FiskDir. Skr. Ser. HavUndersøk., *14*: 183—198.

RELATION BETWEEN THE NORWEGIAN SPRING-SPAWNING STOCK AND THE SPRING-SPAWNING GROUP OF HERRING IN THE NORTH-EASTERN NORTH SEA

By
STEINAR HARALDSVIK
Institute of Marine Research, Bergen

INTRODUCTION

It has been stated by several workers (BROCH 1909, BJERKAN 1917, JOHANSEN 1924, KREFFT 1954) that the north-eastern North Sea is a mixing area for spring- and autumn-spawning groups of herring. Early in this century spring-spawners dominated the catches from this part of the North Sea during spring, summer and autumn (BJERKAN 1917). In recent years, however, the spring-spawners have been in majority only during the short seasons from late July to early September (HARALDSVIK 1966 a) while the autumn-spawners have dominated the rest of the year.

The spring-spawning group in the northern North Sea is suggested to be a mixed population of Shetland spring-spawners (WOOD 1936), Viking Bank spring-spawners (RUNNSTRØM 1941), Skagerak spring-spawners (ANDERSSON 1949) and Norwegian spring-spawners. The occurence of Norwegian spring-spawners in the northern North Sea has been demonstrated by morphological characters (BROCH 1909, HJORT and LEA 1911, BJERKAN 1917) and by tagging experiments (AASEN 1953).

Since 1960 herring in prespawning condition have arrived at the west coast of southern Norway in January, spawned in inshore waters in March and April, and disappeared again in May. In length, age and scale type these herring differ from herring at the spawning grounds further north, and it has been suggested that the southern herring were originating from the North Sea.

This report presents some results of an investigation carried out on spring-spawning herring in the north-eastern North Sea during the years 1961—63. An attempt is also made to detect from analysis of racial characters the admixture of the two stocks of spring-spawning herring which occur along the coast of Norway.

MATERIAL AND METHODS

Twentythree samples were collected from September 1961 to May 1963, comprising a total of 3825 specimens. Most of the material originate from commercial catches, but 6 samples were collected on-board research vessels.

Table 1. Sampling localities and composition of spring- and autumn-spawners in the samples (%) from north-eastern North Sea, 1961—63.

Sample number	Date	Gear	Locality	Spring spawners	Autumn spawners	Uncertain	N
1	11/9 —61	Trawl	N 59°00 E 03°00	11.3	84.1	4.5	88
2	24/9 —61	Trawl	N 58°55 E 03°09	9.0	86.0	5.0	100
3	16/10 —61	Trawl	N 59°20 E 03°00	11.0	86.5	2.5	200
4	19/12 —61	Trawl	N 59°00 E 03°00	13.5	82.0	4.5	200
5	19/12 —61	Trawl	N 59°08 E 03°10	19.0	76.0	5.0	200
6	19/1 —62	Trawl	N 58°07 E 04°36	18.4	78.4	3.2	250
7	20/1 —62	Trawl	N 59°00 E 03°30	24.4	72.0	3.6	250
8	1/3 —62	Drift	N 59°45 E 03°35	44.7	50.5	4.7	190
9	24/3 —62	Trawl	N 60°20 E 01°50	4.6	89.3	6.1	197
10	6/5 —62	Drift	N 58°01 E 05°15	22.0	61.0	17.0	100
11	7/5 —62	Drift	N 57°42 E 05°55	16.7	68.7	14.7	150
12	22/5 —62	Trawl	N 60°00 E 03°20	15.0	83.0	2.0	100
13	7/6 —62	Trawl	N 59°00 E 03°34	15.3	81.3	3.3	150
14	27/7 —62	Trawl	N 59°45 E 00°16	70.7	24.7	4.7	150
15	28/8 —62	Drift	N 57°55 E 04°50	55.3	26.0	18.7	150
16	3/9 —62	Trawl	N 59°47 E 01°35	78.0	17.5	4.5	200
17	25/9 —62	Drift	N 58°06 E 05°14	19.0	76.0	5.0	100
18	9/10 —62	Drift	N 57°50 E 05°40	45.3	50.0	4.7	150
19	28/11 —62	Drift	N 57°43 E 05°22	20.0	72.5	7.5	200
20	22/1 —63	Trawl	N 58°40 E 03°40	23.0	66.0	11.0	200
21	20/2 —63	Trawl	N 58°20 E 04°04	15.5	81.0	3.5	200
22	23/3 —63	Trawl	N 60°05 E 03°30	3.0	90.5	6.1	200
23	3/5 —63	Purse-seine	N 60°28 E 04°18	11.0	82.0	7.0	100
Total				25.0	68.8	6.2	3 825

Otolith characters were used to separate spring-spawning herring from autumn-spawners (PARRISH and SHARMAN 1958). This procedure left 956 spring-spawners to be studied.

Sampling localities, gears and the proportion of spring- and autumn-spawners in the samples are given in Table 1.

The samples from the spring-spawning stock on the west coast of southern Norway were collected to the west and south of Bergen during March and April 1962 and 1963.

Four samples from east Icelandic waters during July and August 1962 have also been investigated. The members of the Norwegian spring-spawning stock in these samples were separated from the Icelandic spring- and summer-spawning herring by scale characters.

All the herring were examined as to age and stage of maturity. Stage of maturity were determined according to the maturity scale recommended in 1962 by the ICES Herring committee (ANON. 1963).

Both scales and otoliths were used for age determinations. Secondary rings within the summer growth zones, transparency of otoliths and regenerated scales sometimes complicated the determinations or made readings impossible. In the samples from trawl and drift-net several specimens had lost all scales suitable for age readings. Therefore, ages could only be determined from 55 per cent of the scales and from 85 per cent of the otoliths. However, considering the two methods together, positive age determinations were achieved for about 90 percent of the total material.

Number of vertebrae, first growth zone measurement on otoliths and l_1, l_2 and l_3 lengths were determined for part of the material.

The first growth zone in otoliths was measured from the centre of the opaque nucleus, along an axis to the post-rostrum to the distal edge of the first winter-ring.

The growth of the herring was estimated from scales applying the modified growth formula by LEA (1938).

RESULTS AND DISCUSSION

AGE COMPOSITION

The samples of spring herring from the north-eastern North Sea have been grouped into periods of 4 months and the age compositions are illustrated in Fig. 1. The ages ranged from 1 to 12 years, but with a strong dominance of the younger year-classes. The 1959 year-class was dominant in 1961 and 1962. In 1963, however, it was replaced by the 1961 year-class. The reduction of the 1959 year-class

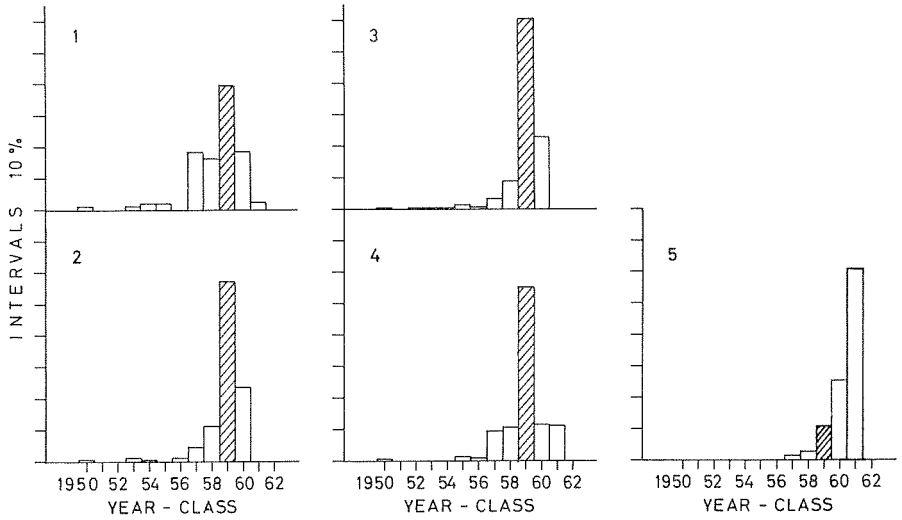

Fig. 1. Age composition of spring-spawning herring from north-eastern North Sea, 1961—63.
1) Sept.—Dec. 1961, N = 94,
2) Jan.—April 1962, N = 194,
3) May—Aug. 1962, N = 253,
4) Sept.—Dec. 1962, N = 234,
5) Jan.—May 1963, N = 84.

in winter and spring 1963 may either be due to an emigration or to a high abundance of the 1961 year-class. The latter explanation seems to be the most reasonable since the 1961 year-class proved to be strong in the north-eastern North Sea in both 1964 and 1965 (HARALDSVIK 1966 b and 1967). In Fig. 2 are shown the age compositions in the samples collected in 1962 north and south of latitude 59°N. From these histograms it appears that the 1 and 2 year old herring were most abundant in the southern area, and this may indicate that the spring-spawning group of herring in the north-eastern North Sea is recruited from the southern area.

The age compositions for the spring-spawners at the west coast of southern Norway are shown in Fig. 3. It appears that the 1958 year-class in 1962 and the 1960 year-class in 1963 were more abundant in this area than in the north-eastern North Sea.

The Norwegian spring-spawning stock was in the years 1961 and 1962 dominated by the 1950 year-class, which contributed about 60 percent of the herring. The 1958 and 1959 year-classes were represented by less than 1 percent during the same years (DEVOLD and ØSTVEDT 1963 and 1964).

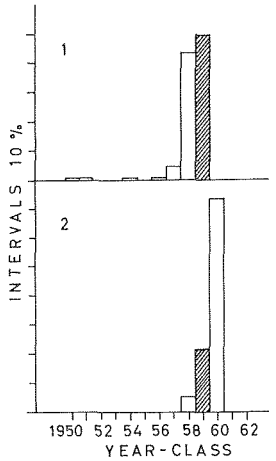

Fig. 2. Age composition of spring-spawning herring sampled north and south of latitude 59° N in north-eastern North Sea, 1962.
1) North of N 59°, N = 321,
2) South of N 59°, N = 283.

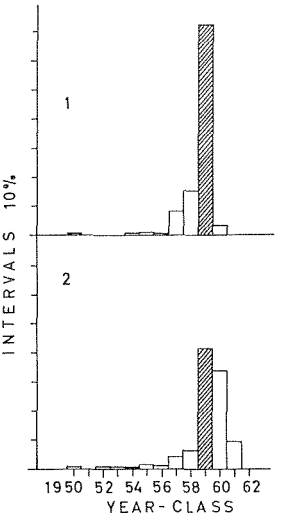

Fig. 3. Age composition of spring-spawners from the west coast of southern Norway, 1962 and 1963.
1) 1962, N = 177,
2) 1963, N = 188.

The age compositions therefore do not indicate any evident connection between the spring-spawning group of herring in the north-eastern North Sea and the two spring-spawning stocks along the coast of Norway.

VERTEBRAE

The frequency distributions of the vertebrae counts in the samples from the north-eastern North Sea are given in Table 2. The mean number of vertebrae ranged from 56.90 to 57.32, but no geographical trend or trend in time was observed. An analysis of variance showed that the differences of vertebrae counts within samples were insignificant compared with the differences between means of samples ($F = 1.076$, $p < 0.05$). It may therefore be concluded that the samples are drawn from the same stock or same mixture of stocks. It is then, however, presupposed that a real difference in vertebrae number occur between the various spring-spawning stocks. In Table 3 the vertebrae frequency distribution of the spring-spawning group from the North Sea is compared with the vertebrae frequency distribution for the Norwegian spring-spawning stock and the spring-spawners at the west coast of southern Norway. The significances of the differences

Table 2. Vertebrae counts of spring-spawners from north-eastern North Sea, 1961—63.

Sample number	Date	Vertebral Count						N	$\bar{x}$ [1]	σ^2
		55	56	57	58	59	60			
1.....	11/9 —61	—	3	5	2	—	—	10	—0.1000	0.5444
2.....	24/9 —61	—	3	4	1	1	—	9	0.0000	1.0000
3.....	16/10 —61	—	1	16	5	—	—	22	0.1818	0.2511
4.....	19/12 —61	—	4	17	6	—	—	27	0.0741	0.3789
5.....	19/12 —61	—	1	23	13	—	—	37	0.3243	0.2808
6.....	19/1 —62	—	4	34	7	1	—	46	0.1087	0.3213
7.....	20/1 —62	—	15	32	13	1	—	61	0.0000	0.5333
8.....	1/3 —62	1	18	53	11	2	—	85	—0.0588	0.4846
9.....	24/3 —62	—	1	7	1	—	—	9	0.0000	0.2500
10.....	6/5 —62	—	2	16	4	—	—	22	0.0909	0.2771
11.....	7/5 —62	—	5	13	7	—	—	25	0.0800	0.4933
12.....	22/5 —62	—	2	10	3	—	—	15	0.0667	0.3524
13.....	7/6 —62	—	4	12	6	—	—	22	0.0909	0.4675
14.....	27/7 —62	—	20	63	21	1	—	105	0.0286	0.4319
15.....	28/8 —62	—	10	49	23	—	—	82	0.1585	0.3820
16.....	3/9 —62	1	21	92	41	—	1	156	0.1346	0.4656
17.....	25/9 —62	—	2	14	2	—	—	18	0.0000	0.2353
18.....	9/10 —62	—	11	44	12	1	—	68	0.0441	0.4010
19.....	20/11 —62	—	5	17	14	1	—	37	0.2973	0.5480
20.....	22/1 —63	—	11	23	11	1	—	46	0.0435	0.5758
21.....	20/2 —63	—	4	24	3	—	—	31	—0.0323	0.2323
22.....	23/3 —63	—	2	2	2	—	—	6	0.0000	0.8000
23.....	3/5 —63	—	—	9	2	—	—	11	0.1818	0.1636
Total		2	149	579	210	9	1	950	0.0821	0.4274

[1] $\bar{x}$ = average deviation from «working mean», 57 vertebrae.

in mean vertebrae count have been tested, giving $t = 1.588$ ($0.1 < p < 0.2$) between the spring-spawners from the North Sea and the Norwegian spring-spawning stock, and $t = 2.931$ ($p < 0.01$) between the spring-spawners from the North Sea and those from the west coast of southern Norway. It should, however, be noted that the results of this test are probably not reliable as different year-classes are dominating in the different groups of herring considered. Further, the mean vertebrae count of the spring-spawners from the west coast of southern Norway is based upon only three samples in which the means varied considerably (57.31, 57.20, 57.09).

An admixture of the two spring-spawning stocks from the coast of Norway cannot therefore be excluded by the available data on the vertebrae count. The mean vertebrae numbers in the present material show good conformity with earlier findings on spring-spawning herring in the northern North Sea (Runnstrøm 1941, Wood 1936).

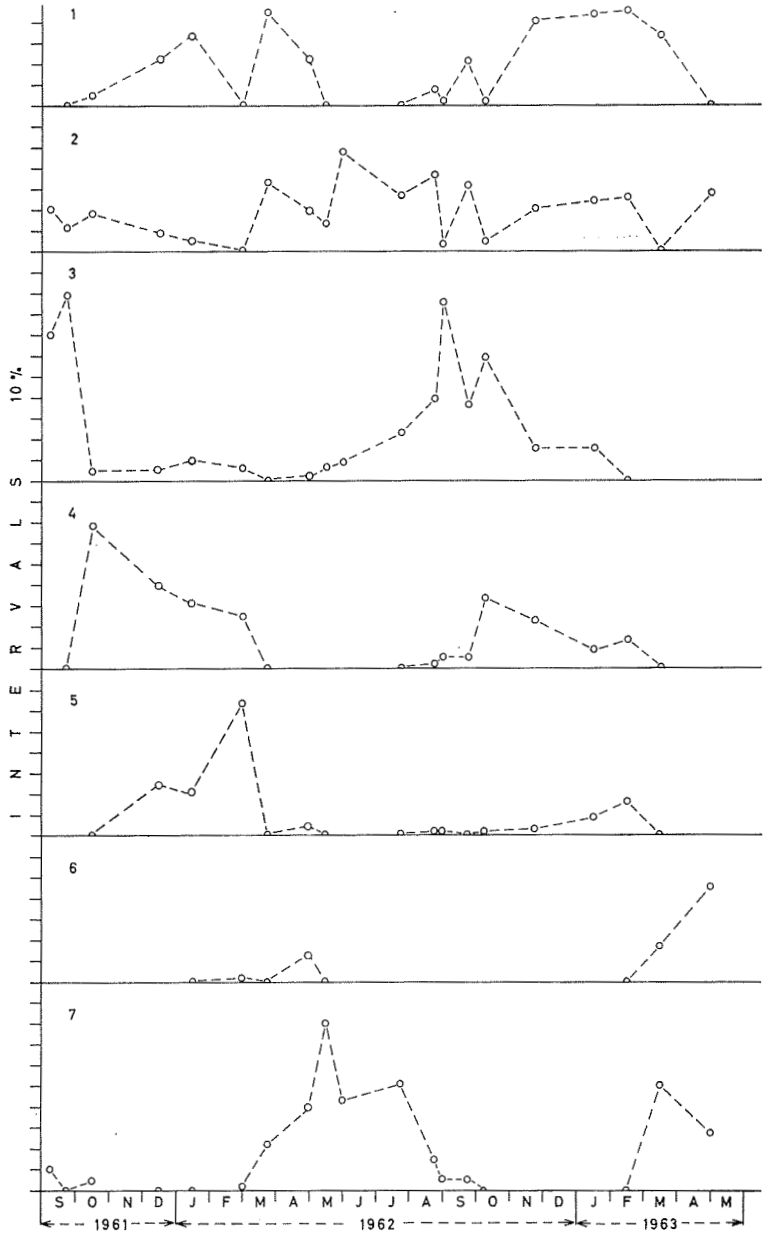

Fig. 4. Percentage composition of maturity stages in spring-spawning herring from north-eastern North Sea, 1961—63.

1) Maturity stage I,
2) Maturity stage II,
3) Maturity stage III,
4) Maturity stage IV,
5) Maturity stage V,
6) Maturity stage VII,
7) Maturity stage VIII.

Table 3. Vertebrae counts of the Norwegian spring-spawning stock, spring-spawners from the west coast of Southern Norway and the spring-spawning group in north-eastern North Sea.

Categories	Vertebral Count						N	$\bar{x}$ [1]	σ^2
	55	56	57	58	59	60			
Norwegian spring-spawning stock, 1962	—	65	308	120	4	1	498	0.1325	0.1434
Spring-spawners, SW coast of Norway, 1962 and 1963	—	35	176	81	7	—	299	0.2007	0.2079
Spring-spawners, North Sea, 1962....	2	149	579	210	9	1	950	0.0821	0.4274

[1] $\bar{x}$ = average deviation from «working mean», 57 vertebrae.

MATURITY

The samples from the north-eastern North Sea have been collected throughout the year and the maturity investigations may therefore give a rough picture of the maturing cycle for the spring-spawning herring in this area (Fig. 4). The low percentage of herring in spawning condition, and the low abundance of spring-spawners in the samples from the end of March in 1962 and 1963 (Table 1) may indicate that the spawning grounds are situated outside the north-eastern North Sea.

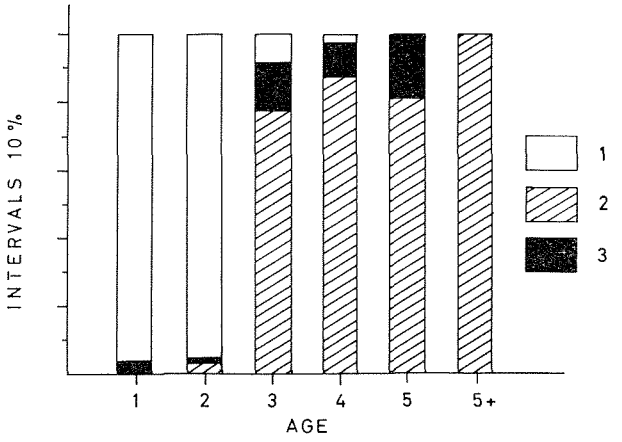

Fig. 5. Compositions of immature herring, herring in maturity stage III and mature herring amongst 1—5+ year old spring-spawners in north-eastern North Sea during the winter and spring 1962—1963.
1) Maturity stage I—II,
2) Maturity stage III,
3) Maturity stage IV—VIII.

Spent herring in stage VII were recorded in the samples from the end of March and the beginning of May. A duration of three weeks of this maturity stage (JAKOBSSON 1962) should indicate a spawning season from second half of February to mid April. Recovering spent herring were in dominance from the end of March to the first half of August. Stage III occurred in most of the samples, but were dominant from mid August to the beginning of October. Stages IV and V were found from the end of August to the beginning of March, but had their maxima before and after the turn of the year respectively. It must, however, be emphasized that the number of samples and the number of specimens within several of the samples are few and one must therefore be very careful in generalizing from the present data.

The Norwegian spring-spawning stock and the spring-spawners at the west coast of southern Norway had in the years 1962 and 1963 their spawning season from the end of February to the end of March and from mid March to mid April respectively. These spawning periods were thus inside the range of the spawning season for the spring-spawning group of herring in north-eastern North Sea. A connection between the spring-spawners in the north-eastern North Sea and the spawning grounds at the coast of Norway cannot therefore be excluded.

Maturing cycle of the two spawning stocks at the coast of Norway is unknown. Investigations in Icelandic waters during summer suggest, however, that the herring of the Norwegian spring-spawning stock pass over from stage VIII to stage III in the first half of July (ØSTVEDT 1962), i.e. about one month earlier than indicated for the spring-spawning group in the north-eastern North Sea.

AGE AT FIRST SPAWNING

It was impossible to differentiate the winter-rings on the scales of the spring-spawning herring in north-eastern North Sea into «coastal», «oceanic» and «spawning» rings (RUNNSTRØM 1936), except for six herring belonging to the northern type of the Norwegian spring-spawning stock. Therefore a different approach was used to determine age at first spawning. The age at first spawning has been based upon the maturity compositions by age in the samples collected during the period January to July. Herring in stage III in this period are classified as uncertain, i.e. they may be immature and do not spawn before the next season, or herring in stage III at the beginning of

the period may reach maturity and further, herring in stage III at the end of the period may have spawned and already recovered their gonads. The percentage composition of immatures (stage I and II), uncertain (stage III) and spawned herring (stages IV–VIII) in each age group are presented in Fig. 5. It will be seen that a few herring already spawned at an age of two years, but the majority, about 77 percent, were spawning at an age of three. Only about 2 percent of the four year old herring were immature.

The Norwegian spring-spawners may attain maturity at an age between three and nine years. However, in 1962 and 1963 the three year-old spawners were scanty represented on the spawning grounds off Møre (DEVOLD and ØSTVEDT 1964, ØSTVEDT 1965). The herring at the west coast of southern Norway were, on the other hand, in the same years dominated by three year olds, which were all in spawning condition.

FIRST GROWTH ZONE MEASUREMENT MADE ON OTOLITHS

The six herring, belonging to the northern type of the Norwegian spring-spawning stock, had typical otoliths which were easily picked out. These otoliths had thin, sharp winter-rings and a growth pattern similar to that on the scales. In the rest of the spring-spawning herring from the north-eastern North Sea it was impossible to recognize distinct otolith types. The major part of the otoliths had relatively large first and second growth zones and «soft» first and second winter-rings.

The ranges and means of the first growth zone measurements are presented in Table 4. It appears that the ranges and means were of the same order in the samples from 1961 and 1962. The high values obtained in 1963 may be explained by growth differences between year-classes. As stated before the 1960 year-class dominated the samples from 1963, while the 1959 year-class was the most prominent one in 1961 and 1962. Considering the total material the first growth zone measurements ranged from 13 to 29 units (one unit = 0.0409 mm), and had a mean value of 22.90 units (standard error = $\pm$ 0.153).

The values of first growth zone measurements were less than those recorded previous for the autumn-spawning group of herring in the same area (HARALDSVIK 1966a). The difference is probably connected with differences in age at formation of the first winter-ring. The spring-spawners lay down a winter-ring during the first winter, while the autumn-spawners do not form winter-rings before the second winter.

Table 4. Ranges and means of first growth zone measurement on otoliths from the spring-spawning group of herring in north-eastern North Sea (1 units = 0.0409 mm), 1961—63.

Sample number	Date	Range	Mean	N
1.....	11/9 —61	18—25	23.2	10
2.....	24/9 —61	22—26	23.7	7
3.....	16/10 —61	14—28	23.2	19
4.....	19/12 —61	15—26	22.1	22
5.....	19/12 —61	13—25	22.2	31
Sum 1961		13—28	22.6	89
6.....	19/1 —62	15—26	22.2	45
7.....	20/1 —62	18—27	22.6	60
8.....	1/3 —62	17—29	23.3	83
9.....	24/3 —62	20—25	23.4	9
10.....	6/5 —62	14—27	22.4	21
11.....	7/5 —62	21—27	23.9	23
12.....	22/5 —62	19—25	22.2	15
13.....	7/6 —62	18—26	23.1	23
14.....	27/7 —62	15—28	22.4	99
15.....	28/8 —62	15—27	22.9	78
16.....	3/9 —62	15—27	22.8	138
17.....	25/9 —62	20—26	23.1	17
18.....	9/10 —62	14—27	22.7	51
19.....	28/11 —62	20—27	23.8	28
Sum 1962		14—29	22.8	690
20.....	22/1 —63	22—29	24.9	35
21.....	20/2 —63	20—27	23.2	24
22.....	23/3 —63	22—26	23.3	6
23.....	3/5 —63	21—24	22.7	11
Sum 1963		20—29	23.9	76
Grand total		13—29	22.9	855

In Fig. 6 are shown the distributions of first growth zone measurements for the spring-spawning group of herring in north-eastern North Sea, for the Norwegian spring-spawning stock and for the spring-spawners at the west coast of southern Norway. The 1959 year-class is dominating in the stocks considered. The figure shows good conformity between the spring-spawners in north-eastern North Sea and those at the west coast of southern Norway. Suggesting that the size of the first growth zone is linked to the food supply during the first year, the good comformity in the first growth zone measure-

ment may indicate that the spring-spawning herring in north-eastern North Sea and those at the west coast of southern Norway have the same feeding grounds during their first year of life.

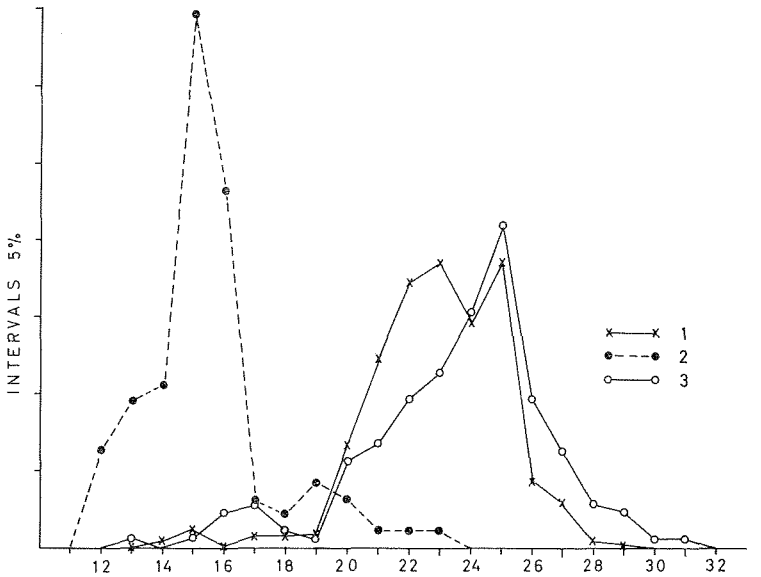

Fig. 6. Frequency distributions of otolith zone measurements, 1961—1963.
1) Spring-spawners from north-eastern North Sea,
2) Norwegian spring-spawning stock,
3) Spring-spawners from the west coast of southern Norway.

GROWTH

The growth of the herring is one of the main characters used to distinguish between various herring stocks. LEA (1910, 1938) has shown that the relation between scale length and total length of the herring is approximately linear. The l_1 distributions of the 1959 year-class of the spring-spawning group of herring from north-eastern North Sea, the Norwegian spring-spawning stock (S-type) and the spring-spawners at the west coast of southern Norway are given in Fig. 7. The mean l_1, l_2 and l_3 values for the same stocks are presented in Table 5. From these data it appears that the growth of the S-typed herring of the Norwegian spring-spawning stock deviated considerably from the growth of the two other stocks. The l_1 distribution and the mean values of l_1, l_2 and l_3 for the spring-spawners in north-eastern North Sea were slightly lower than those for the spring-spawners at the west coast of southern Norway. It should be noted that the

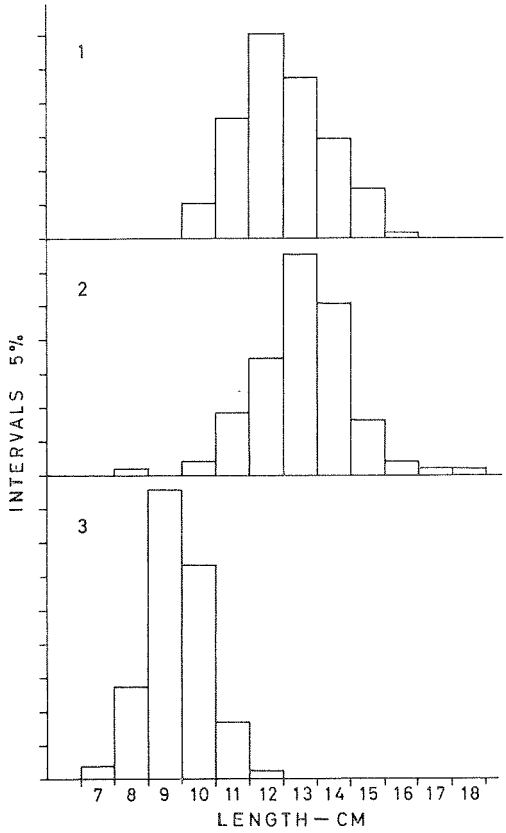

Fig. 7. Frequency distributions of l_1 of three year-olds in 1962.
1) Spring-spawners from north-eastern North Sea,
2) Norwegian spring-spawning stock,
3) Spring-spawners from the west coast of southern Norway.

Table 5. Mean l_1, l_2 and l_3 values of three year-old (1959 year-class) spring-spawning herring from the north-eastern North Sea and the coast of Norway, 1962.

Categories	l_1	N	l_2	N	l_3	N
Spring-spawners, NE North Sea	13.00	135	22.89	135	27.68	88
Spring-spawners, SW coast of Norway .	13.60	98	23.40	96	28.66*	98
Norwegian spring-spawning stock (S-type)	9.85	152	16.94	152	24.07	152

* Total mean length of three year olds in April.

herring from the west coast of southern Norway were caught by net with a large mesh size (winter herring net), and the selectivity of the net may probably affect an overestimation of the mean l_1, l_2 and l_3 values for this stock.

Taking this into consideration and assuming that the growth rate of the fish is related to the feeding, it seems reasonable to postulate that the spring-spawned herring in the north-eastern North Sea and those at the west coast of southern Norway have inhabited the same feeding grounds during the first, second and third year of life.

CONCLUDING REMARKS

In an attempt to outline the connection between the spring-spawning group of herring in the north-eastern North Sea and the two spring-spawning stocks at the coast of Norway, i.e. the Norwegian spring-spawning stock and the spring-spawners at the west coast of southern Norway, some biological characters for these groups of herring have been compared. Due to the plasticity of these characters it is impossible to identify the individual fish, but comparing several characters and large samples this method may, however, provide valuable informations in this identification work.

The age composition, age at first spawning, scale type, growth characteristics for the spring-spawning group of herring in the north-eastern North Sea deviated considerably from those obtained for the Norwegian spring-spawning stock. It is therefore concluded that the occurence of herring from the Norwegian spring-spawning stock was negligible in the north-eastern North Sea during the years 1961—63. This is in contrast to results obtained by Broch (1909), Hjort and Lea (1911) and Bjerkan (1917), who found the Norwegian spring-spawning stock to be dominating within the spring-spawners in this area. The absence of Norwegian spring-spawners in the north-eastern North Sea in recent years may be explained by the change of spawning grounds for this stock (Devold 1963). The spawning grounds have since 1960 been off Møre and it is reasonable to assume that the migration route to and from the feeding area in the Norwegian Sea in recent years is north of the North Sea.

Comparing the spring-spawning group of herring in the north-eastern North Sea and the spring-spawners at the west coast of southern Norway, good agreement is found in age at first spawning, scale type and growth rate during first, second and third year of life. These characters are susceptible to environmental influence, and the good conformity may argue for the herring compared to have the same feeding and overwintering areas during the three first year of

life. The characters deviate from those of herring which have their nursery and adolescent stages in coastal waters (RUNNSTRØM 1936), and it is therefore suggested that the spring-spawners at the west coast of southern Norway have spent their three first years in the North Sea.

The spring-spawning stock at the west coast of southern Norway differ from the spring-spawning group of herring in the northern North Sea by being spawning in inshore waters of relative low salinity and temperature, having different abundance of year-classes and probably also a higer mean number of vertebrae. Outside the spawning season this spring-spawning stock probably mix with the spring-spawners in the north-eastern North Sea. The low total mean number of vertebrae, and the low abundance of the 1960 year-class in the spring-spawning group of herring in the north-eastern North Sea may, however, indicate that the spring-spawners from the west coast of southern Norway only constitute a minor part of the spring-spawning group of herring in the north-eastern North Sea.

SUMMARY

1. Age composition, number of vertebrae, age at first maturity, scale type and growth characteristics for the spring-spawned herring in the north-eastern North Sea in 1961—1963 have been analysed.
2. Some of these characters have been compared with those for the two spring-spawning stocks at the coast of Norway; i.e. the herring spawning off Møre and the herring spawning at the west coast of southern Norway.
3. Less agreement with the spawners off Møre, indicates that members of this stock were scanty represented in the spring-spawning group in the north-eastern North Sea.
4. Good agreement with the spawners at the west coast of southern Norway, indicates that this herring stock outside the spawning season may be distributed in the north-eastern North Sea.

REFERENCES

AASEN, O. 1953. Tagging experiments. *Annls biol., Copenh., 9*: 171—173.

ANDERSSON, K. A. 1949. Swedish investigations. *Annls biol., Copenh., 5*: 82—84.

ANON. 1963. Herring Committee. *Proces-Verbal Reun. Cons. perm. int. Explor. Mer, 1962*: 66—77.

BJERKAN, P. 1917. Age, maturity and quality of North Sea herring during the years 1910—1913. *FiskDir. Skr. Ser. HavUndersøk., 3* (1): 1—119.

BROCH, H. 1909. Norwegische Heringsuntersuchungen wärend der Jahre 1904—06. *Bergens Mus. Aarb., 1909* (1): 1—69.

DEVOLD, F. 1963. The life history of the Atlanto-Scandian herring. *Rapp. P.-v. Reun. Cons. perm. int. Explor. Mer, 154*: 98—108.

DEVOLD, F. and ØSTVEDT, O. J. 1963. The Norwegian herring fisheries in 1961. *Annls biol., Copenh., 18*: 148—149.

— 1964. The Norwegian herring fishery, 1962. *Annls biol., Copenh., 19*: 124—129.

HARALDSVIK, S. 1966 a. The autumn spawning group of herring in the north-eastern North Sea. *Coun. Meet. int. Coun. Explor. Sea, 1966* (H 26): 1—15, 11 tab., 9 fig. [Mimeo.]

— 1966 b. The Norwegian herring fisheries in the North Sea and Skagerak in 1964. *Annls biol., Copenh., 21: 147—149.*

— 1967. The Norwegian herring fisheries in the North Sea and Skagerak in 1965. *Annls biol., Copenh., 22*: 148—153.

HJORT, J. and LEA, E. 1911. Some results of the international herring investigations 1907—1911. *Publs Circonst. Cons. perm. int. Explor. Mer, 61*: 8—34.

JAKOBSSON, J. 1962. The annual cycle of the maturity stages of the Icelandic herring. *Coun. Meet. int. Coun. Explor. Sea, 1962* (paper 97): 1—2, 2 tab., 3 fig. [Mimeo.]

JOHANSEN, A. C. 1924. On the summer and autumn-spawning herring of the North Sea. *Meddr Kommn Havunders., Serie: Fiskeri, 7* (5): 1—119.

KREFFT, G. 1955. Untersuchungen zur Rassenfrage beim Hering. *Mitt. Inst. Seefisch., 6*: 12—23.

LEA, E. 1910. On the methods used in the herring investigations. *Publs Circonst. Cons. perm. int. Explor. Mer, 53*: 7—33.

— 1938. A modefication of the formula for calculation of the growth of herring. *Rapp. P.-v. Reun. Cons. perm. int. Explor. Mer, 108*: 14—22.

PARRISH, B. B. and SHARMAN, D. P. 1958. Some remarks on methods used in herring «racial» investigation with special reference to otolith studies. *Rapp. P.-v. Reun. Cons. perm. int. Explor. Mer, 143*: 66—80.

RUNNSTRØM, S. 1936. A study on the life history and migrations of the Norwegian spring-herring based on the analysis of the winter-rings and summer zones of the scale. *FiskDir. Skr. Ser. HavUndersøk., 5* (2): 1—103.

— 1941. Racial analysis of the herring in Norwegian waters. *FiskDir. Skr. Ser. HavUndersøk., 6* (7): 1—110.

Wood, H. 1936. Race investigation of the herring population of Scottish waters. *Scient. Invest. Fishery Bd Scotl., 13*: 1—52.

ØSTVEDT, O. J. 1962. Maturity stages in the Norwegian spring spawning herring in relation to time of spawning. *Coun. Meet. int. Coun. Explor. Sea, 1962* (paper 154): 1—3, 5 fig. [Mimeo.]

— 1965. The Norwegian herring fishery, 1963. 3. Biological data. *Annls biol., Copenh., 20*: 166—168.

Received 3 February 1968

Printed 13 Sepemtber 1968