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THE STATE OF THE ARCTIC COD.

A Report Based on Some Investigations of the Skrei Fisheries

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INTRODUCTION

The shoals of skrei (i. e. large mature cod) which each winter migrate from the Barents Sea to the spawning grounds on the Norwegian coast have always been the most important resources for the cod fisheries of North Norway. It is therefore with great concern that the Norwegian authorities have noted the marked decline which has taken place in the yield of this fishery in later years. The following report is an attempt to study this decline.

The biological and statistical data which were available to us while working up this report were restricted and in part unsatisfactory. By waiting some years more for further information we could undoubtedly have presented a more complete picture of the state of the arctic cod. It was felt, however, that some of the features of this preliminary report were important enough to deserve close consideration by the nations which are interested in this northern area.

THE SKREI FISHERIES.

The Yield of the Norwegian Skrei Fishery since 1866.

In Norway a systematic exploitation of the migrating skrei can be dated back at least one thousand years. Official statistics are available from about 1860. They record the yield for each season and the number of men and vessels taking part in the fishery. Fig. 1 shows the total annual catch of skrei in numbers and the distribution by districts since 1866. The "southern district" comprises Vestlandet, Møre and Romsdal and Trøndelag. Nordland county including Lofoten is shown separately because it is the most important spawning district, and Troms and Finnmark counties are given as the "northern district". (Owing to lack of data, Finnmark has not been included in the statistics until 1908.)

Fig. 2 presents the same data, but here the short-time fluctuations have been smoothed out by a moving five-year mean. The figure for 1868 is thus the mean of the years 1866-1870; that for 1869, the mean of 1867-1871, etc.

From figures 1 and 2 it is evident that both the total yield and the yields of the various districts have fluctuated greatly during the last ninety years.

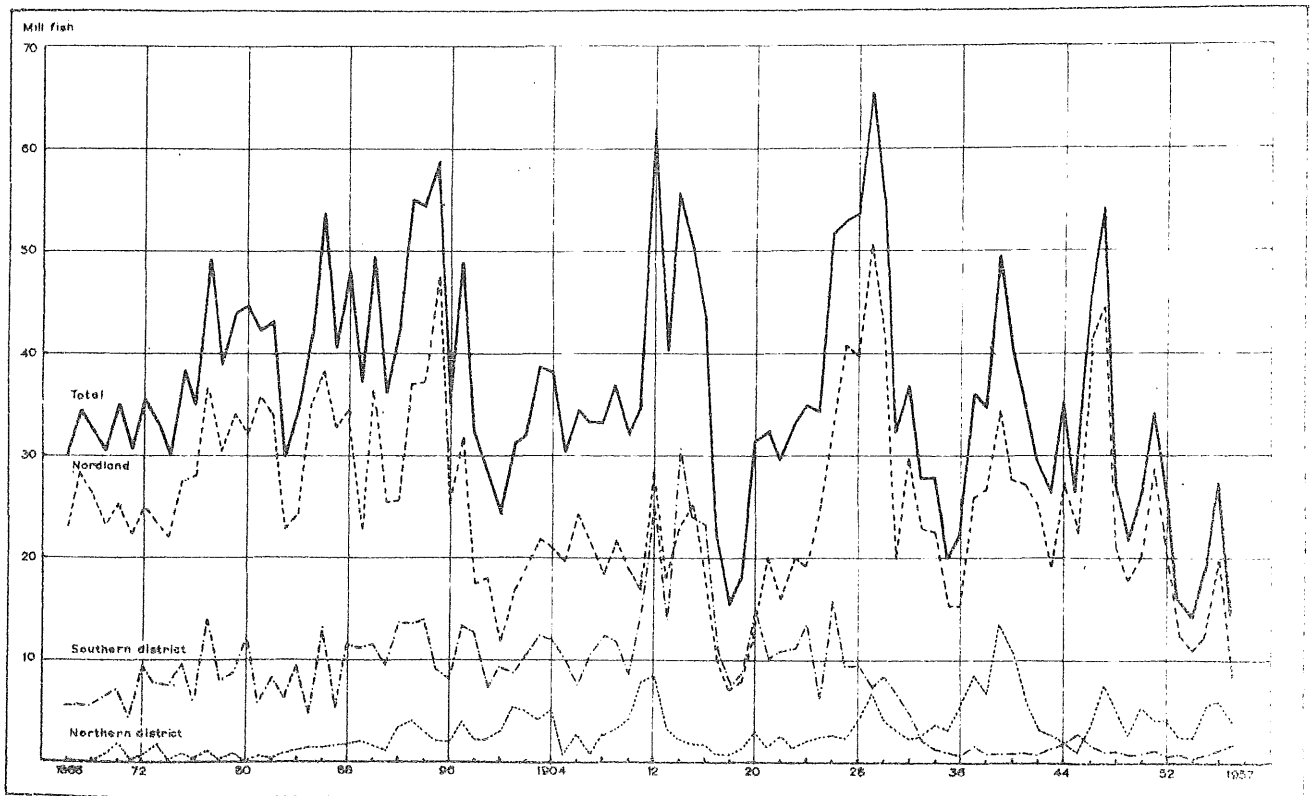


Fig. 1. Annual catch of skrei since 1866.

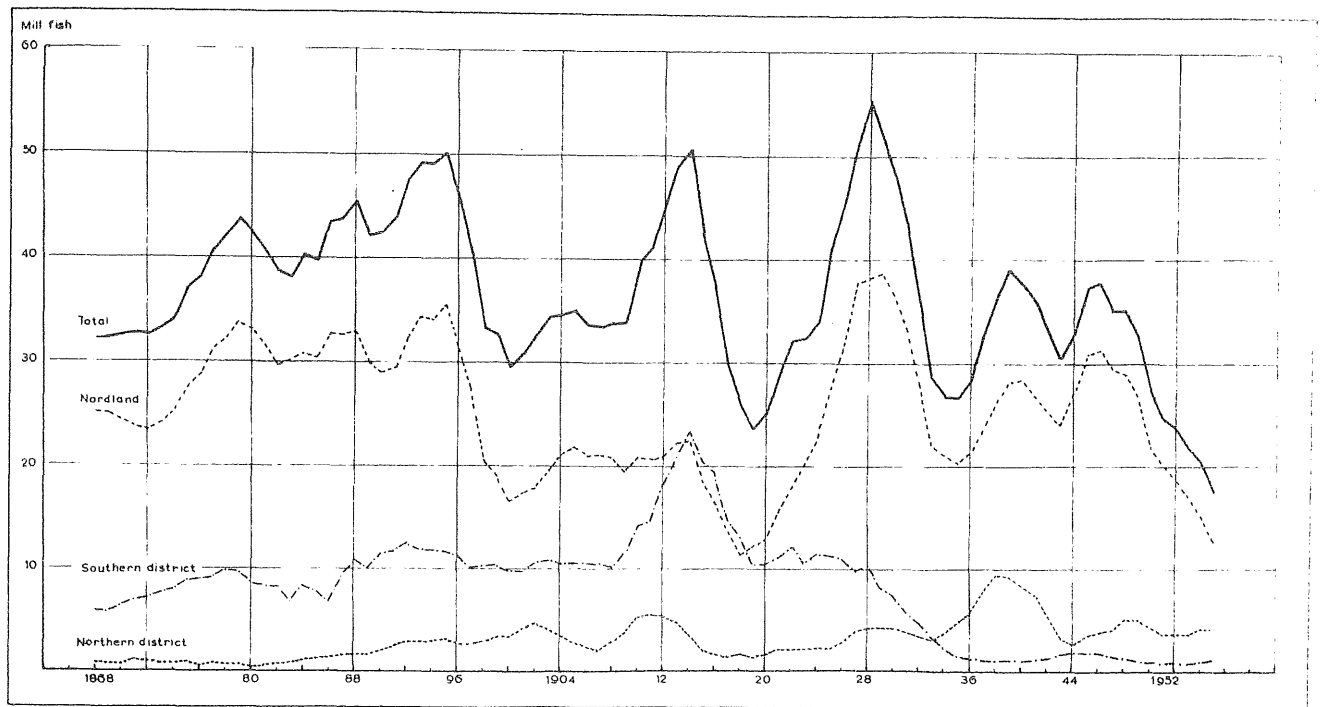


Fig. 2. Catch of skrei since 1866. Moving five-year mean.

Causes of the Fluctuations in Yield.

The size of the yield in the various years is determined by several factors of which the following three are probably the most important: the abundance of fish present on the fishing grounds, the availability of the fish to the various gears, and the magnitude of the fishing effort.

It is highly probable that, in some cases, variations in availability have had an important influence on the yield of the skrei fisheries. Thus in the Lofotens the skrei is in some years found farther from the shore and in deeper waters than usual. Especially in earlier times when the vessels were small and driven by oars and sails only, this factor must have been important. Today it is mainly the fishery with hand lines and purse seines which is influenced by variations in the vertical distribution of the fish shoals.

As shown in fig. 2 there has also been some shifting of the yield by districts in the last ninety years. In the southern district the skrei fishery has been insignificant since about 1930. This is not due to lack of interest in the fishery in this area, but probably to a displacement of the spawning district northwards. We believe, however, that at present such geographical

variations in the migrations of the skrei can have but little influence on the yield. In the skrei season, fishing takes place all along the coast. Major concentrations of skrei cannot escape notice, and with our modern mobile fishing fleet they would soon be effectively exploited.

The abundance of the skrei is undoubtedly the factor which, besides the fishing effort, has the greatest influence on the yield. Its dominating influence comes out in a simple way in fig. 3. This diagram is a comparison of the catch of the spring cod fishery in Finnmark and the skrei fishery in Lofoten for some years. The spring cod fishery is mainly based on young immature Barents Sea cod. A difference of three years has been applied in the time scale of the two curves because this is the average age difference between the spring cod and the skrei.

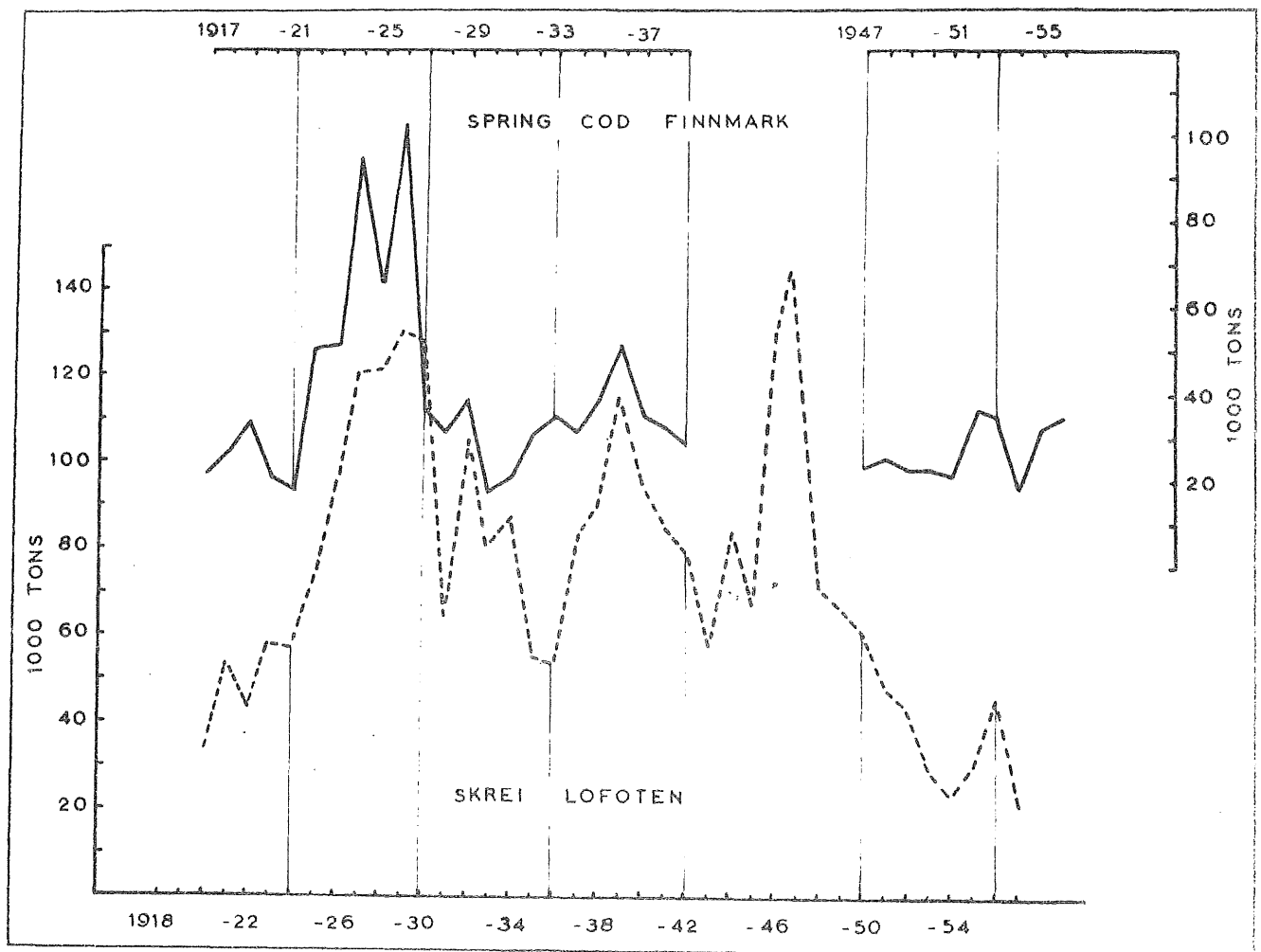


Fig. 3. Annual yield of spring cod in Finnmark and skrei in Lofoten. Part of catch taken by trawl in Finnmark 1952-56 and by purse seine in Lofoten 1950-57 not included. Three years' displacement of time scales.

There is a fair agreement between the fluctuations of the curves; the tendency of the variation in the Finnmark fishery is later repeated in the Lofoten one. And there is only one feature that can be said to be common to the Finnmark fishery in one year and the Lofoten fishery three years later, namely that they are based on mainly the same year classes of the arctic cod.

Thus, the fluctuations in yield must in a great measure have been caused by variations in the abundance of the stock of skrei. Probably these variations are largely so-called natural fluctuations of the population. It is a well-known phenomenon in fishery science that the abundance of the various broods may vary greatly.

Unfortunately detailed information of the abundance of the stock of skrei in the various periods is difficult to obtain. If we suppose that variations in availability have had only a comparatively insignificant influence on the yield of the skrei fishery, a relative measure of the abundance could be obtained by dividing the yield by the total fishing effort. But our knowledge of the effort in the skrei fishery is incomplete. Mostly it consists of only a seasonal census of the number of men and vessels taking part in the fishery. The relation between the number of men or vessels and the actual fishing effort is complicated and has changed considerably over the years. It is influenced by a number of factors, such as the size of the vessels, their seaworthiness and engine power; further, by the type and the number of units of gear used, by the operation of the gears, by the ability of the fishermen to set their gear in the best concentrations of fish, by the quality of the bait, and by several other factors, all of which we know have changed markedly during the period we consider. For these reasons the catch per fisherman or per vessel will not give us comparable values of abundance over longer periods.

Although there is thus a regrettable lack of exact information as regards the fishing effort in the skrei fisheries, we are not wholly ignorant of its order of magnitude in the various periods. Fig. 4 shows the variations in the number of men taking part in these fisheries since 1876. There is a considerable drop in the total number of men from the nineteen-thirties till the postwar years. This drop is sharpest in the southern district where, as already mentioned, the concentrations of skrei have been thin since 1930. As for North Norway (i. e. Nordland, Troms and Finnmark), which in the last 25 years has been the most important skrei district, the average seasonal number of fishermen for the period 1951-55 is 20 per cent lower than for the 1936-40 period.

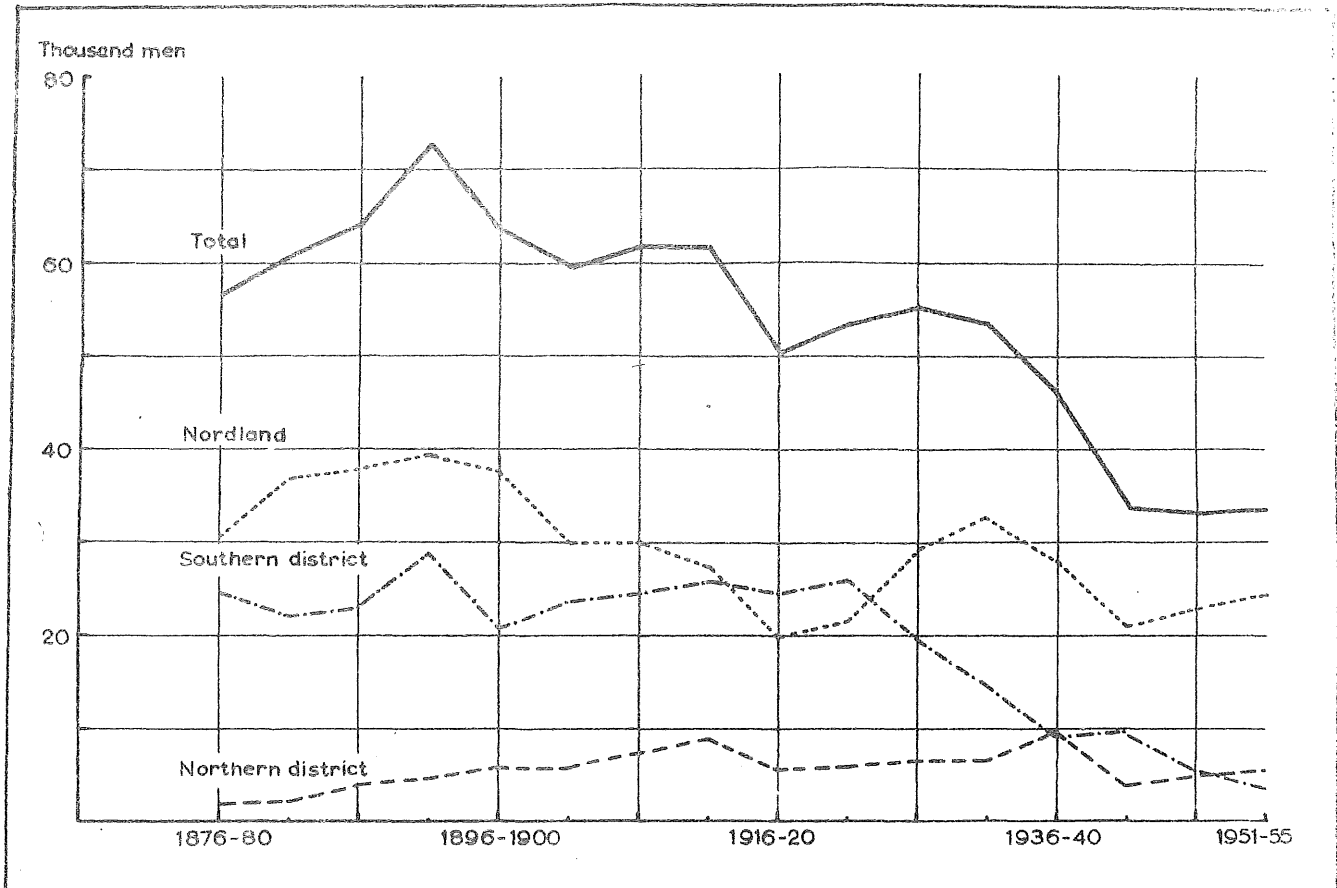


Fig. 4. Number of men engaged in the Norwegian skrei fisheries. Seasonal averages of five-year periods based on the official censuses.

It is probably the tonnage of the fishing fleet which bears the most direct relation to its fishing capacity. Estimates of the total tonnage of the Norwegian fishing fleet is available from the year 1940, and for each year since 1952. These data show an increase of 31 per cent in the total tonnage of the fishing fleet of North Norway from 1940 to 1956. During the same period a significant increase in the efficiency of the fleet has occurred through improvement in machinery, increased mechanization and the introduction of new instruments such as echo sounders and radio telephones.

Changes have also occurred in the types of gear used. Thus in the course of the last few years, gill nets made of artificial fibers (nylon and perlon) have almost completely replaced the earlier conventional nets which were made of cotton and hemp. Comparative experiments have shown that the fishing power of these new types of net is from three to four times greater than the cotton or hemp nets (Sætersdal 1957). In the long line fishery also,

materials made of artificial fibers have to a large extent replaced the old types. Here too a change in the fishing power has been observed, not indeed as marked as that due to the gillnets, but still significant (Oppedal 1956). Even the characteristics of the hand line, the simplest of the gears, have probably changed as a result of the change-over to nylon filament and the Swedish tin-bait. Finally, since 1950 a new and efficient gear, the cod purse seine, has been used in the Lofoten fishery.

This increased efficiency of the fishing fleet and of the gears has probably more than compensated for the reduced participation in the fishery in North Norway (i. e. in Nordland and the "northern district" in fig. 4) over the last twenty years.

The Abundance of the Population of Skrei in Recent Years

As shown in figures 1 and 2 the yield of the skrei fisheries has been unusually low in recent years. The averages of the last three five-year periods, 1951-55, 1952-56, 1953-57, have all been lower than in any similar period since 1866. In view of what has already been said of the fishing effort, there is every reason to think that the abundance of skrei has been abnormally low of late years, probably lower than at any time since 1866.

For the comparatively short period since 1946 there are some data available on the catch per unit of fishing effort; they may give a reasonably correct picture of the changes in the abundance of skrei in these years. In fig. 5 three different sets of observations are compared, namely catch per hours of trawling by British trawlers on the Norwegian coast during the skrei season; catch of "large" cod per hours of trawling by Soviet trawlers in the Barents Sea, and catch per vessel per week of the gill net fishery in Lofoten.

The three curves agree fairly well. As they are of very different origin this agreement confirms that the observations are closely related to the abundance of the skrei.

Fig. 5 shows that the catch per unit of effort was high in 1946 and in 1947. One of the year classes which entered the stock of skrei in these years was very rich. Probably the partial protection of the arctic cod during the war was a contributory cause.

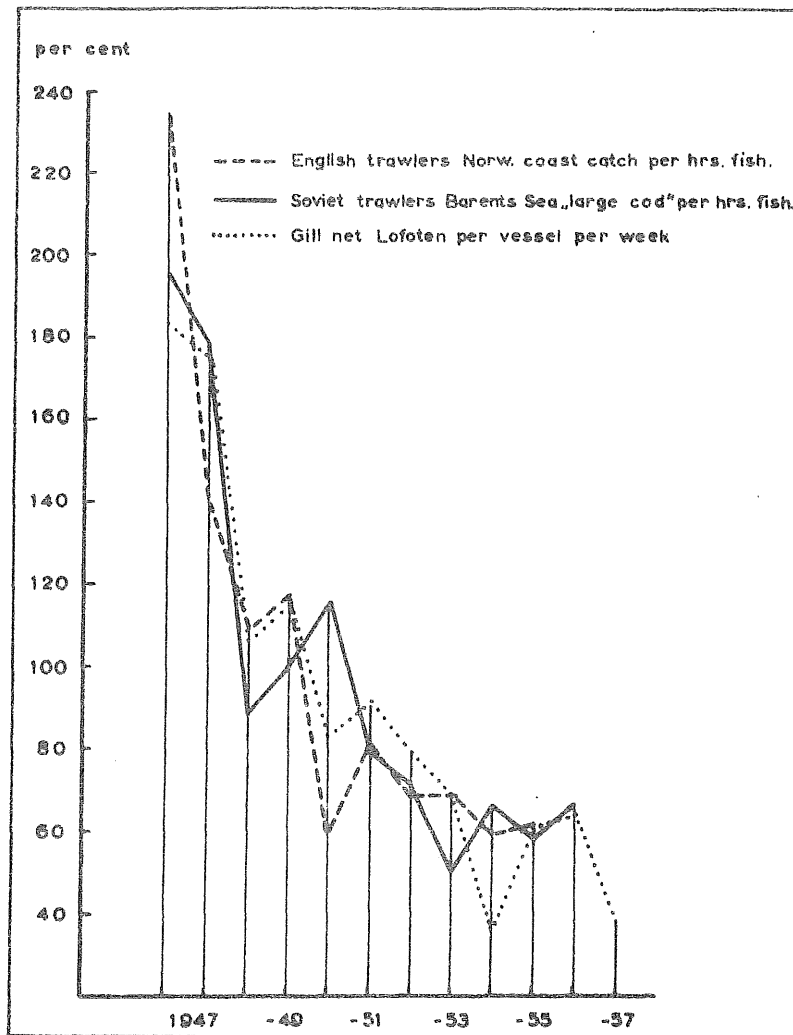


Fig. 5. Comparison of data showing mean annual catch of cod per unit of fishing effort expressed as a percentage of mean values for the period 1946-1955. English data from official statistics. Soviet data from Maslov (1956).

Apparently there has been an almost continuous reduction of the abundance of skrei since 1947. It should be noted that the values of the Lofoten gill net fishery are probably too high for the last few years because the increased efficiency of the nylon nets has not been accounted for.

We are thus of the opinion that the stock of skrei has been unusually poor in recent years - so poor, in fact, that there is serious reason to ask whether this can have been caused by natural fluctuations alone.

The Relation between the Abundance of the Young Cod and the Skrei

In fig. 3 we compared the total catch of the spring cod fishery in Finnmark and the skrei fishery in Lofoten; we showed that, owing to the natural variations in the abundance of the population, the yields of these two fisheries fluctuate largely in the same way at an interval of approximately three years.

In fig. 6 we have gone a step further in an attempt to compare the relative abundance of the two different stages of the arctic cod, namely the young immature fish and the skrei. The curves represent the seasonal catch divided by our measures of fishing effort. Since long lines and hand lines are the dominating gears in the Finnmark fishery, we have for the diagram used the catch per vessel per week by the same gears in Lofoten.

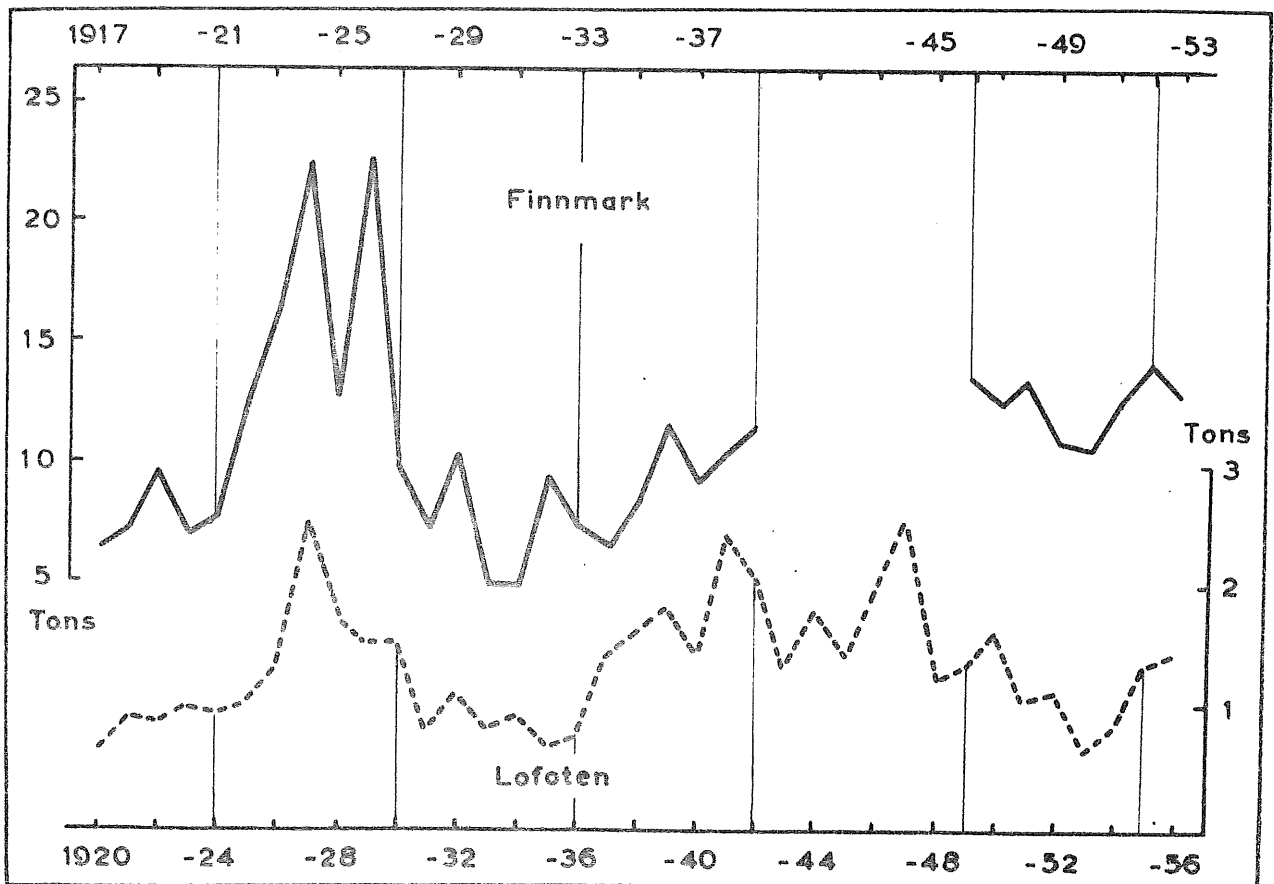


Fig. 6. The abundance of young cod and of skrei. Annual mean catch of spring cod per vessel in Finnmark compared with mean catch of skrei per vessel per week on long lines and hand lines in Lofoten. Note the three years' displacement in the time scales.

As the purpose of these data is to compare contemporaneous intervals, the change in the efficiency of the vessels and gears should not invalidate this comparison, for the technical development has been largely the same in the two fisheries.

Fig. 6 shows that our measures of the relative abundance of young cod and skrei fluctuate in very much the same way. But in later years the skrei curve drops off relatively to the one representing the young cod; the skrei population has apparently been less abundant as compared with the population of young cod than it was before the war. This is the type of effect we must expect to find if the reduction of the stock of skrei is not largely a result of natural fluctuations, but has been caused by an increase in the total exploitation of the arctic cod. The number of old and large fish is reduced relatively to that of the younger and smaller fish.

Detailed information of the abundance of the various broods is regularly obtained by age analysis of the catches of young cod from the Barents Sea. Thus Norwegian, German (Lundbeck 1954) and Russian (Maslov 1955) investigations agreed in showing that the younger age groups of the year class 1948 was relatively abundant in the Barents Sea. In accordance with this, an increase was expected in the abundance of the skrei from the 1956 to the 1957 season after this year class had matured. But no such increase occurred,

The present situation is that we expect a relative increase in the abundance of skrei in the seasons 1958 and 1959, when the rich year class of 1950 enters the mature stock.

Changes in the Mean Age of the Skrei

It has already been mentioned that the age and size composition of the total population may be influenced by the exploitation. As the fishing intensity increases fewer fish will reach the higher age groups and the mean age will be reduced. We are not able to present a comprehensive picture of the changes in the age of the total population of the arctic cod, but we have a series of observations of the age of the Lofoten skrei for each year since 1932.

Fig. 7 shows the variations in the mean age compared with the total mean for the period 1932-57. There has been a considerable and almost continuous reduction since 1949.

Undoubtedly the course of this curve is in part determined by the

natural fluctuations in the abundance of the broods. But this factor alone should cause only relatively short fluctuations above and below a mean value. There is also the possibility that a physiological change in the maturity age has occurred. But the fact that this striking reduction of the mean age has taken place simultaneously with a serious reduction in the abundance of the stock of skrei (but not of the young fish) is to us an indication that the change in age is an effect of an increased exploitation.

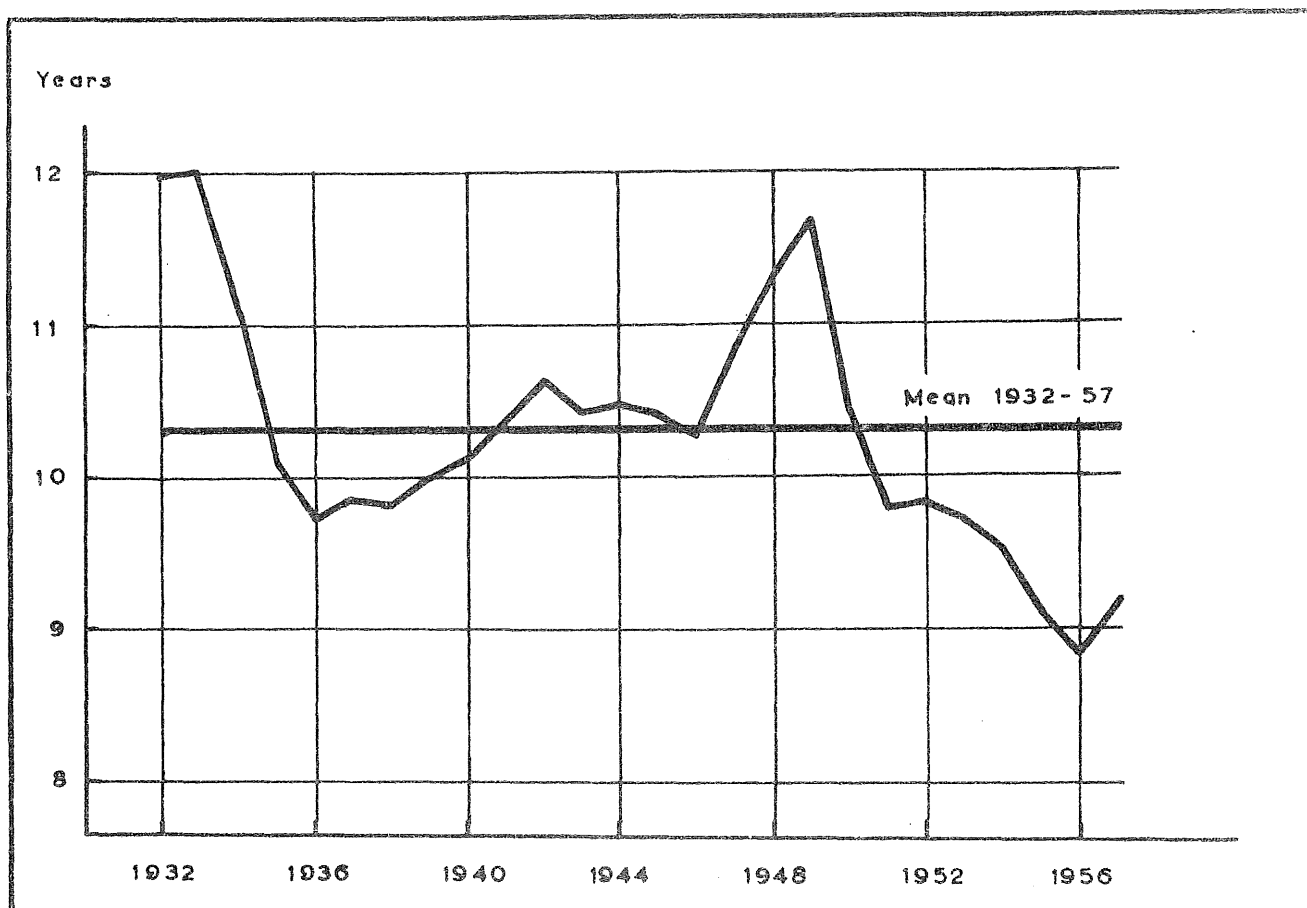


Fig. 7. Annual mean age of the skrei caught on long lines in Lofoten since 1932 and the total mean of the period 1932-1957.

THE TOTAL EXPLOITATION OF THE ARCTIC COD

The Total Annual Catch

Up to about 1920 Norway was almost alone in the cod fisheries in northern waters; but at that time British and German trawlers started fishing in the Barents Sea. About 1930 a trawl fishery also developed on the Bear Island Grounds and along the coastal banks off Lofoten and Troms. During the last war there was a decline in the fishing, as it was confined mainly to a Norwegian exploitation of the stock of skrei. Since the war there has been a considerable and probably almost continuous increase of the total fishing effort in northern waters.

Unfortunately we have not had complete information of the catch of the arctic cod by all the nations which take part in this fishery. In spite of this we venture to present a diagram of the total catch cfr. fig. 8; but we wish to stress that the figures relating to the Soviet-Russian catch and to its proportion of the total are given with reservations as to their reliability.

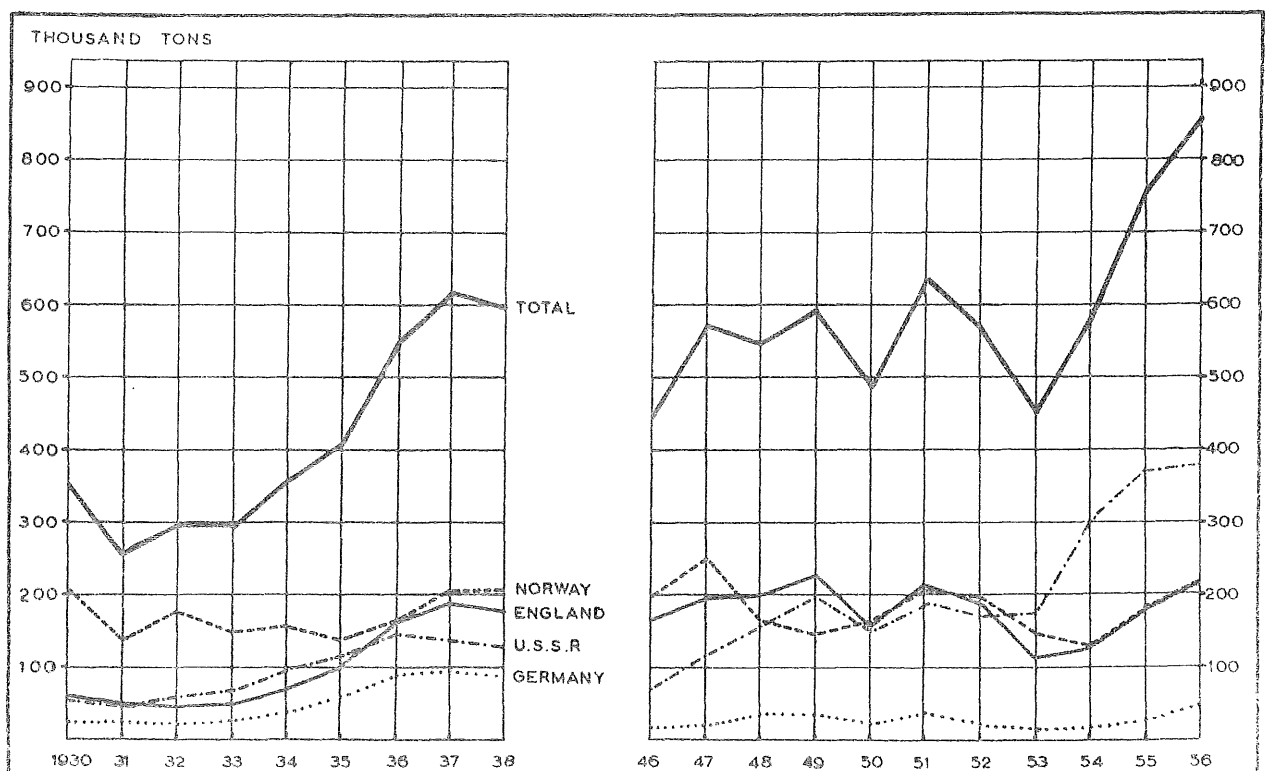


Fig. 8. Total catch of arctic cod and by nations. (Gutted weight.) See text for comments on data given for U. S. S. R.

For most of the years before 1952 our data of the Russian catch are estimates based on scarce information of the size of the fleet and its efficiency. For the years 1952 to 1956, however, there are more exact data; In RIBNOE KHAZAISTVO No 8, 1957 records are given of the total Russian catch of Gadidae taken by trawlers in the Barents Sea. Now, from Maslov (1955) it seems probable that the cod forms some 80 per cent of these catches. As the figures refer to round weight a conversion factor of 1.33 has been used to get the gutted weight shown in fig. 8.

There has been a great increase in the total yield of the arctic cod fisheries since the middle of the nineteen-thirties, probably to twice or three times as much. This higher yield has been obtained by an increase in the fishing effort of trawlers, mainly in the Barents Sea and Bear Island areas.

The Change in the Character of the Exploitation.

The increased yield in terms of weight does not, however, reveal the real change in the exploitation which has taken place in the last two decades. The change in the character of the fishery may be of equal importance. While previously long lines, hand lines and gill nets were the most frequent gears, by far the largest part of the catch is now taken by trawl. There has also been a shifting of the most important fishing areas from the Norwegian coastal banks, populated mainly by old and large fish, to the more distant fishing grounds of the Barents Sea which form the feeding grounds of the young cod.

The effect of these changes has been to reduce the mean age of exploitation. We are not in the position to show the actual magnitude of this reduction; but table 1, which compares the selectivity of long lines and of trawls (of a mesh size of 11 cm), shows that the age at first capture is about two years lower for the trawl. We know that part of the trawler fleet in these waters use a mesh size of 11 cm, but the mean effective mesh size of the whole fleet is probably lower than that.

The change in the character of the exploitation is essential because the number of fish caught is very important from the point of view of conservation. As a result of the smaller mean weight of the trawl-caught fish, the yield of arctic cod in terms of numbers must have increased

Table 1. Selective properties of lines and trawls.

	Characteristics of fish when fully vulnerable to gear. (Mean values).		
	Age	Length	Weight
Lines (Hook No 7)	5 years	55 cm	1,5 kilos
Trawl (Mesh size 11 cm)	3 "	40 "	0,6 "

considerably more than that in terms of weight shown by the statistics.

The decrease of the yield of the Norwegian skrei fishery is nearly concurrent with this increase in total yield. When we consider the evidence which we presented in the first chapter of this report we think it is reasonable to relate these two phenomena to each other.

SUMMARY AND CONCLUDING REMARKS

The shoals of skrei (i. e. large mature cod) which migrate to the spawning grounds on the Norwegian coast have always formed an important part of the natural resources of the cod fisheries of Norway. The official statistics of the yield of the skrei fishery which is available from 1866 on show that, during the last 90 years, considerable fluctuations have occurred. These have mainly been due to variations in the fishing effort and to the differing abundance and availability of the fish. It is thought that the natural variations in abundance have probably been the most important cause of the fluctuations up till recent years. The average yield of the skrei fishery over the last seven years is unusually low. This is not a result of a decrease in the fishing effort, but is probably caused by a reduction in the abundance of the skrei in later years. A main part of this reduction is not of the same nature as the natural fluctuations because a similar reduction has apparently not taken place in the young immature part of the arctic cod population. A striking decrease in the mean age of the skrei has occurred at the same time as the abundance has dropped. Although detailed statistics of the total international catch of arctic cod is not available, there is no doubt that there has been a great increase of late years. The change-over to the trawl as the main fishing gear has brought about a considerable decrease in the mean age of exploitation. If we therefore consider the total yield in terms of numbers, the increase of the exploitation is far greater than that shown by the statistics of the catch in terms of weight.

We think that the evidence we have presented allows us to conclude that the increased exploitation of the arctic cod has in later years influenced the population in such a way that there are reasons for considering more rigorous conservation measures in the northern area.

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