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Racial Analysis of the Herring in Norwegian Waters

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CONTENT

INTRODUCTION.

Since HEINCKE'S investigations on herring races appeared 1898 much work has been done as to the origin and distribution of various herring communities. The opinions of fishery biologists have, however, diverged very much on the question whether the communities really represent true races, distinguishable by hereditary characters or whether the distinguishing characters are only the result of environmental factors. This question, hardly to be solved by statistical methods, has come much in the foreground. The meeting of herring experts at Lowestoft 1935 however, considered that this question was a matter of secondary importance. Biological herring communities undoubtedly exist and it was recommended that morphological characters should be used as an aid to the identification of these groups and that vertebral counts on selected material should be continued.

The racial analysis of the Norwegian herring population, which in other respects has been investigated in a fundamental manner, has been rather neglected since the investigations by BROCH in 1904—1906 and different assumptions as to the uniformity of the population have appeared without being thoroughly founded on investigations. The present paper intends to give a more complete knowledge of the composition of the herring occurring in Norwegian waters based on an analysis of a great material of vertebral counts. The investigation has shown that the numeral characters, though highly influenced by the environment, have given valuable information as to the relation between the different »kinds« of herring, e. g. »large« herring and »spring« herring, on which the important Norwegian herring fisheries are based.

The material was collected by the Fishery Directorate, Bergen in the years 1932—1936 and the investigation has been supported by grants from the Investigation Fund of the Fishery Industries. Some of the material has been treated in preliminary reports. In working up the great material I have been assisted by mr. Th. RASMUSSEN and mr. T. KROG, trained experts in scale reading and counting of vertebrae, and by miss JAHNSEN who has assisted in the tabulating and calculating work. I am much indebted to them all for their valuable help.

THE NORWEGIAN LARGE- AND SPRING HERRING FISHERY IN PAST AND PRESENT.

The Norwegian herring fishery is based on different kinds of herring representing various stages in the life history of the fish, vid.: small- and fat herring and the large- and spring herring. The small- and fat herring are the young and immature individuals while the large- and spring herring represent the fullgrown individuals which immigrate to the coast in order to spawn.

The large herring fishery lasts from the early winter to the end of January when a new season begins namely the springherring season which lasts into April. Commonly these two fisheries have been located in different regions of the coast which have been called the »large herring district« and the »spring herring district«. The large herring represent fullgrown fishes with hard roe and milt and not quite ready to spawn, and they are caught on their way to the spawning grounds. They correspond to the »fulls« in the North Sea fishery. The spring herring, which are caught on the spawning grounds proper, have running roe and milt or, at the end of the spawning season, spent gonads.

From a physiological point of view the large- and spring herring only represent different stages in the ripening of the gonads. From a commercial point of view, however, the designations »large-« and »spring« herring denote different qualities the large herring being fatter and more valuable than the spring herring. As there is no sharp limit between the two kinds it has been difficult to demarcate the two seasons. In later years the fishermen fix a certain day before and after which the fishing product from a commercial point of view is regarded as large herring or spring herring respectively.

In the statistical treatment of the herring fishery nowadays the large- and spring herring fisheries are not distinguished, all catches being referred to as »winter herring«. If, however, the weekly catches during the winter herring fishery are treated graphically as in fig. 1 (from SUND 1938) one gets a clear impression of two seasons. A culmination of the fishery is occurring in January caused by immigration of large herring, a strong decrease at the end of January or in the beginning of

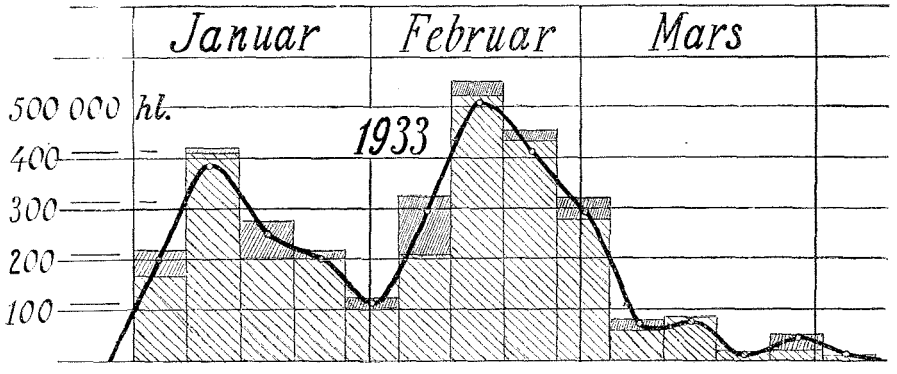

Fig. 1. Weekly catch of winter herring in the season 1932—1933. The thick line indicates $^0/_0$ of the total catch. (From Sund 1938).

February, when the large herring disappear from the coastal waters, and then again a culmination in February corresponding to the immigration of the spring herring to the spawning grounds.

In fig. 2. I have demonstrated the geographical distribution of the large- and spring herring fishery in present time based on the average catches in the years 1932—36. The Norwegian coast is divided in regions corresponding to well-known fishing places and for each district the quantity of caught herring is shown by rings each representing 10 000 hl. The rings filled out with black denote the amount of herring caught before 1. Feb. mainly consisting of large herring. The open rings show catches in the spawning season after 1. Feb. and thus mainly represent the spring herring fishery. The figures are based on the actual catches in the different districts as given in the reports of the district officers and not on the quantities landed in each area, as published in »Norges Fiskerier«. One finds that the winter herring fishery is carried on from the Trondheim Fjord in the north to Lindesnes in the south. The fishery is not, however, evenly distributed along the coast. Certain areas show a much greater catch than the adjacent districts. Thus between Bergen and Lindesnes (the districts Rogaland and S. Hordland) the fishery culminates on the important spawning grounds along the island Karmoy and in the Skude Fjord (between Stavanger and Haugesund). This region is a pronounced spring herring district. The herring may appear at the end of January outside this district but the main fishery takes place in February and March, when the herring has arrived on the spawning grounds.

Further north, between Bergen and the Stat peninsula (districts N. Hordland and Sogn and Fjordane) the fishery culminates outside

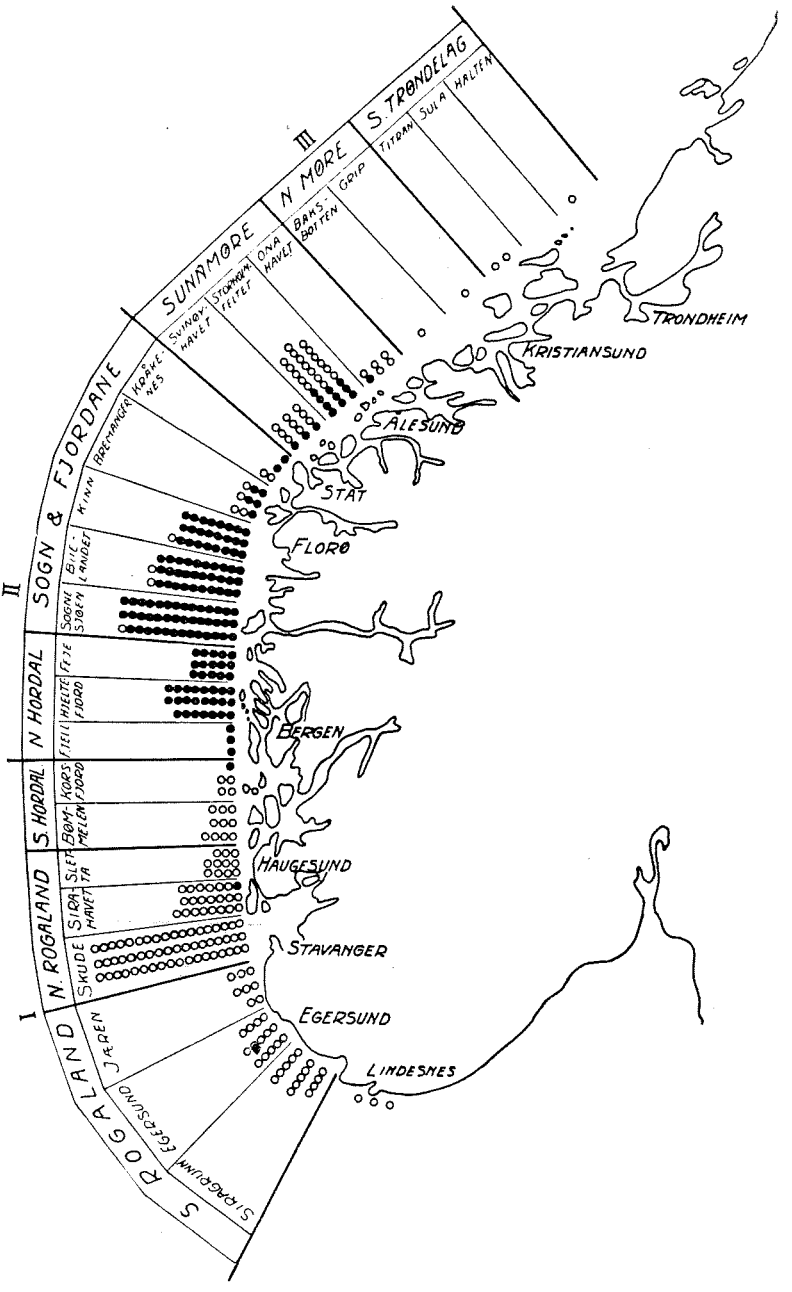

Fig. 2. Distribution of the large- and spring herring fishery at the Norwegian west coast in present time.

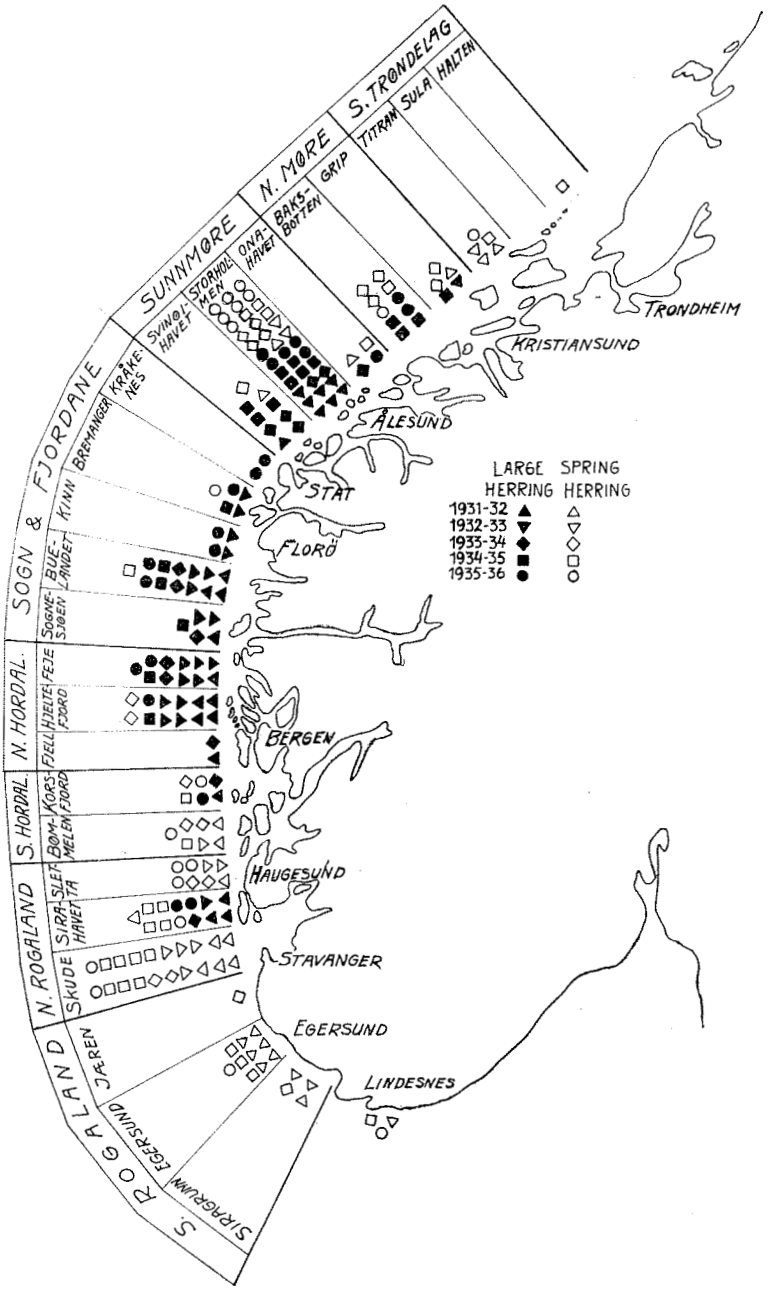

Fig. 3. Distribution of the large- and spring herring samples collected in the period 1932—1936.

the Sogne Fjord. This region is in the present time almost exclusively a large herring district. The fishery begins already in December and is practically finished when the large herring disappear at the end of January.

North of Stat one finds a third region (Møre and S. Trøndelag) where the fishery culminates off Ålesund. This district was in earlier years the most important for the large herring fishery but this fishery has declined in later years and the spring herring fishery is now dominating. The large herring appear at the same time as in the neighbouring district to the south, but no more in great masses, and the fishery is not finished at the end of January but continues as a spring herring fishery throughout February and March.

Thus one can recognise three different fishery districts along the Norwegian west coast at present: I; the spring herring district between Lindesnes and Bergen, II; a large herring district between Bergen and Stat, III; a district between Stat and the Trondheim Fjord, where the spring herring fishery dominates.

The Norwegian winter herring fishery has shown very great fluctuations as well in respect of quantity as in regard of the geographical distribution. In the following I will give a short historical review of the fishery.

We know that a *spring* herring fishery has taken place at the SW.-coast as long ago as historical informations reach back, although with interruptions of shorter or longer duration in the same manner as the herring fishery at the W coast of Sweden. A *large* herring fishery is known, however, for the first time in the latter half of last century, and took place in N. Norway.

We have more exact informations about the herring fishery from the beginning of the last century. The quantities of herring caught in different districts from 1808 to present time are shown in figs. 4 and 5.

A spring herring period at the SW. coast seems to have ended about 1784 and a new period began in the year 1808, when the herring again appeared near the coast. In the first years the herring was caught in the usual places off Stavanger but later on the fishery was extended farther northwards to Bergen, but until 1850 the fishery was restricted to the district Lindesnes—Bergen, which region was called the »southern spring herring district«, corresponding to district I in the chart fig. 2. As seen from fig. 4 the fishery rapidly increased and had the character of a spring herring fishery culminating during the spawning season in February and March. The herring did not appear in the more northern district Bergen—Stat until 1850 (district II on the chart fig. 2). The fishery had also here the character of a spring herring fishery and the region was called the »northern spring herring district«. At the same time

a less important spring herring fishery took place at the part of the Møre coast between Stat and Ålesund. In the year 1870 the fishery in the »southern spring herring district« was a total failure and in the next years the herring disappeared almost entirely from this region. Some years later the same happened in the more northern districts, and in 1874 practically the whole spring herring fishery came to an end.

In the last part of this period one hears for the first time about a large herring fishery. In the year 1861 an unexpected immigration of herring took place at Lofoten and Vesterålen in Northern Norway. The herrings were fullgrown fish with well developed, but hard roe and milt. They appeared already in September and the fishery lasted until the end of January, when the herring disappeared from the coast. Spawning herring was not observed. In the following years the fishery spread along the coast of northern Norway from Helgeland to Troms and culminated in the winter 1871—72 as shown in fig. 4. In the year 1874 however, the large herring fishery ended suddenly at the same time as the spring herring fishery.

The winter herring fishery, which in the beginning of the period 1808—1874 was restricted to the SW coast, was thus in the last years of the period extended to the whole coast from Lindesnes in the south to Troms far in the north, but had in the southern part the character of a spring herring fishery and in the northern Norway the character of a large herring fishery.

In the next years following 1874 the winter herring fishery was very unimportant and restricted to the »southern spring herring district« as seen in fig. 5. The herring was observed in the open sea but did not enter the habitual spawning grounds near the coast. In 1882 however the herring began to visit these old grounds. The catches were still in many years very small then increasing gradually.

In the same manner as in the former period the herring fishery in the first part of the present period was restricted to the old fishing places off Stavanger and Haugesund. North of Bergen no fishery took place until the year 1886. In September of that year a great immigration of herring took place in the district Sogn and Fjordane (fig. 2), and which corresponds to the »northern spring herring district« in the former period. The time for the arrival and the kind of herring was extraordinary to the fishermen who only had experience of a spring herring fishery, and there is no doubt that one had here to do with large herring of the same kind as that which appeared in Northern Norway at the end of the former period. A rich fishery took place from September and throughout the winter. This fishery was, however, in the next years very unimportant until 1896 when a rich large herring fishery was carried on from November

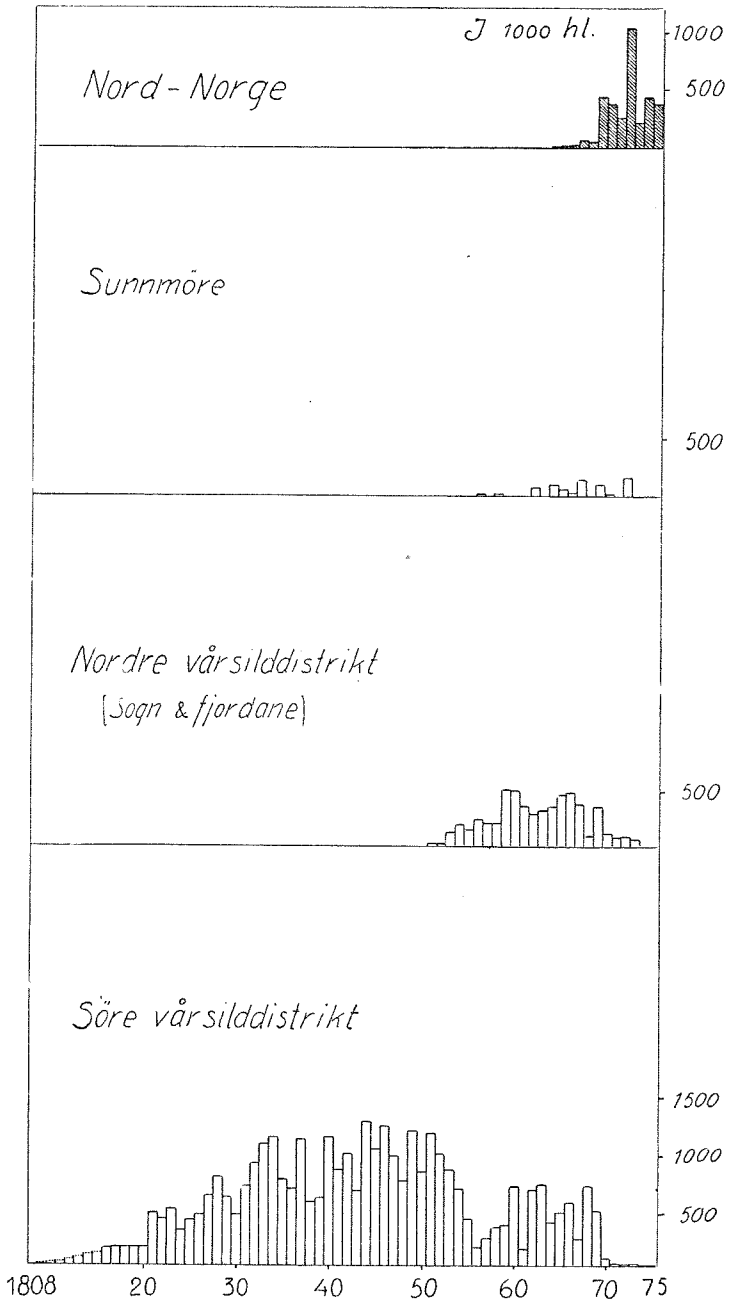

Fig. 4. Yearly catch of winter herring in different Norwegian coastal regions during the last herring period 1808—1875.

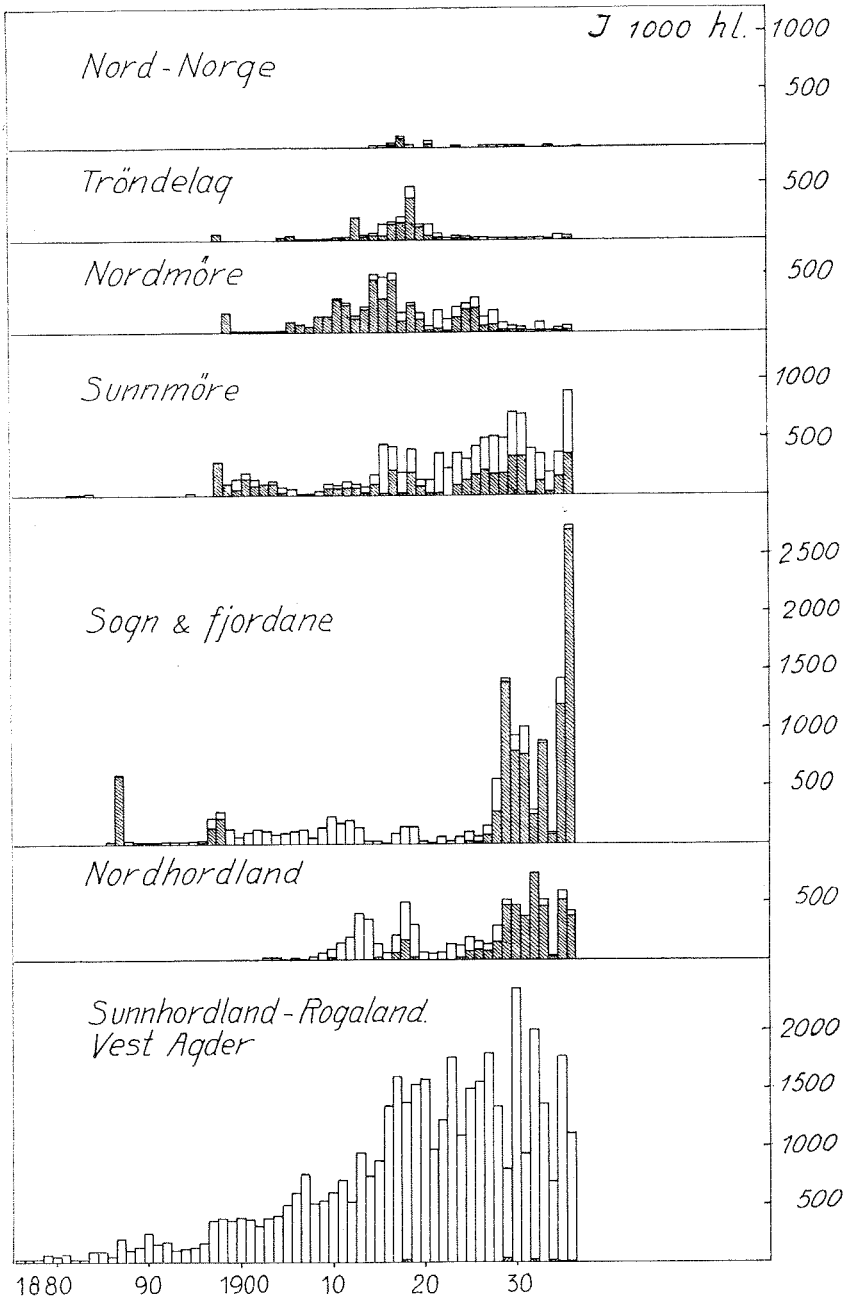

Fig. 5. Yearly catch of winter herring in different Norwegian coastal regions during the present herring period. The hatched parts of the columns indicate catch large herring.

to Christmas in the same district. In the winter 1897—98 the large herring appeared also north of Stat in the southern part of the Møre coast. The fishery began in September and lasted to the end of January at which time the herring disappeared before they had spawned, in the same manner as in the seventies in Northern Norway. The large herring appeared mainly in the open sea and did not enter the fjords. When the fishermen had learnt to catch the herring with drift nets in the open sea, however, a rich large herring period was introduced at the Møre coast which lasted for many years. At the same time this sort of herring disappeared from the district Sogn and Fjordane south of Stat, where the large herring originally had appeared. In the latter district then only an unimportant spring herring fishery took place, as shown in fig. 5.

Thus at the beginning of this century one had a large-herring district at the Møre coast north of Stat and a spring-herring district south of Stat, and the latter was in the same manner as in the former period regarded as being divided into a »northern spring-herring district« (Sogn and Fjordane) and a »southern spring-herring district« (Hordaland, Rogaland). The main spring herring fishery took place in the southern district.

The large herring fishery north of Stat has, however, shown certain movements within this district as shown in fig. 5. In the first years the richest fishery took place in the southern part (Sunnmøre), later on in the northern part (Nordmøre and Trøndelag), and about 1918 the large herring also appeared in the southern part of Northern Norway partly on the same places as in the former period. The fishery then again became predominant in the southern part of the Møre coast where now also a spring herring fishery began to develop later in the season.

As mentioned before the region between Stat and Bergen, where the large herring originally immigrated, had become an unimportant spring herring district. However, in the season 1928 a change in the character of the fishery took place. The herring appeared earlier in the season than usual and a veritable large herring fishery took place in January followed by a spring-herring fishery later in the season. In the next winter 1928—29 the herring appeared already in December, and as extraordinarily rich fishery for this district took place throughout January. This was not only the case in the district Sogn and Fjordane, but also in the district N. Hordland (fig. 5). In the later years the large herring fishery between Stat and Bergen has been entirely dominating over the spring herring fishery in the same district, and the catches of large herring here have in certain years (as 1929 and 1936) been much richer than the catches of spring herring within the main spring herring district between Bergen and Lindesnes.

Meanwhile the large herring fishery in the old large-herring district

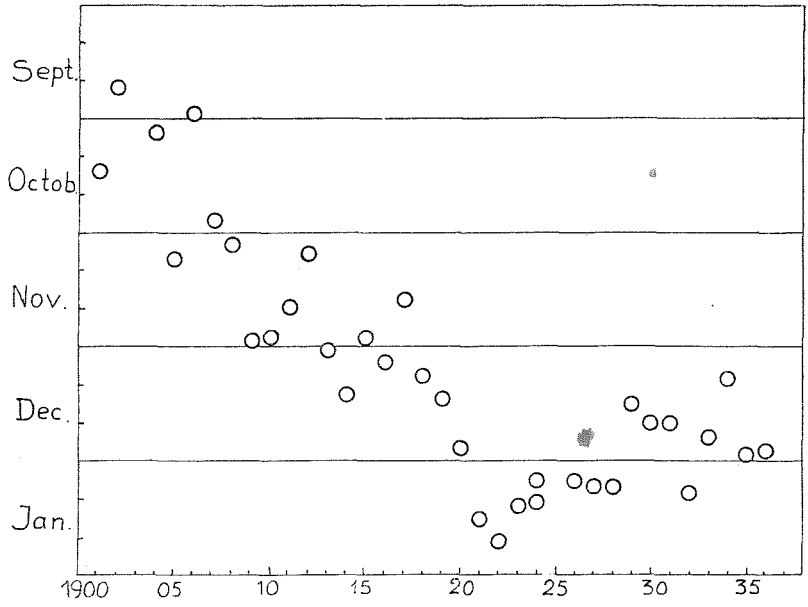

Fig. 6. Graphical demonstration of the date of beginning of the large herring season in different years.

north of Stat had been strongly reduced and this part of the coast seems now to become mainly a spring-herring district, as already shown in fig. 2. in discussing the present distribution of the fishery.

Thus we have seen that the geographical distribution of the winter herring fishery has fluctuated very much. The spring-herring fishery on the spawning grounds at the south west coast has been comparatively constant, while the large herring fishery has been rather irregular. First the large herring appeared for a short period in Northern Norway. When the large herring after several years again appeared in coastal waters, they entered further south and a rich fishery took place at the Møre coast. At the present time days immense masses of large herring immigrate to the coast between Bergen and Stat in early winter and leave again before the spawning season.

The time of arrival of the large herring to the coastal waters has also fluctuated as shown in fig. 6. In the beginning of the large herring fishery in the present period the herring appeared already in September, in the same manner as during the large herring fishery in Northern Norway in the former period. The figure shows that the arrival in later years has been more and more delayed until the fishery in the years 1920—1928 was restricted to the month of January. Since 1929 the fishery again has started somewhat earlier (in December).

EARLIER INVESTIGATIONS ON THE NORWEGIAN LARGE AND SPRING HERRING.

At the end of the former herring period investigation were carried out by the Norwegian biologists BUCH, BOCK, JENSEN and G. O. SARS. Different opinions had been held about the relationship of the various kinds of herring along the Norwegian coast and G. O. SARS (1872) was the first to recognise that the fat herring does not represent a distinct race, but is only the young of the spring herring. SARS (1873) was of the opinion that the spring herring spawning at the Norwegian West Coast belonged to one and the same stock but that the large herring in Northern Norway represented a separate stock with a more northern distribution. He regarded the fat herring of N. Norway as related to the large herring in the same way as the fat herring of the west coast to the spring herring of this region, apparently considering the large herring as spawning in N. Norway. This opinion was based on the fact that the large herring fishery was at that time widely separated from the spring herring fishery. However when SARS got an occasion to study the large herring fishery on the place in 1874, he was struck by the fact that the large herring did not spawn at the coast at all. Only at one occasion he observed spawning large herring at the end of January, but these herrings were kept enclosed in a net, and the main part of the large herring had at that time disappeared from the coast. In his report from 1874 he writes therefore that he had to a certain degree altered his opinion about the migration of the herring, and that probably a closer relation existed between the large herring and the spring herring than he had formerly supposed.

HJ. BROCH (1908) then made a racial analysis of herring from Norwegian waters based on the methods introduced by HEINCKE. BROCH mentions that different opinions exist on the question whether large and spring herring belong to the same stock, and both kinds of herring were therefore thoroughly investigated on material sampled in 1904 and 1905. As a result of the investigation BROCH adopted the opinion that large- and spring herring may possibly represent two different stocks, but that most facts speak for the supposition that

they belong to one and the same stock which also includes the Norwegian fat herring.

In spite of BROCHS doubts as to the racial homogeneity of the Norwegian herring HJORT and LEA (1911) concluded from informations obtained by the study of age and growth that the Norwegian herring is very uniform, and that the different herring fisheries in the Norwegian waters are based on different stages of herring of one and the same stock.

LEA (1929) then drew up the general outline of life history of the Norwegian herring. From the main spawning grounds at the SW. coast the fry are dispersed along the whole coast right up to the north of Finnmark, and the herrings also spend the second year of life in the coastal waters. In the southern part the herring then leave the coast, while in the northern part it may remain in the coastal waters as fat herring before the transition to the oceanic stage. In the oceanic stage the contingents from the different coastal parts join and develop to mature herring, which arrive later on to the spawning grounds as recruit spawners, joining the older spawners. Thus according to LEA there must be two contingents of herring on their way to the spawning places. The one contingent, regularly noticed as the first and most abundant, contains the older spawners, herring which has spawned in previous years. This contingent which contains the oldest and largest individuals of the stock, is found by the fishermen first of all at some distance to the north of the main spawning grounds and some time before they are ready to spawn (large herring). The second contingent is not usually noticed to any extent before it appears on the spawning grounds proper. The individuals in this group are all smaller and younger, and they become ready to spawn rather later than the bulk of the older spawners. These are the previously mentioned recruit spawners. The spring herring on the spawning grounds consist thus according to LEA of the same shoals as the large herring but mixed with the recruit spawners.

A. C. JOHANSEN (1919) has, however, statistically treated the material of BROCH and by comparing samples of spring herring from the west coast with samples of large — and fat herring from northern Norway (Nordland) JOHANSEN found a real difference between the mean number of vertebrae, and he concludes that it is doubtful, whether all herrings in the Norwegian coastal waters belong to one race. The difference found between the Nordland herring and the spring herring from the south west coast may according to JOHANSEN be explained in different ways and he mentions four possibilities:

I. The difference may be due to the circumstance that the Nordland fat- or large herrings have not been unmixed but have contained elements of local races with a lower number of vertebrae.

II. The relatively high number of vertebrae found in the south west Norwegian spring herring may not be a constant character for all year classes.

III. The difference found may be due to an average difference in the conditions of nature in the places, where these herrings have their spawning places. In that case the difference may have been fixed through inheritance. It is then probable that the Nordland herring chiefly spawns in the northern and colder part of the spawning area perhaps between Bremanger and the Trondheims Fjord, while the south west Norwegian spring herring in preference spawns in a more southern and warmer area, about Haugesund and Bergen.

IV. The differences may be racial and have their roots in the past, the causes of their origin being unknown.

JOHANSEN hopes that future investigations may enable us to see which explanation is the right one.

SCHNAKENBECK (1931) has then in his paper »Zum Rassenproblem by den Fischen« investigated some herring samples from Norwegian coastal waters and he means to proof the existance of two morphological types with differing frequency curves for Vert. S. He therefore assumes the existence of two races in Norwegian waters but without being able to distinguish them in regard to place and time of spawning. In a preliminary report (1933) I have discussed the results of SCHNAKENBECK.

OTTESTAD has in paper from 1934 given an analysis of the Norwegian Herring based on his study of different growth types. He writes: »The opinion at which we have arrived of the life history of the herring differs from the preliminary description by HJORT (1914) therein that the growth definitely indicates the existence of two Norwegian herring stocks, a southern and a northern one. This opinion is based on the fact that there is only a portion of the northern fat herring stock, viz. the individuals of the A-type or only a portion of them, which later join the southern large and spring herring shoals. This agrees well with results arrived by the investigations of the spawning grounds«. OTTESTAD means that the southern stock spawns at the west coast and that the fat herring, which appear from Trøndelag southwards belong to this stock, while the northern stock spawns on the by RUNNSTRÖM (1933) proved spawning places outside Vesterålen and Lofoten. The young herring of the northern stock forms according to his opinion an essential part of the northern fat herring shoals. As I have shown in a paper from 1936, however, all the three growth types found by OTTESTAD among the northern fat herring can be encountered among the spring herring spawning at the south west coast and thus the basis for the conclusions of OTTESTAD fails.

Thus it has been very different opinions about the composition of the herring in the Norwegian waters and with the hypothesis of OTTESTAD the originally opinion of G. O. SARS has reappeared again. We know that small-, fat-, large- and spring herring represent different stages in the life history of the herring but this fact does not prove that the different kinds of herring, which appear at different parts of the coast, belong to one and the same race. To solve this problem a large material of observations on racial characters must be sampled from different regions and different seasons. In the present paper I will give an analysis of the great material of vertebral counts sampled during the later years of the Norwegian herring investigations.

MATERIAL AND METHODS.

The distribution of the samples of large- and spring herring collected for racial investigation in the years 1932—1936 at the Norwegian west coast is demonstrated in fig. 3. The black symbols represent samples from the large herring seasons in December and January and the other symbols samples from the spring herring season in February to April. As shown in the figure the samples »cover« the large- and spring herring fishery rather well. A number of samples of large- and spring herring from northern Norway are also collected which however are not indicated on the chart. The number of samples investigated in the five years is 202 and the samples include about 32 000 individuals.

Also a great number of samples of immature small- and fat herring from different parts of the coast including about 22 800 individuals have been to my disposal for racial analysis. Further a number of herring samples from the Norwegian Skagerak coast including 2100 individuals have been investigated.

In later years the Norwegian fishermen have started a driftnet fishery at the north eastern edge of the North Sea plateau along the Norwegian Deep (Revkanten) and a number of samples including 1900 individuals have been collected from this area.

The samples have been sent in fresh condition to the Fishery Directorate for investigation. For each herring has been noted length, weight, maturity, age and number of vertebrae. For the stage of maturity has been used the scheme recommended by the international council. As regards the vertebral counts the urostyle has been counted as the last vertebra.

In the table I at the end of the paper I have given the results of the vertebral counts for each sample grouped according to different areas investigated and in tables II and III the vertebral number of successive yearclasses is given. For each frequency serie is given the mean (M), the standard deviation (δ) and the standard deviation of the mean (μ), calculated according to the formulae $\delta = \sqrt{\frac{\Sigma\, H(x) \cdot (X-M)^2}{N}}$ and $\mu = \frac{\delta}{\sqrt{N}}$

In order to test if the difference between two means is significant the standard deviation of the difference has been calculated according the formula $\sqrt{\mu^1{}_2 + \mu^2{}_2}$. If the difference between the means is three or more times greater than its standard deviation, it is supposed to be significant.

As different races are supposed not to mix on the spawning grounds, it is by racial analysis of importance to work with pure spawning shoals. In the present investigation it has been laid stress upon a thorough knowledge about the spawning areas along the Norwegian coast in order to see if separated spawning communities exist, which may support the idea of the presence of different herring races in Norwegian waters. It is also of importance to study the composition of the shoals on the spawning grounds as regard the maturity in order to test if the spring herring represents pure spawning shoals.

The intention of the present work is thus to investigate if geographical separated spawning areas exist along the Norwegian coast and if so, whether the herring spawning in these areas differ morphologically as regards the vertebral number. Further the relation between the large herring visiting the coastal waters before the spawning season and the spawning shoals proper will be tested.

THE SPAWNING GROUNDS ALONG THE NORWEGIAN COAST.

In a paper from 1933 I have studied the pelagic distribution of the herring larvae along the Norwegian coast in order to get an orientation as to the spawning places by localizing the newly hatched larvae. The black symbols on the chart fig. 7 show the distribution of the length group 6—10 mm representing larvae with yolc sack. The occurrence of these newly hatched larvae indicates that spawning must have taken place in close proximity to the locality of catch.

The common oponion has been that the Norwegian herring stock mainly spawns at the south west coast of Norway. The material demonstrated in fig. 7 shows however that spawning takes place along extensive parts of the coast from 58° to 69° N. Lat. and also at the Norwegian Skagerak coast. But it seems as if certain parts of the coast constitute districts of concentration of the spawning. At the west coast there is a concentration of newly hatched larvae outside Haugesund and Stavanger where according to fig. 2 also the main spring herring fishery takes place. In the next region from Bergen to Stat no young larvae are observed and no important spawning seems to take place here in present time, which agrees with the fact that this district is now mainly a large herring district, where the fishery on spring herring is very unimportant. North of Stat one finds a spawning centre at the Møre coast, where a concentration of herring larvae with yolc sack is found outside Ålesund.

The most interesting fact is the appearence of newly hatched larvae as far north as about 69° N. Lat. Apparently spawning takes place at the Helgeland coast and on the sea banks at Røst as well outside Lofoten and Vesterålen. The young larvae have been observed in these northern districts in different years in March and April. Since the greate large herring fishery in 1861—74 no fishery on mature herring has taken place in these districts. When on crouises with M/S Johan Hjort I visited these districts in the spring 1935, the fishermen observed however, an immigration of a kind of herring, which was strange to them. A fishery took place on this herring from the end of March to the

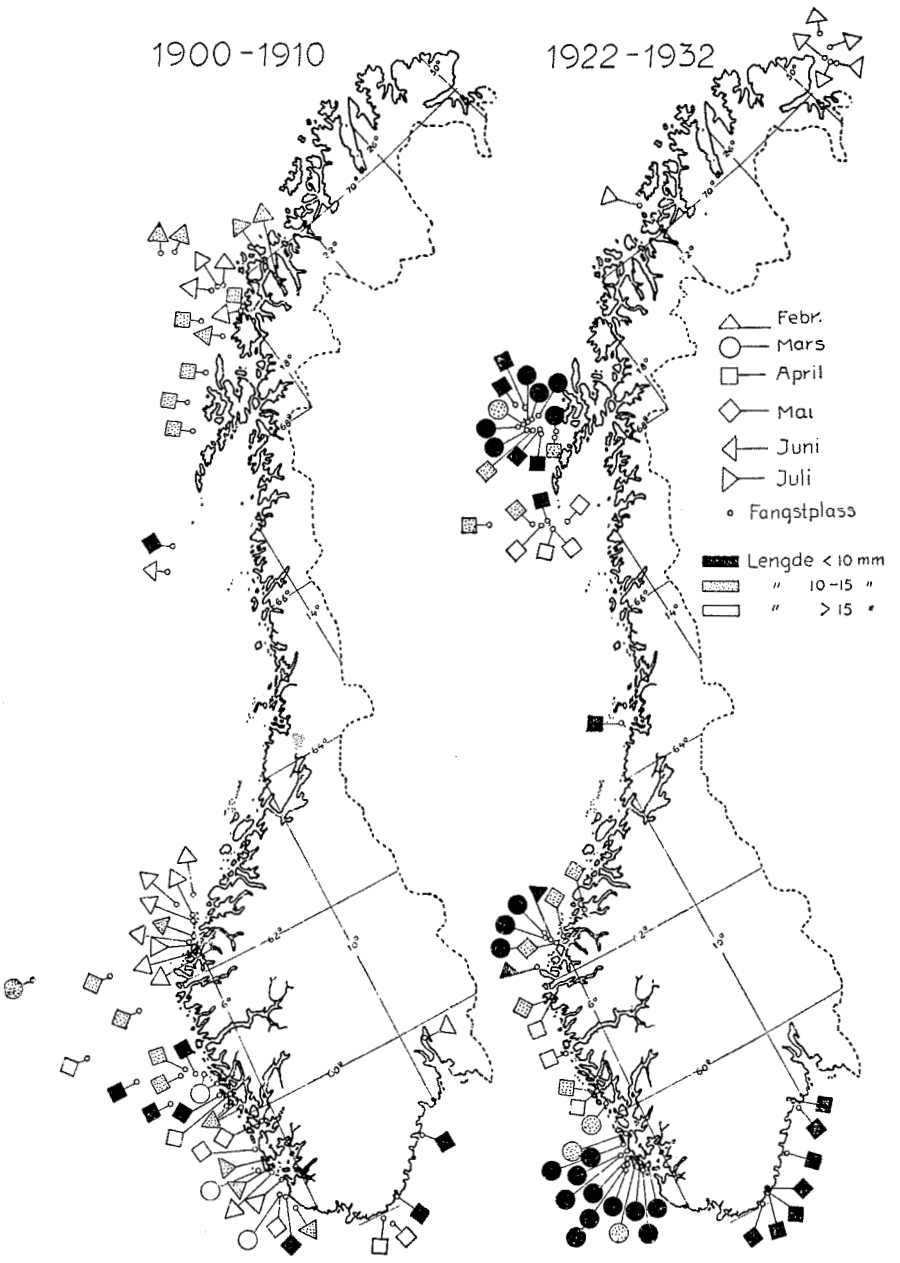

Fig. 7. Distribution of catches of herring larvae along the Norwegian coast. The black symbols indicate catches of larvae with yolc sack.

beginning of April in the inner part of the And Fjord some distance north of Vesterålen. I could personally state that the herring represented real spring herring which had immigrated into the fjord in order to spawn. The nets were covered with fertilized roe from the spawning herring. Later in April I could further state the occurrence of spawning herring on Traena Bank at the Nordland coast south of Lofoten and on Halten Bank in N. Trøndelag. A rather great material of herring samples was collected from Northern Norway. In 1936 large herring was observed in Vesterålen and Troms in January but no immigration of spawning herring took place into the fjords later in the season. It is probable that the immigration in 1935 was due to certain hydrographic conditions and that the herring normally spawns on the sea banks outside the coast, where they are not observed by the fishermen. About the mass of herring spawning here we have no idea but in this area there are sea banks of great extension with depth and bottom condition favourable for spawning.

The material of herring larvae from the Skagerak coast has been collected mainly from one and the same year and therefore the material does not say anything about the existence of a regular spring spawning in this area. A regular spring herring fishery of importance does not exist here, but in certain years shoals of spring herring may pass Lindesnes and immigrate to the Skagerak coast.

Material of young herring larvae with yolc sack taken by Norwegian investigations in the near of Viking Bank in the period 1900—1910 shows that herring spawn also on the north eastern edge of the North Sea plateau (Revkanten) in the open sea some distance from the Norwegian west coast. This has also been stated by MIELCK (1929) and CLARK (1933).

The investigations has thus shown that spawning takes place along the coast far up to northern Norway but it seems as if certain parts of the coast constitute areas of more intense spawning. Such spawning centres are the SW. coast between Lindesnes and Bergen, the Møre coast N of Stat and the banks off Lofoten and Vesterålen in N. Norway.

As regards the spawning time the fig. 7 shows that newly hatched larvae occur in February, March and April at the W. coast and N. Norway and in April and May at the Skagerak coast. As regards the spawning time on the grounds at the SW. coast and at Møre we have more exact observations. In each of the years 1931—1938 I have made regular observations on the distribution of the herring roe on the main spawning grounds of these districts by investigations with bottom grab. By hatching the herring eggs in the laboratory I have determined the age

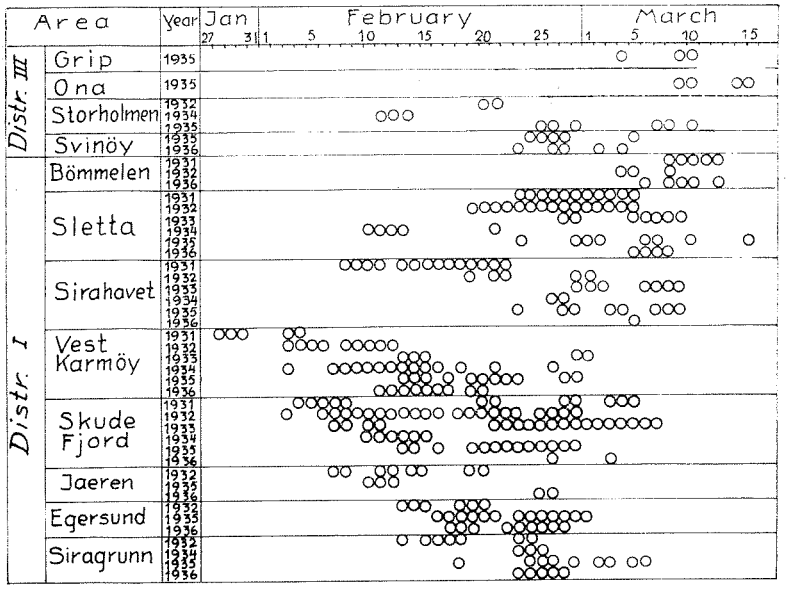

Fig. 8. The main spawning seasons of the spring herring in different spawning areas at the south west coast and Møre coast, stated on determination of the age of herring roe taken with the bottom grab.

of different stages of development. Thus it has been possible to determine the point of time when the eggs found on the spawning grounds have been fertilized.

However, the spawning is not even distributed troughout the whole area in the main spawning districts. The spawning is restricted to by the fishermen wellknown spawning grounds with sandy or rocky bottom separated by fjords or deeper ridges with soft bottom. By entering the coast the herring follows these deep ridges until they meet the spawning grounds proper. The herring does not spawn simoultaneously on the different grounds and the fishing fleet moves from one place to another troughout the spawning season, and this movement is rather regular from season to season.

In fig. 8 I have demonstrated the spawning time on the more important spawning grounds in the two main spawning districts at the south west coast (district I) and the Møre coast (district III) according to the previously mentioned observations on the herring roe taken with the grab. The spawning grounds are in the table classified according to the different smaller fishing areas demonstrated on the chart in fig. 2.

In the spring herring district between Lindesnes and Bergen the

herring is first observed on the open sea outside the small island Utsira, and the herring then follows the deep ridge which ends in the Skude Fjord situated between Stavanger and Haugesund. Already in the last days of January the spawning may begin at the south west coast of the island Karmøy at the northern part of Skude Fjord and a short time later also on the spawning grounds in the inner part of the fjord. On these spawning grounds situated in the centre of the district also the richest fishery takes place as demonstrated on the chart fig. 2. Then somewhat later in the season, but before the spawning is ended on the previously mentioned grounds, the spawning begins gradually on the more southern grounds outside Jæren, Egersund and on the Sira Ground and in the same manner on the more northern grounds at Sira Fjord, Sletta and Bømmelen. In the most northern area, Bømmelen, the spawning begins first in March and the main spawning is ended in the middle of March, when also the main fishery is ended. The herring visiting the last mentioned area is represented mostly by younger age classes which spawn for the first time, the so called recruit spawners.

Also at the Møre coast the spawning begins in the centre of the district, where also the richest fishery takes place (Storholmen on the chart fig. 2), and then later in the season the herring spawn on the more northern and southern spawning grounds. However, on the whole the spawning begins later at the Møre coast than at the south west coast, and the main spawning lasts from the middle of February to the middle of March. However, a less important spawning may occur later in the season until April.

It is very probably that we have to do with different isolated runs to the different spawning grounds, the shoals following different deep ridges to the coast. The herring shoal remains on one and the same spawning ground for weeks until the spawning is finished and the shoal disappear from the coastal water. This has been confirmed by registrating different shoals with the echo sounder throughout a longer period (RUNNSTÖM 1937). In the day time the herring mostly seek to deeper water, while in the night they rise to shallower water and enter the spawning grounds. We must not regard the spawning immigration to the Norwegian coast as an immense bulk of herring coming along the coast but there exist many isolated runs to the spawning grounds along the whole coast from Lindesnes in the south to Vesterålen and Troms in the north.

THE COMPOSITION OF THE LARGE- AND SPRING HERRING AS REGARDS MATURITY AND AGE.

Fig. 9 demonstrates the composition of the herring shoals as regards maturity, when they appear in the coastal waters throughout the large- and spring herring season in the four regions: I Lindesnes—Bergen (Rogaland , S. Hordland), II Bergen—Stat (N. Hordland, Sogn and Fjordane), III Stat—Trondheims Fjord (Møre, Trøndelag), IV northern Norway (Helgeland, Nordland, Troms).

The material includes a great number of samples collected since the Norwegian investigations started regular observations on the composition of the herring stock in 1907 up to present days, and thus the figure gives the average composition as regards maturity based on a long period of observations.

The herring from the large herring season December—January mainly consist of fishes in the stages IV and V and to a less degree in stage III with a small admixture of immature herrings in the stages I and II. At the end of January a small part of the fishes have got running roe and milt (stage VI). When the spring herring season begins in February the main part of the herring appearing in the southernmost district I consist of spawning (stage VI) or spent (stage VII) herrings but with an admixture of individuals in the stages IV and V. In the two more northern districts II and III, however, the herring is sexually less developed and herrings in the stages IV and V are still dominating over the spawning and spent individuals. This is in accordance with the fact that the spawning begins later at the Møre coast than at the south west coast as shown in the previous chapter. In northern Norway a strong admixture of immature herring can be noticed in February.

In March, however, the most part of the herrings in all districts consist of spawning individuals or spents in the stages VI and VII and the admixture of herrings in the stages IV and V is less than in the previous month. The same conditions are found in the month April with the exception that a number of recovering spents are found in this month.

Thus the material demonstrates that spawning herring appear in all the four districts but, as shown in fig. 2, the shoals appearing in the

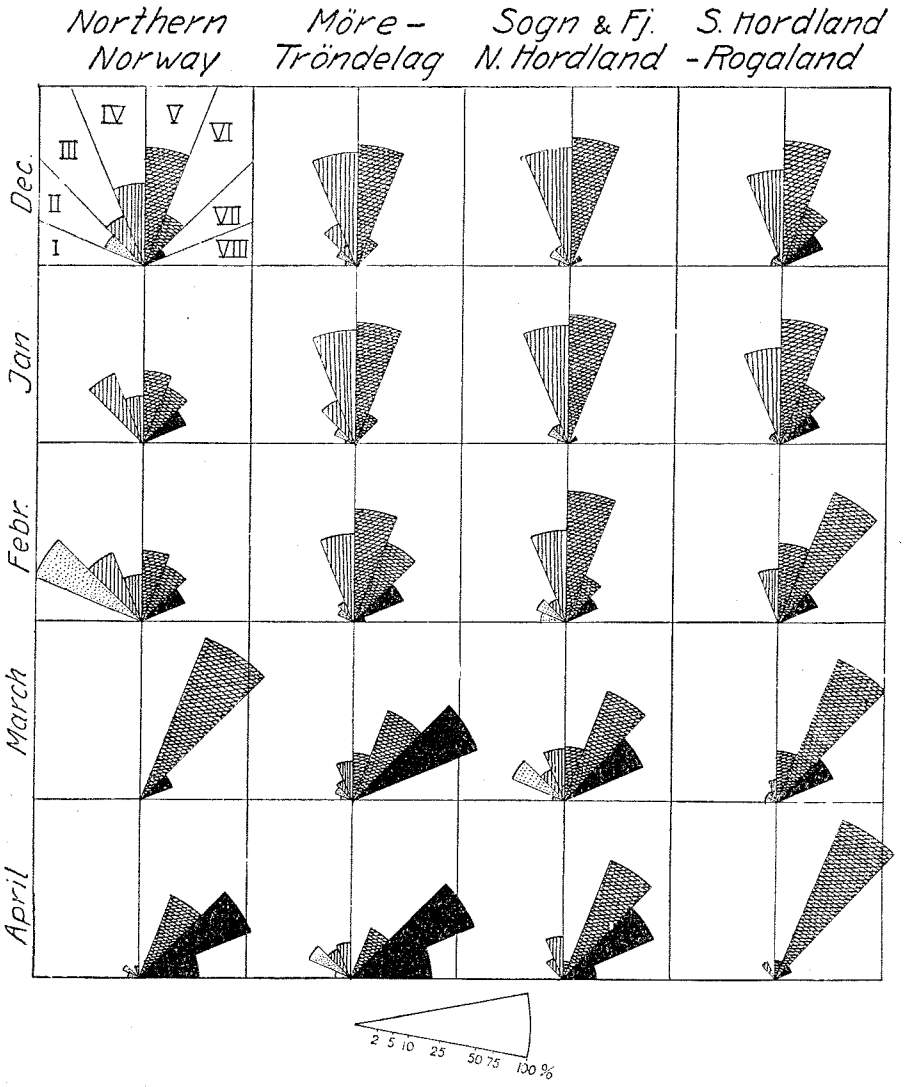

Fig. 9. Composition of the herring shoals as regards maturity in different coastal regions throughout the large- and spring herring season.

spawning season in the district II between Bergen and Stat are of minor importance and in Northern Norway the shoals of mature herring are only occasionally met with by the fishermen. The herrings appearing in the coastal waters in December—January are mainly in the stages IV and V, while the herring throughout the spawning season does not represent pure shoals of spawning individuals but have an admixture of fishes still in the stages IV and V, which is most apparent in February. It is thus no sharp limit between the large- and spring herring season as regards the maturity and the only criterion on the spring herring season is that spawning has started.

The question may be raised if the large herring, which appear in the winter some time before the spawning season, really spawn in the following spawning season in the early spring. The herring in the stages I and II undoubtly must be eliminated as an admixture of immature fat herrings. As regards the stages III—V however we do not know very much about the duration of these stages.

LEA (1929) has supposed that the large herring represent the older spawners, which on the spawning grounds join the recruit spawners later in the season. As LEA has shown and I later confirmed (RUNNSTRÖM 1936) the young herring reach the maturity and join the spawning shoals at an age of 3—7 years and as a matter of fact all the herrings more than 7 years old have spawned one or more times in their life, and obviously the herring spawns each year. It will therefore be of interest to analyse the age composition of the herring shoals in order to see if the large herring represent fullgrown individuals of the same age composition as the herring spawning in the earlier part of the spawning season.

In fig. 10 I have given the age composition of the herring shoals appearing at the west coast throughout the season 1933—1934, herrings in different stages of maturity treated separately. The conditions in this season can be regarded as typical for the conditions in the later years.

One finds that the stage III of the large herring in December—January mainly represents a component of younger individuals with 5 and 6 years old herring predominant. The age composition of this group is very similar to that of the recruit spawners appearing in March and April, and it is probably that this group of large herring have not spawned before in their life. This group of younger herrings has in the later years regularly appeared in the beginning of the large herring season. The stages IV and V in December—January represent mainly a component of older individuals with the greatest number of herring older than 7 years, which must be supposed to have spawned once or more times

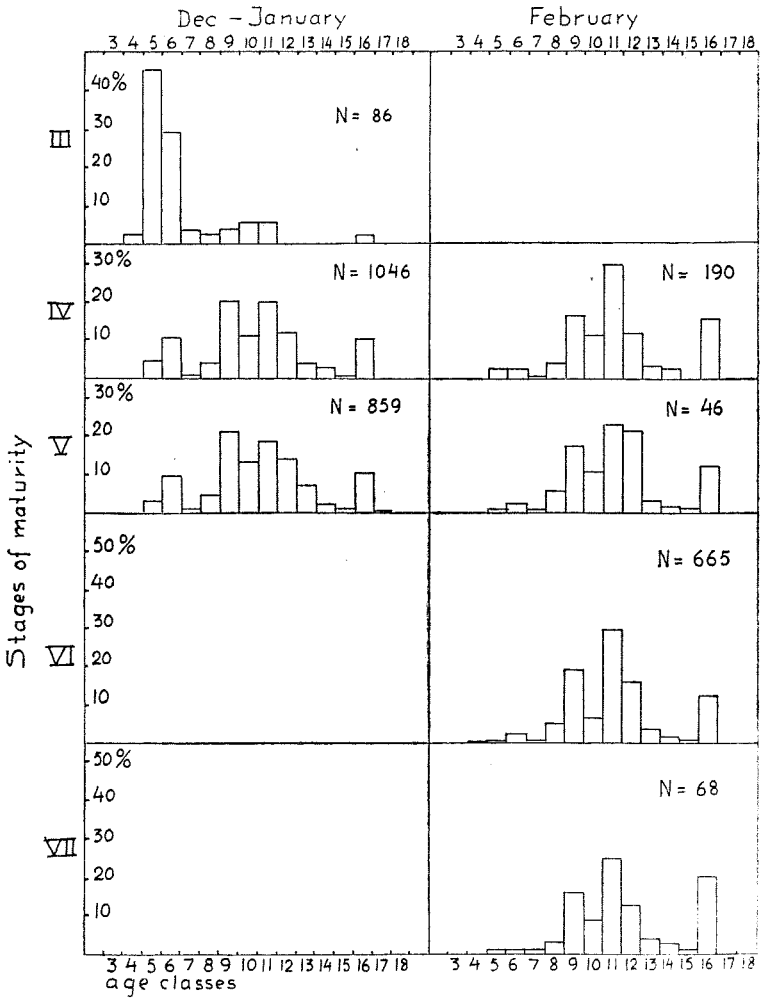

Fig. 10 a.

The age composition of herring in different maturity stages

before and which must be expected also to spawn in the following spawning season. The age composition is very similar to that of the herring in stages VI and VII in February with the 9, 11 and 16 years old herrings, representing the rich year classes 1925, 1923 and 1918, predominant.

In February the different stages IV—VII represented in the herring shoals are very uniform as regards the age composition and the shoals consist almost exclusively of older herrings.

In March, however, the component of younger herrings appear

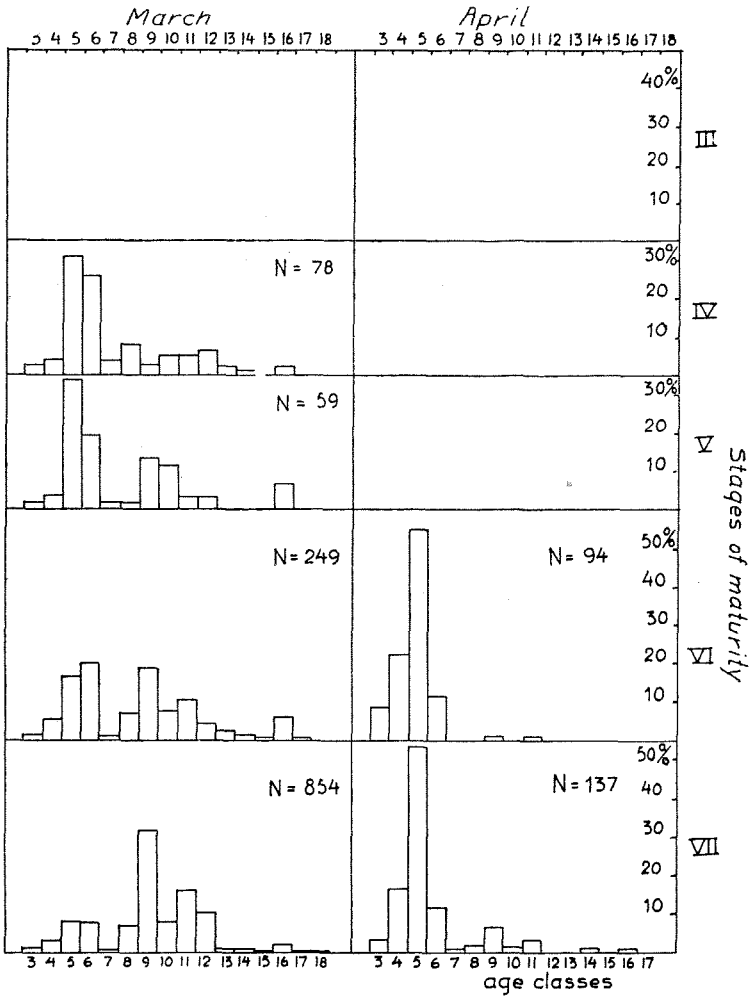

Fig. 10 b.

throughout the large- and spring herring season 1933—1934.

on the spawning grounds. One finds the same condition as in December —January namely that the sexually less developed individuals (stages IV and V) are represented by younger age groups mainly consisting of 5 and 6 years old herrings. Also the spawning herring in stage VI includes a group of younger individuals but this group is not predominant. The spent herrings (stage VII) consist mainly of older herrings in the same manner as the shoals in February. Thus with increasing maturity the average age also increases.

The spawning and spent herring which appear in April consist

almost exclusively of 3—6 years old individuals representing rather pure shoals of recruit spawners. The age composition of this spawning shoals is rather similar to that of the herring in stage III in the early part of the large herring season and of the herring in stage IV and V appearing in March.

In the main features thus we can confirm the opinion of LEA about the age composition of the large- and spring herring. The large herring in the stages IV and V represents mainly older spawners of the same age composition as the spring herring in the early spawning season in February. In the later years however a sexually less developed group of younger herrings have appeared in the beginning of the large herring season which have an age composition very similar to the recruit spawners appearing in the later part of the spawning season. If these herrings really spawn in the immidiately following spawning season cannot be decided surely. In March the recruit spawners, which spawn for the first time in their life, appears on the spawning grounds and it is apparent that the younger age groups reach maturity later than the older spawners. The heterogenity of the spring herring in March as regards maturity is due to this circumstance.

A STATISTICAL ANALYSIS OF THE VERTEBRAL NUMBER OF THE LARGE- AND SPRING HERRING IN NORWEGIAN WATERS.

From the previous description we have seen that a pre-spawning migration takes place to the west coast which forms the base for an important large herring fishery in December—January mainly in coastal regions where only an unimportant spawning takes place. In February—April a spawning migration takes place to the main spawning districts at the south west coast and the Møre coast, which forms the base for the spring herring fishery. As we have seen no fundamental differences exist as regards the age composition of the large herring and spring herring shoals and according to OTTESTAD (1934) also no growth divergencies can be proved. Thus the only difference between the two kinds of herring seems to be the degree of maturity.

However investigations by BROCH, JOHANSEN and SCHNAKENBECK, cited in a previous chapter, have shown that certain morphological divergencies may exist, which seem to indicate that the Norwegian herring population is not homogeneous from a racial point of view.

In the following I will give a statistical analysis of the great number of vertebral counts on large- and spring herrings made in the years 1932—1936. In the first place it will be tested if the spring herring appearing on the spawning grounds throughout the spawning season is racially homogeneous and then the relation between the large herring and the spring herring will be analysed.

The Spring Herring.

As have been demonstrated in figures 2 and 7 two main spawning centres (districts I and III) exist at the Norwegian coast and where also the main spring herring fisheries take place. These two spawning districts are separated by a large herring district (II) where only an unimportant spawning takes place. Further a spawning centre was found in northern Norway (district IV) outside Lofoten and Vesterålen but where no regular fishery takes place. It will in the following be tested if the herring appearing in these different spawning districts

throughout the spawning season February—April differ morphologically as regards the vertebral number.

In the second column of table 1 I have given the mean number of vertebrae for the whole material of spring herring from each of the four districts I—IV. The greatest number of individuals comes from the two main spawning districts I and III while the material is rather sparse from the district II where spawning shoals more seldom are met with. In the table I have given the number of herring investigated (n), the mean number of vertebrae (M) and the standard deviation of the mean (μ).

The mean number of vertebrae of the spring herring from the two main spawning districts I and III is 57.353 ± 0.007 and 57.280 ± 0.009 respectively and the difference between the means is 0.073 ± 0.011 which measured with its standard deviation is equal to 6,5. The difference must therefore be regarded as significant and the possibility is very small that the difference would be eliminated if new observations were added.

The mean number of vertebrae of the spring herring from Northern Norway (district IV) is 57.273 ± 0.019 and is thus only a little lower than the mean for district III but considerable lower than that for district I. The difference between the means for districts I and IV is 0.080 ± 0.020 which measured with its standard deviation is equal to 4.0. Thus the spring herring from the south west coast (I) differ significantly from those appearing in the spawning districts III and IV north of Stat.

However also a scanty spawning occurs in the district II and the mean number of vertebrae of the spring herring appearing in this district is 57.326 ± 0.029. This mean has an intermediate position between the means for the two neighbouring districts I and III but the differences are not statistically significant.

By comparing all four districts one finds the highest mean in the most southern district and then decreasing values from south to north.

In a previous chapter we have seen that the spring herring shoals on the spawning grounds do not represent pure spawning shoals but the spawning and spent herrings (stages VI and VII) have a rather important admixture of individuals in the stages IV and V which are not quite ready to spawn. This is most prominent in February. In the two last columns of table 1 I have given the mean number of vertebrae of the two maturity groups IV + V and VI + VII separately.

When the maturity group VI + VII from the four different regions are compared one finds, in the same manner as for the whole material, decreasing mean values from south to north. The difference between the means for districts I and III is 0.080 ± 0.014 which measured

Table 1. *Vert. S. 1932—1936.*

Districts			Large herring	Spring herring February—April		
			M. stages	Maturity stages		
			IV + V	IV + VII	IV + V	VI + VII
IV	Northern Norway	n	370	1 243	43	1 200
		M	57.186	57.273	57.302	57.272
		μ	± 0.035	± 0.019	± 0.102	± 0.019
III	Trøndelag Møre	n	5 261	5 544	2 231	3 313
		M	57.194	57.280	57.273	57.285
		μ	± 0.009	± 0.009	± 0.014	± 0.012
II	Sogn & Fjord N. Hordland	n	7 780	592	196	396
		M	57.158	57.326	57.367	57.306
		μ	± 0.007	± 0.029	± 0.047	± 0.037
I	S. Hordland Rogaland	n	951	10 403	2 632	7 771
		M	57.308	57.353	57.316	57.365
		μ	± 0.022	± 0.007	± 0.013	± 0.008
	Total	n	14 362	17 782	5 102	12 680
		M	57.182	57.324	57.299	57.334
		μ	± 0.006	± 0.005	± 0.010	± 0.006

with its standard deviation is equal to 5.7. The difference between the means for districts I and IV is 0.093 ± 0.021 which measured with its standard deviation is equal to 4.4. The pure spawning shoals at the south west coast differ thus significantly from those at the Møre-Trøndelag coast and northern Norway.

In following table will be tested if there is any real difference between the means of the maturity groups IV + V and VI + VII within one and the same area, in the spawning season February—April

District IV: Diff. stage IV + V — stage VI + VII = 0.030 ± 0.104
» III: » » » — » » = 0.012 ± 0.018
» II: » » » — » » = 0.061 ± 0.060
» I: » » » — » » = 0.049 ± 0.015

Only in the southernmost district I a real difference between the two maturity groups can be noted which is more than three times its standard deviation. In the other districts there are no significant differences between the two groups.

In table 2 I have sub-classified the material according the different months February, March and April in order to see if the spring herring is homogeneous throughout the spawning season. The two maturity groups are treated separately.

In the district I at the south west coast the material only includes February and March while a spring herring fishery seldom takes place here in April. As regards the spring herring appearing in February one finds as for the whole material a lower mean for the maturity group IV + V than for the group VI + VII and the difference between the means, 0.062 + 0.018, is significant. As regards the spring herring in March the sexually less developed herrings (IV+V) have a mean number of vertebrae rather similar to that of the corresponding group in the previous month. But also the spawning and spent herrings (VI + VII) have a lower mean than the corresponding maturity group in February.

The lowering of the mean in March might be due to the immigration of the recruit spawners which takes place in this month. In order to test this supposition I have in the following given the mean of the 3—7 years old recruit spawners and the mean of the herring older than 7 years appearing in March:

Recruitspawners M = 57.331 + 0.018
Older spawners M = 57.343 + 0.025 Diff. = 0.012 + 0.031

It is thus no significant difference between the two age groups appearing in March and also the older herrings show a somewhat lower mean than the older spawners in February. The lowering of the mean in the later part of the spawning season must be due to other circumstances which will be discussed later.

In the other main spawning district III at the Møre coast no real differences exist between the means of the different groups of herring appearing in the different months of the spawning season as demonstrated in table 2. Also the mean number of vertebrae of the recruit spawners (57.263 ± 0.030) does not differ significantly from that of the whole contingent of herring appearing in March (57.274 + 0.017).

Summarizing the results we have found that the herring spawning in the main spawning districts between Lindesnes and Bergen and between Stat and Trondheims Fjord, which districts are separated by a region where only a scanty spawning takes place, differ significantly as regards the vertebral number. Also the herring spawning in Northern Norway differ significantly from those spawning at the south west coast, but has a vertebral number rather similar to that of the herring from the Møre coast. Thus it seems to exist two racially different spawning communities along the Norwegian coast. However if this is the case each of the spawning communities must be racially uniform, as different

Table 2. *Vert. S. Spring herring 1932—1936.*

Districts			February Maturity stages		March Maturity stages		April M. stages
			IV+V	VI+VII	IV+V	VI+VII	VI+VI
IV	Northern Norway	n	43	34		28	1 138
		M	57.302	57.265	—	57.393	57.269
		μ	±0.102	±0.104		±0.137	±0.020
III	Trøndelag Møre	n	2 068	1 298	163	1 741	274
		M	57.277	57.300	57.227	57.274	57.288
		μ	±0.015	±0.019	±0.050	±0.017	±0.046
II	Sogn & Fjord. N. Hordland	n	134		62	126	255
		M	57.351	—	57.403	57.246	57.314
		μ	±0.050		±0.101	±0.065	±0.046
I	S. Hordland Rogaland	n	2 228	5 482	404	2 289	
		M	57.316	57.378	57.319	57.335	—
		μ	±0.015	±0.010	±0.034	±0.015	

herring races are expected not to mix in the same spawning area during the spawning season. In the Møre—Trøndelag district the herring stock seems to be rather uniform throughout the spawningseason. At the south west coast however, the sexually less developed herring differs from the spawning herring in February and the later ones have a higher mean value than the herring spawning in March. It will therefore be of interest to make a further analyse of the herring appearing in different minor areas within one and the same main spawning district.

In a previous chapter I have shown that we probably have to do with different runs to the different spawning grounds within one and the same spawning district, and that these different shoals do not spawn at the same time. The herring first appears in the centre of the district and then shoals gradually immigrate to the other grounds.

In table 3 I have given the mean number of vertebrae of the herring from the different spawning grounds along the coast situated in the fishing areas indicated on the chart fig. 2. The herring appearing in the spawning season February—April are separated in the two maturity groups IV + V and VI + VII.

If we first consider the southernmost district I comprising Rogaland—S.Hordland in table 3, we find the highest mean value for the herring in stages VI + VII in the southern part of the district on the grounds outside Egersund and Jaeren (57.425 and 57.463) and the

lowest values in the northernmost part of the district at Bømmelen and Kors Fjord (57.332 and 57.305). The difference between the means for Egersund and Bømmelen is 0.093 ± 0.031 which measured with its standard deviation is equal to 3.0. It is also a real difference between the mean of the herrings spawning outside Egersund an that of the herring spawning at Skude Fjord in the centre of the district. This difference is 0.075 ± 0.024 which measured with its standard deviation is equal to 3.1. The herring spawnings in the main spawning district at the south west coast is thus not racially homogeneous, and the racial analysis confirms the previously mentioned opinion, that we have to do with different independent runs to the different spawning grounds.

We can now also understand why the mean number of vertebrae is lower in March than in February in this district. As we have seen in fig. 8, demonstrating the spawning time on the different grounds, the herring arrives to the northernmost spawning grounds, Bømmelen and Kors Fjord, first in March and these herrings have a lower mean number of vertebrae than the herrings spawning earlier in the season on the more southern grounds.

We have in table 1 seen that the maturity group IV + V of the herring appearing mainly in February in district I differ significantly as regards the vertebral number from the maturity group VI + VII in the same district. Table 3 demonstrates, however, that the maturity group IV + V of the herring appearing in the spawning season is also very heterogeneous. The highest mean value (57.521) is found on the grounds outside Jaeren and the lowest mean (57.146) on the northernmost grounds within the district at Kors Fjord, in the same manner as has been domonstrated for the group VI + VII. The difference between the means for the herring from Jaeren and Kors Fjord is 0.375 ± 0.076, which measured with its standard deviation is equal to 4.9. But real differences exist also between the mean for Jaeren on the one side and the means for Skude Fjord and Sira Fjord on the other hand. These differences, measured with their standard deviations, are equal to 3.1 and 3.9 respectively. However, when the two maturity groups from one and the same spawning area are compared in table 3, one does not find any differences which are significant from a statistical point of view. The difference obtained by comparing the whole material of the two maturity groups from district I may be explained by the circumstance, that the groups are composed of heterogeneous elements in different proportions.

In the other main spawning district III, at the Møre—Trøndelag coast, the material seems to be more homogeneous and no significant differences can be found between the means of the spawning groups on the different spawning grounds. There are also no significant differences

Table 3. *Vert. S. Large- and Spring herring 1932—36.*

		Localities	Large herring Dec.– Jan.	Spring herring February—April	
			M. stages IV+V	M. stages IV+V	M. stages VI+VII
Distr. IV	Nord-Norge	Troms	57.201 ± 0.039		57.247 ± 0.029
		Vesterålen			57.263 ± 0.052
		Helgeland	57.140 ± 0.074		57.267 ± 0.028
District III	Trøndelag	Vikna			57.247 ± 0.057
		Halten			57.308 ± 0.055
		Titran		57.217 ± 0.033	57.202 ± 0.046
	Møre	Griphavet	57.225 ± 0.040	57.344 ± 0.050	57.303 ± 0.038
		Baksbotten	57.240 ± 0.024	57.282 ± 0.033	57.260 ± 0.031
		Onahavet	57.198 ± 0.037	57.240 ± 0.049	57.306 ± 0.116
		Storholmen	57.216 ± 0.015	57.199 ± 0.054	57.296 ± 0.024
		Rundøy	57.180 ± 0.021	57.313 ± 0.026	57.297 ± 0.023
		Svinøy	57.121 ± 0.021	57.272 ± 0.049	57.394 ± 0.081
District II	Sogn & Fjordane	Kråkenes	57.161 ± 0.038		
		Bremanger	57.155 ± 0.026	57.403 ± 0.101	57.246 ± 0.065
		Kinn	57.241 ± 0.025		
		Bulandet	57.163 ± 0.016		
		Sognesjøen	57.113 ± 0.024		
	Nord. Hordl.	Feie	57.142 ± 0.015	57.351 ± 0.050	
		Hjeltefjord	57.109 ± 0.019		57.306 ± 0.044
		Fjell	57.274 ± 0.034		
District I	Sunn-Hordl.	Korsfjord	57.218 ± 0.032	57.146 ± 0.052	57.305 ± 0.050
		Bømmelen		57.328 ± 0.050	57.332 ± 0.024
	Rogaland	Sletta		57.377 ± 0.027	57.369 ± 0.024
		Sirafjord	57.308 ± 0.022	57.256 ± 0.038	57.361 ± 0.024
		Skudefjord		57.294 ± 0.022	57.350 ± 0.014
		Jæren		57.521 ± 0.056	57.463 ± 0.100
		Egersund		57.354 ± 0.079	57.425 ± 0.019
		Siragrunn			57.363 ± 0.030
		V. Agder		57.273 ± 0.053	57.354 ± 0.036

between the means of the two maturity groups IV + V and VI + VII in one and the same spawning area. On the whole the mean values, with exception of that for Svinøy, are lower than those found in district I. The same is the case with the means of the herring from the different spawning areas in northern Norway.

As regards the district II (N. Hordland, Sogn and Fjordane) the scanty material seems to show, that the herrings appearing in the southern part of the district (Hjelte Fjord) have a mean number of vertebrae similar to that of the herring in the northern part of district I (Kors Fjord), while the herring spawning in the northern part (Bremanger) has a lower mean value more corresponding to those found in district III.

Thus the racial analysis has shown that we have not to do with two distinct races represented by the spawning community at the south west coast and that north of Stat, but also within one and the same spawning district the shoals appearing on the different grounds may differ significantly as regards the vertebral number. The two main spawning districts are also not quite distinct separated from each other and a scanty spawning takes place in the intermediate district II. The spawning in the last mentioned district must have been of rather great importance in certain periods, when a rather great spring herring fishery tooks place there (compare fig. 4).

It is more in conformity with the facts to regard the spawning as rather continuous along the whole coast from Lindesnes to Northern Norway but with a more important spawning in certain areas. Instead of two or more distinct spawning communities we have apparently to do with a great number of local spawning runs to the grounds along the coast which differ morphologically and which therefore must be supposed not to intermingle in greater degree. From the table 3 one gets the impression, that the vertebral number of the different spawning shoals gradually decreases from south to north.

The relation between the Large herring and the Spring herring.

As demonstrated in fig. 2 the main large herring fishery takes place in the district II between Bergen and Stat, where no spring herring fishery of importance occurs, and to a less degree in the district III between Stat and Trondheims Fjord. The large herrings appear in December and disappear again from the coastal waters at the end of January, which is marked by a declean of the fishery between the large herring and the spring herring seasons. In the southernmost district I no corresponding large herring fishery takes place but the first herring shoals, which appear at the end of January immediately before the spawning season, are commonly not quite ready to spawn and may therefore be characterized as large herrings. In northern Norway large herring shoals have occasionally been met with in January.

The large herring include mainly individuals in the maturity stages IV and V and to a less degree individuals in stage III. The herrings in the last mentioned stage consist mainly of young individuals, and it cannot be decided, if this group will spawn in the following spawning season. The sexually more developed individuals in stages IV and V include however mainly older herrings of the same age composition as the spring herrings met with in February. In the following analysis I will therefore only treat the large herring in the stages IV and V.

In table 1 is given the mean number of vertebrae of the large herring appearing in December—January in the four districts I—IV. One finds that the large herring does not constitute a homogeneous stock. The herring from the main large herring district II has the lowest mean number of vertebrae, while the large herring from the more northern districts III and IV have somewhat higher means. The large herring from the southernmost district I has, however, a considerable higher mean value than the herrings from the other three districts. The differences between the mean for district I and the means for the districts II, III and IV are 0.150 ± 0.23, 0.114 ± 0.024 and 0.122 ± 0.041 respectively. In all three cases the difference measured with its standard deviation is equal to or more than 3.

It is however also a real difference between the means of the herring from the two main large herring districts II and III. This difference is 0.036 ± 0.011 which measured with its standard deviation is equal to 3.3.

In the following the relation between the large herring, appearing in December—January, and the spring herring, appearing in February—April, will be discussed.

By looking on the chart fig. 2 one finds that a spring herring fishery of dimensions corresponding to the great herring fishery between Bergen and Stat only is found at the south west coast between Lindesnes and Bergen. If the bulk of large herrings really spawn at the Norwegian coast after leaving the district II they must be supposed to immigrate to district I in the spawning season. At the Møre coast a spring herring fishery of dimensions corresponding to the large herring fishery in the same district exists and it is therefore naturally to suppose that the large herrings appearing in district III also spawn in this coastal region.

The mean number of vertebrae given in table 1 demonstrates however that the large herrings generally have lower mean values than the spring herrings. The mean number of vertebrae of the whole material of large herring is 57.182 ± 0.006 ($n = 14362$) and that of the whole material of spring herring 57.324 ± 0.005 ($n = 17782$). The difference between the two means, 0.142 ± 0.008, is considerable and measured with its standard deviation equal to 17.8.

In the following table 4 I have given the differences between the means of the large herring in each of the four districts I—IV and the means of the maturity groups VI + VII and IV + V of the spring herrings in the corresponding districts. The differences are measured with their standard deviations $\left(M_1 - M_2 : \sqrt{\mu_1^2 + \mu_2^2}\right)$.

When one compare the large herrings appearing in the two main large herring districts II and III with the spawning herrings (maturity group VI + VII) in each of the four districts I—IV, one finds real differences between all the mean values, which measured with their standard deviations are equal to or more than 3.

The difference between the means of the large herring from the main large herring district II and the spawning herring from the main spring herring district I is 0.207 ± 0.011 which measured with its standard deviation is equal to 18.8. The differences between the means of the large herring from districts III and IV and the spawning herring from district I are 0.171 ± 0.012 and 0.179 ± 0.036 respectively which measured with their standard deviations are equal to 14.3 and 5.0. The only group of the large herring which does not differ significantly from the spawning herring in district I is the large herring which appear in the same district immediately before the spawning season. The difference between the means of these two groups is 0.057 ± 0.026 which measured with its standard deviation is equal to 2.2.

Thus we have seen that the bulk of large herring appearing in December—January differ significantly as regards the vertebral number from the spring herring spawning in February—April in any of the four districts I—IV situated along the coast between Lindesnes and Northern Norway. Only the small amount of large herring appearing in the southernmost district I at the end of January seems to be identical with herring spawning in the same district. The large herrings occasionally met with in Northern Norway (district IV) also do not differ significantly from the herring spawning in this northern district but the number of large herring investigated from this district is rather small.

Also when the bulk of large herring from districts II and III are compared with the maturity group IV + V of the spring herring appearing in February—April in the three districts I, II and III, one finds differences which measured with their standard deviations are considerable greater than 3 (table 4). The spring herring in stages IV and V from Northern Norway are not considered while the number of individuals investigated (43) is very small. Only the large herring from district I does not differ significantly from maturity group IV + V of the spring herring.

Table 4. $M_1 - M_2 : \sqrt{m_1^2 + m_2^2}$

Spring herring February—April.

Diff. →

Large herring. Districts ↓	Maturity stages IV + V			
	Districts			
	IV	III	II	I
IV	$\frac{0.116}{0.108} = 1.1$	$\frac{0.087}{0.038} = 2.3$	$\frac{0.181}{0.059} = 3.1$	$\frac{0.130}{0.037} = 3.5$
III	$\frac{0.108}{0.110} = 1.0$	$\frac{0.079}{0.017} = 4.6$	$\frac{0.173}{0.048} = 3.6$	$\frac{0.122}{0.016} = 7.6$
II	$\frac{0.144}{0.105} = 1.4$	$\frac{0.115}{0.016} = 7.2$	$\frac{0.209}{0.048} = 4.4$	$\frac{0.158}{0.015} = 10,5$
I	$\frac{0.006}{0.104} = 0.1$	$\frac{0.035}{0.026} = 1,3$	$\frac{0.059}{0.052} = 1.1$	$\frac{0.008}{0.026} = 0.3$

Diff. →

Large herring. Districts ↓	Maurity stages VI + VII			
	Districts			
	IV	III	II	I
IV	$\frac{0.086}{0.040} = 2.2$	$\frac{0.099}{0.037} = 2,7$	$\frac{0.120}{0.051} = 2,4$	$\frac{0.179}{0.036} = 5.0$
III	$\frac{0.078}{0.021} = 3,7$	$\frac{0.091}{0.015} = 6.1$	$\frac{0.112}{0.038} = 2.9$	$\frac{0.171}{0.012} = 14.3$
II	$\frac{0.114}{0.020} = 5.7$	$\frac{0.127}{0.014} = 9.1$	$\frac{0.148}{0.038} = 3.9$	$\frac{0.207}{0.011} = 18.8$
I	$\frac{0.036}{0.029} = 1.2$	$\frac{0.023}{0.025} = 0.9$	$\frac{0.002}{0.043} = 0.1$	$\frac{0.057}{0.026} = 2.2$

By a sub-classification of the material of large herring according to the different minor fishing areas along the coast demonstrated on the chart fig. 2 one finds from table 3 that the large herring within one and the same main district is heterogeneous, in the same manner as found for the spring herring. If the main large herring district II is considered, one finds rather variating means for the large herring visiting the different fishing areas. The large herring from Hjelte Fjord and Sognesjøen have the lowest mean values, which differ significantly from the means found in the neighbouring areas. Thus the difference

between the means from Hjelte Fjord and Fjell is 0.165 ± 0.039 which measured with its standard deviation is equal to 4.2. Further the difference between the means from Sognesjøen and Kinn is 0.128 ± 0.035 which measured with its standard deviation is equal to 3.7. Also the difference between the means from Hjelte Fjord and Kinn, 0.132 ± 0.031 is more than three times its standard deviation.

Within the district III the large herring from Svinøy has a lower mean number of vertebrae than the large herrings from the more northern areas. The differences between the mean for Svinøy and the means for Storholmen and Baksbotten are 0.095 ± 0.026 and 0.119 ± 0.032 respectively, and in both cases the difference is more than three times its standard deviation and thus significant.

However, generally the means of the different large herring groups are lower than those of the spring herring spawning on the different grounds along the coast with exception of the large herring appearing at Sira Fjord in the southernmost district, the mean of which corresponds rather well with that of the herring spawning in the same area. When for instance the spawning herring (maturity group VI + VII) from the Skude Fjord area, where according to the chart fig. 2 the richest spring herring fishery takes place, is compared with the large herrings visiting the different areas situated within the main large herring districts II and III, one finds in all cases, with exception of the herring from Fjell, a real difference between the means, which measured with its standard deviation is equal to or more than three as demonstrated in the table 5.

Table 5.

					$M_1 - M_2 : \sqrt{m_1^2 + m_2^2}$
Diff.	Springherring	Skudefjord	— Largeherring	Fjell	0.076 : 0.037 = 2.1
»	—»—	—»—	—»—	Hjeltefjord	0.241 : 0.024 = 10.0
»	—»—	—»—	—»—	Feie	0.208 : 0.021 = 9.9
»	—»—	—»—	—»—	Sognesjøen	0.237 : 0.028 = 8.5
»	—»—	—»—	—»—	Bulandet ..	0.187 : 0.021 = 8.9
»	—»—	—»—	—»—	Kinn.....	0.109 : 0.029 = 3.8
»	—»—	—»—	—»—	Bremanger	0.195 : 0.030 = 6.5
»	—»—	—»—	—»—	Kråkenes	0.189 : 0.040 = 4.7
»	—»—	—»—	—»—	Svinøy	0.229 : 0.025 = 9.2
»	—»—	—»—	—»—	Rundøy ..	0.170 : 0.025 = 6.8
»	—»—	—»—	—»—	Storholmen	0.134 : 0.021 = 6.4
»	—»—	—»—	—»—	Ona	0.152 : 0.040 = 3.8
»	—»—	—»—	—»—	Baksbotten	0.110 : 0.028 = 3.9
»	—»—	—»—	—»—	Grip	0.125 : 0.042 = 3.0

The investigations by Schnakenbeck on the »mode of variability«.

SCHNAKENBECK (1931), analysing the herring races in the North Sea by vertebral counts, avoids the use of the mean, standard deviation and standard deviation of the mean and prefers to use the shape of the frequency polygon as a criterion of the »mode of variability« of the sample. He finds in this manner different »types« which according to SCHNACKENBECK represent pure races, and he means that »intermediate modes of variability« must represent mixtures of races.

SCHNAKENBECK has also treated vertebral counts of some herring samples from Norwegian coastal waters apparently representing large and spring herring as well as immature fat herring from different parts of the coast. He recognizes here two types A and B with different shape of the frequency polygons. The A-type has a steep frequency polygon with maximum at Vert 57 and the B-type at flat frequency polygon with vert 57 and Vert 58 more equally represented. SCHNAKENBECK means that these two types must represent two well distinguished herring races.

In fig. 11 I have given the frequency polygons for the vertebral counts of the large herring from December—January and the spring herring from February—April from the different areas along the coast demonstrated on the chart in fig. 2.

The frequency polygons of the large herrings are all, with exception of that from the southernmost area Sira Fjord, identical with that, which SCHNAKENBECK termes the A-type. The bulk of the large herring must thus according to the opinion of SCHNAKENBECK be very homogeneous which however is not in conformity with the fact.

As regards the spring herring from the different spawning grounds one finds that the herrings from Jæren at the southern part of the coast have a frequency polygon which is rather similar to SCHNAKENBECK's B-type, while the herrings from the spawning grounds in northern Norway represent the A-type. The herrings from the spawning-grounds situated between Jæren and northern Norway have »intermediate modes of variability« and must thus according to the opinion of SCHNAKENBECK represent mixtures of the two races A and B.

However SCHNAKENBECK has laid stress on the definition of a race given by HEINCKE namely, that a race includes a group of individuals which live in the same area and under the same conditions and which by means of cross fertilization are in close relation with each other. The race is according to SCHNAKENBECK in the first hand a physiological group, a spawning community (Leichgemeinschaft) and this means

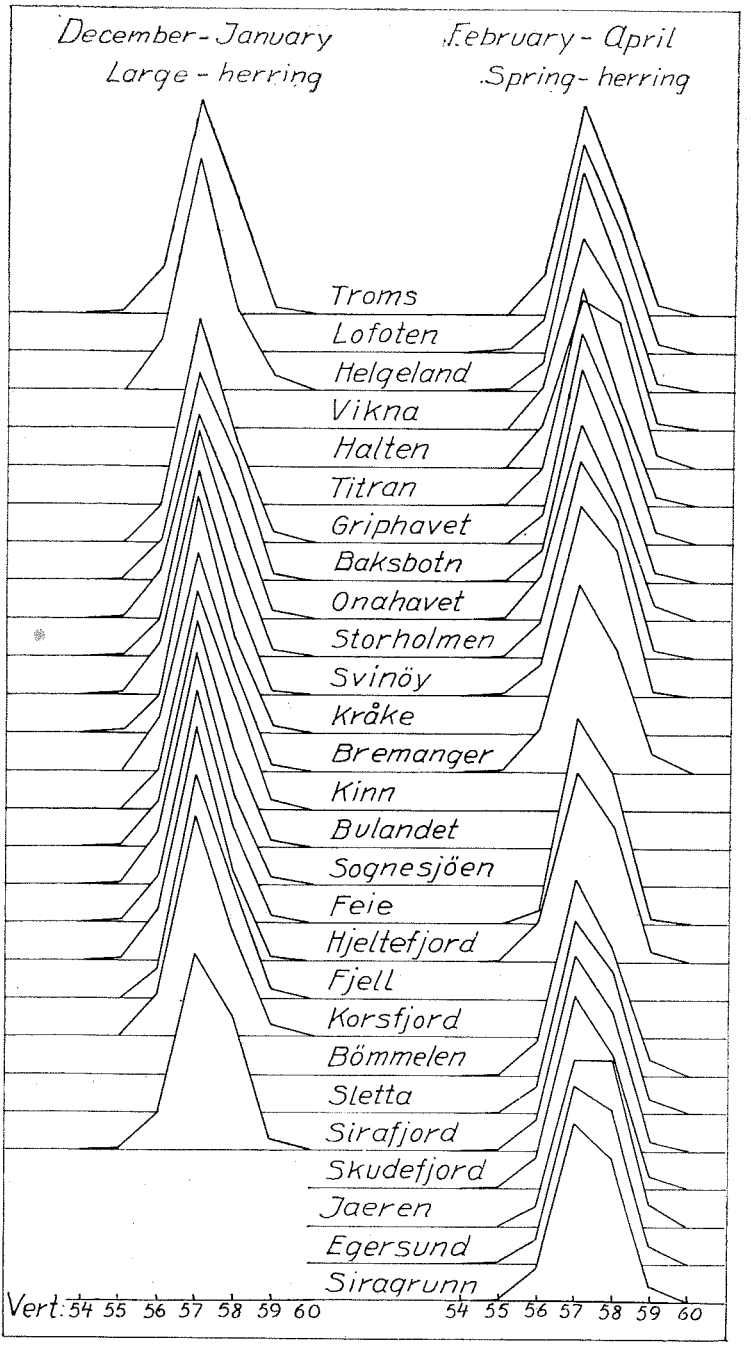

Fig. 11. Frequency polygons for Vert. S arranged according to the geographical distribution of the fishing areas.

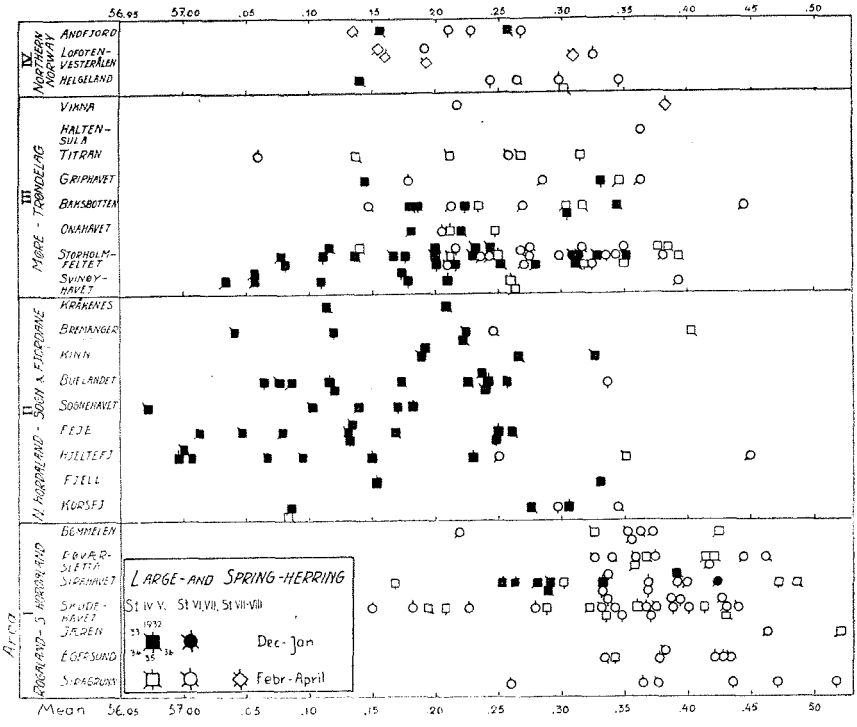

Fig. 12. The mean of vertebral counts of each large- and spring herring sample in relation to area.

that two races do not mix in the same spawning area during the spawning season.

The spring herring groups from February—April represent, however, spawning herring from the spawning grounds and cannot therefore be supposed to represent mixture of races. The different shape of the frequency polygons is only an expression for a gradation of the means with decreasing values from south to north as demonstrated in table 3.

The impression of a gradation of the means from south to north is strengthened when the means of each sample is graphically plotted in relation to area as demonstrated in fig. 12. The black symbols represent samples of large herring from December—January and the open symbols spring herring samples from February—April but separated in the maturity groups IV + V and VI + VII. The mean values of the different samples show a rather great variation within one and the same area but on the whole it is a marked continuous gradation of the means of the spring herring samples from south to north, while the means

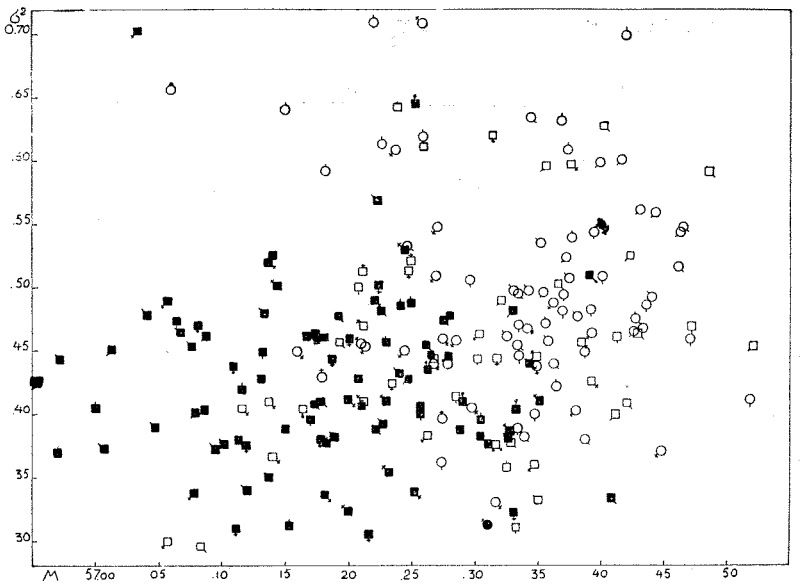

Fig. 13. Variance plotted against the mean of each sample of vertebral counts.

of the large herring samples are grouped about a lower average value than those of the spring herring.

SCHNAKENBECK's empirical method for distinguishing herring races by means of the »mode of variability« has been criticised by BUCHANAN-WOLLASTONE (1933). He writes: »The space distribution of Dr. SCHNAKENBECK's samples, as specified by »shape« of the frequency curve of vertebrae, is extremely *suggestive* but proves nothing. The shape is merely a function of the position of the mean«. BUCHANAN-WOLLASTONE has investigated SCHNAKENBECK's vertebral counts according to FISHER's method of the Analysis of Variance and comes to the result that the distribution of variance in the samples is found not to differ significantly from the normal distribution, indicating that the samples with intermediate »modes of variability« are not mixtures but intermediate in character between SCHNAKENBECK's »types«. He states further that there is no evidence of the existence of any given *number* of races as defined by mean vertebral number, vertebral number may vary *continuously* with area.

BUCHANAN-WOLLASTONE also has employed a graphical method to test the presence of mixture of races by means of plotting variances against means of corresponding samples. Such mixtures should be indicated by increased variance in the mixed samples. In fig. 13 this

method is used for the whole material of Norwegian large and spring herring samples. There should be a distinct drop at the ends in the plotted points and a hump in the middle, if the lower and higher means are pure racially and the intermediate means belonge to mixtures. However there is no signs of such an effect.

The vertebral number of different year classes and the variation of Vert. S from season to season.

We have seen that the vertebral number of the spawning groups along the Norwegian coast shows a gradation in relation to area. This gradation cannot be due to mixture of races and it is more probably to suppose that the gradiation is related to different hydrographical conditions along the coast. When the variation of the vertebral number with area is due to environmental factors, one may also expect to find differences in the vertebral number of different year broods owing to fluctuations in the external conditions from year to year.

In table 6 I have given the mean number of vertebrae of succesive year classes represented among the large herring from districts II and

Table 6. *Vert. S. of different year classes.*

Year class	Large herring		Spring herring	
	District II Sogn & Fjord. N. Hordland	District III Trøndelag Møre	District I S. Hordland Rogaland	District III Trøndelag Møre
1933				57.400 ± 0.130
1932	57.086 ± 0.077	57.191 ± 0.061	57.413 ± 0.066	57.127 ± 0.077
1931	57.080 ± 0.056	57.065 ± 0.041	57.213 ± 0.054	57.217 ± 0.084
1930	57.293 ± 0.025	57.256 ± 0.018	57 342 ± 0.017	57.329 ± 0.025
1929	57.202 ± 0.049	57.129 ± 0.049	57.397 ± 0.036	57.348 ± 0.059
1928	57.014 ± 0.034	57.050 ± 0.043	57.440 ± 0.039	57.176 ± 0.062
1927	56.956 ± 0.099		57.206 ± 0.137	57.139 ± 0.105
1926	57.097 ± 0.037	57.231 ± 0.072	57.344 ± 0.039	57.305 ± 0.042
1925	57.148 ± 0.017	57 167 ± 0.026	57.345 ± 0.019	57.246 ± 0.023
1924	57.135 ± 0.022	57.031 ± 0.037	57.378 ± 0.033	57.302 ± 0.044
1923	57.102 ± 0.019	57.156 ± 0.025	57.309 ± 0.018	57.238 ± 0.023
1922	57.221 ± 0.028	57.228 ± 0.030	57.311 ± 0.026	57.260 ± 0.025
1921	57.144 ± 0.046	57.295 ± 0.070	57.418 ± 0.046	57.253 ± 0.083
1920	57.106 ± 0.049	57.255 ± 0.064	57.417 ± 0.045	57.176 ± 0.095
1919	57.288 ± 0.076		57.538 ± 0.083	
1918	57.196 ± 0.031	57.277 ± 0.036	57.412 ± 0.026	57.426 ± 0.051
1917			57.158 ± 0.095	

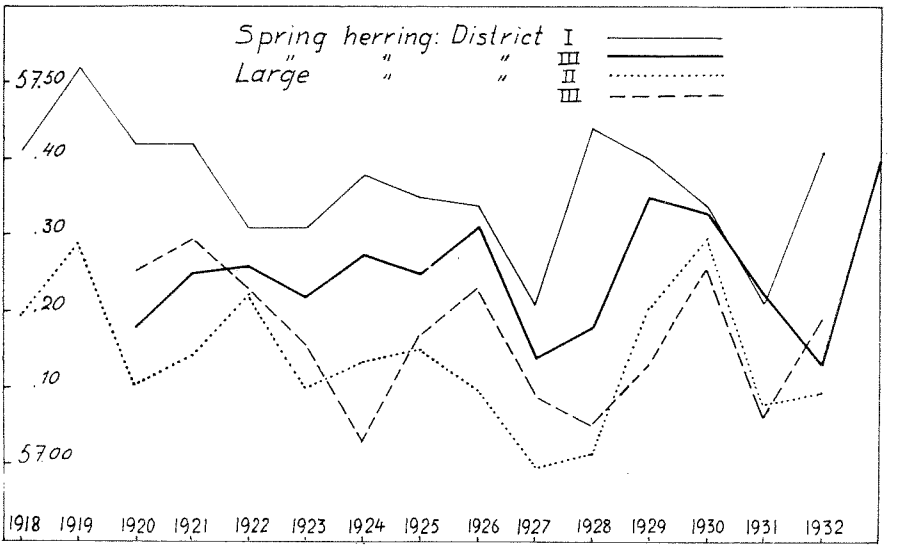

Fig. 14. Graphical demonstration of the variation of the vertebral number of succesive year classes of large- and spring herring from different coastal regions.

III and the spring herring from districts I and III. The variations of the means are also graphically demonstrated in fig. 14.

From fig. 14 we can state that the fenomenon, previously demonstrated, namely that the large herring has a lower mean number of vertebrae than the spring herring and that among the spring herring those from the district III have a lower mean value than those from the more southern district I is prominent throughout a long period including the years 1918—1933.

The vertebral number of the different year broods within each of the four herring groups variates however considerable from year to year. In order to test if the mean values of the different year classes differ significantly I have calculated the differences between the means measured with their standard deviations. In the following tables 7—10 I have given the differences which measured with their standard deviations are equal to or more than 3, and which therefore may be supposed to be significant.

Among the large herring from both districts II and III the year class 1930 has a comparatively high mean number of vertebrae and the year class 1928 a rather low mean value and within each of the two districts both year classes differ significantly from a great number of the other year classes represented in the material. Among the large herring further the year class 1923 from district II and the year classes 1924 and 1931

from district III differ significantly from several of the other year classes (tables 7 and 8).

But also among the spring herring from the main spawning district I (table 9) one finds real differences between the year class 1931 and the year classes 1918, 1919 and 1928 respectively and further between the year classes 1928 and 1923 and between 1923 and 1918. Among the spring herring from district III the year class 1918 has a high mean number of vertebrae which differs significantly from the means of five other year classes (table 10).

The age composition of the herring stock is however not constant, but changes from year to year through the immigration of new year classes and the disappearing of older ones as demonstrated for the Norwegian herring stock in fig. 15. Some of the year classes may be richer than the other ones and may predominate for a certain period. In the year 1932 the year classes 1923 and 1925 were predominating and the formerly very rich year class 1918 is reduced in number. In this and the next years an immigration of the two new year classes 1928 and 1929 can be noticed, which immigration culminates in 1934. In 1935 however, the age composition is strongly changed due to the rich immigration of the year class 1930, which year class is quite predominent in the following year 1936.

Through the variation of the vertebral number of the different year classes as previously demonstrated, one may expect a variation of the vertebral number of the herring stock from season to season owing to the different age composition of the stock. This is really the

Table 7. *Large herring, District II.*

			$M_1 - M_2 : \sqrt{m_1^2 + m_2^2}$
Diff.	yearclasses	1930—1931	0.213 : 0.061 = 3.5
»	—»—	1930—1928	0.279 : 0.042 = 6.6
»	—»—	1930—1927	0.337 : 0.102 = 3.3
»	—»—	1930—1926	0.196 : 0.045 = 4.4
»	—»—	1930—1925	0.145 : 0.030 = 4.8
»	—»—	1930—1924	0.158 : 0.033 = 4.8
»	—»—	1930—1923	0.191 : 0.031 = 6.2
»	—»—	1930—1920	0.187 : 0.055 = 3.4
»	—»—	1928—1929	0.188 : 0.060 = 3.1
»	—»—	1928—1925	0.134 : 0.038 = 3.5
»	—»—	1928—1924	0.121 : 0.040 = 3.0
»	—»—	1928—1922	0.207 : 0.044 = 4.7
»	—»—	1928—1919	0.274 : 0.083 = 3.3
»	—»—	1928—1918	0.182 : 0.046 = 4.0
»	—»—	1923—1922	0.119 : 0.034 = 3.5

Table 8. *Large herring, District III.*

		$M_1 - M_2 : \sqrt{m_1^2 + m_2^2}$
Diff. yearclasses	1931—1930	0.191 : 0.045 = 4.2
» —»—	1931—1922	0.163 : 0.051 = 3.2
» —»—	1931—1918	0.212 : 0.055 = 3.9
» —»—	1930—1928	0.206 : 0.047 = 4.4
» —»—	1930—1924	0.225 : 0.041 = 5.5
» —»—	1930—1923	0.100 : 0.031 = 3.2
» —»—	1928—1922	0.178 : 0.052 = 3.4
» —»—	1928—1921	0.245 : 0.082 = 3.0
» —»—	1928—1918	0.227 : 0.056 = 4.1
» —»—	1924—1925	0.136 : 0.045 = 3.0
» —»—	1924—1922	0.197 : 0.048 = 4.1
» —»—	1924—1921	0.264 : 0.079 = 3.3
» —»—	1924—1920	0.224 : 0.074 = 3.0
» —»—	1924—1918	0.246 : 0.052 = 4.7

Table 9. *Spring herring, District I.*

		$M_1 - M_2 : \sqrt{m_1^2 + m_2^2}$
Diff. yearclasses	1931—1928	0.227 : 0.067 = 3.4
» —»—	1931—1919	0.325 : 0.099 = 3.3
» —»—	1931—1918	.0199 : 0.060 = 3.3
» —»—	1928—1923	0.131 : 0.043 = 3.0
» —»—	1923—1918	0.103 : 0.032 = 3.2

Table 10. *Spring herring, District III.*

		$M_1 - M_2 : \sqrt{m_1^2 + m_2^2}$
Diff. yearclasses	1918—1932	0.299 : 0.092 = 3.3
» —»—	1918—1928	0.250 : 0.080 = 3.1
» —»—	1918—1925	0.180 : 0.056 = 3.2
» —»—	1918—1923	0.188 : 0.056 = 3.4
» —»—	1918—1922	0.166 : 0.057 = 2.9

case as demonstrated in table 11, which gives the mean number of vertebrae of the large herring from districts II and III and the spring herring from districts I and III in each of the years 1932—1936.

As regards the large herring one finds considerable differences between the means for the years 1933 and 1936 and between those for 1934 and 1936 in districts II, and at least the first difference may be regarded as statistically significant. In district III one finds real differences between the means for the years 1933 and 1934, and besween 1934 and 1936, as demonstrated in the table 12. In both districts the means for 1934 is lower than those for 1932, which may be due to the immigration

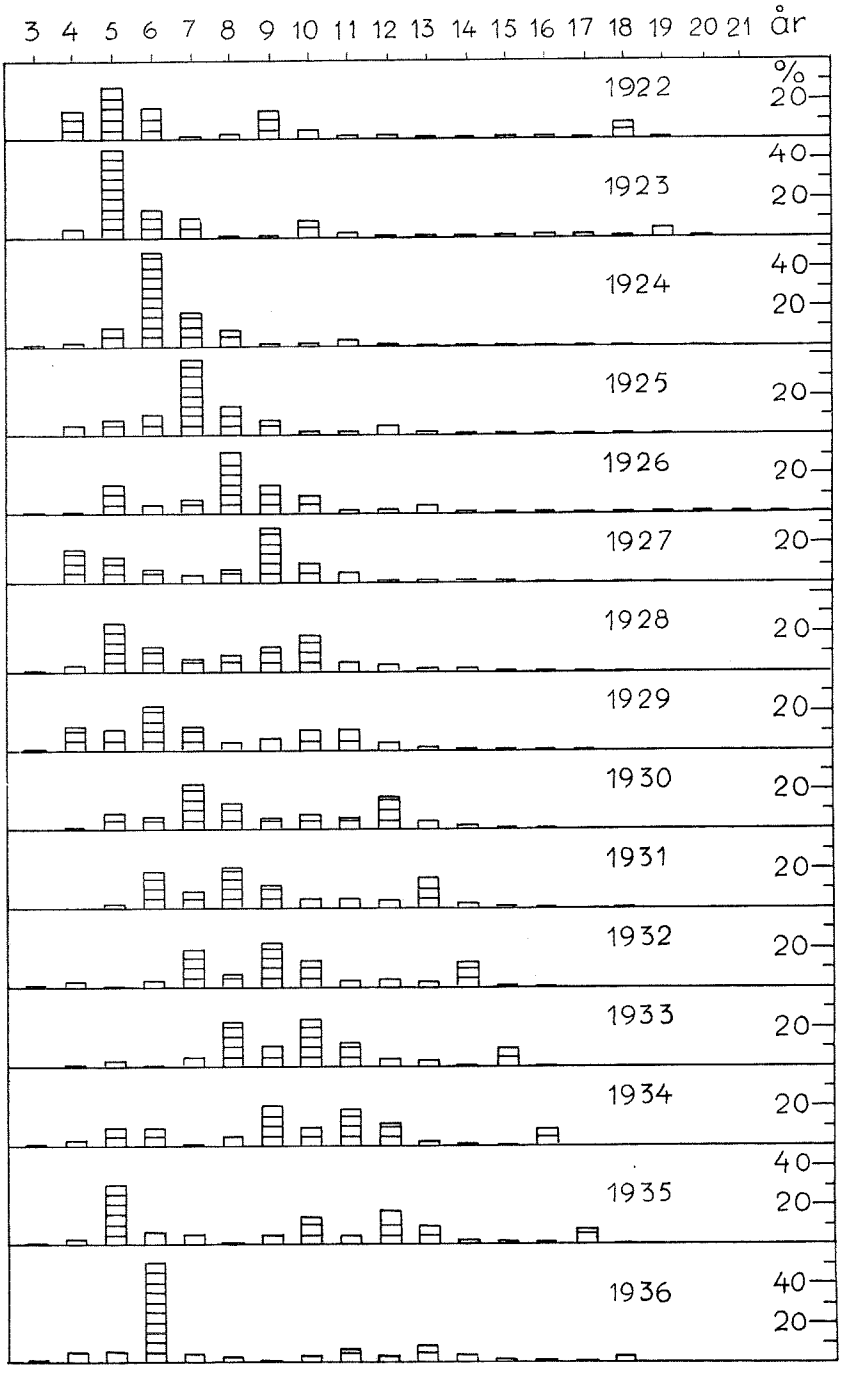

Fig. 15. The age composition of the winter herring catches in the years 1922—1936.

Table 11.

Year	Large herring				Spring herring			
	District II		District III		District I		District III	
	n	M	n	M	n	M	n	M
1932	693	57.165 ± 0.025	100	57.210 ± 0.064	1 554	57.305 ± 0.019	523	57.185 ± 0.032
1933	2 917	57.120 ± 0.012	1 278	57.237 ± 0.019	1 992	57.369 ± 0.016	715	57.283 ± 0.026
1934	958	57 144 ± 0.022	921	57.128 ± 0.022	1 563	57.406 ± 0.018	1 524	57.305 ± 0.018
1935	1 020	57.165 ± 0.020	1 855	57.188 ± 0.015	3 249	57 352 ± 0.012	1 064	57.289 ± 0.021
1936	1 649	57.210 ± 0.016	962	57.209 ± 0.021	1 729	57.333 ± 0.016	1 306	57.284 ± 0.018

of the year class 1928, which year class had a very low mean number of vertebrae in this districts. In the years 1935—36 the mean values are increasing, which may be due to the rich immigration of the year class 1930 with a comparatively high mean value.

As regards the spring herring from district I it is real differences between the means for the years 1932 and 1934, and between those for 1934 and 1936. In district III the same is found between the means for the years 1932 and 1934, 1932 and 1936 as demonstrated in the table 12. One finds here in contradiction to the large herring increasing mean values in the years 1932—34 and decreasing values in 1935—36, (table 11), which may be explained by the circumstances that the year classes 1928 and 1929, immigrating in the first period at least in district I had very high mean values, while the year class 1930 immigrating in the two last years had a somewhat lower mean.

Thus we have seen that the vertebral number of the herring spawning in one and the same spawning district is not constant from year to year. This phenomenon is due to the variation of the vertebral number of the different year broods and the different age composition of the herring stock from year to year. The vertebral number is apparently merely an expression for the temporary composition of the herring stock. This may explain the rather high vertebral number, which BROCH found in 1905—06 for the spring herring in district I (57. 60) and for the large herring from district III (57. 50).

It is however questionable if the variation from season to season merely is due to the variation of the vertebral number of the different

Table 12.

Large herring:

			$M_1 - M_2 : \sqrt{m_1^2 + m_2^2}$
District	II.	Diff. 1934—1936	0.066 : 0.027 = 2.4
»		» 1933—1936	0.090 : 0.020 = 4.5
District	III.	» 1933—1934	0.109 : 0.029 = 3.8
»		» 1933—1935	0.049 : 0.024 = 2.0
»		» 1934—1936	0.081 : 0.030 = 2.7

Springherring:

District	I.	Diff. 1932—1934	0.101 : 0.026 = 3.9
»		» 1934—1935	0.054 : 0.022 = 2,5
»		» 1934—1936	0.073 : 0.024 = 3.0
District	III.	» 1932—1934	0.120 : 0.037 = 3.2
»		» 1932—1936	0.099 : 0.037 = 2.7

year classes. It is doubtful if the bulk of herring visiting one and the same spawning area represent quite identical shoals from season to season. My investigation of the spawning on the coastal banks throughout a serie of years seem to show that it must exist rather great fluctuations in the migration to the coastal grounds. In certain years a part of the spring herring stock apparently does not visit the banks but must spawn on more off shore grounds.

Summary.

We have seen in the present chapter that the spring herring appearing in the Norwegian coastal waters in the spawning season February —April is heterogeneous as regards the vertebral number. The herrings from the main spawning districts differ significantly, but also within one and the same spawning district spawning groups visiting neighbouring spawning grounds may differ significantly. It seems thus to exist several local runs to the Norwegian coast with differing vertebral number and which therefore must be supposed not to intermingle to any great extent. The herrings in the maturity stages IV and V mainly appearing in the early part of the spawning season do not differ significantly from the spawning and spent herrings in the same area.

The large herring in the maturity stages IV and V appearing in the coastal waters in December—January some time before the spawning season is also heterogeneous as regards the vertebral number. The large herrings from the two main large herring districts II and III differ significantly but also within each of the two districts significant differences between herring from different fishing areas have been proved. Thus the large herring does not represent a homogeneous bulk

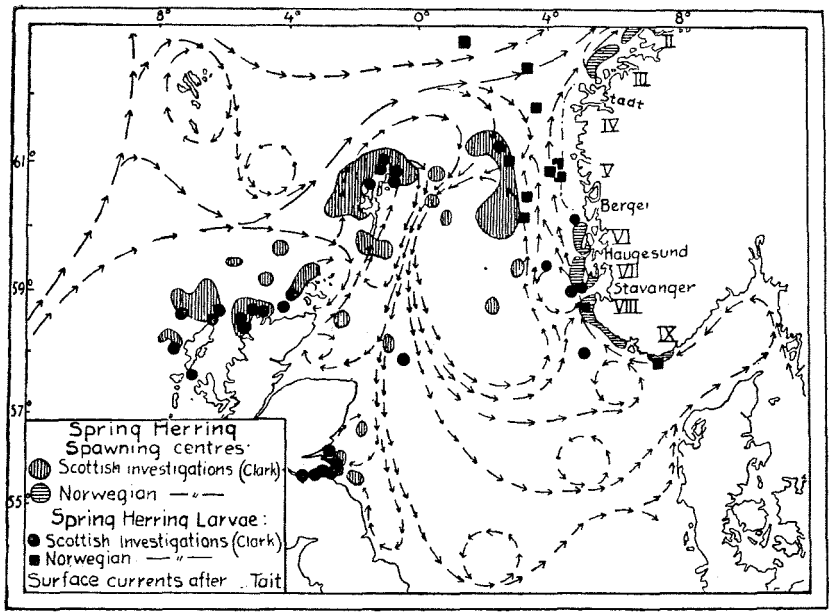

Fig. 16. The distribution of the spawning grounds of spring spawning herring in Northern North Sea. The arrows indicate schematically the surface currents according to Tait (1934).

BJERKAN (1917) has then investigated a great number of herring from northern North Sea caught in the years 1910—13 as regards age, maturity and quality. He found that the year class 1904 was predominant among the herrings from the »Revkant« in the same manner as among the Norwegian spring herring, and he concluded that the bulk of herring frequenting this area during the summer are herrings belonging to the Norwegian herring stock, which after having spawned on the grounds at the Norwegian coast emigrate to recover after propagation.

However one sample from the »Revkant« taken in the beginning of May consisted of spawning and spent herring, which indicated that spawning also takes place in this area. BJERKAN concluded therefore that the presumed spring spawners on the »Revkant« may have a certain independence in their relation to the Norwegian spring herring stock, but exchange of spawning grounds might occur with changing hydrographical conditions.

WOOD has in his previously mentioned investigation shown that the immature herring caught between Shetland and Norway are derived almost exclusively from a spring spawning stock, but the adult herring population in northern North Sea during summer is a very complex one including spring spawners as well as autumn spawners. Also the vertebral number of the herrings from the grounds between the Patch,

Bressay Bank and Viking Bank in the spring and early summer definitely indicate mixtures of spring and autumn spawners.

In recent years Norwegian fishermen have taken up again the herring fishery on the grounds at the »Revkant« and I have investigated some samples taken in the spring and summer mainly on Viking Bank. The material has been completed by two samples from Viking Bank taken in April, kindly placed to my disposal by Mr. Wood. In tables 13—15 the composition of the samples as regards age, maturity and vertebral number is given.

From table 13 one finds that the three samples from April mainly include spawning and spent herrings with an admixture of immature and maturing individuals. Apparently we have to do with genuine Viking Bank spawners mixed with younger individuals. Throughout the summer the immatur and maturing herrings are predominant mixed with a smaller group of recovering spents. As regards the age composition the 3—7 years old individuals are predominant with a small group of somewhat older herrings (table 14).

Table 13. *Viking Bank Herring.*

Year	Month	Maturity stages %								No. of Fish
		I	II	III	IV	V	VI	VII	VIII	
1937	April	0.3	—	—	3.1	—	9.6	87.0	—	291
1937	April	27.6	24.5	1.6	—	—	2.7	43.6	—	257
1937	April	—	17.9	3.6	0.8	—	7.6	64.2	6.0	251
1936	May	3.7	59.3	32.4	0.9	—	—	—	3.7	108
1935	June	1.5	34.3	14.7	3.7	—	—	—	45.9	327
1935	July	2.0	36.7	44.7	1.5	—	—	—	15.1	199
1933	July	—	13.7	51.0	31.4	3.9	—	—	—	51
1934	August ..	23.0	50.0	16.5	6.5	—	2.5	—	1.5	200
1934	August ..	7.4	44.0	37.9	0.5	—	1.9	—	8.3	216

Table 14. *Viking Bank Herring.*

Year	Month	Age (Summerzones) %											No. of Fish
		2	3	4	5	6	7	8	9	10	11	12	
1937	April	—	—	29.2	25.8	33.0	7.6	3.1	0.3	—	0.7	0.3	291
1937	April	—	5.4	35.8	42.0	10.1	4.3	1.6	0.8	—	—	—	257
1937	April	—	5.2	24.7	41.2	16.9	8.2	3.0	0.7	—	—	—	267
1936	May	—	29.1	31.3	26.1	8.3	2.1	6.3	2.1	1.0	—	1.0	96
1935	June	0,4	13.1	58.3	15.5	6.1	4.0	2.4	0.4	—	—	—	297
1935	July	—	20.2	61.7	15.4	1.6	1.1	—	—	—	—	—	188
1933	July	—	48.7	10.0	24.9	11.1	2.2	1.7	1.1	0.1	—	—	181
1934	August	—	—	78.2	12.3	4.8	4.3	—	—	0.5	—	—	187
1934	August	—	—	70.5	22.5	5.0	1.0	—	1.0	—	—	—	200

Table 15. *Viking Bank Herring. Vert S.*

Year	Month	Maturity stages			
		I—II	III—IV	VI—VII	VIII
1937	April			56.983 ± 0.036	
1937	April	57.158 ± 0.058		57.000 ± 0.060	
1937	April	57.133 ± 0.102		57.051 ± 0.051	57.400 ± 0.187
1936	May	56.960 ± 0.070	56.750 ± 0.091		
1935	June	57.009 ± 0.073	56.712 ± 0.093		56.878 ± 0.051
1935	July	57.052 ± 0.078	57.033 ± 0.064		57.167 ± 0.142
1933	July		56.714 ± 0.136		
1934	August	56.897 ± 0.060	56.674 ± 0.087		
1934	August	57.128 ± 0.061	57.253 ± 0.061		

From table 15 one finds that the spawning and spent herrings occurring on Viking Bank in April have a mean number of vertebrae about 57.0. It is possible that the spents in the sample with the lowest value have included some few autumn spawning herrings. The vertebral number is rather similar to that of the spring spawners in Shetland waters found by WOOD. The recovering spents in June and July with a vertebral number ranging from 56.878 to 57.167 include to a greater part spring spawners and the same is the case for the immature herrings with mean values ranging from 56.897 to 57.158. The maturing herrings have generally lower mean values indicating a greater admixture of autumn spawners.

As regards the genuine Viking Bank spawners from April the low number of vertebrae shows no relation to the spring herring spawning at the Norwegian west coast, but is more in accordance with that of the large herring visiting the west coast of Norway in December—January. However the Viking Bank spawners, in the same manner as the Scottish spring spawners, are composed of younger age groups than the bulk of the large herrings, and the age composition of the first ones remembers very much on that of the recruit spawners appearing at the Norwegian coast. However in the early part of the large herring season a group of younger individuals mainly in the maturity stage III appears as demonstrated in fig. 10. The mean number of vertebrae for 672 individuals of this group is 57.190 ± 0.026, which mean does not differ significantly from the mean, 57.051 ± 0.051 for the third sample in table of the Viking Bank spawners.

The bulk of the large herrings include however older herrings with an age composition differing from that of the Viking Bank spawners. As we have seen previous the younger spawners appear at the end of the spawning season in Norwegian waters and it is therefore not un-

reasonable to suppose that herrings spawning earlier in the season on Viking Bank may be composed of older spawners but no material exists which can prove this.

However WOOD has secured two interesting herring samples caught at the slope north of Shetland in February and March 1937 and these herrings were remarkable larger and older than the herring commonly met with in Shetland waters. The composition of these samples as regards age, length, maturity and vertebral number, as demonstrated in tables 16—17, is kindly placed to my disposal by Mr. WOOD.

The age composition of the samples remembers very much on that found in Norwegian waters with very old individuals of the year classes 1925, 1923 and 1922 predominating. The herrings from February are

Table 16.

Locality	Date	Maturities %				Years %					
		IV	V	VI	VII	4	5	6	7	8	9
12' NW—N Flugga	18.2 1937	63.1	36.4	0.5	—	—	—	6.2	1.6	4.1	3.6
18' N—E Ronas Voe	18.3 1937	15.6	11.2	72.1	1.1	1.1	1.7	4.5	6.2	2.8	3.3

Locality	Years %											No. of fish
	10	11	12	13	14	15	16	17	18	19	20	
12' NW—N Flugga	7.3	9.8	45.1	9.8	0.5	3.1	1.6					193
18' N—E Ronas Voe	2.2	4.5	26.3	18.4	15.1	3.9	3.9	2.8	1.7	1.1	0.5	179

Table 17.

Locality	Date	Length cm												Vert. S.	No. of Fish
		28	29	30	31	32	33	34	35	36	37	38	39	40	
12'NW-N Flugga	18. 2 1937	—	—	—	0.5	2.6	7.3	26.9	35.2	16.1	8.8	2.1	0.5	—	57.057 ± 0.041	193
18' N-E Ronas Voe	18. 3 1937	0.6	—	2.2	2.2	3.9	6 2	15.1	31.9	25.1	10 0	2.2	0.6	—	57.000 ± 0.039	179

mainly in the maturity stages IV and V and only a few individuals have begun to spawn. In March however the main part of the herring are spawning. The mean vertebral number of the two samples, 57.057 $\pm$ 0.041 and 57.000 $\pm$ 0.039 do not differ from the means of many of the large herring samples from Norwegian waters as recorded in fig. 12 or table I, where samples with mean values as low as 56.970 and 56.972 are found.

Thus these samples demonstrate that a group of older spawners spawn at the northern edge of the North Sea plateau and it is not unprobably to suppose that the large herring after leaving the Norwegian coastal waters before the spawning season migrate to spawning-grounds along the Atlantic slope between Norway, Shetland and the Faroes. Anyhow the low number of vertebrae of the large herring appearing in Norwegian waters in December—January is more in accordance with the vertebral number of the spring spawning herring, spawning under more Atlantic conditions in the Northern North Sea, than with that of the spring herring spawning in the Norwegian coastal waters.

Wood (1936) means that the spring spawning group of the herring found on the Viking Bank moves towards the Shetland coast in early summer. However herring shoals are met with in certain years in the skerries and fjords of the Norwegian south west coast in the summer, which have a rather similar composition as those found on Viking Bank. The age composition of the shoals including immature and maturing individuals is in accordance with that of the herring from Viking Bank demonstrated in table 14. In table 18 one finds that the immature herrings have a mean vertebral number ranging from 56.784 to 57.117 which indicates that we have to do with spring spawners more or less mixed with autumn spawners. The maturing herrings have lower mean values ranging from 56.488 to 56.776 thus apparently including a greater number of autumn spawners.

Lea (1929), who has analysed the sample from August—September 1927 as regards age and growth, concluded that these herrings represent the oceanic intermediate stage in the life history of the Norwegian springherring with an admixture of young coastal herrings and a small number of individuals which according to the »scale type« was considered as »extraneous«. The main part of the herring would thus appear as recruit spawners at the Norwegian west coast in the following year according to Lea. The mean number of vertebrae of the »extraneous« herring was 56.6 and that of the remaining herring 57.1.

I have in the same manner as Lea tried to classify 1195 individuals of the herring appearing at the south west coast in the summer according to the »scale type« and found that 947 individuals belonging to

Table 18. *Vert. S. of immature and maturing herring, Bergens Skjærgård.*

Year	Month	Maturity stages	
		I—II	III—IV
1928	June	56.887 ± 0.067	56.488 ± 0.111
1931	June	56.784 ± 0.064	56.776 ± 0.116
1928	July	56.928 ± 0.035	56.577 ± 0.120
1927	Aug.—Sept.	57.117 ± 0.025	56.619 ± 0.054

the »Norwegian type« with a mean number of 57.082 ± 0.023 apparently represent spring spawners, while 148 »extraneous« herrings with a mean value of 56.493 represent pure autumn spawners. However the low value for the spring spawners does not indicate any relation to the spring herring, spawning at the south west coast of Norway, but is more in accordance with that of the herring spawning on the Viking Bank.

THE RECRUITMENT OF THE NORWEGIAN SPAWNING STOCK FROM THE YOUNG HERRING STOCK.

As I have shown in a previous paper (1936) the Norwegian spawning stock is composed of individuals with different life- and growth history. The young herring fry in the first summer of life is distributed along the whole coast from the south west coast to the remotest parts of northern Norway. The young herring is however already in an early stage of life split up in groups, some remaining in the coastal region and some emigrating to the open sea. This phenomenon is apparently related to the growth as Lea (1929) has stated, and the fast growing individuals emigrate earlier from the coastal region than the slow growing ones, and therefore the young herring from the more southern parts of the coast disappear earlier than the herring from the more northern parts. The young herrings thus grow up under different conditions, and this is not only marked on the growth, but also on the appearence of the winter rings. The winter rings of the young herring living in the coastal waters of northern Norway are commonly more sharp than those of the herring living in more southern parts, and one can therefore distinguish between »northern« and »southern« types according to the appearence of the winter rings.

On the bases of the ring types and the growth I have in the previous mentioned paper given an analysis of the composition and recruitment of the spawning shoals. When the herrings begin to mature they form shoals in the open sea, which are composed of individuals which differ in age but do not vary greatly in length or stage of maturity. The younger age groups represent fast growing individuals mainly of the »southern« scale type and the older age groups more slow growing individuals mainly of the »northern« type. When these shoals are ready to spawn they appear on the spawning grounds as recruit spawners. Thus the spawning shoals are composed of individuals, which have grown up under very different conditions and representing different growth types. Individuals of one and the same year brood do not reach maturity at the same age but is split up in groups spawning for the first time at an age varying from 3 to 8 years according to the external

Table 19. *Composition as regards »southern« (S) and »northern« (N) scale type.*

	Distict IV		District III		Distict II		District I	
	S	N	S	N	S	N	S	N
Young herring	11 %	89 %	58 %	42 %	78 %	22 %	99 %	1 %
Spring herring	15 %	85 %	34 %	66 %	40 %	60 %	42 %	58 %

conditions during the earlier years of life, the fast growing individuals reaching maturity earlier than the slow growing ones.

In table 19 I have given the composition of the young herring and the spawning spring herring from the coastal districts I—IV as regards »southern« (S) and »northern« (N) scale types. One finds that the young herring in northern Norway mainly include »northern« types and that the percentual values for the »southern« type increases southwards and is very predominant in the southern districts. As regards the spring herring one finds also here a gradation along the coast in the manner that the »northern« type is predominant in the more northern districts while the both types are more equally represented in the southern districts.

By comparing the composition of the spring herring with that of the young herring one finds that in northern Norway both groups have about the same composition, but in the more southern districts the »northern« component of the spring herring has increased compared with the young herring in the corresponding area, which means that an immigration of herrings grown up in more northern parts of the coast has taken place.

A spawning group is thus composed of individuals which according to the different scale types have grown up in different areas. However we do not know anything about the origin of the herring with different scale types as regards the spawning grounds. The scale type can be recognized first after the formation of the first winter ring and in the previous time the fry can have drifted away from the spawgrounds. In order to get some information about the migration of the young herring and the origin of the herrings with different scale types it is necessary to analyse the vertebral number.

In table 20 I have given the mean number of vertebrae of young herring in the first to fifth summer of life from the different coastal districts. The herrings in the first summer of life show a gradation of

Table 20. *Verts. S. Small- and Fat Herring.*

Age (Summe zones)	Northern Norway IV		Møre—Trøndelag III		Sogn & Fjordane-N. Hordland II		S. Hordland—Rogaland I	
	n.	M	n.	M	n.	M	n.	M
1	5 560	57.187 ± 0.009	2 981	57.198 ± 0.012	1 339	57.352 ± 0.019	1 250	57.524 ± 0.021
2	3 935	57.156 ± 0.011	982	57.070 ± 0.021	1 755	57.236 ± 0.017	333	57.090 ± 0.040
3	2 305	57.134 ± 0.015	340	57.212 ± 0.036	486	57.086 ± 0.032		—
4	858	57.211 ± 0.022	102	57.098 ± 0.070	135	57.148 ± 0.064		—
5	167	57.383 ± 0.055	43	57.163	159	57.151 ± 0.056		—
Total	12 925	57.173 ± 0.005	4 405	57.168 ± 0.010	3 874	57.226 ± 0.011	1 583	57.433 ± 0.019

the vertebral number from south to north in the same manner as the spring herring, spawning along the coast. The herring fry from district I at the south west coast has a high mean vertebral number and the values then decrease from south to north. One must suppose that the herring fry in the different districts represent the off spring of the herring spawning in the corresponding districts and that no important displacement of the fry has taken place in relation to the spawning grounds where they are hatched.

In the second year of life one finds that the herrings originally present in the southernmost area have disappeared and are replaced by herrings with a very low number of vertebrae. Also in the district II one finds a decrease of the mean value in the second year of life and this phenomenon is still more pronounced in the third to fifth year of life. The decreasing values in the southern districts is due to the disappearing of the spring herring off spring and the immigration of herring of the same composition as those found on the Viking Bank in the summer as discussed in the previous chapter.

In the more northern districts, especially in northern Norway, one finds in contrary an increase of the values, which probably means that a certain immigration of herrings hatched on more southern spawning grounds has taken place.

The distribution of the mean values thus seems to indicate that the young herring disappear at an early age from the more southern parts of the coast and are replaced by young herring originating from the North Sea which occasionally may visit the west coast. A certain part of the young herring from the southern parts of the coast apparently migrate northwards along the coast but probably a great deal of the herrings migrate into the open sea.

As regards the herring with »southern« and »northern« types of winter rings it is the question if the »southern« types have their origin from southern spawning places while the herrings of »northern« type have been hatched on more northern spawning places. In this case it must exist a rather considerable difference in the vertebral number of the two groups.

In table 21 I have given the mean values of the number of vertebrae of the two types represented by herring in the second year of life from the different coastal districts. One finds that no significant difference exists between the two types within one and the same area even if the »northern« types tend to have somewhat higher means than the »southern« types. However, within one and the same type one finds a marked gradation of the vertebral number along the coast as previously found for the whole material. It thus seems as if the two types present in one and the same area mainly origin from the same spawning districts. It is reasonable to suppose that herrings with »southern« scale type origin not only from southern spawning places, but also from more northern ones. This type is probably represented by individuals which as fry have emigrated from the different parts of the coast into the open sea and there have grown up under more oceanic conditions and which occasionally visit the coastal regions. The »northern« type is

Table 21. *Vert. S of young herring (Bladsill) with different Scale types.*

Districts	Scale types			
	S (southern)		N (northern)	
	n.	M	n.	N
IV Northern Norway	412 9.9 %	57.121 ± 0.034	3 748 90.1 %	57.159 ± 0.011
III Møre— Trøndelag	482 57.8 %	57.085 ± 0.031	352 42.2 %	57.142 ± 0.036
II Sogn & Fj. N. Hordl.	627 95.1 %	57.214 ± 0.028	32 4.9 %	57.344 ± 0.105

Table 22. *Vert. S. of Large herring and spring herring with different scale types (S and N).*

Districts	Large herring				Spring herring			
	S (southern)		N (northern)		S (southern)		N (northern)	
	n.	M	n.	M	n.	M	n.	M
IV Northern Norway	66 14%	57.061 ±0.080	401 86%	57.189 ±0.033	183 15%	57.191 ±0.052	1 000 85%	57.261 ±0.021
III. Møre— Trøndelag	1 452 31%	57.146 ±0.018	3 206 69%	57.201 ±0.011	1 387 34%	57.213 ±0.019	2 655 66%	57.298 ±0.013
II. Sogn &Fj. N. Hordl.	2 951 47%	57.095 ±0.012	3 324 53%	57.203 ±0.011	—		—	
I S.Hordl.- Rogaland	367 43%	57.281 ±0.035	486 57%	57.290 ±0.030	3 257 42%	57.365 ±0.012	4 588 58%	57.347 ±0.010

represented by herrings, which as fry remained in the skerries and fjords, and which have grown up in coastal waters.

As demonstrated in table 19 the mature herrings of the two types join the spawning shoals in different proportions in the different spawning areas with increasing number of »northern« types from south to north. In table 22 is given the mean vertebral number of the herring with »southern« and »northern« scale types present in the different spawning districts. One finds also here a gradation of the vertebral number within each of the two types with decreasing mean values from south to north in the same manner as found for the immature herrings in the second year of life.

While the two components in the southernmost spawning district (I) have a rather similar vertebral number, however, the differences between the means of the two components in the more northern spawning districts is more pronounced than those found in the second year of life. The herrings with »northern« scale type have a higher vertebral number than the herrings with the other scale type and at least in the district III the difference between the means is significant from a statistical point of view. The differences between the means of the different spawning groups from south to north along the coast is thus less pronounced in the »northern« component than in the »southern« one.

As the herrings of the »northern« type is supposed to grow up in coastal waters it is probably that these herrings with increasing age have a greater chance to intermingle through the influence of the north going coastal current than the herring of the other type growing up

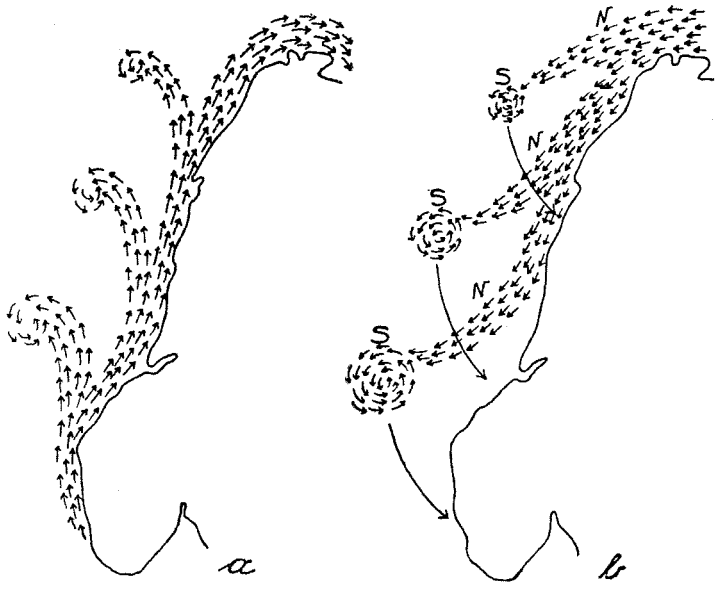

Fig. 17. Schematical illustration of the supposed migration of the herring larvae (a) and the formation of the spawning shoals from elements of different origin (»northern« (N) and »southern« (S) types).

in the ocean. The later ones are also more fast growing and join the spawning shoals at an earlier age.

In order to give a clearer illustration of what happens in the first years of life of the Norwegian spring herring I have in fig 17 scetched the supposed movements of the immature young herring.

The fig. 17 a illustrates the movement of the herrings in the first year of life. From the three main coastal spawning districts I, III and IV a part of the fry emigrate into the open sea and grow up under oceanic conditions and the winter rings will get the appearence of the »southern« type, which better may be called the »oceanic« type. The fry remaining in the coastal region drift northwards with the coastal current and grow up in the fjords and skerries in the northern part of Norway and get »northern« winter rings, which better may be termed »coastal« rings. As seen in fig. 7 herring fry is found already in July in the eastern Finnmark and according to Averinzew (1935) the young herring met with at the Murman coast also must be regarded as off spring of the Norwegian spring herring.

Undoubtly a certain mixture of the fry from the different spawning places takes place in the coastal water which tends to eliminate the differences in the vertebral number but probably the fry from the

northern spawning places drift farther to the north and east than the fry from the southern ones and therefor a certain gradation of the vertebral number may remain. The different groups of young herring growing up in the open ocean will probably remain more isolated, which is favoured by the cyclonic movements of the Atlantic current, and the gradation of the vertebral number will be more pronounced. They also join the spawning shoals at an earlier age than the herring growing up in the coastal waters.

When the gonads begin to develop the young herring emigrate from the coastal region into the open sea. In the ocean the older herrings from the coastal region with »northern« winter rings join a group of younger oceanic herring with »southern« winter rings in the manner illustrated in fig. 17 b. The herrings from the more southern parts of the coast will join the oceanic off spring from the southern spawning grounds and the herring grown up in more northern coastal regions join oceanic herrings originating from northern spawning places. After reaching maturity the different herring groups immigrate to the next spawning grounds at the coast as recruit spawners as indicated by the arrows.

In the way sketched in fig. 17 young herring grown up in very different areas but mainly originating from the same spawning area will join to form a spawning shoal which as recruit spawners return to the spawning area where they was born. In this manner the gradation in the vertebral number of the spawning groups will remain.

However certain divergences from this scheme might occur. For instance the rich year class 1930 consisted almost entirely of »northern« types also on the southern spawning grounds. It is not reasonable to suppose that the »southern« component has migrated to other spawning places and one must assume that the main part of the young herring have grown up in northern coastal waters. This may be due to a strengthen coastal current in 1930 which has displaced the main part of the fry northwards. It is then to expect that the gradation in the vertebral number of this year class owing to a stronger intermingling of the brood is more eliminated and this is also the case as demonstrated in fig. 14.

THE HERRING AT THE NORWEGIAN SKAGERAK COAST.

A spring herring fishery of the same importance as that at the west coast of Norway does not occur at the Norwegian south coast between Cape Lindesnes and the Oslo Fjord in present time. In certain years the spring herring may pass Lindesnes and a spring herring fishery take place off Kristiansand. Further east a small herring fishery of more local character may take place. In the summer and autumn immature and maturing herring are met with. The vertebral number of the different maturity groups throughout the summer and autumn and of the mature herring in the spring is given in table 23.

The vertebral number of the immature herrings (stages I and II) arnges from 56.496 to 57.079. Some of the samples probably represent rather pure off spring of autumn spawners from the North Sea, while other ones probably represent mixtures of autumn- and spring spawners in different proportions. The same is the case with the maturing herrings with a vertebral number ranging from 56.559 to 57.145. The mature herrings from Arendal taken in March and April have a vertebral number of 57.114 and 57.203. The age composition of these samples differ

Table 23. *Vert. S. of herring from the Norwegian Skagerak coast.*

Locality	Year	Month	Maturity stages					
			I—II		III—IV		V—VII	
			n.	M	n.	M	n.	M
Tønsberg	1928	August	387	56.496	—		—	
Farsund	1929	Septemb	62	56.629	34	56.559	—	
Sømskilen	1932	Oktober	165	57.079	83	56.711	—	
Arendal	1935	Novemb	59	56.831	85	57.059	—	
Grimstad	1931	Desemb.	80	56.863	—		—	
Flødeviken ..	1931	Decemb.	87	56.758	94	56.926	—	
Arendal	1930	Januar	21	56.571	55	57.145	39	57.102
Arendal	1931	March	—		21	57.000	79	57.114
Arendal	1936	April	—		—		143	57.203

Table 24. *Spring spawning herring from Oslo Fjord.*

Locality	Maturity stages						Age %						
	II	III	IV	V	VI	VII	3	4	5	6	7	8	9
Hvaler 17. 3. 1935	—	—	—	—	289		3.5	77.7	12.1	3.5	2.1	0.7	0.4
Langesund 8. 3. 1935	1	—	—	2	125	—	8.4	70.0	10.0	5.0	1.7	5.0	—
Horten .. 22. 3. 1935	—	1	2	2	84	11	8.2	49.5	42.3	—	—	—	—
Stavern .. 19. 3. 1935	—	1	1	1	85	16	1.0	10.1	84.8	3.0	1.0	—	—

from that of the spring herring spawning at the Norwegian west coast and probably we have to do with a small local herring stock.

In the spring 1935 an unusual rich herring fishery took place in the outer part of the Oslo Fjord. The fishermen meant that this fishery was the introduction to a new rich herring period of the same kind as that, which occurred at the Skagerak coast at the same time as the last rich herring period at the Bohuslän coast.

Four samples taken in March showed that the herring almost exclusively included spawning herrings with a small admixture of spents, as demonstrated in table 24. In the same table one finds that the age composition is not uniform in all samples. In the sample from Stavern the 5 years old herrings representing the year class 1930 are predominating in the same manner as in the Norwegian spring herring from the west coast. In the samples from Hvaler and Langesund however the 4 years old herrings representing the year class 1931 are predominant. In the sample from Horten the year classes 1930 and 1931 are equally represented.

As seen from the table 25 the herrings from Hvaler and Langesund are smaller than those from Stavern. This is not only due to the different age composition, but the difference in size is also present within one and the same year class as demonstrated in the table. As regards the sample from Horten the herrings of the year class 1931 have about the same size as the herrings of the corresponding year class from Langesund, while the individuals of the year class 1930 are larger than those from Langesund and of about the same size as the corresponding year class from Stavern.

It seems thus to be two different herring groups present. One including smaller herrings with the year class 1931 predominant repre-

Table 25. *Spring spawning herring from Oslo Fjord.*

Locality	Mean Length (cm)			Vert. S.			No. of Fish
	Total	Year class 1931	Year class 1930	Total	Year class 1931	Year class 1930	
Hvaler 17. 3. 35	24.7	—	—	56.990 ±0.051	—	—	289
Langesund 8. 3. 35	26.1	25.8	26.9	56.913 ±0.067	56.913 ±0.090		129
Horten 22. 3. 35	26.6	24.9	29.1	57.072 ±0.068	57.000 ±0.100	57.231 ±0.106	97
Stavern .. 19. 3. 35.	29.6	28.8	29.8	57.165 ±0.069		57.220 ±0.073	99

sented by the samples from Hvaler and Langesund and another including larger individuals with the year class 1930 predominant represented by the sample from Stavern. The herrings from Horten seem to represent a mixture of these two groups with the slow growing herrings of the year class 1931 and the more fast growing herrings of the year class 1930 equally represented.

As regards the vertebral number (table 25) the herrings from Hvaler and Langesund have a rather low number of vertebrae (56.990 and 56.913) which seldom are met with within the Norwegian spring herring, while the herrings from Stavern have a higher vertebral number (57.165). The vertebral number of the herrings from Horten (57.072) has an intermediate position between the values of the two other groups. When one considers the different age groups, the year class 1930 from Horten has a vertebral number, which is rather similar to that of the same year class from Stavern, while the year class 1931 is more in accordance with that of the same year class from Langesund.

It is apparent that we have to do with two spawning groups of different origin which have immigrated to the Oslo Fjord and which have joined on the same spawning place at Horten. The spawning group observed at Stavern corresponds to the Norwegian spring herring as regards age, size and vertebral number, while the spawning group from Hvaler and Langesund are not identical with the Norwegian spring herring as regards these characters.

It is probably that the later group is identical with the herring which JOHANSEN (1923) calls the »winter spawning herring of the Kattegat«. The vertebral number of this herring ranges from 56.75 to 56.90 according to JOHANSEN and they have a smaller size than the Norwe-

gian spring herring. The winter herring of Kattegat spawns in January —March and the main spawning places seem to be in the eastern Kattegat. During the winter they may be present in great quantities in the south eastern Skagerak and in poor herring periods they may be dominating in the catches in the boundary area between the Kattegat and Skagerak according to JOHANSEN.

In the year 1935 spawning shoals of the winter spawning herring apparently have taken a more westerly direction and immigrated to the outer part of the Oslo Fjord, where they have met Norwegian spring herring. Spring herrings were noticed at Lindesnes in the beginning of March and this herring must have migrated further east than usual.

If the interpretation of the data is correct, we have here the curious phenomenon, that mature individuals of two different »races« occur in one and the same spawning shoal and have spawned simultaneously on the same spawning place at Horten.

THE VERTEBRAL NUMBER OF SOME LOCAL FJORD FORMS.

Hj. Broch (1908) has stated the occurrence of a local herring form in the Beistad Fjord situated in the inner part of the Trondheims Fjord. This herring form spawns in the Beistad Fjord in the season March—May. The herring is very slow growing and spawning individuals of a length less than 120 mm have been observed. Broch has counted the vertebrae of 100 mature individuals taken in the Beistad Fjord in April 1905. The average length was 221 mm and the mean vertebral number 56.55 $\pm$ 0.078 which value is considerable lower than that of the Norwegian spring herring. In August 1905 59 immature and maturing specimens from the outer part of the Trondheims Fjord were investigated. The vertebral number of these herrings was 56.97 $\pm$ 0.126 and Broch concludes that they also belong to the Beistad Fjord herring, which forms a for the Trondheims Fjord characteristic local herring stock.

Johansen (1919) means however that the herrings from the outer part of the Trondheims Fjord is a mixture of two local forms or of a local form and young herring of the Norwegian spring herring stock. A sub classification according to the maturity stages seems to prove that the later supposition is the right one. 23 specimens in the stage I have a vertebral number of 57.57 and 36 specimens in the stages II and III have a mean value of 56.581, which later mean is in accordance to that of the herring spawning in the Beistad Fjord.

The Beistad Fjord herring has been a subject for a very fluctuating fishery with years of rich fishery and years when there was only traces of herring. Bjerkan (1929) means that these fluctuations are due to the circumstance that the Beistad Fjord herring is a Norwegian sea herring which immigrates to the fjord and there may be »landlocked« for some years and then migrates out of the fjord again. The herring propagates in the fjord under extreme conditions and thereby changes certain of its »race characters«.

When I visited the Beistad Fjord in August 1932 a rather rich fishery had started in the fjord and I secured a sample in order to see if the herring was identical with the form investigated by Broch in

Table 26. *Beistad Fjord Herring.*

Year	Month	No.	Maturity stages %						
			I	II	III	IV	V	VI	VII
1932	August	163	39.9	22.7	31.9	5.5	—	—	—
—	Oktober	410	67.7	20.7	3.2	4.9	3.7	—	—
—	November ..	196	43.3	21.9	3.6	15.3	15.8	—	—
1933	April	200	—	0.5	—	—	—	96.0	3.5
—	November ..	44	2.3	—	2.3	77.3	18.2	—	—
—	November ..	160	0.6	0.6	19.4	50.6	28.8	—	—
1934	April	200	—	—	—	—	3.5	65.0	31.5
—	November ..	200	2.5	1.0	13.5	80.0	3.0	—	—
—	November .. (Trondh.Fjord)	200	39.0	3.0	5.0	50.5	2.5	—	—
1935	April	200	—	—	—	—	—	98.5	1.5

Year	Month	No.	Age (summer zones)			
			2	3	4	5
1932	August	163	—	94.9	4.6	0.6
—	Oktober	410	3.7	92.0	3.7	0.5
—	November	196	10.9	88.6	0.5	—
1933	April	200	—	100.0	—	—
—	November	44	—	2.4	97.6	—
—	November	160	0.6	—	98.1	1.3
1934	April	200	—	—	100.0	—
—	November	200	1.0	10.3	—	88.7
—	November ..... (Trondh. Fjord.)	200	38.3	60.7	—	1.1
1935	April	200	—	33.8	0.5	65.7

1905. The material was completed by samples from the autumn 1932, 1933 and 1934 and from April 1933, 1934 and 1935.

In table 26 the age composition and the vertebral number of the different maturity groups is demonstrated. All the samples are taken in the Beistad Fjord with exception of the last one from 1934 which comes from Hummelvik in the Trondheims Fjord. The samples from the autumn included immature (stages I and II) and maturing (stages III and IV) herrings, while the samples from April represented almost pure shoals of spawning herring (stage VI) with a small admixture of spent herrings (stage VII).

As regards the age composition the main part of the herring in the autumn 1932 was 3 summers old representing the year class 1930. The spawning herring in April 1933 was exclusively represented by

this year class and the same was found in the autumn 1933 and the spring 1934. In the autumn 1934 the year class 1930 is still predominant in the Beistad Fjord, but in the sample from the outer Trondheims-Fjord one finds a new year class 1932 predominating with an admixture of the year class 1933. The year class 1932 consisted of maturing herring and the year class 1933 of immature ones. In the following spring, April 1935, one finds that the year class 1932 has joined the spawning shoals in the Beistad Fjord and forms here 34 % of the stock while the year class 1930 is still predominant with 66 %. It is very probably that the herrings of the year class 1932 have immigrated to the Beistad Fjord from the Trondheim Fjord. As regards the vertebral number one finds in table 27 that the spawning herring from April has a vertebral number ranging from 56.190 to 56.292 with an average value of 56.255. The vertebral number is somewhat lower than that found by BROCH, but apparently we have to do with genuine Beistad Fjord herring. The maturing herrings found in the Beistad Fjord in the autumn with mean values ranging from 56.195 to 56.354 (average value 56.329) also represent rather pure shoals of Beistad Fjord herring. The immature herrings with mean values ranging from 56.814 to 57.217 must represent a mixture of off spring of the great Norwegian spring herring stock and of the Beistad Fjord herring.

The maturing herrings of the year class 1932 found in the Trondheims Fjord in November 1934 have a vertebral number of 56.431 and must therefore mainly represent Beistad Fjord herring, while the immature herrings of the year class 1933 with a mean value of 56.774

Table 27. *Beistad Fjord Herring. Vert S.*

Year	Month	No.	Maturity stages		
			I—II	III—V	VI—VII
1932	August	163	56.814	56.295	—
—	Oktober	410	57.217	56.354	—
—	November	196	57.188	56.338	—
1933	April	200	—	—	56.292
—	November	44	—	56.195	—
—	November	160	—	56.316	—
1934	April	200	—	—	56.190
—	November	200	—	56.292	—
—	November ..... (Trondh. Fjord)	200	56.774	56.431	—
1935	April	200	—	—	56.285
	Total:		57.093 ± 0.028	56.329 ± 0.029	56.255 ± 0.031

probably have a greater admixture of young individuals of the Norwegian sea herring. In the spring 1935 the year class 1932 among the spawning herring in Beistad Fjord had a vertebral number of 56.281 and the year class 1930 56.292.

The herrings immigrating from the Trondheims Fjord to the Beistad Fjord apparently do not represent sea herrings on their way from the sea to the fjord, but these herrings must be hatched on the spawning places in the Beistad Fjord, to which places they return by reaching maturity. The Beistad Fjord herring is surely a self contained local fjord form characterized by a small size and a low number of vertebrae and which apparently has occurred in the fjord for years. The herring spawns in the inner part of the fjord in the late spring in brackish water probably of a rather high temperature and the distribution of the young herring is restricted to the Trondheims Fjord where they may intermingle with the off spring of the sea herring. As we have seen the spawning stock is composed only of one or a few year classes and it must therefore be supposed to exist great fluctuations in the stock according to the occurrence of rich and poor year broods. There is no proof for the supposition that these fluctuations are due to an immigration and emigration of sea herrings.

Certainly also other local herring forms occur in the fjords and large saltwater ponds along the Norwegian coast. HJORT (1914) mentions a local herring form from the Lyse Fjord south of Bergen.

Another local form is known from the Borg Fjord situated at the west coast of the Lofoten island Vest Vågøy. A small fishery on this herring takes place in the summer and the herring is known to be very large in contrary to the Beistad Fjord herring.

The Borg Fjord is a large and deep saltwater bassin with a very narrow and shallow inlet from the open sea. The fishermen are of the opinion that the herrings spawn and live their whole life in the fjord. The fishery can be traced back to the last part of the last century. The fishermen mean that large herring shoals visiting the place during the great large herring fishery in the seventies, immigrated into the fjord and remained there after the large herring had disappeared from the coastal waters.

In August 1933 a sample was sent to me from Borg Fjord including 190 herrings and in table 28 the composition as regards maturity, age and vertebral number is demonstrated.

The herrings are supposed to spawn in the late spring or early summer. The main part of the herrings in the sample, however, included immature individuals but one finds some maturing herrings and a few ones in the maturity stages V and V—VI. The occurrence of some

herrings soon ready to spawn in August indicates, that spawning also may take place rather late in the summer. The main part of the herrings had four summer zones on the scale representing the year class 1930. The mean vertebral number of 187 herrings was 55.845 which is an extremely low value in Norwegian waters.

Table 28. *Herring from Borg Fjord, August 1933.*

Maturity stages						No.
I	II	III	IV	V	VI	
84	83	13	5	2	2	189

Age (summerzones)				No.
3	4	5	6	
15	113	19	5	152

Vert. S					M
53	54	55	56	57	
2	4	48	100	33	55.845 ± 0.056

Autumn spawning herring has also been observed in northern Norway, which is confirmed by the investigation of a sample from Go Fjord taken in November 1915. This fjord is situated in the inner part of the And Fjord north of Vesterålen and the inner fjord is in open connection with the outer one. As seen in table 29 the main part of there herrings were mature or spawning (maturity stages V and VI). The length of the herrings ranged from 25 to 31 cm. The vertebral number of 53 individuals was 56.472 and this mean value is in accordance to that of the autumn spawners in the North Sea. However one can hardly suppose that North Sea herrings have migrated so far to the north and probably we have to do with a local fjord form.

In the winter immediately before the large herring season the fishermen may caught a sort of herring which they call blood herring. This is especially the case in Nord Møre. The fishermen regard the appearence of these herrings as a sign, that the large herring masses soon will arrive to the coastal waters. The blood herrings are apparently spent herrings which are recovering and which probably have spawned

in the late autumn. I have not succeded in getting a pure sample of these blood herrings, but often the large herring samples from the early part of the season include some few recovering spents. However, the vertebral number of these recovering spents do not differ significantly from that of the genuine large herrings.

In July 1939, however, TH. RASMUSSEN (1940) examined two herring samples taken at Kal Fjord (Troms) and Batalden (north of Bergen) including individuals ready to spawn in July-August. Some of the herring from Batalden with a mean vertebral number of 56.44 apparently represented North Sea herrings, but another more fast growing type had a mean of 56.93 vertebrae and this later type was identical with the Kal Fjord herring. RASMUSSEN considers this summer spawning herringtype, which he regards to be in good accordance with the recovering spents often found intermixed with the Norwegian large herring early in the season, to be Icelandic herring which on their migrations have come near to the Norwegian coast.

Table 29. *Herring from Go Fjord, October 1915*

Maturity stages						No.
II	III	IV	V	VI	VII	
2	4	28	44	16	5	99

Vert. S.				No.	M
55	56	57	58		
4	22	25	2	53	56.472 ± 0.095

THE VARIATION OF THE VERTEBRAL NUMBER IN RELATION TO THE HYDROGRAPHICAL CONDITIONS.

In a previous chapter we have seen that the spring herring spawning along the Norwegian coast show a gradation of the vertebral number with decreasing mean values from south to north. We have also found variation in the number of vertebrae from year to year. This variation has been supposed to be related to variations in the environmental conditions and it will in the following be tested if the environmental factors show a geographical gradation corresponding to that of the vertebral number.

As regards the hydrographical conditions along the Norwegian coast one finds according to HELLAND-HANSEN and NANSEN (1909) two watermasses of different origin namely Atlantic water with salinities above 35.0 $^0/_{00}$ and coastal water with salinities below 35.0 $^0/_{00}$ which later is formed by mixture of Atlantic water with effluvies from continental rivers and fjords. The Atlantic water, passing through the Faroe-Shetland Channel, advances through the eastern part of the Norwegian Sea as the Norwegian Atlantic Current while the coastal water is moving along the coast of Norway as a continuation of the Baltic Current. The salinity of the coastal water is on the whole increasing along the route northwards owing to intermixing with Atlantic water. Of the same reason the coastal water has salinities which constantly increase from the shore seawards. The waters of the Baltic Current are cooled to a low temperature in winter and the intermediate temperature found in Skagerak in the spring is lower than farther to the west and north, where the cooling in winter is less, owing to the effect of the Atlantic water in the Norwegian Sea.

In fig. 16 the arrows indicate schematically the main features of the surface current system of northern North Sea according to the drift bottle experiments carried out by TAIT (1934). One finds that one branch of the Atlantic Current, passing through the Faroe-Shetland Channel, moves northwards along the Norwegian coast while another is moving southwards and enters the northern North Sea between Shetland and Norway. This southgoing current moves in the direction

of Viking Bank but turns here abruptly westwards against Shetland and forms then a great eddy in the central part of northern North Sea with a southgoing current in the western part and a northgoing one in the eastern part which here runs parallell to the northgoing Norwegian coastal current. In the boundary between the two last mentioned current systems smaller whirls are formed outside the Norwegian south west coast.

By studying the spawning immigration of the herring to the Norwegian coastal waters I was interested in getting more detailed and regular observations on the hydrographical conditions in the northern North Sea and due to grants from the Investigation Fund of the Fishery Industries I was able to start cruises with the M.s Armauer Hansen in the spring 1935 which was repeated in the years 1936 and 1937. The programme, which was prepared in collaboration with the hydrographer of the Fishery Directorate Mr. J. EGGVIN, included four sections across the northern North Sea and two more northern sections as demonstrated in fig. 18. The hydrographical material has been treated by Mr. EGGVIN who has published a preliminary report (1937) on some of the results, from which paper the figures 18 and 19 are reproduced.

In fig. 18 the isohalines in the upper layer in the year 1936 are demonstrated. One finds that the western part of the northern North Sea was covered by Atlantic water with salinities above 35 $^0/_{00}$ while water of salinities below 35 $^0/_{00}$ was widely distributed in the central and eastern area causing an extensive formation of whirls. The central area is mainly covered by North Sea water (34—35 $^0/_{00}$) while the area along the Norwegian coast is covered by coastal water with salinities below 34 $^0/_{00}$.

In the Norwegian coastal waters one finds a marked gradation of the salinity. In the spring herring district at the south west coast one finds the lowest salinity, 31.5 $^0/_{00}$, close to the coast between Jaeren and Stavanger, while somewhat more southwards off Egersund the water has a somewhat higher salinity. From Stavanger the salinities increases gradually northwards and at the level of Bergen water of a salinity of 33.5 $^0/_{00}$ is met with. In the large herring district between Bergen and Stat water of higher salinity is penetrating and off Feie North Sea water of 34 $^0/_{00}$ is recorded close to the coast. In the spawning district at the Møre coast north of Stat coastal water of salinities of about 33.0—33.5 $^0/_{00}$ is rather evenly distributed.

As regards the bottom temperature demonstrated in fig. 19, one finds also a marked gradation along the Norwegian west coast with 5.7° off Egersund and then gradually increasing temperatures northwards with 7.5° off Ålesund at the Møre coast.

However great fluctuations in the hydrographical conditions at the northern North Sea takes place from year to year due to variations in the inflow of Atlantic water between Shetland and Norway. HELLAND-HANSEN (1934) found by hydrographical observations in the »Sogne-Fjord section« in May 1939 that »it might seem probable that comparatively »strong« Atlantic water flowed into the Norwegian Sea in the summer of 1928 and continued to flow for many months or even years afterwards.« Our observations in the spring of the year 1935 also show a strong inflow of Atlantic water to the North Sea and as demonstrated in fig. 1 in the paper by EGGVIN (1937) the Atlantic water covered a much greater area of the northern North Sea than in the following year 1936 and the North Sea water was of less importance. The bottom temperature in the year 1935 was also generally 0.5°—1.0° higher than in 1936 and this decline of temperature continued until April 1937. In the Norwegian coastal waters however a corresponding gradation was found in 1935 as in 1936. In the spring herring district at the south west coast the lowest salinity, 30.5 $^0/_{00}$ was found at the same place off Jaeren, and the salinity increased gradually northwards to 33.5 $^0/_{00}$. In the large herring district North Sea water of 34 $^0/_{00}$ was found close to the coast off Feie, and at the Møre coast a salinity of 33.5 $^0/_{00}$ was met with. The bottom temperature increased from 6.0 ° in the south to 7.5° at the Møre coast.

By comparing the hydrographical conditions with the distribution of the Norwegian large- and spring herring fishery one can state that the spring herring immigration and the main spawning takes place in the areas at the south west coast and the Møre coast which are covered with coastal Bank water, while the immigration of the bulk of large herring seems to be related to the inflow of North Sea water to the coast between Bergen and Stat.

As regards the relation between the hydrographical conditions and the gradation of the vertebral number of the spring herring spawning along the Norwegian west coast one finds that the decreasing mean number of vertebrae from south to north is related to increasing salinities and temperatures in the coastal water. As has been demonstrated the most pronounced gradation of the coastal water masses is found at the south west coast between Lindesnes and Bergen where the lowest salinity and temperature is recorded off Jaeren while the values are increasing northwards and to a certain degree also southwards. In good accordance with these conditions we found that the greatest differences between the means of the vertebral number existed at the south west coast (comp. table 3) and the highest mean value was recorded at Jaeren with decreasing mean values northwards and southwards. At

units of a numerical character are not, as a rule, established all at once but appear succesively during development. This circumstance may explain why a short formative period is correlated with low values and a long formative period with high values of a character which, like the vertebrae, exhibits a variation in number«.

He further calls attention to the circumstance that we cannot take one factor at a time for comparising with our data for the geographical variation of vertebrae, postulating that all the other factors have a constant value within the area in question. We have to consider the combined effect of the factors. A clear geographical representation of the variation in the number of vertebrae can only be given for species living in areas where the environment shows a geographical gradation of the total effect of the envirenmental factors.

JOHNSEN concludes from some experiments by JOHS. SCHMIDT that the average number of vertebrae decreases with increasing density, i. e. with the decreasing volume of the egg. Also with regards to temperature high values are correlated with low values for the vertebral number. The general rule that within a species the average number of vertebrae increases from southern to northern localities is explained by the circumstance that in the waters of western and northern Europe the temperature generally decreases northwards to a remarkable degree, as do also the salinity and the density.

As regards the Norwegian spring herring we found a decreasing number of vertebrae from south to north which is apparently in contradiction to the general rule. However we have stated that the salinity and temperature along the Norwegian coast increases northwards and thus the variation in the vertebral number is in good accordance with the presumed effect of these factors. In the same manner we found that the vertebral number of the spring spawning groups in northern North Sea increases from west to east with falling salinity and temperatur.

SCHNAKENBECK (1936) has made the interesting observation that the eggs of herrings from Norwegian waters are larger than those of the herrings from the North Sea. This phenomenon may be in accordance with the circumstance that a lower density increases the volume of the egg and the number of vertebrae. A more detailed study of this phenomenon would be of interest.

We have seen that the bulk of large herring appearing in Norwegian coastal waters some time before the spawning season does not spawn on the coastal banks. The spawning of this herring group seems to take place on more off shore grounds in water of higher salinity than the coastal water. The immigration to the Norwegian coast seems to

be related to the inflow of North Sea water, and it is probable that the sporadic appearence of the large herring in Norwegian coastal waters is highly related to fluctuations in the current system.

It is known that the circulation of the Norwegian Sea undergoes long enduring modifications due to pulsations in the strength on the part of the Atlantic current which probably influences the migrations of the herring. Thus OTTO PETTERSSON (1922) means that the secular periodicity of the Bohuslän herring fishery is caused by an alteration in the circulation of the northern Atlantic Ocean, the inflow of Atlantic water from Shetland into the Norwegian Channel and Skagerak being partly arrested and supplanted by an inflow of Bank water from the coastal banks of Norway. In such periods there will be a great transport of herrings into the Skagerak which will give a rich Bohuslän fishery. Even if we cannot accept the assumption of OTTO PETTERSSON that the Norwegian herring altered their racial characters and immigrated into the Skagerack, fluctuations in the inflow of Atlantic water apparently may cause an alteration in the position of the spawning places of the Norwegian herring, which have had the effect that the Norwegian spring herring fishery in certain periods almost ceased.

The spawning of the Norwegian spring herring is mainly limited to the coastal Bank water (32—34 $^0/_{00}$) and the occurrence of the large herring is apparently related to the more saline North Sea water (34—35 $^0/_{00}$). By a decreasing inflow of Atlantic water the salinity will be lowered and the Bank water will be extended seawards over a greater area. The large herring will then first disappear from the coast and at last also the spring herring will get more favorable spawning conditions on more off shore grounds. My investigations into the spawning at the south west coast of Norway over a serie of years have shown that smaller displacements of the spawning places really take place from year to year which are related to alterations in the hydrographical conditions. By a lowering of the salinity and temperature in the coastal water the herring spawn in deeper water and farther away from the coast than under normal conditions.

At the end of the last Norwegian herring period the spring herring fishery at the south west coast decreased, but the herrings did not migrate southwards, by contrary the fishery was extended northwards and in northern Norway great masses of large herring appeared. This northern herring fishery was apparently related to a strong inflow of Atlantic water which according to IVERSEN (1923) was indicated by the phenomenon that great masses of cod appeared in the fjords and sounds of Spitsbergen which coast in that time was free from ice. In 1874 the herring entirely disappeared from Norwegian coastal waters

and in 1876 a rich Bohuslän fishery started which according to OTTO PETTERSON was caused by a decreased inflow of Atlantic water. In 1896—97 when the Bohuslän fishery ceased the waters of the Atlantic current flowed with unusual strength over the north part of the North Sea according to PETTERSSON. From this year we can note an increase of the spring herring fishery in Norwegian coastal waters and at the same time also the suddenly appearance of large herring at the Møre coast took place. In the winter 1928—29 a great change took place in the character of the herring fishery in the coastal area between Bergen and Stat. In this area which for a long period had been a spring herring district great masses of large herring appeared and then the main large herring fishery has taken place in this area. HELLAND—HANSEN (1934) has stated that comparatively »strong« Atlantic water flowed into the Norwegian Sea in the summer of 1928 and continued so to flow for many months or even years afterwards. From his Sogne Fjord section one finds that water of high salinity filled the Norwegian Channel in the Sogne Fjord area. The suddenly immigration of large herring in this area in 1928—29 thus was related to an exceptional strong inflow of Atlantic water. According to our observations there was a strong inflow of Atlantic water in northern North Sea still in 1935 but in 1936 and 1937 the inflow had somewhat decreased (EGGVIN 1937).

We have seen that the different groups of spring spawning herring in northern North Sea in their spawning are limited to water masses of different physical characters. The Shetland herring spawn under Atlantic conditions, the large herring in North Sea water and the Norwegian spring herring in coastal Bank water. By changing distribution of the water masses the herring alter their spawning places in order to get favourable spawning conditions. It is not unreasonable to suppose that we have to do with different spawning groups which react in different manners to the environment and which to a certain degree compensate the fluctuations in the environment by changing their spawning places. We must then suppose that the variations of morphological characters as the vertebral number, caused by variation in the environmental factors, is restricted to certain limits which however will differ for the different biological groups.

SUMMARY AND CONCLUSIONS.

HEINCKE (1898), the founder of racial investigations on fishes, defines the race as such shoals which deposit their eggs at the same season on more or less neighbouring spawning places of the same or very similar conditions of the water and the bottom, disappear afterwards and return in the next year at the same time and in the same stage of maturity. Thus he regards the race as a spawning community. He tried, by means of measurable and countable characters, to recognize the races of the herring outside their spawning places and he assumed these characters to be inherited. HEINCKE laid stress en the influence of the environment on the formation of the races, but apparently he was of the opinion that the racial characters in the course of generations was hereditary fixed.

Since HEINCKES great work on herring races appeared, many papers on this subject have been published and the opinions of the fishery biologists about the constancy of the racial characters diverges very much. Authors as JOHANSEN (1921), HUBBS (1925), TÅNING (1929), BJERKAN (1929), TESTER (1937) and other consider that the countable characters are not strictly inherited but are to a certain degree the result of environmental factors. JOHS. SCHMIDT (1919—1921) has proved directly by experiment that external factors are capable of altering the average characters by which races in the fishes are determined and MOTTLEY (1937) has also modified the number of vertebrae in trout by experimental methods. Some authors as DAVIS (1936) mean therefore that the term »race« is unapplicable owing to the postulate that racial characters are hereditary and propose that any group of herring spawning in a given area at a given season from year to year should be defined as the natural »Biological Group«. LISSNER (1934) also means that HEINCKE'S definition of a race is no longer held to be true and he tries to give a new hypothesis. He has further developed a method by which the influence of the environment called »plasticity« or »lability« can be estimated. By contrary SCHNAKENBECK (1931) means that no definite proof on the inconstancy of the racial characters has been given

and he has made great effort to prove that the countable characters of the herring races are strictly inherited.

The Norwegian spring herring represents a typical herring race in the sense of HEINCKE. During hundreds of years the spring herring has visited the same spawning grounds along the Norwegian west coast where they from year to year spawn at the same time and under the same conditions of water characterized by the coastal bank water. In the short periods when the herring has been absent from the common coastal grounds, these grounds have probably been covered by water-masses unfavourable for the spawning and the herring have found normal conditions on more offshore grounds. Contrary to the spring herring fishery the Norwegian large herring fishery, based on the full grown herring appearing some time before the spawning season, has not the same old traditions and has been much more irregular. The large herrings have appeared for longer or shorter periods outside different coastal regions, often in more open waters and far away from the common spawning grounds and has then been away for long periods. A more regular fishery on this herring was started first when a driftnet fishery on the open sea was introduced in Norway.

The herring occurring in the Norwegian waters has commonly been regarded as a very uniform herring stock, the spring herring representing the spawning herring and the large herring the same shoals in an earlier stage of maturity on their way to the spawning grounds at the west coast. The racially investigation by BROCH (1908) which also was statistically analysed by JOHANSEN (1919) gave however some doubt on the uniformity of the Norwegian herring but the investigation gave no definite solution of the problem. In a later paper SCHNAKENBECK (1931) means to have shown that the Norwegian herring includes at least two distinct herring types or races. In the years 1932—1936 I have collected a great material of vertebral counts which has partly been treated in preliminary reports (RUNNSTRØM 1933, 1937). At the same time more thoroughly investigations on the spawning and the hydrographical conditions in the spawning area was made. In the present paper a statistically analysis of the whole material including in all 59.000 herrings is given.

The spring herring spawns in February and March and to a less degree also in April. The spawning seems to be rather continuous along the whole coast from Lindesnes in the south to at least Lofoten and Vesterålen in the north. The main spawning takes place at the south west coast between Bergen and Lindesnes but one finds also a great concentration of the spawning at the Møre coast north of Stat and to a less degree at Lofoten and Vesterålen. These spawning centres do

not represent isolated spawning regions but also in the intermediate areas a scanty spawning takes place. In the region Bergen—Statt, situated between the two main spawning centres at the south west coast and the Møre coast, the main large herring fishery in present days takes place in December—January. The hydrographical investigations have shown that more saline North Sea water reaches near to the coast in this large herring area while the main spawning areas are covered by coastal water.

Within each spawning region the spawning does not take place simoultaneously over the whole region but we have to do with single spawning shoals successively immigrating in a regular manner to the different, by deaper ridges or fjords isolated grounds. The fishing fleet therefore moves in a regular manner from one fishing area to another throughout the season. A new spawning shoal seldom immigrates to a ground where spawning already has taken place and the fishermen know that the fishery in a certain area soon is ended, when its water get milky. We have thus to do with an immigration of many more or less independent spawning shoals visiting different spawning grounds along the coast. In certain regions there is a concentration of the spawning probably due to more favourable bottom- or hydrographical conditions.

The mean vertebral number of 17782 spring herrings, collected throughout the spawning season February—April in the years 1932—1936, is 57.324 ± 0.005 and that of 14362 large herrings of maturity stages IV and V, collected in December—January in the same period, is 57.182 ± 0.006. Thus the large herring has a significant lower vertebral number than the spring herring and according to the analysis it is probable that the large herring does not spawn at all on the Norwegian coastal banks, but that they spawn on more off shore banks in northern North Sea covered by more saline water. The vertebral number of the large herring is also more in accordance with that of the spring spawning herring occurring in the N. E. North Sea e. g. Viking Bank, than with that of the Norwegian spring herring. The large herring apparently does not migrate towards the Norwegian coast in order to spawn there, but they only touch the coast on their way to more off shore spawning grounds. The immigration to the coast seems to be related to an inflow of North Sea water to certain areas of the Norwegian coast. These facts explain the great irregularities in the coastal large herring fishery. It may also be of interest for the fishermen to know that the two important fisheries do not fish on the same herring masses. The spring herring represents a new immigration after that the large herring has left the coastal waters.

However, the spring herring, spawning along the Norwegian coast, is not uniform. When the material is subdivided according to the main spawning centres one finds a real difference between the vertebral number of the herring spawning at the south west coast and those spawning at the Møre coast and farther north. But also in the intermediate region a scanty spawning occurs and the herring from this region has a vertebral number with a mean value intermediate between the values from the two main spawning centres. A further subdivision according to the single spawning grounds within each of the great spawning regions has demonstrated, that significant differences also may exist between the mean number of vertebrae of herring visiting neighbouring spawning grounds.

When the mean values of the herring from the different single spawning grounds are arranged according to the geographical position of the grounds, one get a rather continuous serie along the coast with decreasing values from south to north. This gradation of the vertebral number is related to rising temperatures and salinities of the coastal water from south to north, due to an inflow of cold Baltic water with low salinity from the south, which is gradually intermingled with warmer and more saline Atlantic water along the coast. Thus it exists no definit number of well distinguished races within the Norwegian spring herring as supposed by SCHNAKENBECK but we have to do with a continuous gradation of the vertebral number due to the influence of environmental factors. This gradation is in accordance with the gradation with latitude of the vertebral number of the Pacific herring along the west coast of North America as stated by HUBBS (1925), ROUNSEFELL (1930) and TESTER (1937). HESSLE (1925) has also shown a similar gradation as regards the autumn spawning herring in the Baltic.

In the same manner as regards the spring herring one finds significant differences between the means of large herring visiting neighbouring fishing areas within the large herring district. However it is always distinct differences between the means of large and spring herring from one and the same area.

When the different year classes of the large- and spring herring are treated separately, one finds statistically significant differences between means of successive year classes, which was to be expected if the vertebral number is influenced by the environment. This observation is in accordance with that of ROUNSEFELL and DAHLGREN (1932) and TESTER (1938), who have found, that the mean vertebral count of successive year classes of the Pacific herring varies inversely with the temperature of the water during the period of spawning and early development.

Through a long serie of successive year classes one finds a mainly parallel fluctuation of the means of the large- and spring herring and the large herring has always a lower mean vertebral number than the spring herring. The gradation of the vertebral number of the spring-herring along the coast is also distinct within one and the same year class.

Due to the different age composition of the herring stock from year to year one finds also significant differences between the means from season to season within one and the same area. This circumstance may explain the fact that the mean vertebral number of the Norwegian spring herring in present time is lower than that found by BROCH (1908) in the years 1904—1906 (461 herrings with a mean of 57.56 vertebrae). Also the vertebral number of the Icelandic spring herring in the period 1932—34 was considerable lower than the mean found by JOHANSEN in the year 1924 (RUNNSTRÖM 1936). Also as regards the Faroe herrings WOOD (1935) found a much lower vertebral number than earlier stated by JOHANSEN and according to LISSNER (1934) the autumn spawning herring in the North Sea also seems to have a lower mean value than the commonly accepted one. Undoubtly the northern waters has had a rather »warm« period in recent years, as pointed out by AD. S. JENSEN (1939), which may have lowered the vertebral number of the herring in these waters.

Along the Norwegian coast one finds also small apparently self contained local herring forms living under extreme conditions in the inner parts of deep fjords or in salt water poonds. The small grown Beistad Fjord herring, wellknown from the investigation by BROCH (1908) in the years 1904—1905, is still to be recognized in the inner part of the Trondheims Fjord. In the period 1932—1935 600 spawning herring had a vertebral number of 56.255 which is somewhat lower than the value found by BROCH (56.550). Another local form living in the great salt water bassin Borg Fjord in Northern Norway had the extreme low mean value of 55.845 vertebrae.

The analysis of the vertebral counts of the Norwegian spring herring has thus proved that the countable characters of a herring group, which may be regarded as a typical race in the sense of HEINCKE, are not constant but are highly influenced by environmental factors. The Norwegian spring herring can not be characterized by a fixed mean number of vertebrae, but the mean value is only a statistical expression for the temporary conditions. The fact that the number of vertebrae may be highly modified by the environmental conditions suggests great caution in distinguishing herring races only on differences in the countable characters without to have a thoroughly knowledge of the biological conditions.

Whichever view one holds as to the question whether the distinguishing characters are hereditary or environmental the most fishery biologists agree in the existence of herring communities which spawn regularly at a certain season under certain conditions under definite physical conditions. In the time between the spawning seasons the herring may scatter and intermingle with other communities, but when the maturity period approaches they return to the places where they were born. We know from experimental investigations on different marine evertebrates (RUNNSTRØM 1927, 1929) that the spawning and early development of the eggs is adapted to more narrow temperature limits than the vegetative processes of the fullgrown individuals. Within one and the same area one finds species with different temperature limits for the development, spawning at different seasons of the year. But also within one and the same species one may find »physiological races« with different optimal temperatures for the spawning and development. In the same manner the natural herring groups spawning at different seasons or in different areas may represent such »physiological races« which for the spawning and early development need definite environmental conditions. Thus in the Norwegian waters one finds two natural groups, the large herring and the spring herring, apparently spawning in different water masses i. e. North Sea water and coastal Bank water with definite physical and chemical conditions.

In many cases the biological herring groups can be distinguished by means of countable characters as the vertebral number and we have seen that the large herring generally has a distinct lower number than the spring herring. These different morphological marks of the herring groups may be induced by the modifying influence of the different area conditions during the early development. However we can not ignore the possibility that the countable characters of the herring groups may also be partly of hereditary nature. As JOHS. SCHMIDT (1917) has pointed out these characters may be a result of co-operation between certain »internal« and »external« factors and thus be of both genotypical as phenotypical nature. The hereditary character must not be a fixed number of vertebrae but the possibility on the basis of a certain genotypical constitution to react in a certain manner on certain external factors. But this problem can not be solved by statistical methods, but only by genetic experiments. However undoubtly natural biological herring groups exist and the question whether they represent pure races or only local modifications does not influence the importance of isolating and defining them according to the outlines drawn up by HEINCKE.

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Table I. *Large- and Spring herring samples in the years 1932—1936.*

N = number of fish M = Mean.
δ = standard deviation. μ = standard deviation of the mean.

Season	Date	Sample Nr.	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	60	N	M	δ	μ
1931—	22. XII	4	Svinøy	S. Møre	IV—V				11	58	30		1	100	57.210	0.637	0.064
1932	20. »	3	Bulandet	S. & Fjord.	»				14	57	23		1	95	57.116	0.647	0.066
	28. »	9	Solund	»	»				10	62	26		1	99	57.182	0.609	0.061
	23. »	5	Feie	N. Hordl.	»				11	57	28		4	100	57.250	0.698	0.070
	28 »	6	Manger	»	»				13	52	34		1	100	57.230	0.676	0.068
	19. »	1	Marstein	S. Hordl.	»				6	59	30		3	98	57.306	0.629	0.064
	26. I	14	Bulandet	S. & Fjord.	»			1	10	54	32		2	99	57.242	0.698	0.070
	6. »	11	Hjelte Fjord	N. Hordl.	»				12	62	25		1	100	57.150	0.622	0.062
	11. »	10	»	»	»				19	66	14		1	100	56.970	0.608	0.061
	2. »	8	Fjell	»	»				9	65	24			98	57.153	0.560	0.057
	21. »	12	Utsira	N. Rogal.	»				7	54	36		2	99	57.333	0.636	0.064
	27. II	31	Griptaren	N. Møre	IV—V				1	8	5		1	15	57.400	0.712	0.184
					VI—VII				10	45	22		1	78	57.179	0.655	0.074
	9. »	20	Buadypet	S. Møre	IV—V				7	29	14		2	52	57.212	0.716	0.099
	9. »				VI—VII				4	16	8		1	29	57.207	0.713	0.132
	10. »	19	Storholmen	»	IV—V			1	5	23	19			48	57.250	0.722	0.104
					VI—VII				5	27	19			51	57.275	0.628	0.088
	3. »	16	Svinøy	»	IV—V		1		11	47	40		1	100	57.260	0.783	0.078
	3. »	15	Ferkingstad	N. Rogal.	VI—VII		1		7	47	41		4	100	57.370	0.796	0.080
	8. »	18	Skude	»	VI—VIII			2	13	52	29		3	99	57.182	0.770	0.077
	12. »	22	Jarstein	»	IV—V				1	15	8		1	25	57.360	0.625	0.125
					VI—VII		1		6	43	23		2	75	57.227	0.784	0.091
	16. »	24	Bokn	»	IV—V					4	6			10	57.600	0.490	0.155
					VI—VII			1	11	79	46		3	140	57.279	0.666	0.056

Season	Date	Samp-le Nr.	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	60	N	M	δ	μ
1931—1932	22. »	28	Nedstrand	N. Rogal.	IV—V				4	2	1	1		8			
					VI—VII			2	26	65	43	4		140	57.150	0.801	0.068
	17. »	26	Håstein	»	IV—V				1	4	5			10			
					VI—VII				12	71	52	5		140	57.357	0.687	0.058
	11. »	21	Egersund	S. Rogal.	IV—V			1	1	8	6	1		17			
					VI—VII			2	7	34	34	6		83	57.422	0.837	0.092
	18. »	25	Egersund	»	IV—V				1	8	3			12			
					VI—VII				9	68	54	7		138	57.428	0.690	0.059
	25. »	30	Egersund	»	IV—V					1		1		2			
					VI—VII				10	46	37	5		98	57.378	0.735	0.074
	5. »	27	Hidra	»	VI—VII			2	22	65	57	4		150	57.260	0.787	0.064
	16. »	23	Flekkefjord	»	IV—V				2	16	5			23			
					VI—VII				9	65	49	3		126	57.365	0.650	0.058
	24. »	29	Søgne	V. Agder	IV—V			3	15	53	43	3		117	57.239	0.802	0.074
					VI—VII				2	13	15			30	57.433	0.616	0.112
	15. III	33	Titran	S. Trøndel.	VI—VII	2		23		71	35	2		133	57.060	0.811	0.070
	2. »	32	Bremnes	S. Hordl.	VI—VII		1	17		48	27	7		100	57.220	0.844	0.084
	1. »	35	Føyna	N. Rogal.	VI—VII		1	4		34	20	5		64	57.375	0.781	0.098
	19. IV	36	Lofoten	N. Norw.	VI—VII		1	9		41	31	4		86	57.326	0.769	0.083
	26. »	38	Lofoten	»	VI—VII			8		55	25			88	57.193	0.581	0.062
	26. »	37	Helgeland	»	VI—VII		1	7		67	40	2		117	57.299	0.644	0.060
1932—1933	21. XII	2	Storholmen	S. Møre	IV—V		1	23		122	46	6		198	57.167	0.680	0.041
	15. »	1	Bulandet	S. & Fjord.	»			25		121	42	3		191	57.120	0.632	0.046
	31. »	3	Bulandet	»	»		2	29		122	42	3		198	57.076	0.674	0.048
	5. I	6	Storbåen	N. Møre	»			24		88	36	5		153	57.144	0.709	0.051
	17. »	11	Storholmen	S. Møre				10		75	54	3		142	57.352	0.641	0.054

Season	Date	Sample Nr.	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	60	N	M	σ	μ
1932—	19. I	15	Storholmen	S. Møre	IV—V				20	109	60		2	191	57.230	0.639	0.046
1933	31. »	25	Storholmen	»	»				9	80	34		2	125	57.232	0.595	0.053
	17. »	12	Rundøy	»	»			1	17	100	71		6	195	57.328	0.698	0.050
	24. »	20	Rundøy	»	»				18	75	40		6	139	57.245	0.728	0.062
	31. »	27	Rundøy	»	»				11	86	38			135	57.200	0.568	0.049
	6. I	13	Bremanger	S. & Fjord.	»				29	85	29		3	146	57.041	0.691	0.057
	24. »	22	Bremanger	»	»				24	71	47		5	147	57.224	0.754	0.062
	8. »	10	Kinn	»	»				11	78	57		1	147	57.327	0.619	0.051
	12. »	18	Kinn	»	»				15	92	39		2	148	57.189	0.619	0.051
	10. »	16	Bulandet	»	»				16	80	47		2	145	57.241	0.657	0.055
	5. »	17	Sognesjøen	»	»			1	29	89	23		2	144	56.972	0.666	0.056
	17. »	14	Sognesjøen	»	»			1	17	96	32		1	147	57.102	0.614	0.051
	5. »	4	Feie	N. Hordl.	»				20	126	42		2	190	57.137	0.529	0.043
	6. »	5	Feie	»	»				16	122	50		5	193	57.228	0.627	0.045
	10. »	7	Feie	»	»				27	115	46		3	191	57.131	0.654	0.047
	8. »	21	Feie	»	»			1	20	88	37		3	149	57.134	0.692	0.057
	29. »	24	Feie	»	»				25	94	30		1	150	57.047	0.625	0.051
	10. »	23	Hjelte Fjord	»	»				25	100	24		1	150	57.007	0.594	0.049
	11. »	19	Hjelte Fjord	»	»				28	88	26		1	143	57.000	0.637	0.053
	12. »	8	Hjelte Fjord	»	»				26	120	42		1	189	57.095	0.610	0.044
	13. »	9	Hjelte Fjord	»	»			2	21	94	29		3	149	57.067	0.682	0.056
	31. »	26	Utsira	N. Rogal.	»				17	102	68		2	189	57.291	0.638	0.046
	1. II	28	Titran	S. Trøndel.	IV—V			1	13	86	50		3	153	57.268	0.667	0.054
	28. »	41			VI—VII				2	8	3		3	16			
	28. »	40	Titran	»	IV—V				2	24	5		2	33	57.212	0.640	0.111
					VI—VII	1			6	65	36		4	112	57.259	0.842	0.080

Season	Date	Sample Nr.	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	60	N	M	σ	μ
1932—1933	6. II	30	Rundøy	S. Møre	IV—V			1	20	89	53	2		165	57.212	0.686	0.053
					VI—VII				1	15	12	2		30	57.500	0.835	0.152
	24. »	36	Rundøy	»	IV—V				12	68	54	3		137	57.350	0.668	0.057
					VI—VII				7	37	16	2		62	57.210	0.675	0.086
	7. »	31	Hjelte Fjord	N. Hordl.	IV—V				6	76	51	1		134	57.351	0.576	0.050
					VI—VII					6	8	1		15			
	6. »	29	Skudesnes	N. Rogal.	VI—VII				11	99	74	10	1	195	57.441	0.702	0.050
	12. »	32	Gjeitung	»	»				19	99	73	7		198	57.343	0.699	0.050
	16. »	33	Karmsund	»	»				18	104	71	5	1	199	57.332	0.695	0.049
	21. »	35	Bokn	»	»				19	93	77	8		197	57.376	0.713	0.051
	16. »	34	Egersund	S. Rogal.	»				16	93	75	7		191	57.382	0.691	0.050
	24. »	37	Egersund	»	»			1	11	95	83	8		198	57.434	0.684	0.049
	23. »	38	Siragrunn	»	»		2		15	87	87	8		199	57.377	0.870	0.062
	1. III	39	Låtersøy	S. Hordl.	IV—V				4	20	8			32	57.125	0.599	0.106
					VI—VII				12	90	58	7		167	57.359	0.677	0.052
	14. »	42	Holsøyerne	»	IV—V				2	26	14	1		43	57.326	0.599	0.091
					VI—VII			1	14	77	57	7		156	57.353	0.732	0.058
	10. »	41	Føyna	N. Rogal.	IV—V					4	6			10			
					VI—VII			1	16	97	72	4		190	57.326	0.680	0.049
1933—1934	6. XII	1	Rundøy	S. Møre	IV—V				16	87	24	1		128	57.078	0.581	0.051
	7. »	2	Svinøy	»	»			1	12	88	21			122	57.057	0.584	0.050
	11. »	3	Bulandet	S. & Fjord.	»				13	84	40	4		141	57.248	0.654	0.055
	14. »	4	Feie	N. Hordl.	»			1	22	93	36			152	57.079	0.634	0.051
	27. »	6	Feie	»	»			1	30	96	30	2		159	57.013	0.673	0.053
	21. »	5	Kors Fjord	S. Hordl.	»				28	83	39	1		151	57.086	0.680	0.055
	13. I	11	Onahavet	S. Møre	»				29	107	61	2		199	57.181	0.678	0.048

Season	Date	Sample Nr.	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	60	N	M	σ	μ
1933—1934	15. I	12	Storholmen	S. Møre	IV—V			2	11	93	55	3		164	57.280	0.668	0.052
	9. »	8	Svinøy	»	»			1	29	91	36	2		159	57.057	0.694	0.055
	12. »	10	Svinøy	»	»	1			27	84	33	4		149	57.034	0.839	0.069
	6. »	9	Bulandet	S. & Fjord.	»			1	28	122	45	1		197	57.086	0.635	0.045
	6. »	7	Sognesjøen	»	»				28	84	42	4		158	57.139	0.725	0.058
	29. »	13	Fjell	N. Hordl.	»				13	81	51	6		151	57.331	0.688	0.056
	28. »	14	Utsira	N. Rogal.	IV—V				19	86	58	4		167	57.281	0.691	0.053
					VI—VII				4	13	14	2		33	57.424	0.780	0.136
	8. II	19	Storbåen	N. Møre	IV—V				7	75	49	2		133	57.346	0.601	0.052
					VI—VII				6	35	20	2		63	57.286	0.677	0.085
	8. »	20	Fugelleden	»	IV—V				13	72	46	4		135	57.304	0.681	0.059
					VI—VII				1	37	24	3		65	57.446	0.609	0.076
	8. »	18	Storholmen	S. Møre	IV—V				3	10	7			20			
					VI—VII				17	76	48	2		143	57.245	0.671	0.056
	3. »	16	Svinøy	»	IV—V				7	58	28	2		95	57.263	0.619	0.064
					VI—VII			1	5	30	35			71	57.394	0.682	0.081
	16. »	22	Urter	N. Rogal.	IV—V				6	66	54	1	1	128	57.414	0.632	0.056
					VI—VII			1	6	31	30	4		72	57.417	0.777	0.092
	22. »	23	Røvaer	»	IV—V			2	7	57	36	7		109	57.358	0.772	0.074
					VI—VII				7	43	33	7		90	57.444	0.747	0.079
	5. »	17	Skudesnes	»	IV—V				11	63	39	5		118	57.322	0.700	0.065
					VI—VII				3	23	14	4		44	57.432	0.751	0.113
	12. »	21	Bokn	»	VI—VII			2	9	97	84	7		199	57.427	0.683	0.048
	1. »	15	Feistein	»	IV—V				7	64	67	8		146	57.521	0.674	0.056
					VI—VII				4	25	21	4		54	57.463	0.738	0.100
	22. »	24	Siragrunn	S. Rogal.	VI—VII			3	12	102	68	15		200	57.400	0.775	0.055
	7. III	27	Ravnan	N. Møre	IV—V				3	13	7			23			
					VI—VII				17	79	41	3		140	57.214	0.674	0.057

Season	Date	Sample Nr	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	60	N	M	σ	p
1933—1934	17. III	30	Kvitholmen	N. Møre	IV—V					6	2			8			
					VI—VII			1	18	104	54	8		185	57.270	0.715	0.053
	26. »	32	Smøla	»	VI—VII				14	95	61	9		179	57.363	0.699	0.052
	8. »	26	Storholmen	S. Møre	IV—V				2	11	2	1		16			
					VI—VII				9	82	60	4		155	57.381	0.635	0.051
	12. »	28	Storholmen	»	IV—V				2	5		1		8			
					VI—VII			2	25	77	59	5		168	57.238	0.781	0.060
	15. »	29	Rundøy	»	VI—VII			1	26	86	71	4		188	57.271	0.741	0.054
	6. »	25	Vorlandsvåg	S. Hordl.	IV—V				6	43	30	6		85	57.424	0.725	0.079
					VI—VII				11	52	42	5		110	57.373	0.724	0.069
	17. »	31	Brandasund	»	IV—V					6	3			9			
					VI—VII				17	94	67	8		186	57.355	0.705	0.052
	6. IV	33	Herdla	N. Hordl.	VI—VII			1	21	92	56	4	1	175	57.251	0.737	0.056
	17. »	34	Herdla	»	»				6	35	36	3		80	57.450	0.687	0.077
1934—1935	28. XII	2	Rundøy	S. Møre	IV—V				17	119	34	1		171	57.111	0.556	0.043
	30. »	3	Bremanger	S. & Fjord.	»				24	116	44	1		185	57.119	0.612	0.045
	5. I	6	Kvitholmen	N. Møre	»				10	62	46			118	57.305	0.618	0.057
	8. »	10	Kvitholmen	»	»				22	98	48	3		171	57.187	0.667	0.051
	8. »	9	Hauggjegla	»	»				4	73	39	2		118	57.331	0.568	0.052
	15. »	15	Baksbotten	»	»			1	23	89	58	3		174	57.224	0.712	0.054
	9. »	8	Storholmen	S. Møre	»		1		16	102	54	1		174	57.201	0.678	0.051
	14. »	12	Storholmen	»	»				21	87	42	3		153	57.176	0.678	0.055
	18. »	16	Storholmen	»	»				10	108	43	1		162	57.216	0.552	0.043
	5. »	5	Rundøy	»	»			1	26	96	35	3		161	57.081	0.687	0.054
	3. »	4	Svinøy	»	»			1	19	74	35			129	57.109	0.662	0.058
	30. »	19	Svinøy	»	»			1	25	111	55	3		195	57.174	0.680	0.049

Season	Date	Sample Nr.	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	60	N	M	δ	μ
1934—1935	9. I	7	Stathavet	S. Møre	IV—V				15	76	38			129	57.178	0.616	0.054
	12. »	11	Bulandet	S. & Fjord.	»				25	85	26	4		140	57.064	0.689	0.058
	14. »	13	Bulandet	»	»				11	89	40	4		144	57.257	0.632	0.053
	20. »	18	Gulen	»	»				21	**117**	47	3		188	57.170	0.630	0.046
	16. »	14	Feie	N. Hordl.	»				29	110	48	3		190	57.132	0.672	0.049
	20. »	17	Hjelte Fjord	»	»		1	14	101	55	2			173	57.249	0.637	0.048
	26. II	33	Titran	S. Trøndel.	IV—V				13	40	31	5		89	57.315	0.787	0.083
					VI—VII				2	4	8			14			
	6. »	23	Baksbotten	N. Møre	IV—V				10	57	29	2		98	57.235	0.651	0.066
					VI—VII				1	13	7			21			
	7. »	22	Onahavet	S. Møre	IV—V				22	85	53	5		165	57.248	0.717	0.056
					VI—VII		1	1	8	8	2			20			
	21. »	28	Rundøy	»	IV—V				4	9	5			18			
					VI—VII				13	97	64	6		180	57.350	0.662	0.049
	7. »	21	Utsira	N. Rogal.	IV—V		2	19	120	53	1			195	57.164	0.636	0.046
	11. »	24	Ferkingsøy	»	IV—V				3	26	12	2		43	57.302	0.666	0.102
					VI—VII		1	9	84	61	1			156	57.333	0.624	0.050
	14. »	26	Ferkingsøy	»	IV—V				2	17	15	2		36	57.472	0.687	0.115
					VI—VII				14	77	66	6		163	57.393	0.695	0.054
	5. »	20	Gjeitung	»	IV—V		2	19	97	51	4			173	57.208	0.707	0.054
	20. »	27	Skude Fjord	N. Rogal.	IV—V				5	61	36	7		109	57.413	0.680	0.065
					VI—VII				6	42	29	5		82	57.402	0.714	0.079
	21. »	29	Tømmervik	»	VI—VII				14	100	77	7		198	57.389	0.671	0.047
	25. »	31	Bokn	»	IV—V					6	3			9			
					VI—VII				18	90	71	11		190	57.395	0.738	0.054
	13. »	25	Egersund	S. Rogal.	IV—V		1	3	18	14	2			38	57.342	0.804	0.130
					VI—VII				6	72	75	7		160	57.519	0.642	0.051

Season	Date	Sample Nr.	Locality	District	Maturity	Vertebrae								N	M	σ	μ
						53	54	55	56	57	58	59	60				
1934—	21. II	30	Egersund	S. Rogal.	VI—VII			1	10	90	90	8		199	57.472	0.679	0.048
1935	26. »	32	Egersund	»	VI—VII			1	7	70	57	7		142	57.437	0.696	0.058
	27. III	46	Topsundet	N. Norw.	VI—VII				2	15	9	2		28	57.393	0.724	0.137
	2. »	36	Rundøy	S. Møre	IV—V				2	20	3			25			
					VI—VII				17	69	59	3		148	57.324	0.700	0.058
	7. »	39	Rundøy	»	IV—V				5	20	19			44	57.318	0.667	0.101
					VI—VII				11	89	35	3		138	57.217	0.611	0.052
	1. »	34	Stolmen	S. Hordl.	IV—V				3	14	1			18			
					VI—VII				8	66	37	5		116	57.336	0.669	0.062
	11. »	41	Glesvær	»	IV—V					6	7	1		14			
					VI—VII				21	91	63	6		181	57.298	0.713	0.053
	11. »	42	Utsira	N. Rogal.	VI—VII				19	94	81	6		200	57.370	0.695	0.049
	1. »	35	Nedstrand	»	VI—VII				17	99	72	9		197	57.371	0.705	0.050
	6. »	37	Førres Fjord	»	IV—V			1	9	69	45	1		125	57.288	0.644	0.058
					VI—VII				5	36	27	1		69	57.348	0.633	0.078
	8. »	40	Bokn	»	IV—V				2	26	17			45	57.333	0.558	0.083
					VI—VII				15	75	58	4		152	57.336	0.687	0.056
	12. »	43	Lindesnes	V. Agder	VI—VII				15	114	67	1		197	57.274	0.601	0.043
	16. IV	49	Kas Fjord	N. Norw.	VI—VII				35	157	102	7		301	57.269	0.690	0.040
	8. »	54	Kas Fjord	»	»				14	82	32	5		133	57.211	0.672	0.058
	13. »	55	God Fjord	»	»				10	56	28	2		96	57.229	0.653	0.067
	17. »	50	Træna	»	»				18	88	49	4		159	57.245	0.680	0.054
	17. »	51	Træna	»	»				7	76	42	5		130	57.346	0.641	0.056
	23. »	53	Vikna	N.Trøndel.	»		1		20	79	53	3		156	57.218	0.762	0.061
	24. »	52	Halten	S.Trøndel.	»			2	11	51	50	4		118	57.364	0.767	0.071

Season	Date	Sample Nr.	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	60	N	M	σ	μ
1935—	23. XII	1	Kas Fjord	N. Norw.	IV—V				13	69	39	3		124	57.258	0.670	0.060
1936	31. »	5	Onahavet	S. Møre	»			1	16	82	42	4		145	57.221	0.699	0.058
	28. »	2	Storholmen	»	»				19	94	30	3		146	57.116	0.636	0.053
	30. »	4	Bremanger	S. & Fjord.	»				20	112	61	1		194	57.222	0.624	0.045
	30. »	3	Bulandet	»	»				24	116	54	2		196	57.173	0.639	0.046
	9. I	8	Troms	N. Norw.	»			1	20	93	45	1		160	57.156	0.657	0.052
	25. »	27	Rødøy	»	»				12	53	18	3		86	57.140	0.685	0.074
	18. »	16	Baksbotten	N. Møre	»				15	101	44			160	57.181	0.580	0.046
	18. »	17	Baksbotten	»	»				11	67	50	3		131	57.344	0.663	0.058
	18. »	15	Storholmen	S. Møre	»				4	45	23	2		74	57.311	0.613	0.071
	20. »	18	Storholmen	»	»				15	80	38	2		135	57.200	0.642	0.055
	22. »	20	Storholmen	»	»			2	24	96	43	4		169	57.136	0.721	0.055
	25. »	22	Storholmen	»	»			1	7	94	44	1		147	57.252	0.581	0.048
	6. »	6	Kråkenes	S. & Fjord.	»				18	92	30	2		142	57.113	0.618	0.052
	8. »	9	Kråkenes	»	»			1	13	88	39	3		144	57.208	0.655	0.055
	16. »	13	Kinn	»	»				25	117	49	7		198	57.192	0.692	0.049
	14. »	14	Kinn	»	»				20	111	63	5		199	57.266	0.668	0.047
	6. »	7	Bulandet	»	»				23	112	53	7		195	57.226	0.694	0.050
	15. »	10	Feie	N. Hordl.	»				22	112	47	3		184	57.168	0.642	0.047
	16. »	12	Feie	»	»			2	12	85	52	2		153	57.261	0.674	0.054
	18. »	11	Hjelte Fjord	»	»				2	22	20			44	57.409	0.577	0.087
	24. »	21	Kors Fjord	S. Hordl.	»				17	118	51	10		196	57.276	0.689	0.049
	24. »	19	Utsira	N. Rogal.	»				9	70	40	2		121	57.289	0.623	0.057
	29. »	23	Utsira	»	»				19	90	80	8		197	57.391	0.716	0.051
	18. II	34	Jektevik	N. Norw.	IV—V				4	23	15	1		43	57.302	0.666	0.102
					VI—VII				2	22	9	1		34	57.265	0.609	0.104
	3. »	25	Titran	S.Trøndel.	IV—V				16	70	30	1		117	57.137	0.639	0.059

Season	Date	Sample Nr.	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	60	N	M	σ	v
1935—1936	20. II	35	Baksbotten	N. Møre	IV—V				8	72	44	2		126	57.317	0.613	0.055
					VI—VII		1	8	45	19	1			74	57.149	0.671	0.078
	27. »	39	Storholmen	S. Møre	IV—V				7	35	15			57	57.140	0.605	0.080
					VI—VII				10	47	40	2		99	57.343	0.684	0.069
	11. »	29	Rundøy	»	IV—V				9	52	45	3		109	57.385	0.676	0.065
					VI—VII					6	6			12			
	19. »	36	Rundøy	»	IV—V				9	55	51	2		117	57.393	0.653	0.060
					VI—VII				10	40	32			82	57.268	0.664	0.073
	22. »	37	Rundøy	»	IV—V				9	34	31	2	1	77	57.377	0.773	0.088
					VI—VII				8	35	25	1		69	57.275	0.679	0.082
	21. »	33	Kors Fjord	S. Hordl.	IV—V				10	82	15	2		109	57.083	0.544	0.052
					VI—VII				4	13	10	2		29	57.345	0.800	0.149
	7. »	26	Røvær	N. Rogal.	IV—V				21	90	82	6		199	57.367	0.710	0.050
	24. »	38	Urter	»	IV—V					5	1			6			
					VI—VII				12	105	71	3		191	57.340	0.618	0.045
	10. »	28	Utsira	»	IV—V				4	12	17	2		35	57.486	0.770	0.130
					VI—VII				13	89	56	6		164	57.335	0.674	0.053
	4. »	24	Gjeitungen	»	IV—V				25	103	55	3		186	57.194	0.676	0.050
					VI—VII				1	6		1		8			
	20. »	32	Skude Fjord	»	IV—V				7	47	42	4		100	57.430	0.682	0.068
					VI—VII				5	52	39	2		98	57.388	0.617	0.062
	12. »	31	Egersund	S. Rogal.	IV—V				3	9	11	1		24			
					VI—VII				16	93	59	8		176	57.335	0.704	0.053
	12. »	30	Kristiansand	V. Agder	IV—V				3	48	22	3		76	57.329	0.615	0.071
					VI—VII				10	48	49	7		114	57.465	0.740	0.069
	25. III	44	Storholmen	S. Møre	IV—V					7	4	1		12			
					VI—VII				15	102	64	3		184	57.299	0.637	0.047

Season	Date	Sample Nr.	Locality	District	Maturity	Vertebrae 53	54	55	56	57	58	59	99	N	M	δ	p
1935—1936	11. III	42	Rundøy	S. Møre	IV—V				1	10	9			20			
					VI—VII				5	76	40	2		123	57.317	0.575	0.052
	5. »	41	Bremanger	S. & Fjord.	IV—V		1	4	31	21	5			62	57.403	0.792	0.101
					VI—VII			18	63	41	4			126	57.246	0.731	0.065
	3. »	40	Ramsholmen	S. Hordl.	IV—V			6	78	55	6			145	57.421	0.640	0.053
					VI—VII			4	23	22	3			52	57.462	0.719	0.100
	12. »	43	Rogøyene	»	IV—V				12	3	1			16			
					VI—VII			13	96	67	6			182	57.363	0.663	0.049

Table II. *Vertebral number of successive year classes of Large herring, Decembre—January 1932—1936.*

District II, Sogn & Fjordane—N. Hordland

Year class	Vertebrae								N	M	δ	μ
	53	54	55	56	57	58	59	60				
1932				14	48	17	2		81	57.086	0.689	0.077
1931			1	16	81	26	1		125	57.080	0.627	0.056
1930				62	401	234	19		716	57.293	0.659	0.025
1929			1	27	103	65	2		198	57.202	0.696	0.049
1928			2	67	227	68	4		368	57.014	0.657	0.034
1927			1	7	31	5	1		45	56.956	0.665	0.099
1926			1	52	187	81	2		323	57.097	0.663	0.037
1925				139	832	297	16		1284	57.148	0.606	0.017
1924				114	525	199	15		853	57.135	0.647	0.022
1923			5	179	730	279	15	1	1209	57.102	0.665	0.019
1922			2	47	314	150	8		521	57.221	0.637	0.028
1921				37	127	60	5		229	57.144	0.700	0.046
1920		1		29	115	53	1		199	57.106	0.697	0.049
1919				7	39	26	1		73	57.288	0.651	0.076
1918			1	55	289	119	16		480	57.196	0.682	0.031

District III, Møre—Trøndelag

Year class	Vertebrae								N	M	δ	μ
	53	54	55	56	57	58	59	60				
1932				18	73	38	1	1	131	57.191	0.700	0.061
1931			1	23	139	36	1		200	57.065	0.575	0.041
1930			2	126	734	426	19		1307	57.256	0.649	0.018
1929				30	113	48	2	1	194	57.129	0.688	0.049
1928		1	1	36	153	47	3		241	57.050	0.668	0.043
1926			1	18	94	53	3		169	57.231	0.679	0.072
1925		1	4	72	383	172	9		641	57.167	0.699	0.026
1924			4	51	195	67	1		318	57.031	0.658	0.037
1923		2	4	74	433	182	8		703	57.156	0.659	0.025
1922	1			52	320	157	14		544	57.228	0.699	0.030
1921				9	52	31	3		95	57.295	0.679	0.070
1920				9	52	33			94	57.255	0.618	0.064
1918				25	197	96	10		328	57.277	0.644	0.036

Table III. *Vertebral number of successive year classes of Spring herring February—March 1932—1936.*

District I, S. Hordland—Rogaland

Year class	Vertebrae								N	M	$\hat{\sigma}$	p_s
	53	54	55	56	57	58	59	60				
1932				7	51	42	4		104	57.413	0.674	0.066
1931				22	84	52	2		160	57.213	0.683	0.054
1930			3	123	885	581	56		1648	57.342	0.673	0.017
1929				18	179	125	13		335	57.397	0.652	0.036
1928				27	155	139	17	1	339	57.440	0.723	0.039
1927				6	17	9	2		34	57.206	0.796	0.137
1926			1	35	174	126	16		352	57.344	0.730	0.039
1925				106	633	452	39		1230	57.345	0.679	0.019
1924				51	248	189	27	1	516	57.378	0.741	0.033
1923	1		7	135	829	568	48	1	1607	57.309	0.711	0.018
1922			3	51	341	229	13		637	57.311	0.666	0.026
1921			3	18	116	107	12		256	57.418	0.740	0.046
1920			1	11	114	89	7	1	223	57.417	0.677	0.045
1919				6	31	37	6		80	57.538	0.740	0.083
1918	1	1	7	57	410	342	46		864	57.412	0.753	0.026
1917				3	27	7	1		38	57.158	0.586	0.095

District III, Møre—Trøndelag

Year class	Vertebrae								N	M	$\hat{\sigma}$	p_s
	53	54	55	56	57	58	59	60				
1933				4	10	16			30	57.400	0.712	0.130
1932				6	36	13			55	57.127	0.574	0.077
1931				11	35	22	1		69	57.217	0.699	0.084
1930				53	351	245	13		662	57.329	0.648	0.025
1929				12	71	50	5		138	57.348	0.688	0.059
1928				17	58	30	3		108	57.176	0.644	0.062
1927				5	21	10			36	57.139	0.630	0.105
1926			1	23	135	91	6		256	57.305	0.679	0.042
1925	1	2	3	100	514	313	17	1	951	57.246	0.709	0.023
1924				34	147	88	16		285	57.302	0.749	0.044
1923		2	1	93	466	278	13		853	57.238	0.682	0.023
1922			1	66	372	223	10		672	57.260	0.654	0.025
1921			2	9	39	32	1		83	57.253	0.758	0.083
1920				7	29	14	1		51	57.176	0.678	0.095
1918			1	11	81	78	5		176	57.426	0.679	0.051