

The Life History of the Atlanto-Scandian Herring

by

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The name Atlanto-Scandian Herring was introduced into marine biology by A.C. Johansen (1919) and it includes most of the herring found along the Norwegian coast, in the Norwegian Sea, off Iceland, off the Faeroes Islands, also to a certain extent in the northern part of the North Sea. According to meristic characters defined by Heincke, A.C. Johansen found it reasonable to include all these herring in one tribe in spite of their widely separated spawning areas, and he believed these herring to have similar meristic characters because the hydrographical conditions during spawning are fairly similar.

For centuries the Atlanto-Scandian herring have been the basis of the great herring fisheries in Norway, and for more than 100 years have been the subject of Norwegian scientific investigations. In 1857 The Norwegian Government gave Dr. Axel Boeck the task of investigating the so-called "Spring Herring", and his results were published in a paper (1871), as well as in reports to The Norwegian Government. Boeck brought together many historical facts about the Norwegian Spring Herring fisheries and he believed the Spring Herring fisheries were periodic, the herring being abundant in the Spring Herring district for many years, but also with a numberd years in succession in which the herring concentrations are so small that no fishery can be based upon them. Similar conditions are found in the great herring fisheries in Bohuslän in Sweden. According to Boeck the symptoms of a Norwegian herring period approaching its end are that the herring arrive later and later each year at the Norwegian coast, until eventually the fishing grounds are invaded by herring schools of mixed origin, (called "Mixed-herring" or "New-herring" by the fishermen), which arrive earlier than the so-called "Spring Herring", and the "Spring Herring" disappear.

In December 1869 and 1870 schools of these "New-herring" showed up in the Spring Herring district and Boeck postulated the approaching end of a period of the Norwegian Herring fisheries. In 1870 the output of the Spring Herring fisheries went seriously down and in the following years only small catches of Spring Herring were caught, mainly off the Norwegian West Coast north of Bergen. Since 1808 the main herring fisheries had taken place south of Bergen. In 1875 no Spring Herring at all were caught in Norway and, as can be seen from Fig. 1, it was many years before the Norwegian Spring Herring fisheries regained their importance.

Boeck's view that the Spring Herring would leave the usual spawning grounds created great fear among the fishermen. The Norwegian Government also asked G.O.Sars to investigate this problem.

Although G.O.Sars was only able to carry out field work in the summer, because of his university duties, he succeeded in drawing a fairly correct picture of the life history of the Norwegian herring after only three years of investigations. He could not accept the general view held at that time that the herring is a fairly stationary fish, which outside the spawning season lives in the deeper parts of the sea close to the spawning grounds. He believed that "The Spring Herring" lived in the surface layers of the open sea between Scotland, Norway and Iceland, feeding mainly on copepods, and attaining maturity when about 6 years old. The spawning area was thought to be off the Norwegian Coast between Stavanger and Kristiansund, from which the larvae are spread northwards by the current. Usually the plankton concentrations are greater in the open sea than in the coastal waters, and the young herring move away from the coast, but in some years special meteorological and hydrographical conditions cause plankton to be abundant in coastal waters which are invaded by immature herring. Instead of many small herring populations along the Norwegian Coast Sars believed there were only two; the "Spring

Herring" in Southern Norway, and the "Large Herring", in Northern Norway. (In the years 1868-1874 great quantities of so-called "Large Herring" (Fig.1) were caught off Northern Norway in the autumn). Sars regarded the "Large Herring" to be a special tribe with unknown spawning grounds. It seems that he later changed his mind as he wrote in his last report (1874) that the connection between the Spring Herring fisheries and the Large Herring fisheries was closer than he had earlier believed possible.

After the first summer's field work in 1872, G.O.Sars returned to the university holding views differing from those of Boeck. Sars had found many herring belonging to the O-group in the Spring Herring area, which led him to believe that the herring had been spawning in the area, but further off the coast than usual. He considered it likely that they would soon return to the old spawning grounds. He questioned whether herring periods really did exist in the Norwegian herring fisheries and thought it unlikely that there should be any connection between the "Spring Herring" and the herring responsible for the great herring fisheries in Bohuslän, Sweden.

The next year he gave an explanation of the poor catch of "Spring Herring". He pointed out that one of the historical facts that Boeck had brought to light was that a "Norwegian" herring period ends when the herring arrive at the coast later and later each year, and that this might be a result of the distance the herring have to cover during their spawning migration. If the distance is great the herring will arrive late, the season will be short, and the catch accordingly poor, but if the herring had only a short distance to cover they will arrive early, the season will be long, and the availability of herring better. He also explained the Bohuslän herring fisheries. He considered that if the "Spring Herring" found good feeding conditions in the North Sea, they might stop there for feeding, then when the spawning time approached, might migrate in the usual southeasterly direction and arrive in Bohuslän to spawn. The next year these herring would return to the same spawning grounds and become the stock of the great Bohuslän fisheries. The disappearance of these herring from Bohuslän might be due, amongst other things, to a lack of food in the Skagerak.

The arrival of the so-called "Mixed Herring" or "New Herring", which according to Boeck heralds the end of a Norwegian Herring period was also explained by Sars. He considered that the Spring Herring have to cover a longer spawning migration route at the end of the period. The immense Spring Herring schools approaching the coast frighten the younger herring met on the route and drive these in front of them to the coast. The longer the distance that the Spring Herring had to cover, the more "Mixed Herring" would arrive at Norwegian Coast.

Axel Boeck died in 1872 and after 1874 G.O.Sars was occupied by other tasks and did not return to herring investigations. The work was continued by Buch and Jensen, who started temperature measurements in the Spring Herring area, and showed that in years with high temperatures the herring were found close to the shore in shallow water. In the years when the surface temperature was low the herring were found in deeper water where the temperature is higher. Jensen described the "New Herring" as a mixture of young mature herring and immature herring, and after the first few years there is no observable difference between these "New Herring" and the "Spring Herring". These herring return to the spawning area but it is quite clear that the stock of Spring Herring was far less than it had been before 1870. Several thousand fishermen are gathering each winter in the same area catching cod instead of herring.

The "Large Herring" caught in Northern Norway in the years 1868-1874 have already been mentioned. The herring fisheries in Northern Norway are usually based upon immature herring, but in these years mature herring penetrated the skerries and were found in shallow areas where great catches could be taken by land-seines. These herring were investigated by Boeck and Sars and were described as herring of the same size as the "Spring Herring", but in much better condition. The ovaries showed that they were not ready to spawn. In December the "Large Herring" disappeared and the spawning of these herring was never observed, except in one case when spawning occurred among herring kept in a seine off Bodø until the middle of January. 1874 was the last year of the "Large Herring" fisheries in Northern Norway. Jensen (1881) tells that a similar fishery took place in Northern Norway in the middle of the eighteenth century.

In the winter of 1877 great schools of herring were discovered penetrating the skerries in Bohuslän, Sweden, and for twenty winters in succession great herring fisheries were carried out inside the skerries there. The herring had

been absent since 1808, but similar periods of herring fisheries in Bohuslän can be traced back in history for about 1000 years, and it looks as though the Bohuslän herring fisheries and the Norwegian Spring Herring fisheries occur alternately. (Strøm, 1782, A.Ljungman, 1883, O. Petersson, 1922). Fig. 1 shows the output of the Bohuslän fisheries and the Norwegian Winter Herring fisheries during the last 200 years.

In the years that the great inshore herring fisheries were carried out in Bohuslän, herring fisheries also grew up on the Norwegian side of the Swedish border. During the last years of these Norwegian herring fisheries about 8000 fishermen were involved. Complete reports are given in "Norges Fiskerier" from 1895-1899 by H.L.Buvik, the inspector of the fisheries in Southern Norway. Buvik has tabulated the number of herring in a "measuring barrel" (150 liters) and also gives the localities in which the herring are caught. The map Fig. 2 shows where the herring were caught and Fig. 3 shows the corresponding number of herring in a "measuring barrel". Fig. 3 also shows the number of Spring Herring in a "measuring barrel" from the same winter. Fig. 4 shows the number of herring which would fill a "measuring barrel", if all the herring were of the same size. It is easy to see from Fig. 3 that the average size of the herring counted by Buvik must have been 32-33 cm. Herring of this size can not be herring from any North Sea population, but are the same size as the mature Atlanto-Scandian Herring.

The winter of 1895-96 was the last winter in which Atlanto-Scandian Herring were caught in the Skagerak in great quantities by Norwegian fishermen. It was also the last winter in which great herring fisheries occurred inside the skerries in Bohuslän. The next winter there were herring concentrations along the coast of Western Norway of the same magnitude as in the good fishing winters before 1870 (H.A.Buvik).

The Atlanto-Scandian Herring did not leave the Skagerak completely in the winter 1895-96. Small schools returned and were caught mainly to the west of the Oslofjord. When H.Broch began his herring investigations in 1904 with scale studies and counts of vertebrae numbers he obtained a sample from Langesund which gave the high vertebrae number of 57.50. These herring must have been Atlanto-Scandian Herring. Until the first world war these larger herring were caught off Arendal, and in 1930 there were still about 400 fishermen using Farsund as a base for "Spring Herring" fisheries. After the winter of 1948 the "Spring Herring" fisheries south of Jæren have been negligible. In 1960 and 1961 the "Spring Herring" did not return to the spawning grounds south of Bergen. The northward trend in the location of the Norwegian herring fisheries in the last decade are shown in Fig. 5 and 6.

During the present century the Atlanto-Scandian Herring have been driven out of the Skagerak and in the last few years have moved northwards along the West Coast of Norway. At the same time the arrival of the herring in Norwegian coastal waters has been later and later, as has the actual spawning. Figure 7. shows the dates of the first catch of the herring in Norwegian coastal waters, and also shows the date on which 50 % of the herring in our samples are in stage VI. Before 1930 the samples were taken insufficiently often throughout the season to demonstrate the spawning.

In the autumn of 1896 great schools of herring were discovered off Ålesund. These were called "Large Herring", and an extensive herring fishery began based on these. The next autumn the "Large Herring" showed up again and in the succeeding years great schools were discovered in the autumn off Møre and Trøndelag. These herring schools disappeared before Christmas, but in January new schools arrived, which appeared to move southwards along the coast and were later mainly caught from Haugesund southwards to Lindesnes. In the beginning of this century the Norwegian winter herring fisheries had two seasons, one based on the "Large Herring", the other on the "Spring Herring". The Large Herring arrived later and later in the coastal waters and after 1921 no herring arrived in the Møre region before the 1st of January.

The "Large Herring" and the "Spring Herring" seem to have become more and more mixed, and during the last twenty years it has been impossible to distinguish between them according to unpublished investigations carried out by Østvedt.

It is now well known that the mature Atlanto-Scandian Herring are feeding along the "polar front" in the Norwegian Sea during the summer. Early in the

summer we find the older herring far to the west and north along the front with the younger mature year-classes further east and south, but this is not so pronounced in the late summer. It might be due to the fact that the older herring leave the spawning area first, and might move faster than the smaller young ones.

During the summer the herring are mainly found above the thermocline in the "polar front" area, but at the end of the summer the herring begin to penetrate the thermocline and in the autumn are usually found deep down in the arctic water of the East Icelandic Current in the day, moving up to the surface layer towards the night. This vertical movement of the herring has been recorded down to 500 m. In the autumn the mature herring are gathered in a comparatively small area east of Iceland, and they keep to this area until late December or early January when the spawning migration begins.

At the beginning of the spawning migration the herring travel in front of the cold water masses of the East Icelandic Arctic Current, at a speed which seems to be 5-7 nautical miles in 24 hours. To reach the spawning grounds the herring have to move into Atlantic water, and after penetrating the front the speeds of the schools in the Atlantic water are much greater, 20-40 miles in 24 hours. As long as the schools are moving in the Arctic water they continue their vertical movements, being close to the surface at night and deep down during the day. This was discovered using R.V. "G.O. Sars" in 1950-51, the first winter in which we followed the schools to the Norwegian Coast. In the last few years, however, the herring have mainly kept below 100 m. deep even at night. When the herring schools are migrating through the Atlantic water they keep to the upper layers even during the day. After reaching the Norwegian coastal water the big migrating schools disperse during the night and regroup the next day into schools which are now much smaller. These schools also again disperse during the night.

About a month after arriving in the spawning area, spawning takes place, after which the herring migrate out to the open sea again. The last schools to arrive in the spawning area consist of recruit spawners mixed with immature herring. The migrations of the mature herring are shown schematically in Fig. 8 which is based upon Norwegian and Russian observations during the last 12 years.

We now know the migration pattern routes of the mature Atlanto-Scandian Herring fairly well, but the behaviour of the immature stock is more uncertain. Einar Lea (1929) has shown that in the scales of the Atlanto-Scandian Herring the first winter rings are as a rule very sharp "as drawn with a pen" after which follows one or two more diffuse winter rings "as drawn with chalk". From this difference in the appearance of the winter rings in the scales of the herring, Lea believed that the first years of the herring's life were all spent in Norwegian coastal water and he therefore called the sharp rings "coastal rings". The later diffuse rings were called "Oceanic rings", as he believed that these were laid down after the herring have moved from the coastal waters out into the Norwegian Sea. This hypothesis of Lea could be accepted until the echo sounder became common in Norwegian fishing boats. After the war echo sounders were installed in hundreds of Norwegian fishing boats which look for herring each year in Norwegian waters. Outside the 0-group very few schools of young immature herring are found in Norwegian territorial waters. A more likely explanation of Lea's "coastal rings" is that the young year-classes of the herring spend the winter under arctic or subarctic conditions in the Barents Sea, where the sharp winter rings are formed. After migrating westwards from the Barents Sea they arrive in areas with more boreal conditions where the more diffuse winter rings form. The still immature, so-called "Fat Herring" have been located by Russian investigators in the Norwegian Sea off the continental shelf of Northern Norway. In the Barents Sea Atlanto-Scandian Herring are found up to the age of about six years. We also find herring with up to six "coastal rings".

The output of the Norwegian winter herring fisheries has declined catastrophically during the five last seasons and our explanation of this is that the stock of mature Atlanto-Scandian herring has received very few recruits since the 1950 year-class attained maturity. We can see from Fig. 9, which shows the age compositions in 1953-1961, that the 1950 year-class constitutes about 60% of the total catch since 1955. In 1958 the total 1950 year-class is mature, and this year-class still constitutes about 60% of the total catch during the seasons 1959-61. The total mature stock must have diminished at the

1950 year-class since the percentage of this year-class in the catches remains constant during these, and this year-class cannot have received any recruit spawners. The stock of mature herring has had a yearly decline of 25-30 % in the last three years.

The herring have left the southern areas so that the fishing fleet has had to concentrate in small areas which are new to many of the fishermen and more exposed to bad weather conditions.

Figure 6. shows the total catch during the Norwegian winter season in the last few years together with the percentages caught in the different areas.

The late arrival of the herring has made the winter season short. In the beginning of this century it lasted about five months compared with only about 5 weeks during the last few years.

What is happening and what will happen in the coming years are problems which we will have to face.

A complete explanation of all the preceding facts, including the alternation of the great herring fisheries is possible if we regard the "Spring Herring", the "Large Herring", and also the herring responsible for the great Bohuslän fisheries, as a unit. If this is so there is only one year in the last 200 in which we do not know where the herring were. This was 1875 in which no herring fisheries were based upon the Atlanto-Scandian herring. If we accept this view, all the obscurities concerning the Bohuslän herring fisheries can be plausibly explained.

If it takes a little more than one year between successive spawnings of the Atlanto-Scandian herring (e.g. 366 days) this cycle about a hundred years is easy to explain. The herring will arrive at the Norwegian coast later and later, and also leave the coast later and later. When they are leaving late, they have to pass the area off the Norwegian Continental shelf where the Copepods show up in the surface layers in order to spawn in April. If the herring pass earlier, the Copepods are in the deeper layers so the herring will continue to the "polar front" but if the Copepods are already in the surface layers, the herring will start feeding and will move northwards off the Norwegian coast.

In the autumn the herring tend to migrate (as is happening at present) to the cold arctic water in the East Icelandic Current, but if they are off Northern Norway when they would usually migrate towards cold water they will be far from the arctic water of the East Icelandic Current. Cold water will, however, be available near the Norwegian coast, where the winter cooling of the coastal waters will have started, and these waters will therefore be invaded by these "Large Herring".

Since the temperature of the coastal water of Northern Norway is about three to four degrees higher than the arctic water of the East Icelandic Current where the herring are usually found, the gonads of these herring will develop faster and so spawning will take place earlier than in the preceding season.

After spawning these herring leave Northern Norway, and in the summer are found feeding along the "polar front" as usual, but in the autumn their spawning migration will start early so that the migrating schools will have to pass through water masses of a higher temperature than usual.

The Norwegian coastal water off Møre, where the herring usually arrive, has a surface temperature above ten degrees centigrade in October, so the herring will therefore avoid this water since they can pass under the Baltic surface water in a temperature of six to seven degrees. The herring probably then pass through the Norwegian Channel into the Skagerrak, and spawn off the Norwegian South coast, off Bohuslän, and perhaps also on the Jylland Bank.

The herring then invade the coastal areas of Bohuslän and South East Norway where they take the "resting time" after spawning, and are therefore found in cold water.

During the eastward migration the winter cooling of the coastal waters of Western Norway has already begun by the time the last schools pass the "Spring Herring" district, and these fish remain here and are caught as the so-called "New Herring".

This also explains why the richest fat herring fisheries occurred in Norway between 1880 and 1890, the years when the winter herring fisheries in

Norway reached a very low level. In these years the spawning area was in the Skagerak, so that the larvae and young herring had to cover a longer distance before they pass the Norwegian coast.

The "Large Herring" fisheries in Northern Norway lasted only a few years. Each year a proportion of the herring spawn earlier and are lost to the fishermen in Western Norway, until at last the main part of the herring tribe has a new spawning time and new spawning grounds in Skagerak. In the last years of a Swedish herring period, according to A. Ljungman (1883) the herring arrive later and later, until one year the herring disappear in the same year a new Norwegian herring period starts. This must be due to the later spawning of the herring making the chance of the herring meeting cold Baltic water in Skagerak on the spawning migrating route greater. If the Baltic water is too cold, the herring will find warmer spawning grounds further west. If the herring have to leave a spawning ground and find a new one, they will return to this new ground for the succeeding spawning. In this way the Atlanto-Scandian Herring are driven out of Skagerak, and later also have to avoid the southern spawning grounds in Western Norway. The herring, at the end of the Norwegian period, are spawning in the area where the winter temperature of the coastal water is the highest, off Møre. This is the present stage. The late arrival of the herring, followed by the late departure from the spawning grounds, increases the chance that they will meet quantities of Copepods off the Norwegian Continental Shelf. I believe that this will happen as soon as new strong year-classes show up in the Atlanto-Scandian Herring. If so the "Large Herring" will again show up in Northern Norway and the following autumn, Atlanto-Scandian Herring will be found in the Eastern Skagerak, and we will also perhaps get "New Herring" or "Mixed Herring" in the Spring Herring area.

If this hypothesis is accepted, a number of facts are easily understood which are very difficult to understand if the Bank Herring are those be responsible for the Bohuslän fisheries.

1. The alternation between Spring Herring fisheries in Western Norway, Large Herring fisheries in Northern Norway and at last in Bohuslän is completely understood.
2. This also explains the higher number of vertebrae (average 57.50) found in the Atlanto-Scandian Herring at the beginning of this century.
3. The herring are found inside the skerries of Bohuslän during the period of the Swedish fishery. The Atlanto-Scandian Herring is a herring which usually enters sounds and fjords during the winter. The Bank herring from the North Sea are never found inside the skerries unless they are mixed with herring from other populations. According to K.A. Andersson (1956) there are no differences between the hydrographical conditions during the Bohuslän herring period and those found after the herring had left the fjords and sounds of Bohuslän.
4. The Bohuslän herring have a high oil content, and are fit for salting despite the main catch being taken in January and February. Mature Bank herring can not be used for oil production when it is caught in January and February, and it is also not suitable for being salted.
5. The Bank herring fisheries in Scotland still show an upward trend at least ten years after the herring have disappeared from inside the skerries in Bohuslän (Fig. 10).

All these facts are very difficult to explain if the Bank herring are responsible for the Bohuslän herring periods. Certainly Bank herring are caught in Bohuslän when the herring are abundant inside the skerries as Fr. Heincke's (1898) sample shows, but as Heincke wrote, this sample was bought at the fish market in Kiel and was imported from Bohuslän in 1877. There is thus no proof that this sample is representative of the main catch.

If we suppose, as G.O. Sars did, that the smaller herring are frightened by schools of big herring, the appearance of Bank herring inside the skerries of Bohuslän is explained, but I do not believe this is the correct explanation. When the herring have reached such a size they can not be eaten by the bigger herring; in fact they are not scared by a school of bigger herring, but on the contrary will join such a passing school. I also do not believe G.O. Sars explanation of the appearance of the so-called "New Herring" which A. Boeck and the fishermen believe to foretell the end of the Spring Herring fisheries. I believe that these herring are the last of the Atlanto-Scandian Herring schools that are passing the area.

We are now at the end of the Norwegian herring period in Western Norway and I believe nature itself very soon will give the true answer as to what is happening. We now are armed with the necessary methods and instruments to follow the changes that takes place.

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CATCH OF HERRING.

- WESTERN NORWAY
- ▨ NORTHERN NORWAY
- ▤ BOHUSLÄN

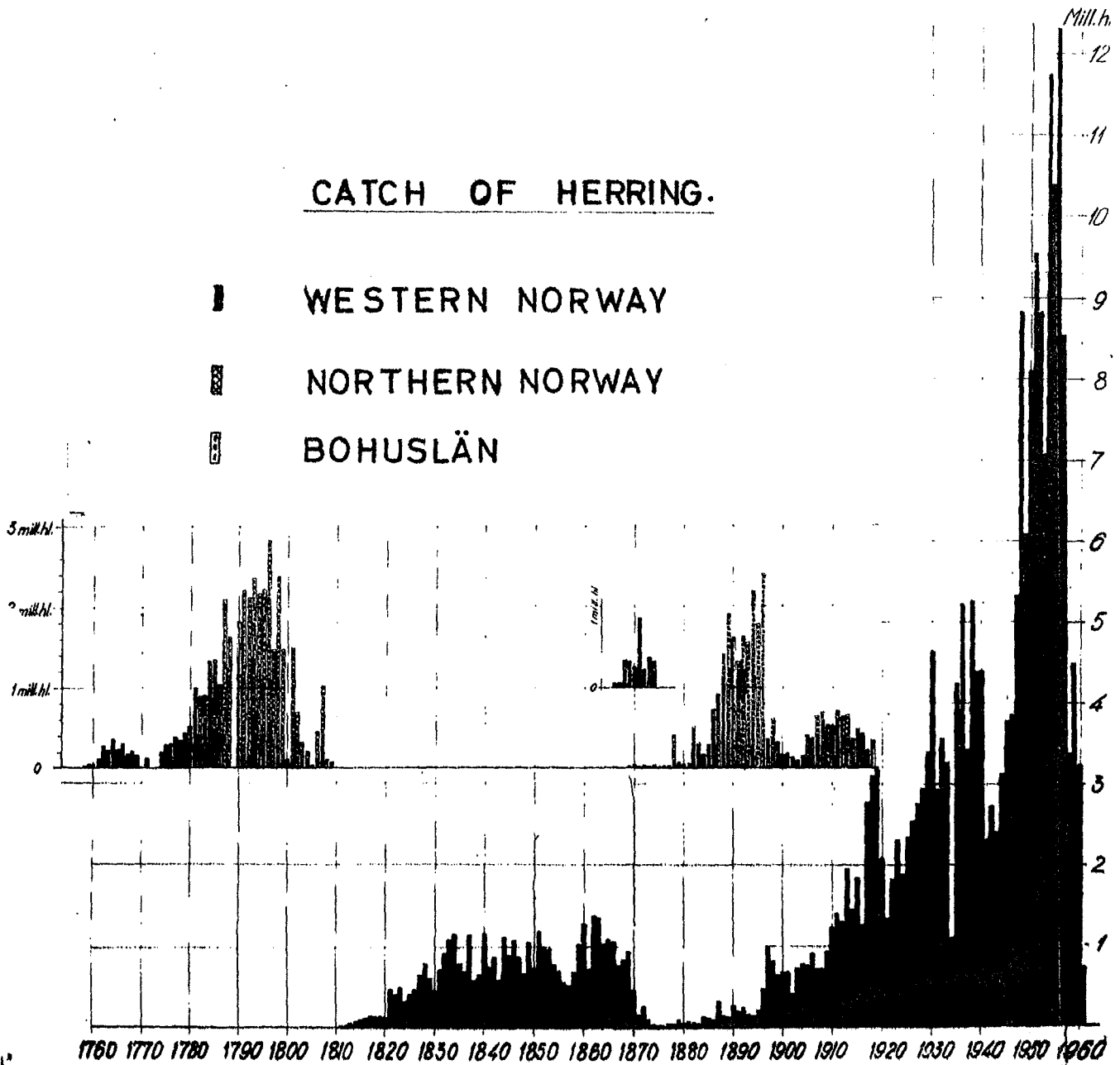


Fig. 1.

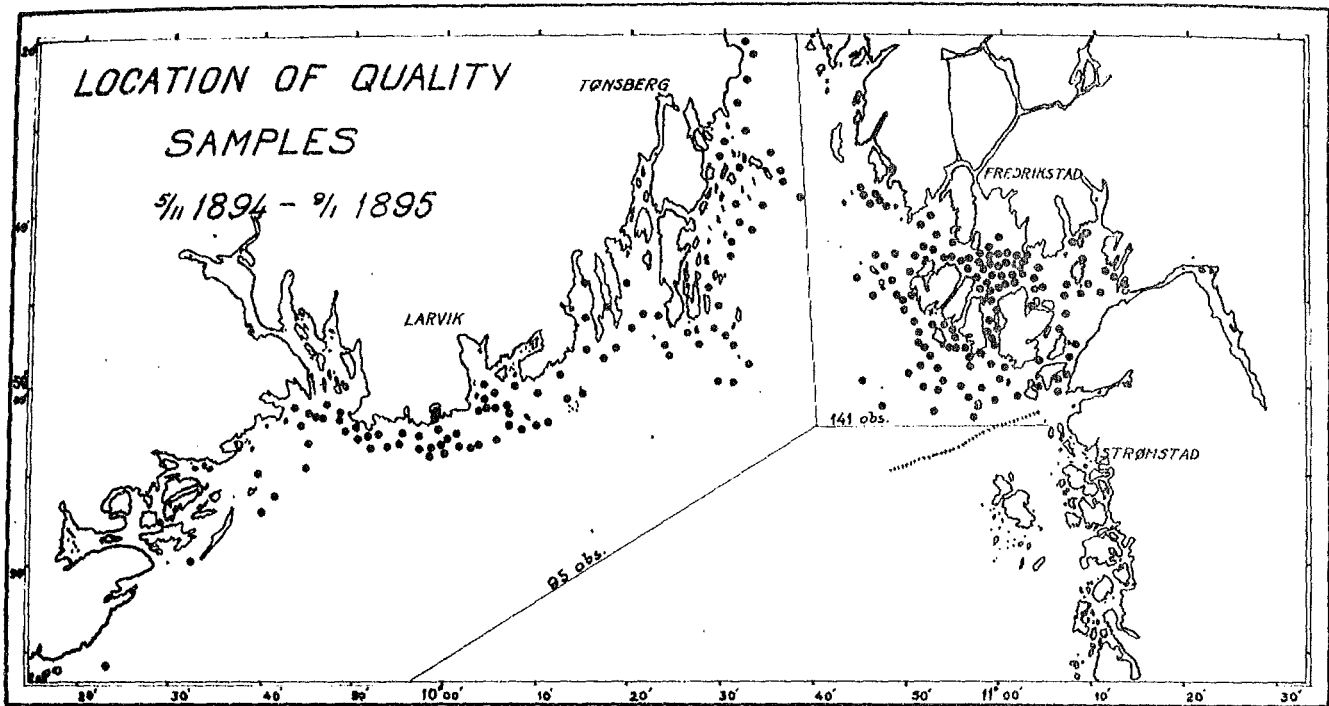


Fig. 2

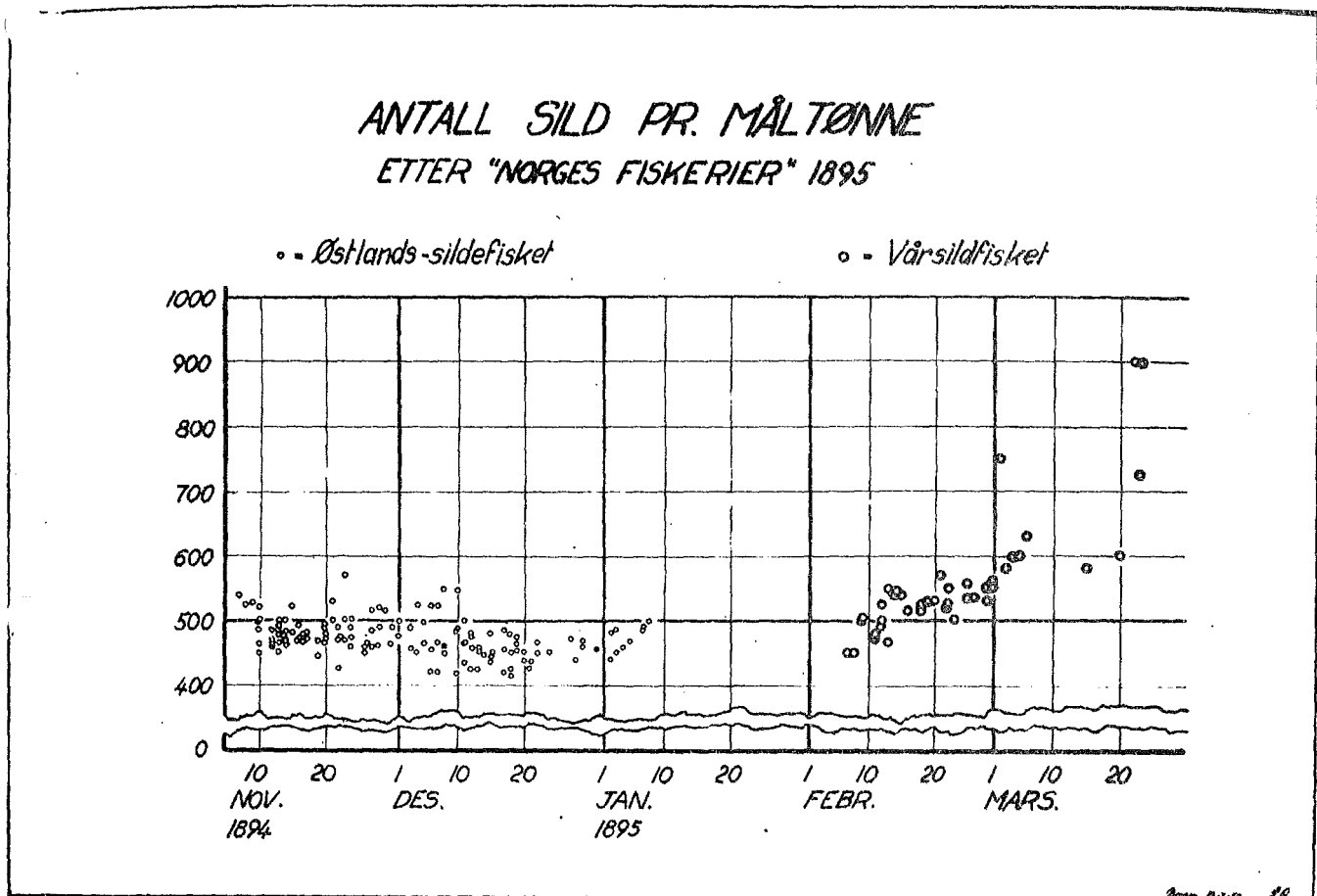


Fig. 3.

NUMBER OF HERRING IN 150 L.

1950-54.

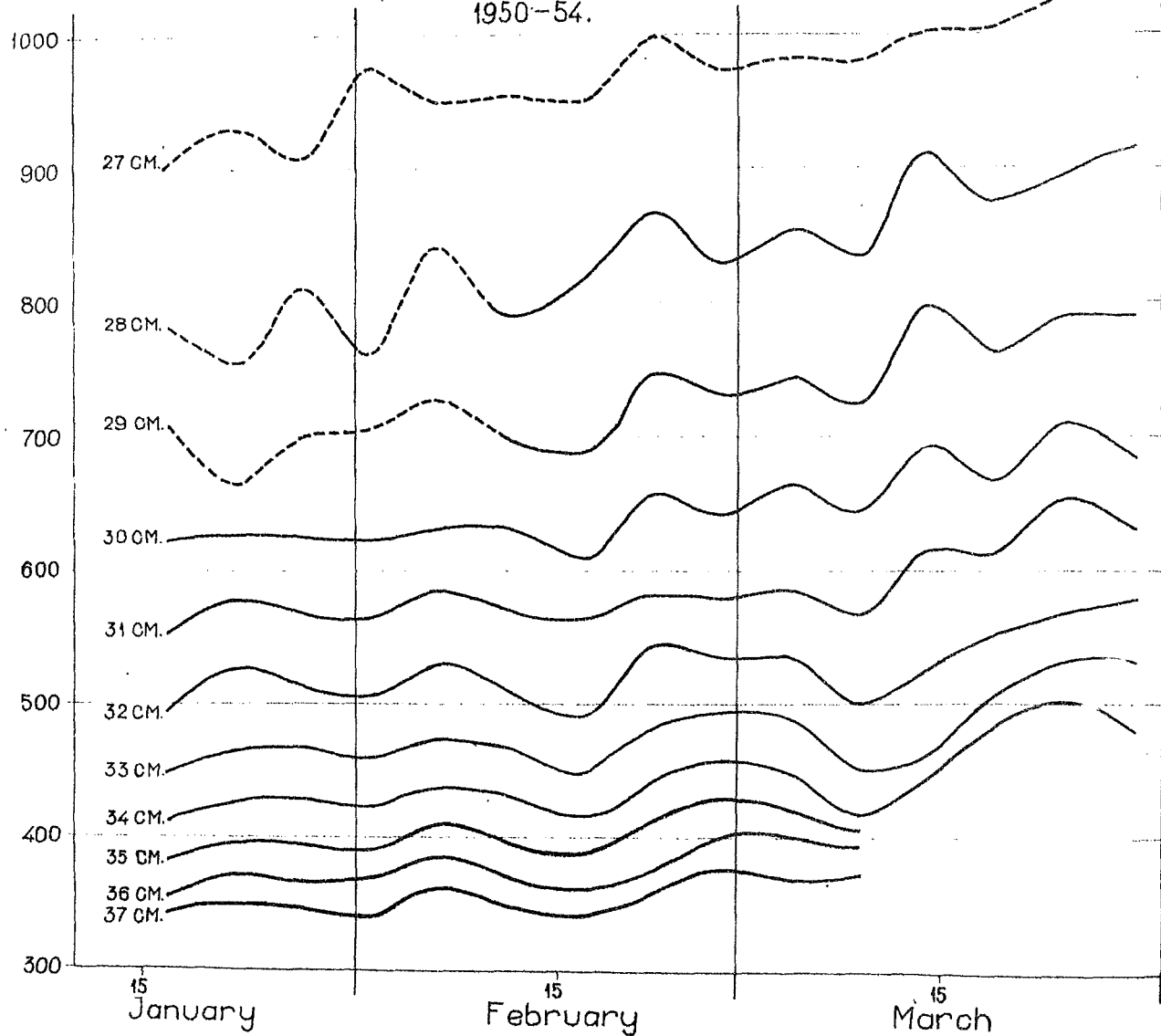


Fig. 4.

Distribution of
Winter Herring Catch

1946 - 1958.

Catch.

Percentage of
total catch.

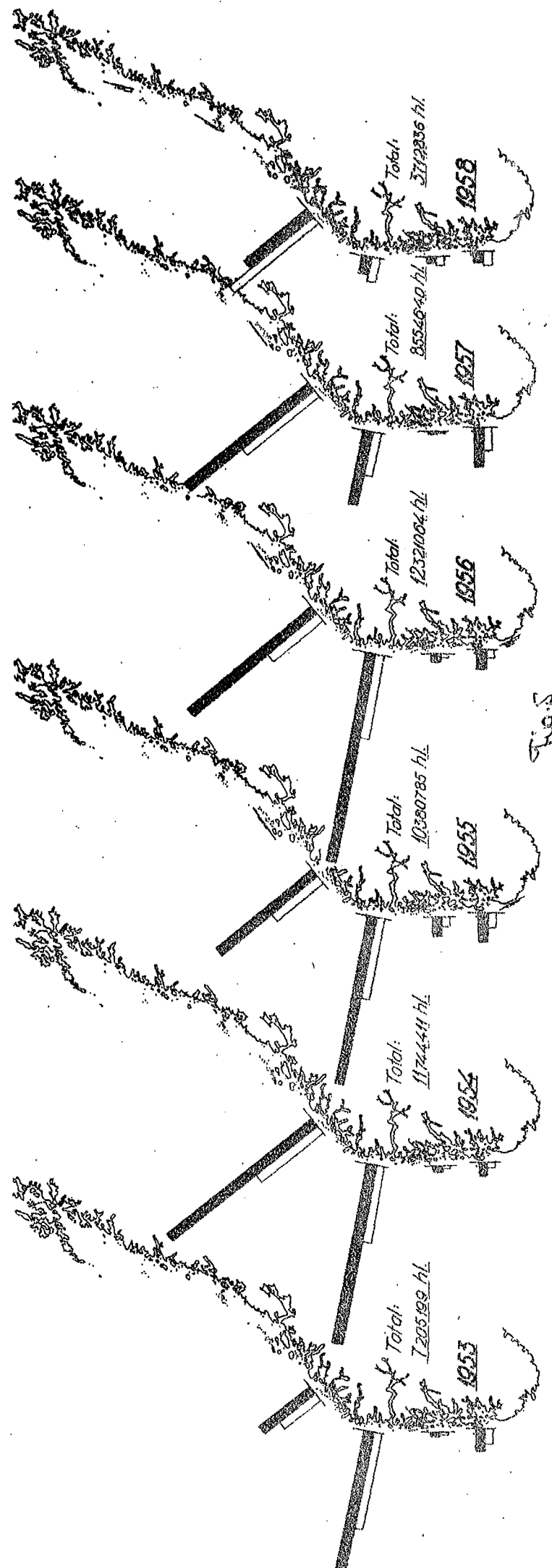
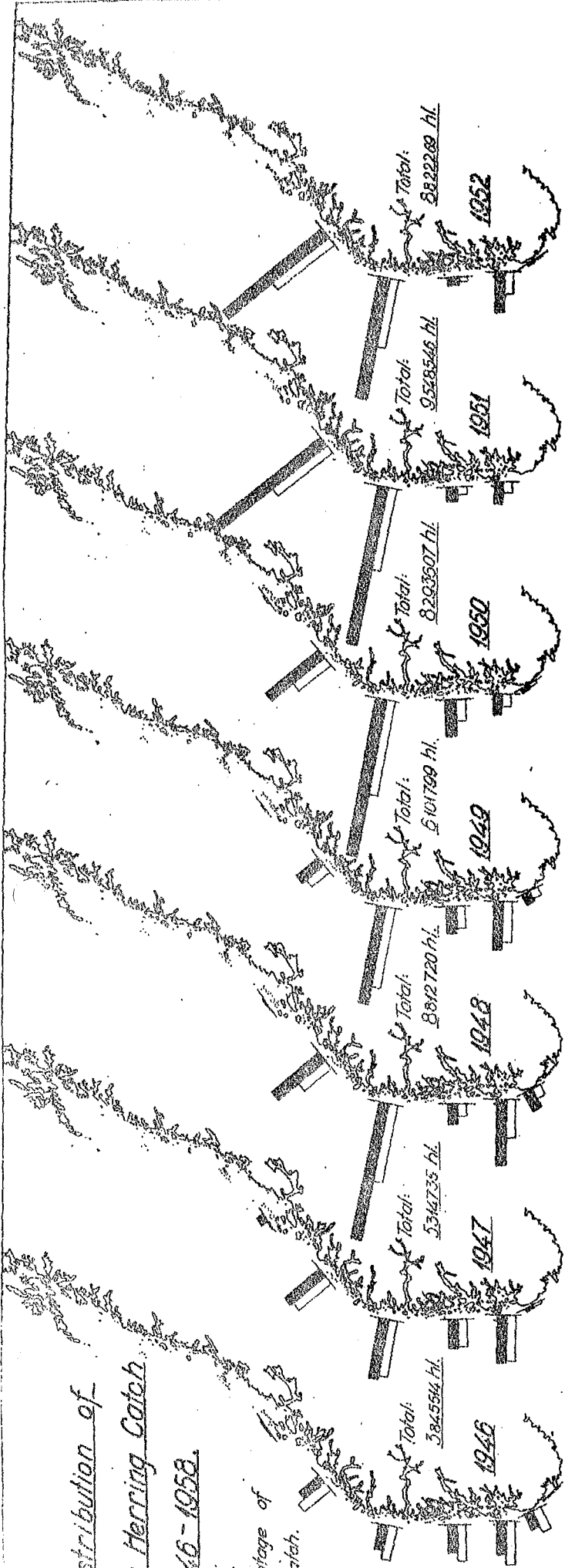


Fig. 5

Distribution of

Winter Herring Catch.

1959 - 1961.

Catch.

Percentage of total catch.

Total:
4,470,891 hl.

1959.

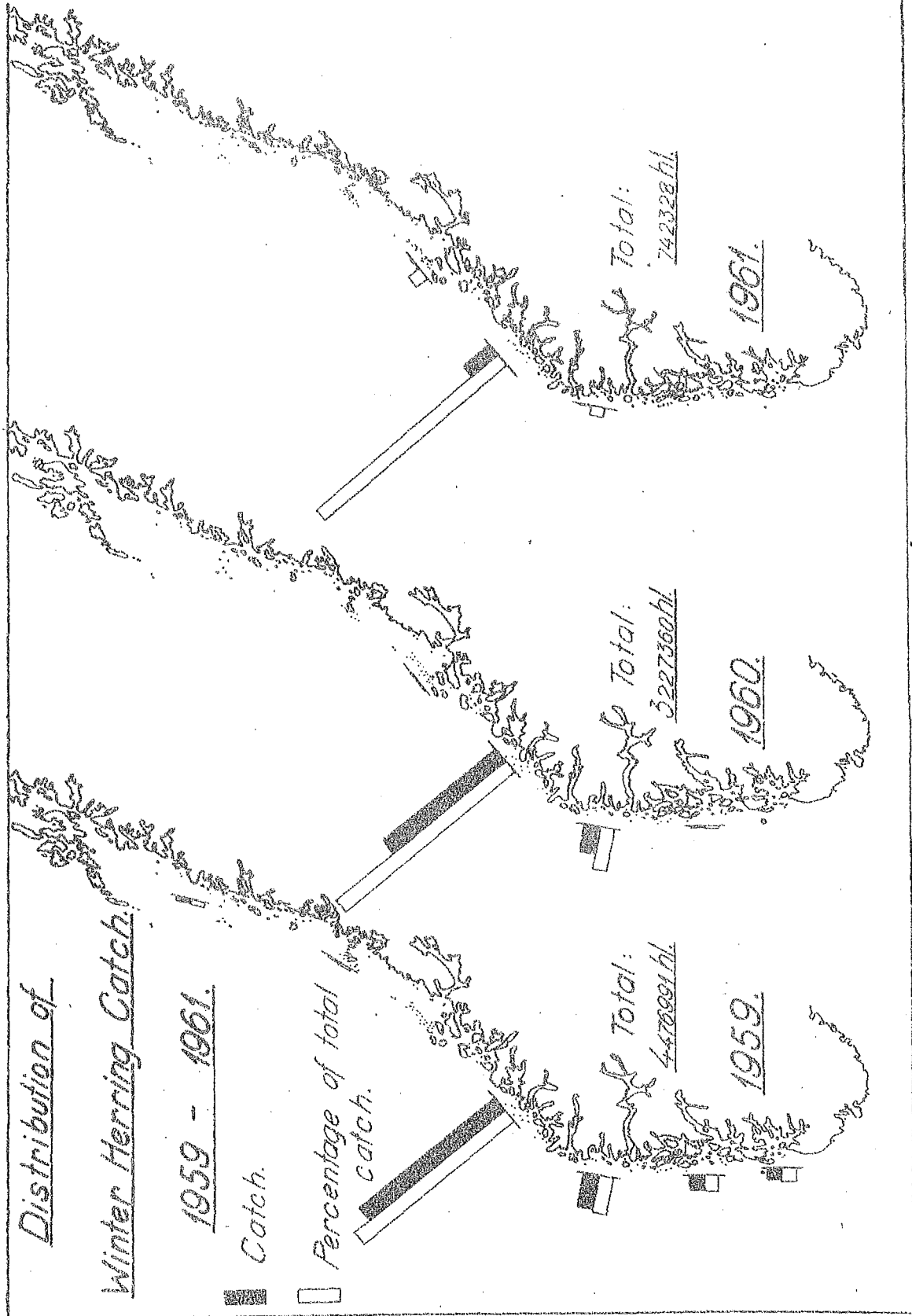
Total:
3,227,360 hl.

1960.

Total:
742,328 hl.

1961.

Fig. 6



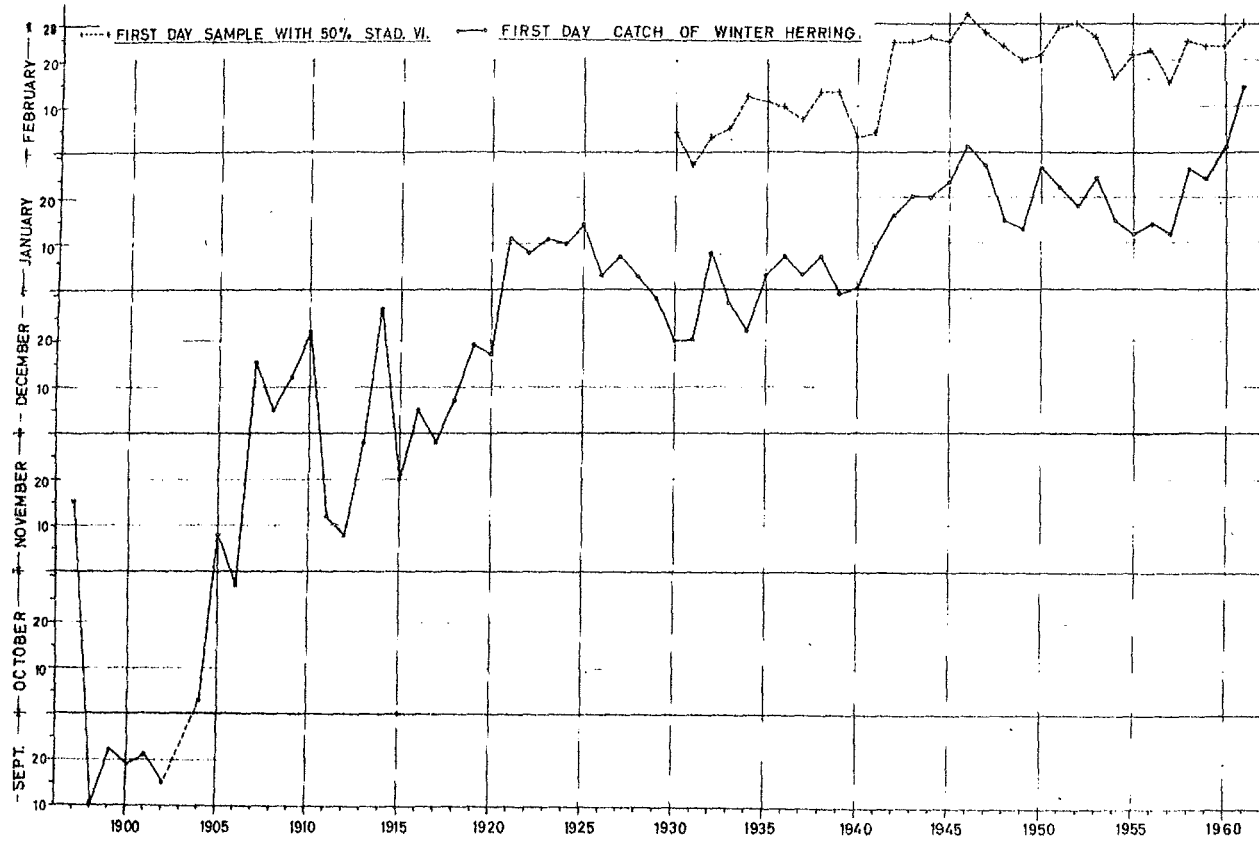


Fig. 7.

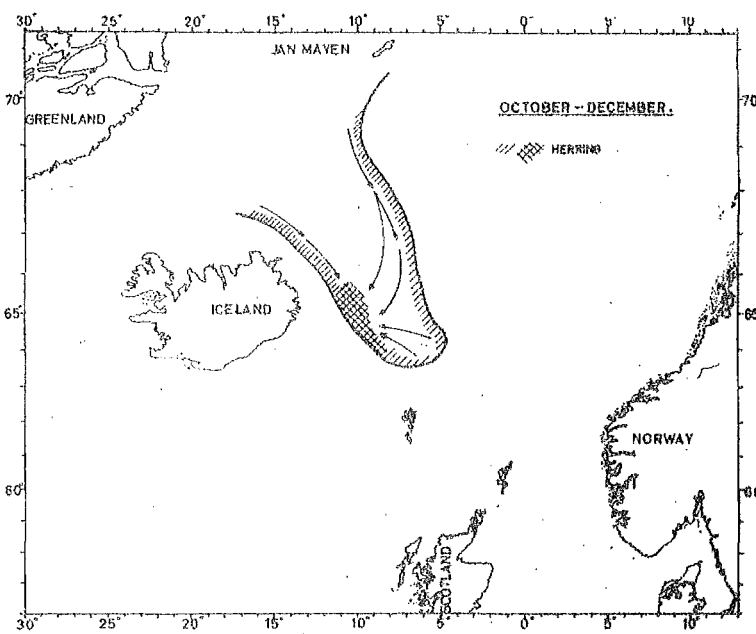
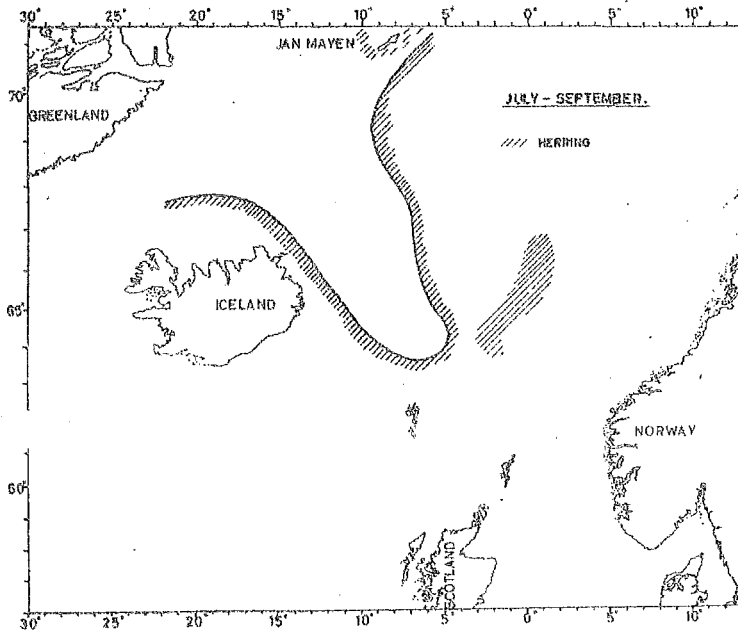
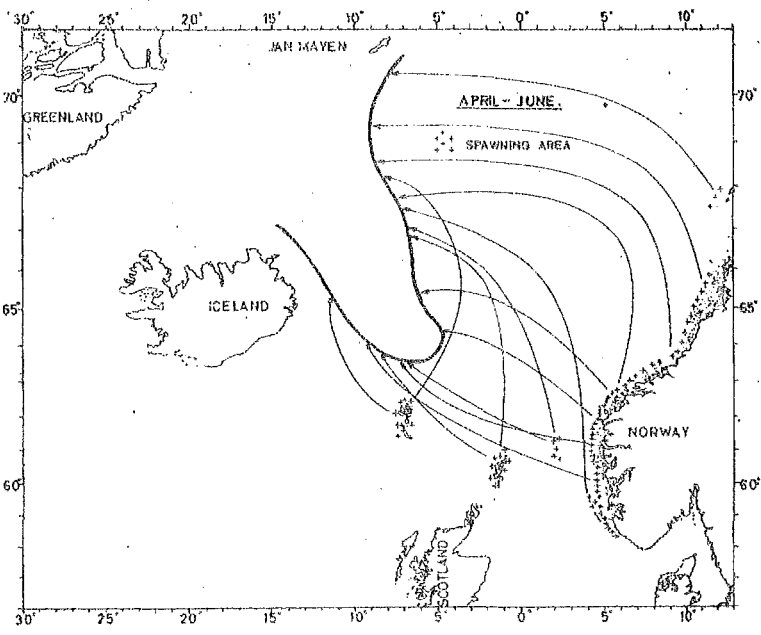
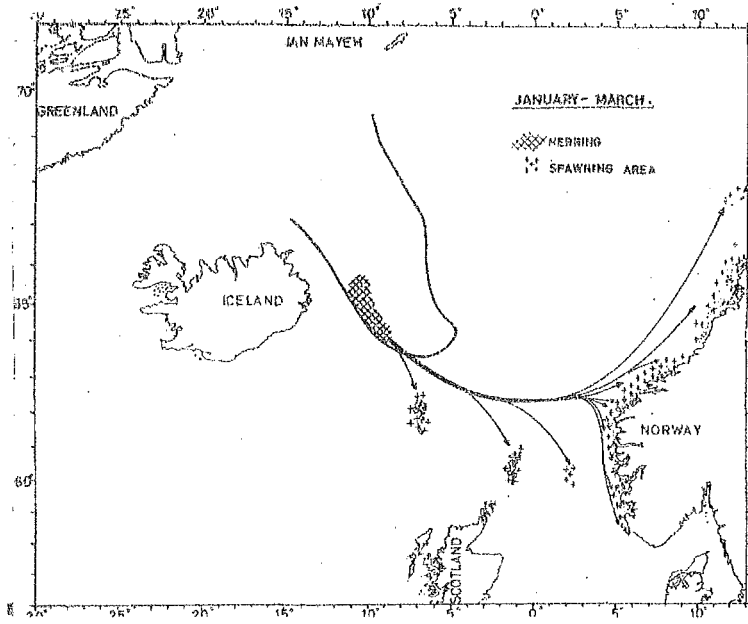


Fig. 8.

Age composition of Norwegian Winter Herring

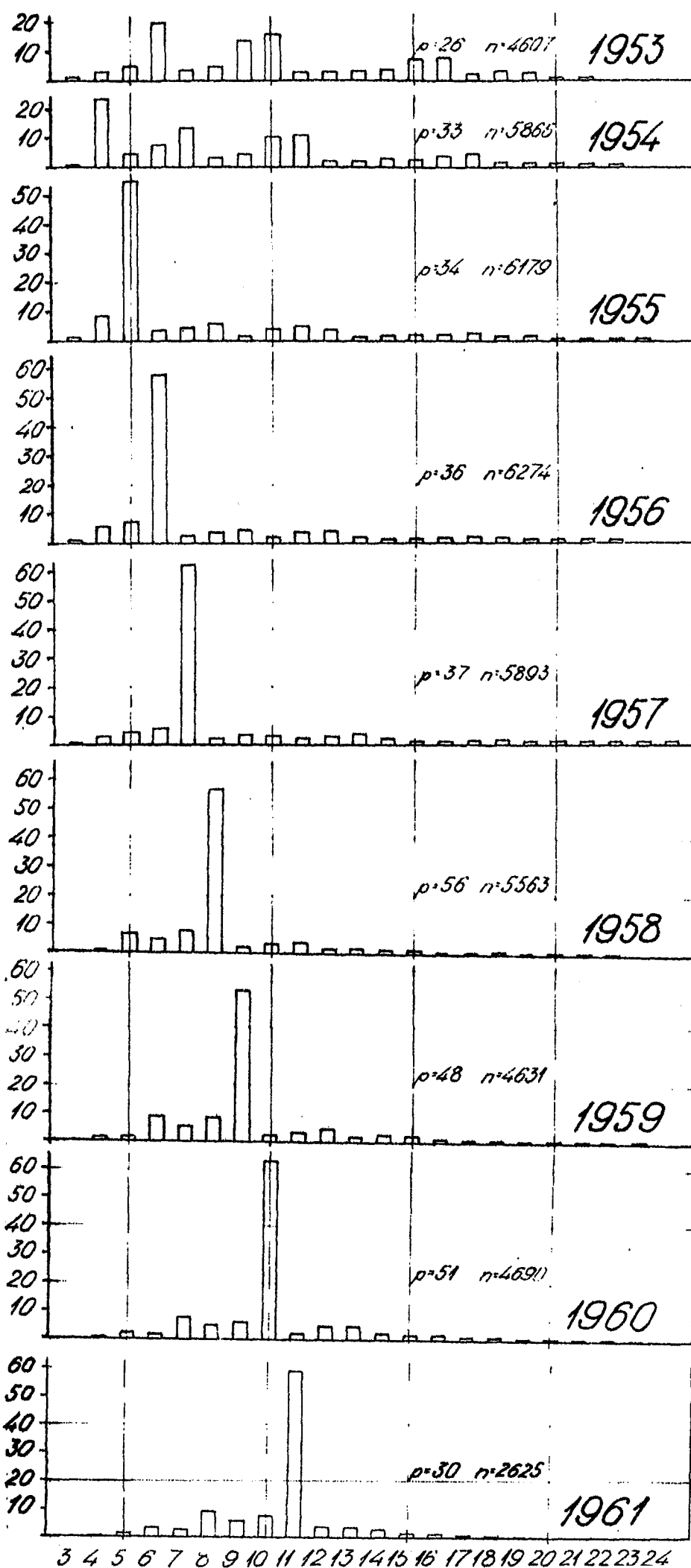


Fig. 9.

HERRING CATCH.

(OTTO PETTERSON.)

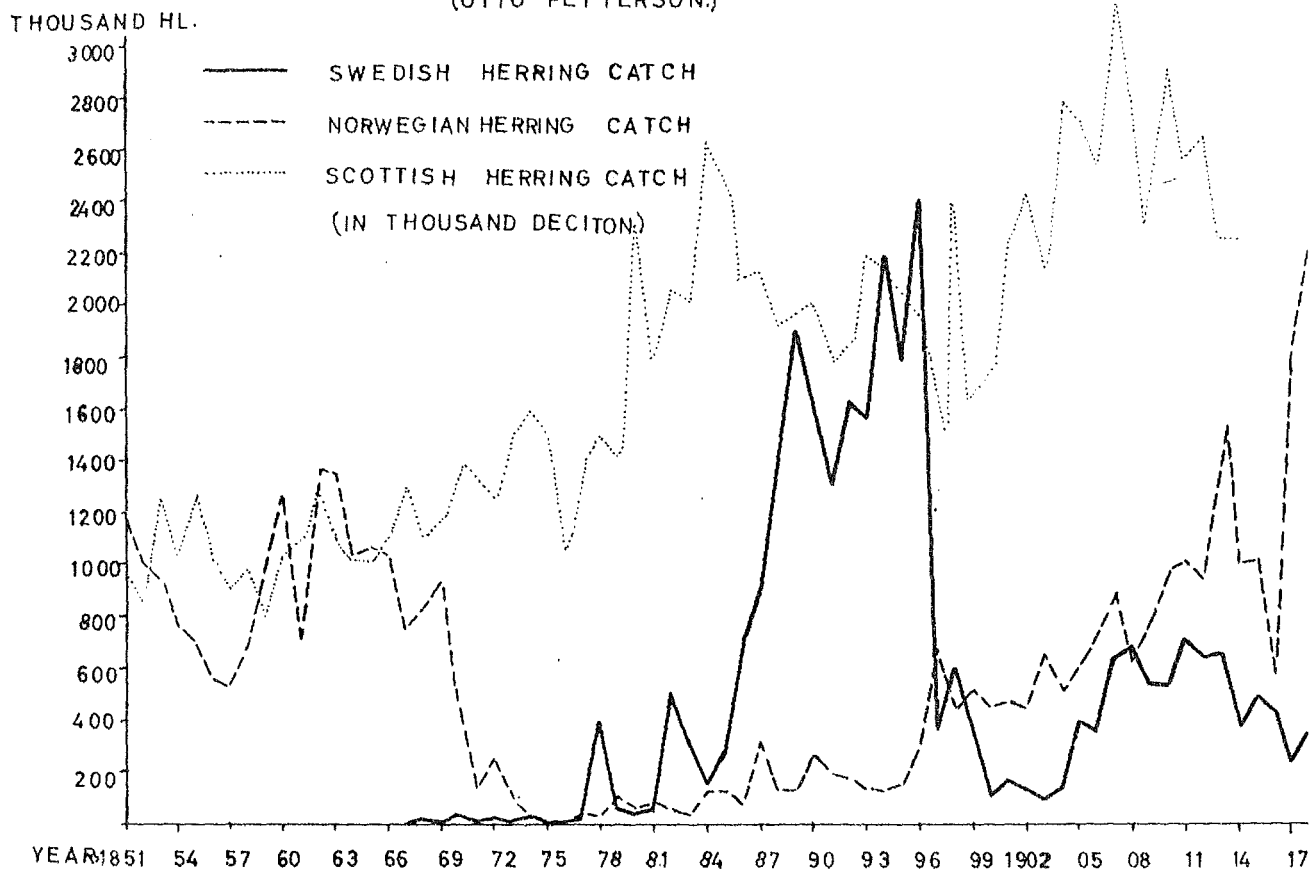


Fig. 10