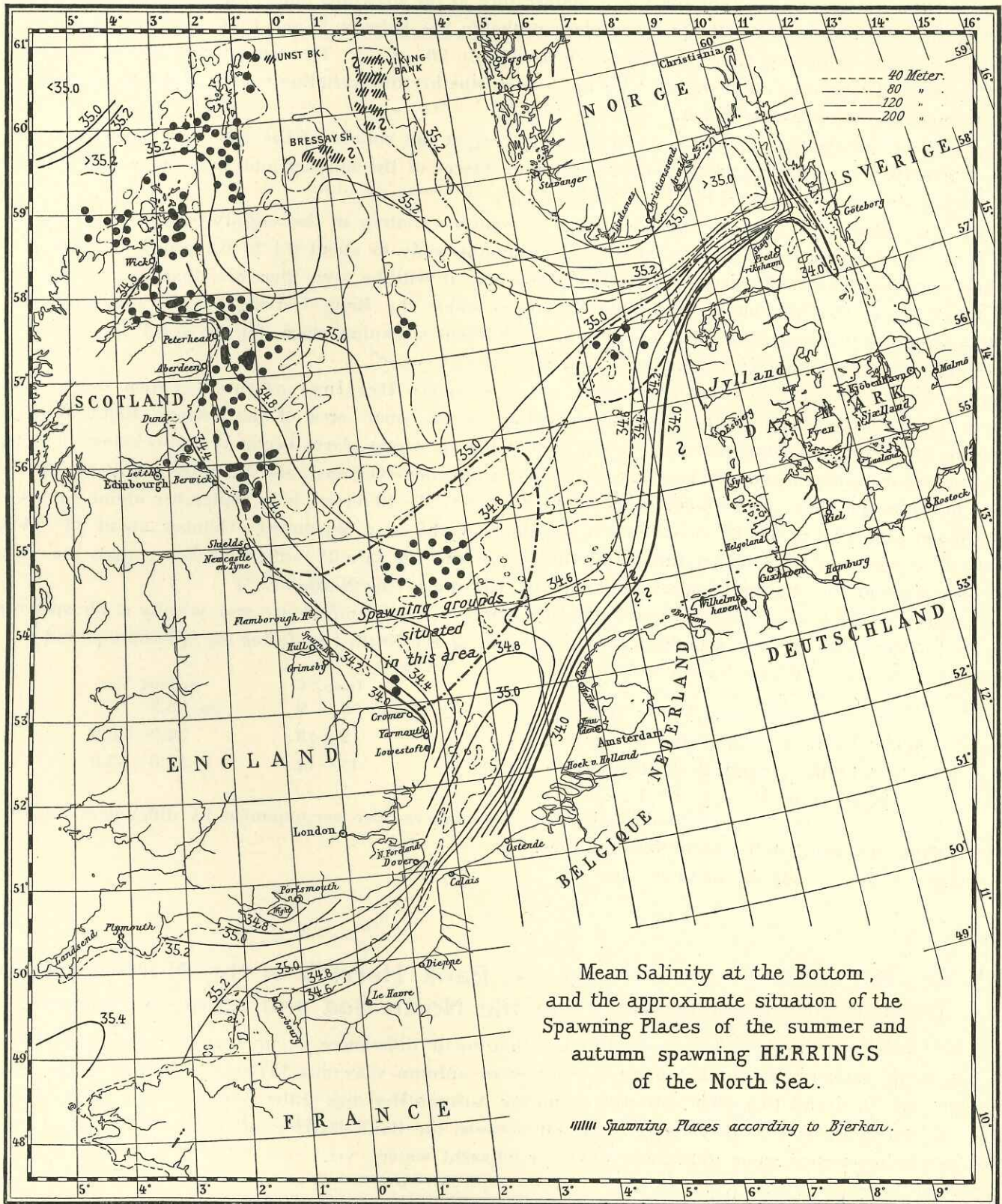


Fig. 10. Mean salinity for the year at the sea bottom, and the approximate situation of the spawning places of the summer and autumn spawning herrings of the North Sea, according to the information available (comp. Chap. IX).

- 1) The autumn spawning herrings of the North Eastern Kattegat (The "Kobbergrund Herrings").
- 2) The winter spawning herrings of the Kattegat.
- 3) The Atlanto-Scandian Herring.
- 4) The Scotch Spring Herring.
- 5) The Channel Sea Herring.
- 6) The West Channel Winter Herring.

A. The Autumn Spawning Herrings of the North Eastern Kattegat (The "Kobbergrund Herrings").

In the north-eastern Kattegat, east of Læsø and east of the plateau between Læsø and Anholt, a considerable herring fishery takes place from the beginning of September until December. From Sweden this fishery is mainly carried out by purse seine, from Denmark mainly by drift-nets. The most important part of the fishery is usually concentrated in the region of the Kobbergrund, Groves Flak, Fladen and Little Middelgrund.

It is not exclusively autumn-spawning herrings which are captured in this area. Winter-spawning and spring-spawning herrings are taken also, and these may form a considerable part of the catch (A. C. Johansen 1923).

HEINCKE has, in "*Naturgeschichte des Herings*" (1898), described a sample of herrings captured in the eastern Kattegat off Varberg on October 10, 1887. The sample comprised 67 specimens of a length from 26—30 cm and of maturity IV—VII. His analysis for the individually constant characters gave the following result:

Vert. S.		Vert. præc.		Vert. caud.		K ₂		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	3	22	2	29	1	13	9	16	10
56	28	23	8	30	4	14	21	17	7
57	24	24	25	31	14	15	20	18	39
58	2	25	13	32	13	16	3	19	1
..	..	26	8	33	20	17	..	..	..
..	..	27	1	34	5	18	1	..	..
<i>n</i>	57		57		57		54		57
<i>m</i>	56.44		24.35		32.09		14.39		17.54
σ	0.66		1.06		1.18		0.96		0.80
σ_m	0.087		0.141		0.157		0.130		0.106
σ_o	0.061		0.099		0.111		0.092		0.075

For 10 specimens only Vert. S. were examined. If we include these we obtain a mean value for Vert. S. of 56.37 ± 0.085 .

The comparatively high number of precaudal vertebrae in connection with a comparatively low number of keeled scales and ventral fin rays is peculiar to this herring.

From Dr. K. A. ANDERSSON I have received a sample of herrings captured by Swedish purse seine fishermen (on October 23, 1915) in the neighbourhood of the Kobbergrund at ca. 57° 08' N. 11° 23' E. The sample consisted of about 300 specimens of the following stages of maturity:

26 specimens of maturity	I—II	(young herrings)
43	II—III	(spring-spawning herrings)
40	V	(winter-spawning herrings)
178	VII	(autumn-spawning herrings)

The sample is described in my previous paper: "Ueber die Winterheringe des Kattegats" 1923.

The 178 specimens of maturity VII were of the following lengths:

cm	♂	♀	♂+♀
21	..	1	1
22	1	..	1
23	2	..	2
24	5	7	12
25	11	11	22
26	10	11	21
27	16	16	32
28	33	15	48
29	11	19	30
30	1	8	9
Total	90	88	178
Aver. length cm ¹	27.49	27.69	27.58

¹ Corrected by adding 0.5.

The analysis gave the following result for the individually constant characters:
Kobbergrund. 23. October 1915. Herrings of Maturity VII.

Vert. S.		Vert. præc.		Vert. caud.		K ₂		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	16	22	3	28	1	13	8	16	43
56	90	23	27	29	7	14	78	17	27
57	66	24	61	30	21	15	66	18	105
58	6	25	50	31	36	16	25	19	3
..	..	26	27	32	59	17	1	..	..
..	..	27	10	33	44	..	..	..	..
..	..	..	..	34	10	..	..	..	..
<i>n</i>	178		178		178		178		178
<i>m</i>	56.35		24.57		31.78		14.62		17.38
σ	0.691		1.14		1.25		0.802		0.870
σ_m	0.052		0.085		0.093		0.060		0.065
σ_σ	0.037		0.060		0.066		0.0425		0.046

The sample at hand has the same racial characters as the sample from Varberg investigated by Heincke. The sample is evidently not a mixture of the North Sea Bank Herring and a smaller autumn spawning Kattegat Herring. Our investigation of the correlation between length and number of vertebrae gives the following result:

Number of vertebrae	Length in cm										Σ_I
	21	22	23	24	25	26	27	28	29	30	
55	..	..	..	1	1	2	3	5	4	..	16
56	..	1	2	8	12	12	12	25	15	3	90
57	1	..	..	3	8	6	16	17	9	6	66
58	..	..	..	..	1	1	1	1	2	..	6
Σ_{II}	1	1	2	12	22	21	32	48	30	30	178

From this we obtain the correlation coefficient $r = 0.041 \pm 0.075$.

Thus the number of vertebrae is practically the same in the smaller as in the larger specimens.

This herring differs in its racial characters distinctly from the North Sea Bank Herring. If we compare the sample from the Kobbergrund with the sample of Scotch Summer Herrings from Balta Sound investigated by me, we obtain the following result:

363 Scotch Summer Herrings (1. Sept. 1921) minus 178 Kobbergrund Herrings (Oct. 23. 1915).

Diff. Vert. S.....	0.15	Standard Dev. of Diff.	0.06
— Vert. præc.....	-0.73	—	—
— Vert. caud.....	0.89	—	—
— K ₂	0.23	—	—
— Ventr. Rays.....	0.35	—	—

It will be seen that considerable differences occur in the number of caudal and precaudal vertebrae as well as in the number of ventral fin rays.

A sample of herrings caught in drift nets at Groves Flak, 57° 08' N. 11° 35' E., on October 7. 1922, consisted almost exclusively of autumn spawners. Four hundred specimens of maturity VI have been investigated. Their lengths were as follows:

cm	♂	♀	♂+♀
20	3	1	4
21	33	8	41
22	55	24	79
23	45	19	64
24	33	14	47
25	37	24	61
26	27	24	51
27	25	13	38
28	4	7	11
29	3	1	4
Total	265	135	400
Aver. length cm ¹	23.77	24.36	23.94

¹ Corrected by adding 0.5.

The distribution of the variants for the individually constant characters was as follows:

No.	Vert. S.	Vert. præc.		Vert. caud.		K ₂		Rays in ventral fins	
	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
52	1	20	1	28	2	13	33	14	3
53	..	22	7	29	4	14	135	15	2
54	1	23	94	30	47	15	176	16	61
55	52	24	158	31	73	16	48	17	42
56	248	25	91	32	145	17	5	18	285
57	93	26	37	33	119	18	3	19	2
58	5	27	10	34	8	..	..	20	3
..	..	28	2	35	2	..	..	..	..
n	400		400		400		400		398
m	56.11		24.23		31.885		14.665		17.56
σ	0.67		1.09		1.11		0.89		0.85
σ _m	0.034		0.055		0.056		0.045		0.043
σ _σ	0.024		0.039		0.039		0.032		0.030

Rays in dorsal fin branched		total	Rays in anal fin branched		unbranched		
No.	Freq.		No.	Freq.	No.	Freq.	
14	39	15	7	12	7	2	8
15	216	16	29	13	37	3	346
16	139	17	155	14	162	4	41
17	4	18	161	15	154	..	..
..	..	19	39	16	33	..	..
..	..	20	4	17	2	..	..
n	398		395		395		395

m	15.27	17.53	14.44	3.08
σ	0.64	0.87	0.86	0.34
σ_m	0.032	0.044	0.043	0.017
σ_o	0.023	0.031	0.031	0.012

Comparing this sample with the sample of 178 herrings from Kobbergrund, 23. Oct. 1915, we obtain the following result:

178 autumn herrings, Kobbergrund, minus 400 autumn herrings, Groves Flak.

Diff. Vert. S.....	0.24	Standard Dev. of Diff.	0.06
— Vert. præc.....	0.34	—	— - — 0.10
— Vert. caud.....	-0.10	—	— - — 0.11
— Keeled scales K_2	-0.05	—	— - — 0.08
— Ventral fin rays.....	-0.18	—	— - — 0.08

The numerical differences are only small, but in case of Vert. S. and Vert. præc. they have a value of 3 to 4 times the standard deviation of the difference.

If we compare the sample from Groves Flak with the sample of Scotch Summer Herrings from Balta Sound, we get the following result:

363 Scotch Summer Herrings, Balta Sound, minus 400 autumn herrings, Groves Flak.

Diff. Vert. S.....	0.39	Standard Dev. of Diff.	0.05
— Vert. præc.....	-0.39	—	— - — 0.07
— Vert. caud.....	0.78	—	— - — 0.075
— Keeled Scales (K_2).....	0.18	—	— - — 0.06
— Ventr. fin rays.....	0.17	—	— - — 0.06
— Branched dorsal rays.....	-0.17	—	— - — 0.05
— Total anal rays.....	-0.42	—	— - — 0.07
— Branched anal rays.....	-0.39	—	— - — 0.065
— Unbranch. anal rays.....	-0.02	—	— - — 0.03

Real differences occur here for almost all characters except for the unbranched anal fin rays.

Having fresh material before me I investigated the state of maturity of about 1000 herrings caught on October 9. 1922 with purse seine by Swedish fishermen E. of Læsø at 57° 12' N. 11° 19' E. The investigation gave the following result:

5 specimens of maturity I	(young herrings)
64 — - — II	(spring-spawning herrings)
44 — - — III	(mainly spring-spawning herrings)
71 — - — IV	(winter-spawning herrings)
c. 500 — - — V, VI	(autumn-spawning herrings)
c. 300 — - — VII	(autumn-spawning herrings)

The specimens of maturity I—IV are described in the paper: "Ueber die Winterheringe des Kattegats" (A. C. Johansen 1923).

Of the herrings of maturity VII, 120 specimens have been analysed. Their lengths were as follows:

cm	♂	♀	♂+♀
21	2	2	4
22	6	13	19
23	11	12	23
24	8	1	9
25	19	11	30
26	10	7	17
27	5	6	11
28	2	3	5
29	..	2	2
Total	63	57	120
Aver. length cm ¹	24.52	24.37	24.45

¹ Corrected by adding 0.5.

The distribution of the variants for the individually constant characters was as follows:

Vert. S.		Vert. præc.		Vert. caud.		K ₂		Rays in ventral fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
53	1	22	3	29	5	12	1	14	1
54	..	23	24	30	8	13	12	15	1
55	18	24	55	31	21	14	49	16	29
56	69	25	23	32	49	15	49	17	15
57	29	26	12	33	34	16	7	18	72
58	3	27	3	34	3	17	1	19	2
..	..	..	..	..	..	18	1	..	..
n	120		120		120		120		120
m	56.12		24.22		31.90		14.47		17.35
σ	0.75		0.98		1.10		0.88		0.95
σ _m	0.068		0.089		0.100		0.080		0.087
σ _σ	0.048		0.063		0.071		0.057		0.061

Rays in dorsal fin branched		total		Rays in anal fin branched		unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
14	5	16	9	13	10	2	1
15	56	17	36	14	41	3	103
16	55	18	52	15	49	4	14
17	3	19	18	16	18	..	..
..	..	20	3	..	..	..	..
n	119		118		118		118
m	15.47		17.75		14.64		3.11
σ	0.62		0.90		0.84		0.34
σ _m	0.057		0.083		0.078		0.031
σ _σ	0.040		0.058		0.055		0.022

It will be seen that no real difference is found to exist between the sample of maturity VII from Læsø (9—10—22) and the sample from Groves Flak (7—10—22).

The samples mentioned above, have not a uniform racial stamp.¹ We shall here compare the mean values found for the main characters investigated:

Locality	Date	No. of specimens	Maturity	Vert. S.	Vert. præc.	Vert. caud.	K ₂	Rays in ventral fins	Branch. dorsal fin rays	Total anal fin rays
Off Varberg	10. 10. 1887	57—67	IV—VII	56.37	24.35	32.09	14.39	17.54		
Kobbergrund	23. 10. 1915	178	VII	56.35	24.57	31.78	14.62	17.38		
Groves Flak	7. 10. 1922	400	VI	56.11	24.33	31.89	14.665	17.56	15.27	17.53
E. of Læsø	9. 10. 1922	120	VII	56.12	24.22	31.90	14.47	17.35	15.47	17.75

It will be seen that the Autumn Herrings of the North Eastern Kattegat differ from the Bank Herring of the North Sea by a lower number of Vertebrae (Vert. S. and Vert. caud.), keeled scales (K₂), fin rays in the ventral fins, and by a higher number of fin rays in anal fin.

¹ In the northern Kattegat a herring race occurs, which is spawning in autumn in shallow water. A sample of 116 specimens probably belonging to this shallow water herring, was picked out by the author from the catch E of Læsø mentioned above. The herrings were of maturity V and their lengths varied from 19 to 28 cm (average 24.5 cm). The mean values found for these specimens were as follows (A. C. Johansen 1923):

Vert. S. = 56.04 ± 0.076 , Vert. præc. = 24.02 ± 0.084 , Keeled Scales (K₂) = 14.77 ± 0.082 , Rays in ventral fins = 17.73 ± 0.074 , Branched dorsal fin rays = 14.94 ± 0.059 , Total anal fin rays = 17.51 ± 0.082 .

It will be noticed that this herring in many respects resembles the Bank Herring of the North Sea but that it differs from it by a lower number of vertebrae.

Still more differing from the Bank Herring of the North Sea are the autumn spawning herrings of the middle and southern Kattegat, the Sound, the Belt Sea and the Baltic (HEINCKE 1898, A. C. JOHANSEN 1915, 1916, 1923). The further we go towards South into the Kattegat and Belt Sea and towards East into the

Baltic, the lower is the number of vertebrae and the number of keeled scales, and the smaller are the herrings at first maturity.

We have seen above that the autumn herrings from the northern Kattegat are different from the Bank Herring of the North Sea. It will now be of interest to investigate whether differences also occur in the temperature or the salinity on the spawning places for the two groups of herrings.

We have at hand only a few direct observations of eggs of the autumn herrings deposited on the sea bed in the north eastern Kattegat. TRYBOM has found the herring eggs at the sea bed at Groves Flak and at Fladen (EKMAN, PETTERSSON and TRYBOM 1907). At the western side of Groves Flak at ca. 23 meters depth we have taken, by haul with a dredge, herring eggs attached to the alga *Desmarestia*. ("Dana" St. 2881. October 7. 1922, 57°05'5 N. 11°32' E.). With the research vessel "Thor" (St. 307 October 28. 1904) we had previously taken herring eggs from algae on the slope between the Kobbergrund and Anholt. The position of the station is 57°01' N. 11°34' E. and the depth 24—40 meters. In this particular area — around Fladen and Groves Flak and east of Kobbergrund — an important fishery of ripe herrings takes place in September and October and of spent herrings in October and November. Considerable captures of young herring fry have also been made here in autumn by the Danish research vessels (Figs. 1—2). There is therefore no doubt that important spawning places for the "Kobbergrund Herrings" occur here.

Only a few direct observations of the temperature and salinity at the spawning places of the "Kobbergrund Herrings" are available. On the station "Dana 2881" at Groves Flak October 7. 1922, mentioned above, the temperature was 13° C. and the salinity 33.3‰ at the depth of 23 meters from which the herring eggs were taken. At "Thor

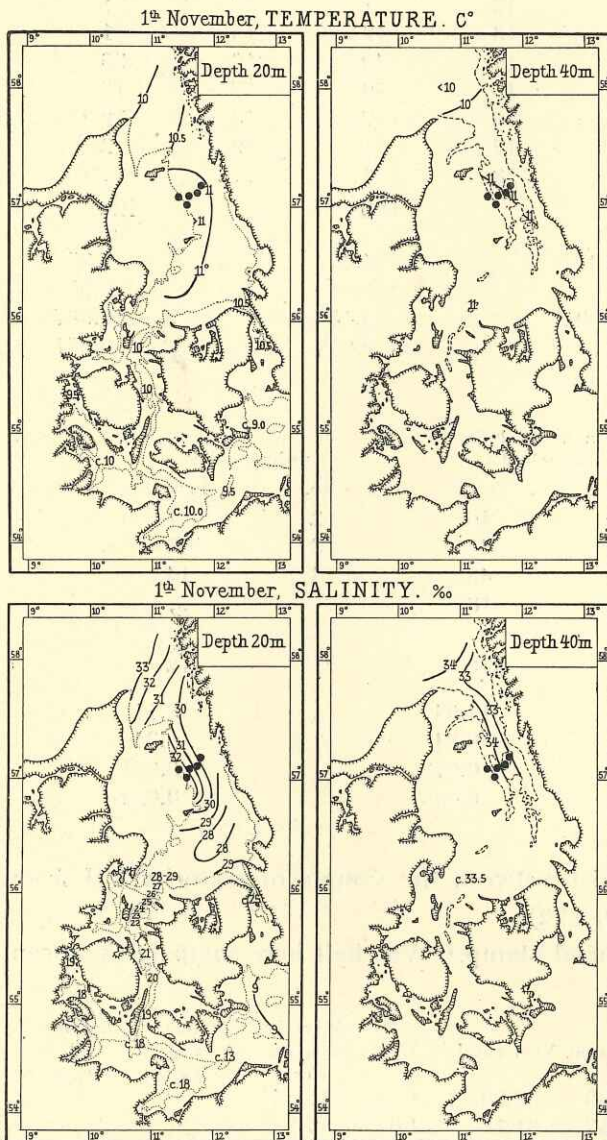


Fig. 11. Mean temperature and salinity in the Kattegat on November 1st and the position of the observed spawning places for the Autumn Herrings of the North Eastern Kattegat. (Temperature and Salinity after J. P. Jacobsen 1908).

St. 307", in the neighbourhood of Kobbergrund, the temperature on October 28. 1904 was about 12° C. and the salinity about 34‰ within the depths from which the herring eggs were taken (24—40 m.)

For further information we will refer here to Fig. 11 showing the situation of some spawning places and the mean values for the temperature and salinity in Kattegat for November 1st, at 20 and at 40 meters depths. It will be seen that the salinity in the neighbourhood of the spawning places varies from about 29—32 pro mille at 20 meters depth, and from 33—34 pro mille at 40 meters depth. During the main spawning time in September and the beginning of October, the salinity is 0.2—0.5 pro mille lower. The

temperature is approximately 11° C. in November at 20 and 40 meters depth, but in the previous month, during the main spawning time, it is about 12—13° C at 20 meters depth.

Thus it will be seen, that the salinity at the spawning places of the "Kobbergrund Herrings" in the north-eastern Kattegat may be estimated to be about 29—34 pro mille, while the salinity at the spawning places for the Bank Herring of the North Sea is about 34.0—35.2 pro mille. As regards the temperature no difference is observed.

As mentioned above the "Kobbergrund Herrings" have not a uniform racial stamp. In this connection it should be noted that the salinity in the Eastern Kattegat varies greatly with the depth, and that herrings spawning in the same area, but at different depths, are spawning in water of different salinity.

B. The Winter Spawning Herrings of the Kattegat.

Morphological differences between the Bank Herring of the North Sea and the winter spawning herrings of the Kattegat are pointed out by the author (1923). The principal differences are here found in the total number of vertebrae, the number of keeled scales (K_2), the number of fin rays in the ventral fins, and the number of rays in the anal fin, as will appear from the survey of the mean values stated below:

	Bank Herring of the North Sea	Winter Herrings of the Kattegat
Total number of vertebrae	56.50 ± 0.05	56.83 ± 0.04
Number of keeled scales (K_2)	14.85 ± 0.07	{ 14.20 ± 0.10 ¹ 14.70 ± 0.10 ¹
Number of fin rays in ventr. fins	17.75 ± 0.05	17.95 ± 0.03
Number of fin rays in anal fin	17.20 ± 0.10	17.77 ± 0.12

The spawning period for the Winter Herrings of the Kattegat is January, February and March. The salinity on the spawning places varies probably from about 29 to 34‰, and the temperature from about 4 to 5° C. (A. C. JOHANSEN 1923).

C. The Atlanto-Scandian Herring.

The Atlanto-Scandian Herring comprises the Norwegian Spring Herring and the Icelandic Spring Herring, both of which reach a much larger size than the Bank Herring of the North Sea.

Morphological differences between the large Atlanto-Scandian Herring and the Bank Herring have previously been demonstrated by the author (1919) and were partly pointed out formerly by HEINCKE (1898) and BROCH (1908). The difference is particularly great in the case of the total number of vertebrae, the number of anal fin rays and the number of keeled scales (K_2). For these three characters the difference has a numerical value of about 1.0, the average being highest regarding the last characters and lowest regarding the two first characters for the Bank Herring of the North Sea.

The spawning period for the Atlanto-Scandian Herring is February, March and April. The salinity on the spawning places varies from about 33 to 35.2‰, and the temperature varies probably from about 4 to 7° C.

D. The Scotch Spring Herring.

The Scotch Spring Herring has been the object of racial investigations by HEINCKE (1898), who found that morphological differences exist between this herring and the summer spawning herring of Scotland etc.

The spawning period for the Scotch Spring Herring is January, February, March and April, and spawning grounds occur both off the west coast, the north coast, and the east coast of Scotland (BOWMAN 1923).

¹ Two different groups.

HEINCKE investigated 30 full herrings caught in February 1892, on Ballantrae Bank (S. W. Scotland), which is a well known spawning ground. Their lengths and state of maturity were as follows:

Length cm	Maturity		
	IV	V	VI
23	..	2	..
24	..	6	1
25	..	6	1
26	1	3	1
27	1	2	1
28	..	2	..
29	..	2	..
31	..	1	..
Total	2	24	4

The state of maturity leaves no doubt that the specimens were spring spawners. The distribution of the variants for the individual constant characters examined was as follows:

Vert. S.		Vert. præc.		K ₂		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
54	1	22	1	13	7	17	1
55	2	23	4	14	13	18	29
56	5	24	16	15	9	..	..
57	16	25	7	16	1	..	..
58	6	26	2	..	..	..	..
<i>n</i>	30		30		30		30
<i>m</i>	56.80		24.17		14.13		17.97
σ	0.96		0.87		0.82		0.17
σ_m	0.18		0.16		0.15		0.03
σ_o	0.12		0.11		0.11		0.02

HEINCKE made a racial study upon 31 badly preserved herrings caught at Barra (the Hebrides) on July 7. 1891. The specimens had a length from 23—31 cm. The main part of the sample were spring spawners of maturity II or VII, and HEINCKE observed the following distribution of the variants for vertebrae etc.:

Vert. S.		Vert. præc.		K ₂		Rays in ventr. fins	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	7	22	1	12	1	15	1
57	17	23	4	13	3	16	..
58	6	24	18	14	19	17	2
..	..	25	6	15	6	18	25
..	..	26	1	16	1	19	2
<i>n</i>	30		30		30		30
<i>m</i>	56.97		24.07		14.10		17.90
σ	0.67		0.79		0.76		0.66
σ_m	0.12		0.14		0.14		0.12
σ_o	0.09		0.10		0.10		0.09

HEINCKE investigated 30 herrings of 245—293 mm caught in the Firth of Forth in January 1892. He found the state of maturity as follows:

Length cm	Maturity				
	III	IV	V	V-VI	VI
24	..	..	1	..	1
25	1	1	4	1	..
26	..	..	4	..	3
27	..	..	5	4	..
28	..	..	3	..	..
29	..	..	2	..	..
<i>n</i>	1	1	19	5	4

There can be no doubt that all these specimens were spring spawners. The distribution of the vertebrae etc., found by HEINCKE, was as follows:

No.	Vert. S.	Vert. præc.		K ₂		Rays in ventr. fins	
	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	7	24	11	13	4	17	1
57	21	25	14	14	15	18	27
58	2	26	5	15	8	19	..
..	..	..	..	16	3	20	2
<i>n</i>	30		30		30		30
<i>m</i>	56.83		23.80		14.33		18.10
σ	0.53		0.71		0.85		0.55
σ_m	0.10		0.13		0.15		0.10
σ_o	0.07		0.09		0.109		0.07

It will be seen that the three samples of spring spawners mentioned here all differ from the Bank Herring of the North Sea by having a greater number of vertebrae (Vert. S.) and of ventral fin rays, but a smaller number of keeled scales.

The samples investigated by HEINCKE seemed to have a rather uniform racial stamp.

As the view of HEINCKE about the differences between the spring spawners and summer spawners of Scotland etc. has been opposed by other authors, as MATTHEWS (1886—87) and JENKINS (1902), I found it desirable to undertake a comparison again between spring- and autumn spawners based on new material, and Mr. D. T. JONES has been kind enough to procure such material for me.

A sample of spring spawners, which I received from Mr. JONES, was caught 12 miles west of Cape Wrath (N. Scotland) on March 5, 1923. The lengths of the specimens varied from 26—32 cm, the average size being 29.9. Most of the specimens were of maturity VI, a few of maturity V and VII. The distribution of the variants for the individually constant characters examined was as follows:

No.	Vert. S	Vert. præc.		Vert. caud.		K ₂	
	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
56	32	23	56	31	14	12	4
57	174	24	128	32	60	13	71
58	60	25	71	33	123	14	143
59	4	26	14	34	68	15	48
..	..	27	1	35	5	16	4
<i>n</i>	270		270		270		270
<i>m</i>	57.13		24.17		32.96		13.91
σ	0.62		0.83		0.87		0.74
σ_m	0.038		0.050		0.053		0.045
σ_o	0.027		0.036		0.037		0.032

Ventral Fin Rays		Dorsal Fin Rays Branched		Total		Anal Fin Rays Branched		Unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
15	1	13	1	16	11	13	12	..	..
16	..	14	29	17	46	14	56	2	4
17	9	15	151	18	128	15	140	3	222
18	247	16	84	19	76	16	57	4	44
19	9	17	2	20	8	17	5	..	..
20	2	..	..	21	1	..	..	..	..
<i>n</i>	268		267		270		270		270
<i>m</i>	18.00		15.21		18.10		14.95		3.15
σ	0.36		0.65		0.87		0.82		0.40
σ_m	0.022		0.040		0.053		0.050		0.024
σ_o	0.016		0.028		0.037		0.035		0.017

The racial characteristics of the Scotch Summer Herring are known from analyses of HEINCKE, BROCH and REDEKE and the author (see Chap. II and III). The largest sample examined is that from Balta Sound investigated by me. Comparing the Spring Spawners from Cape Wrath with the Summer Spawners from Balta Sound we obtain the following result:

363 Shetland Summer Herrings, Balta Sound, minus 270 Scotch Spring Herrings, Cape Wrath:

Diff.	Vert. S.		Standard Dev.	of Diff.
—	Vert. S.	—0.63	—	0.05
—	Vert. præc.	—0.33	—	0.07
—	Vert. caud.	—0.29	—	0.07
—	K_2	0.94	—	0.06
—	Ventr. fin. rays	—0.27	—	0.04
—	branch. dorsal rays	—0.11	—	0.05
—	total anal fin rays	—1.00	—	0.07
—	branch. anal fin rays	—0.91	—	0.07
—	unbr. anal fin rays	—0.09	—	0.03

It will be seen that for almost all characters there are essential differences between the samples, and these are especially great in the case of Vert. S., K_2 and anal fin rays.

For the characters treated by Heincke (Vert. S., K_2 and Rays in ventral fins) I have observed differences of at least the same magnitude as he has found.

The Shetland Spring Herring has a similar racial stamp as the Scotch Spring Herring from Cape Wrath investigated by me. A sample caught on March 21, 1923, 9 miles North of Flugga, consisted of 300 specimens of maturity VII, the lengths of which varied from 25—33 cm, average 29.6 cm. The distribution of the variants for the individually constant characters was as follows:

No.	Vert. S.		Vert. præc.		Vert. caud.		K_2	
	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
55	2	22	1	29	1	12	6	
56	40	23	39	30	6	13	89	
57	197	24	129	31	23	14	165	
58	57	25	95	32	102	15	39	
59	4	26	32	33	112	16	1	
..	..	27	3	34	32	..	..
..	..	28	1	35	4	..	..
<i>n</i>	300		300		300		300	
<i>m</i>	57.07		24.44		32.63		13.80	
σ	0.63		0.92		0.99		0.69	
σ_m	0.036		0.053		0.057		0.040	
σ_o	0.026		0.037		0.040		0.028	

Ventral Fin Rays		Dorsal Fin Rays		Total		Anal Fin Rays		Unbranched	
No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
16	3	14	35	16	1	13	5	..	..
17	8	15	164	17	55	14	68	3	251
18	279	16	96	18	150	15	153	4	49
19	5	17	3	19	83	16	71	..	..
20	4	..	..	20	11	17	3	..	..
<i>n</i>	299		298		300		300		300
<i>m</i>	18.00		15.22		18.16		15.00		3.16
σ	0.37		0.66		0.77		0.76		0.37
σ_m	0.021		0.038		0.045		0.044		0.021
σ_σ	0.015		0.027		0.032		0.031		0.015

Comparing this sample with the spring herring from Cape Wrath we obtain the following figures:
270 Scotch Spring Herrings, Cape Wrath minus 300 Shetland Spring Herrings, Flugga.

Diff. Vert. S.....	0.06	Standard Dev. of Diff.	0.05
— Vert. præc.	-0.27	—	—
— Vert. caud.	0.33	—	—
— Keeled Scales K_2	0.11	—	—
— branch. dorsal fin rays	-0.01	—	—
— total anal fin rays.....	-0.06	—	—
— branch. anal fin rays	-0.05	—	—
— unbr. anal fin rays	-0.01	—	—

It will be seen that there is a small difference in the distribution of the caudal and precaudal vertebrae, while all the other characters agree very closely.¹

If we compare the Shetland Summer Herring from Balta Sound with the Shetland Spring Herring from Flugga we obtain the following result:

363 Shetland Summer Herrings, Balta Sound, minus 300 Shetland Winter Herrings, Flugga.

Diff. Vert. S.....	-0.57	Standard Dev. of Diff.	0.05
— Vert. præc.	-0.60	—	—
— Vert. caud.	0.04	—	—
— Keeled scales K_2	1.05	—	—
— Ventral fin rays	-0.27	—	—

¹ The distribution of the specimens according to age agreed very closely in the two samples. In both samples the great majority of the specimens belonged to the year class 1918 (see p. 115).

It appears from the survey below that the Shetland Spring Herring (and therefore the Scotch Spring Herring) does not differ much from the summer-spawning Herring of Iceland examined by me (A. C. Johansen 1921 a):

477 summer herrings S. W. Iceland minus 300 spring herrings from the Shetland Isles:

Diff. Vert. S.....	-0.02	Standard dev. of Diff.	0.05
— Vert. præc.	0.24	—	—
— Vert. caud.	-0.26	—	—
— Keeled scales (K_2).....	-0.22	—	—
— Ventral fin rays.....	-0.09	—	—
— branch. dorsal fin rays	0.01	—	—
— total anal fin rays	-0.01	—	—
— branch. anal fin rays.....	0.07	—	—
— unbr. anal fin rays	-0.08	—	—

A sample of young herrings caught at Kongshavn, the Faroes (16—8—19) and described by me (A. C. Johansen 1921 a) is also in near agreement with the Scotch and Shetland Spring Herring.

We have evidently a group of North East Atlantic Spring and Summer Herrings, occurring at Scotland, Shetland Isles, the Faroes and South and West Iceland, which are very near related to each other and may belong to one single race. This race differs from the Atlanto-Scandian Herring by a lower number of Vertebrae (Vert. S.).

Diff. branch. dorsal fin rays.....	-0.12	Standard Dev. of Diff.	0.05
— total anal fin rays.....	-1.05	—	—
— branch. anal fin rays.....	-0.95	—	—
— unbr. anal fin rays.....	-0.10	—	—

For almost all characters there are essential differences between the samples. The greatest numerical differences occur in the number of keeled scales and the total number of anal fin rays where it exceeds 1.0.

The spawning places for the Scotch Spring Herring and the Shetland Spring Herring are probably situated at a depth of about 20 to 150 meters (comp. EWART 1884 and BOWMAN 1923). The temperature in February and March varies here from about 5 to 8° C., and the salinity at least from 34.3 to 35.3‰.

E. The Channel Sea Herring.

The winter spawning Herring of the Channel and the south-western corner of the North Sea has been subjected to special race-studies by SAUVAGE et CANU (1892), CLIGNY (1904), DELSMAN (1913) and REDEKE (1918).

CLIGNY (1904) has investigated the number of vertebrae of 125 winter spawning herrings captured in the southern part of the Channel in the neighbourhood of Cap d'Antifer in the winter of 1901—02.

The distribution of the variants was as follows:

Vert. S.		Vert. præc.	
No.	Freq.	No.	Freq.
55	7	23	5
56	48	24	33
57	62	25	58
58	8	26	19
..	..	27	2
..	..	28	2
<i>n</i>	125		119
<i>m</i>	56.57		23.88
σ	0.70		0.90
σ_m	0.063		0.083
σ_σ	0.044		0.059

SAUVAGE et CANU have examined the number of keeled scales of 416 winter spawning herrings captured in the neighbourhood of Boulogne in November—December 1892.

The distribution of the variants was as follows (CLIGNY 1904):

No.	12	13	14	15	16	17
Freq.	3	75	192	117	27	2

From this we get: $m = 14.23$, $\sigma = 0.86$, $\sigma_m = 0.042$ and $\sigma_\sigma = 0.030$.

Of the 416 specimens, 282 were investigated by CANU and 134 by SAUVAGE. The mean values for these groups were 14.3 and 14.1 respectively.

According to CLIGNY the herring captured in autumn near Boulogne belongs to the same race as the herring captured in January—March near Cap d'Antifer.

DELSMAN (1913) investigated 96 herrings of maturity III—V landed in Yarmouth on October 24, 1910. The lengths varied from 21—29 cm, and the average length was 25.5 cm. The number of vertebrae (Vert. S.) in 50 specimens was as follows:

No.	55	56	57	58
Freq.	1	24	24	1

Thus we get: $m = 56.50$, $\sigma = 0.58$, $\sigma_m = 0.082$ and $\sigma_\sigma = 0.058$.

REDEKE has investigated 100 herrings of maturity III, IV (VI) and of lengths from 230—300 mm captured at station H8 (ca. 52° 39' N. 2° 30' E.) on November 5/6 1905.

The distribution of the variants for vertebrae etc. was as follows:

No.	Vert. S.		No.	K ₂		Rays in ventr. fins	
	Freq.			Freq.		No.	Freq.
54	2		12	1	14	1	
55	7		13	11	15	0	
56	37		14	59	16	3	
57	42		15	29	17	12	
58	11		..	..	18	84
59	1		..	..	..	..
<i>n</i>	100			100		100	
<i>m</i>	56.56			14.16		17.78	
σ	0.89			0.65		0.60	
σ_m	0.089			0.065		0.060	
σ_σ	0.063			0.046		0.042	

REDEKE investigated 100 herrings of maturity (III) IV—V and of a length of 214—290 mm captured at 52° 43.5' N. and 2° 50' E. in November 15/30 1905. The variants are distributed in the following way:

No.	Vert. S. ¹		No.	K ₂		Rays in ventr. fins	
	Freq.			Freq.		No.	Freq.
54	1		13	6	16	2	
55	3		14	53	17	7	
56	37		15	38	18	91	
57	50		16	3	..	..
58	9		..	..	..	..
<i>n</i>	100			100		100	
<i>m</i>	56.63			14.38		17.89	
σ	0.73			0.65		0.37	
σ_m	0.073			0.065		0.037	
σ_σ	0.052			0.046		0.026	

It will be seen that these samples have the same number of vertebrae and keeled scales as the herrings from the Channel investigated by CLIGNY, CANU and SAUVAGE. In the number of vertebrae, as well as in the number of keeled scales, the difference is less than twice the standard deviation of the difference. REDEKE also was of the opinion that these samples belonged to the Channel Herring or to the same race as the samples investigated by CLIGNY, CANU and SAUVAGE.

The Channel Sea Herring has evidently a lower number of keeled scales than the North Sea Bank Herring.² If we compare the 363 Shetland Herrings investigated by me with the 416 Channel Herrings in-

¹ Dr. REDEKE has kindly informed me, that the Vertebrae in this sample have been counted according to Orton's method, i. e. with the omission of the urostyle. Here, as in the other cases, the urostyle has been counted as one Vertebra.

² REDEKE investigated 25 herrings caught in the south western part of the North Sea at 53° 06' N. and 3° 0' E. on November 7th 1906. The specimens were of an average length of 25.0 cm, and the maturity stage was III or IV for 22 specimens and VII for 3 specimens. It thus appears that we have to do mostly with herrings which spawn in winter and in a few cases with herrings spawning in autumn. The mean values found were as follows:

	Vert. S.	Vert. præc.	K ₂	Rays in ventr. fins
<i>m</i>	56.56	23.84	15.00	17.84
σ	0.71	0.90	1.00	0.75
σ_m	0.14	0.18	0.20	0.15
σ_σ	0.10	0.13	0.14	0.11

Peculiar to this small sample is the high number of keeled scales, which agrees with that of the Bank Herring. The 3 herrings of maturity VII, which may have spawned in October or November, had respectively 15, 15 and 14 keeled scales, and therefore not a higher number than the specimens of maturity III and IV. We can not expect that the specimens of maturity III and IV would have spawned earlier than December. There seems to be a possibility that the sample belongs to a late spawning branch of the Bank Herring, and not to the Channel Herring.

investigated by CANU and SAUVAGE, we obtain a difference of 0.62, the standard deviation of the difference being 0.06. The difference between the number of keeled scales in the Channel Sea Herring and in the Dogger Bank Herring is probably still greater. If we compare the 416 Channel Herrings with the 65 Dogger Bank Herrings investigated by REDEKE (see p. 15), we obtain a difference of 0.80 with a standard deviation of the difference of 0.11. The Channel Sea Herring has possibly also a little higher number of vertebrae than the North Sea Bank Herring. Of the Channel Sea Herring, 375 specimens had an average number of vertebrae of 56.57, while 803 mature Bank Herrings from various parts of the North Sea had an average number of vertebrae of 56.50.

The spawning period for the Channel Sea Herring is December, January and February. Important spawning places are situated in the eastern part of the Channel. According to REDEKE and VAN BREEMEN (1908) spawning places probably occur also in the North Sea near the entrance of the Channel. BORLEY and RUSSELL (1922) are of opinion that a large spawning ground for herrings spawning late in the season occurs in the neighbourhood of Smith's Knoll (see p. 27 of this paper).

The mean temperature on the spawning places is in January about 7—9° C., and in February 6—8° C. The salinity varies from about 34.4‰ to 35.3‰.

The temperature on the spawning places is for the Channel Sea Herring about the same as for the North Sea Deep Water Herring, and the morphological differences between these two groups of herrings also seem to be very small. The mean figures available for vertebrae, keeled scales and fin rays in ventral fins for the two races are as follows:

	Channel Sea Herring	North Sea Deep Water Herring
Vert. S.	56.57 ± 0.04 (375 spec.)	56.73 ± 0.07 (130 spec.)
Vert. præc.	23.88 ± 0.08 (119 —)	23.63 ± 0.07 (130 —)
K ₂	14.24 ± 0.035 (616 —)	14.41 ± 0.07 (130 —)
Ventral fin rays	17.83 ± 0.04 (200 —)	17.76 ± 0.12 (36 —)

F. The West Channel Winter-Herring.

The winter spawning herring which occurs in the western part of the English Channel, has been made the subject of race-studies by the Biological Laboratory at Plymouth, and Dr. J. H. ORTON has published the results of the investigations in an important treatise: "An account of the Researches on Races of Herrings" (1916).

The samples examined were caught off Plymouth in December 1914 and January 1915. The lengths of the specimens varied from 22—28 cm, and the state of maturity was in most cases IV, V or VI, and in some cases III and VII. The spawning period for this herring is December, January and February.

The survey below, which is constructed on the basis of ORTON's tables, shows the distribution of the variants for the individually constant characters examined in about 1000 specimens of maturity III—VI.

	Vert. S.		Vert. præc.		K ₂	
	No.	Freq.	No.	Freq.	No.	Freq.
55	13		22	23	12	1
56	295		23	356	13	39
57	626		24	502	14	335
58	85		25	130	15	533
59	2		26	10	16	106
..	..		..	..	17	6
..	..		..	..	18	1
<i>n</i>	1021		1021		1021	
<i>m</i>	56.77		23.753		14.71	
<i>σ</i>	0.63		0.738		0.74	
<i>σ_m</i>	0.019		0.023		0.023	
<i>σ_σ</i>	0.014		0.016		0.016	

Unbranched		Rays in dorsal fin Branched		Total	
No.	Freq.	No.	Freq.	No.	Freq.
2	35	13	1	16	1
3	753	14	22	17	12
4	202	15	251	18	185
..	..	16	549	19	550
..	..	17	166	20	235
..	..	18	1	21	7
<i>n</i>	990		990		990
<i>m</i>	3.169		15.869		19.037
σ	0.460		0.712		0.714
σ_m	0.015		0.023		0.023
σ_o	0.010		0.016		0.016

Unbranched		Rays in anal fin Branched		Total	
No.	Freq.	No.	Freq.	No.	Freq.
1	3	12	10	14	1
2	62	13	146	15	11
3	767	14	457	16	130
4	157	15	314	17	421
5	1	16	61	18	334
..	..	17	2	19	91
..	..	..	..	20	2
<i>n</i>	990		990		990
<i>m</i>	3.092		14.279		17.371
σ	0.479		0.832		0.878
σ_m	0.015		0.026		0.028
σ_o	0.011		0.019		0.020

We shall now compare the sample of "Plymouth Herrings" investigated by ORTON and the sample of North Sea Bank Herring from the Shetland Isles investigated by me.

Plymouth Winter-Herring (ORTON) minus North Sea Bank Herring from Balta Sound (Johansen).

Diff. Vert. S.	+ 0.27	Standard deviation of Difference	0.042
— Vert. præc.	— 0.08	—	0.051
— Vert. caud.	+ 0.35	—	c. 0.05
— K_2	— 0.14	—	0.051
— Dorsal, branched	+ 0.77	—	0.042
— Anal, unbranched	+ 0.04	—	0.027
— Anal, branched	+ 0.23	—	0.055
— Anal, total	+ 0.27	—	0.057

It will be noticed that we are dealing here with a real difference both in the number of vertebrae and in the number of dorsal and anal fin rays. The West Channel Winter Herring has a higher number of vertebrae and of dorsal and anal fin rays than the Bank Herring from the Shetland Isles. It will be seen from the survey below that the Plymouth Herring differs from the Channel Sea Herring in having a higher number of keeled scales and also a higher number of vertebrae.

1021 Plymouth Winter-Herrings (ORTON) minus 416 Channel Sea Herrings (CANU).

Difference $K_2 = 0.48$. Standard deviation of Difference 0.048.

1021 Plymouth Winter-Herring (ORTON) minus 125 Channel Sea Herring, Cap d'Antifer (CLIGNY).

Difference Vert. S. = 0.20. Standard deviation of Difference 0.066.