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Report of meeting of Greenland Cod Working Group Copenhagen, 21-25 February 1966

Introduction

At the 1965 meeting of ICNAF a proposal was made by Denmark that Store Hellefiske Bank should be closed to trawling in order to protect the stock of West Greenland cod. After some discussion Panel 1 recommended:-

(i) that the Research and Statistics Committee examine the desirability of further protection of small cod at West Greenland, and in particular in this connection the effects of a closure of Store Hellefiske Bank, and

(ii) that facilities be provided, if required, for a meeting of a small working party of experts to examine the matter.

The problem was further discussed at the meeting of the Assessments Subcommittee in Rome in September, where a detailed program for the work of the group of experts was drawn up. Following an invitation by the Danish Government it was agreed to hold the Working Group meeting in Copenhagen, the actual venue being the ICES headquarters in Charlottenlund.

The meeting took place during the week 21-25 February 1966 and with the following participants:

J. A. Gulland	UK (Chairman)
P. M. Hansen	Denmark
S. A. Horsted	Denmark
A. Meyer	Germany
A. Schumacher	Germany
R. Monteiro	Portugal
D. J. Carrod	UK
A. Treschev	USSR
V. Ponomarenko	USSR

During the meeting it was possible to assemble the essential basic data, carry out many preliminary calculations, and discuss extensively the problems involved. The preliminary results strongly suggested that the protection of the small cod would be beneficial, but there was not time to consider fully quantitative assessments of the results of specific measures for the protection of small fish (though some preliminary results are given in this report).

The present report must therefore be considered preliminary and primarily for scientific use, and it is hoped that a properly considered report to the Commission on the effect of protection of small fish (both in general, and as a result of specific conservation measures) will be prepared at the Madrid meeting.

As mentioned in previous reports (Beverton and Hodder, 1962) the stocks of cod at Greenland can be divided into offshore and inshore groups, the offshore groups being further separable into a northern part (Divisions 1A-1D) and a southern part (Divisions 1E and 1F). So far as possible the northern and southern parts of the offshore fishery are treated separately.

The Group found some difficulties in assessing the state of the stock due to big changes that have occurred in both the stock and the fishery. The changes in the fishery, such as the development of the German fishery from nearly nothing in 1953 to the major fishing country in 1964, made it difficult to determine a single measure of catch per unit effort, or of total effort which can be used throughout the period being studied. There is also a great lack of comprehensive data on discards, and on the size composition of the catches by important sections of the fishery. The Greenland cod stocks are also, among the major ICNAF stocks, among the most susceptible to changes in the environment, particularly to changes in year-class strength. In the past few years catches have benefited from a succession of good year-classes - six out of nine year-classes from 1953 to 1961 were above average - but more recently the three successive year-classes from 1962 to 1964 all appear to be poor. It is therefore to be expected, whatever conservation action is taken, that the catches will decline around 1967-68, when these poor year-classes enter fully into the fishery, and the earlier good year-classes have been depleted. It is therefore particularly necessary to emphasize the remarks usually made, that any assessment made in this, and similar reports, concerning the effect of conservation action (e.g. that the use of larger meshes would benefit the total catches) represent comparisons between possible catches in the future with the larger mesh and catches that might be taken in the same period if the smaller mesh were used.

Total Catches, Catch per Unit Effort and Fishing Effort

Table 1 gives the total catch of cod from 1953 to 1964 by divisions and gears, distinguishing between trawl and line fisheries. The total catch is shown in Fig. 1. In Fig. 2 and 3 the catches, excluding those for which the division is not known, are summarized for Divisions ABCD and EF to show catches from the two principal stocks which inhabit the region. These catches represent 75% of the total.

Looking first at the landings from Divisions ABCD in Fig. 2, when taken over the whole period, there is no trend: landings in 1961, 1963, and 1964 were equal to those of 1954, 1955, and 1956 at 200,000 tons, but intervening poor years 1957-60 suggest a gradual decline in the late 1950s until a recovery took place in 1961 leading to a peak catch of 300,000 tons in 1962. Between fisheries there has been a steady, if slight, decline in landings from the line fisheries apart from better years in 1961 and 1962. In the period 1953-60 the total catch was equally divided between gears, but since 1960 the trawlers have caught two-thirds of the total. Between divisions the catch from A is negligible but there has been some shift in the distribution of catches between B, C, and D. Division 1D was much more important in 1954, 1955, and 1956 but thereafter catches were poor everywhere until 1961, and especially poor in 1C in 1960. Since 1961 the table shows highest landings in 1B in 1961-62, in 1C in 1962-63 and in 1D in 1963-64.

In 1E and 1F trawler landings have been increasing throughout the period with particularly good landings in 1957, 1958, and 1963. On the other hand, the line fisheries of Greenland and Norway reached a peak in 1961 when they reached 50% of the total. Since then the line fisheries have decreased to only 20% in 1964. The majority of the trawl catch has been taken in 1E in recent years but fishing in 1F is more important to the line fisheries.

Overall the fall in landings from Divisions ABCD in the late 1950s was balanced by the improvement in Divisions EF so there is little trend from a level of ca. 275,000 tons in the period 1953-60 (Fig. 1). Since then increased landings from all areas gave a temporary peak of 450,000 tons in 1962.

In both groups of divisions, the outstanding years of high and low landings can to a large extent be accounted for by variations in year-class strength though fluctuations in fishing activity are also important factors. Good or bad

year-classes do not always occur simultaneously in both the northern (ABCD) and southern (EF) stocks (e. g. the 1956 year-class was outstanding in the south but the 1957 was strong in the north). Thus years of good fishing do not necessarily coincide in the two groups of divisions.

Effort and Catch per Unit Effort

The estimation of catch per effort, and hence effective fishing effort, at Greenland is complicated by the wide variety of fleets and changing seasons at which fishing has taken place. No trawler fleet has fished consistently throughout the period in all divisions; the Norwegian longliners give the only continuous series but these are not reliable indices of the stock available to the trawler fleets.

However, Portuguese dory vessels and Portuguese, Spanish, and German trawlers do provide a consistent series of catch per unit effort data for 1 ABCD. These statistics are summarized in Table 2, wherein the catch per effort is expressed relative to the 1956-60 mean and is used to derive an index of effort. This compares very closely with the effort estimated by Horsted (1965a) using a different technique, thus confirming in general the the estimates of stock abundance. In Fig. 4 the data show a sharp fall in abundance beginning in 1957 and reaching a minimum in 1960. The subsequent improvement in the stock did not reach the 1954-56 level of abundance and has declined again since 1962.

From this it can be seen that although the abundance of cod in Divisions ABCD was falling at a time when catches in Divisions EF were rising, the decline continued through to 1960 when catches were relatively low everywhere. These changes in catch probably reflect features in the year-class strengths of the separate stocks.

Table 2 also shows that fishing effort has increased steadily in ABCD throughout the period to a level which is almost double that of 1954-57. Effort statistics for 1964 and 1965 were not available to the Working Group but it is believed that fishing effort has not increased substantially since 1963, and may well have decreased in 1965. There is no comparable series for EF but indices estimated by Horsted (loc. cit.) and those based upon data from English trawlers, indicate a five-fold increase in effort since 1954-56.

National contributions to the catches have not been given in detail but the broad changes in fleet composition are summarized in Table 3 as percentages of the total catch in selected years 1953, 1959, and 1963. Between 1953 and 1959 there is little change, but by 1963 German landings had risen to one-third of the total. Greenland, Norway, Portugal, and Spain have not maintained their proportion of the catch.

In summary, catches in Divisions ABCD were high in 1954-56, and low in 1957-60. In Divisions EF, catches were low until 1957-58, so overall there was a steady yield of ca. 275,000 tons until 1960. Since then a temporary increase in all areas gave a peak landing of 450,000 tons in 1962. Catch per unit effort show the same broad trends as the catches in ABCD, with fishing effort increasing steadily and almost doubling during the period. In all divisions line fisheries have taken a decreasing proportion of the catch and in recent years their actual landings have fallen. It is not clear to what extent this is caused by decreased effort, or decreased abundance, but since the fall parallels that of the trawler fleets it most probably reflects the decline in abundance.

Length Composition of Commercial Landings

The Group found some difficulty in carrying out a satisfactory analysis of the length composition data, and in particular in estimating the total

numbers of each size caught and landed. Because of the big differences between the size compositions of the catches by the different types of vessels, as well as seasonal and area variations in the catches of the same gear, very extensive sampling is required, but this has not been possible. The best sampling of the commercial fleets has been of the landings by trawlers of fresh fish on ice, where samples can be taken when the fish are landed; at the opposite extreme are the catches of the factory trawlers which fillet and freeze their fish at sea; for these virtually no sampling has been possible; this is particularly unfortunate for the important German fishery, where it is known that the smallest fish acceptable for filleting and freezing is considerably smaller than the smallest size acceptable as fish on ice.

Another problem is that virtually all the samples available are of catches by research vessels, or landings by commercial vessels, and few of actual commercial catches before discarding. It is known that both English and German vessels, at least on occasion, discard appreciable quantities of small fish, or use them for fish meal, but there are no good estimates of the actual quantity. A rough estimate has been made by comparing the length compositions of commercial landings and research vessel catches (see below).

In the present calculations, therefore, it has only been possible to make separate analyses for the two major gear classifications - trawl and others, and for each division. For each type of gear and each division all available data on the length composition of the commercial landings during the year have been combined. No account was taken of the season of sampling, though when samples were available from more than one group of vessels e. g. English and German trawlers, the samples have been weighted roughly in accordance with the total catch during the year by the groups of vessels concerned. The resulting mean percentage length composition has been raised by a factor calculated using a weight/length relationship to give the total numbers landed by the two types of gear in each division each year. These calculations have been done for each of the years 1961-64, and the average annual landings by trawl and line are given in Table 4 and 5.

Comparisons have also been made of the length composition of landings by commercial trawlers and catches by research trawlers in each division. These are shown in Fig. 5, which gives for each division the percentage length composition of commercial landings, and the percentage length composition of the research catches, increased by a factor to make the total numbers above 60 cm the same. The difference among the small fish (shaded in the figures) is an estimate of the proportion discarded, which ranges from about 70% in 1B to 15% in 1E. This figure may be an overestimate because, compared with the research vessels, the commercial trawlers may prefer areas where the larger fish predominate, but at least gives some measure of the possible rate of discarding.

Age Composition

Data on the age composition of Danish offshore catches are available for every year since 1952. These, expressed as percentages, are given for the northern divisions in Table 6. Since these samples have been taken with similar gear at about the same time (June-August) each year they will reflect fairly accurately changes in the age composition or mortality of the stock. Precise estimation of the mortality rate is not easy, since the lack of any precise measure of catch per unit effort makes the comparison of the abundance of the same year-class in successive years difficult, while the great fluctuations in year-class strength make estimates from the percentage age composition very variable.

However, by taking the average of the percentage composition for the years 1962-65, some of this variability is removed; these average compositions

for the years 1952-56, 1957-61, and 1962-65 are shown in Fig. 6 and are plotted on a logarithmic scale in Fig. 7. The points for 1962-65 from 5 years old onwards fall on a reasonably straight line, corresponding to 54% surviving each year, or an instantaneous total mortality, Z, of 0.62. Since this mortality rate refers strictly to the period when the fish concerned (between 5 and 10 years old) were entering the fishery, rather than to the period of sampling, this estimate of Z = 0.62 corresponds to the average mortality roughly in the period around 1960.

This value of Z is considerably greater than that obtained by the earlier Assessment Group's report (0.35), based on the average percentage age composition for 1952-57, i.e. referring to the period around 1950.

While age composition data from other sources are probably less reliable as direct quantitative measures of mortality, there is good qualitative agreement in there being recently proportionally much fewer old fish, and hence a higher mortality.

The effort data given earlier show that between 1953 and 1960 the effort nearly doubled. Effort data are not available before 1953, but the rapid increase in catches between 1948 and 1953 suggests that effort too was rapidly increasing, so that the total mortality of 0.62 corresponds to a fishing effort rather more than twice the effort when the mortality was 0.35. Uncertainty concerning the actual effort, and the period to which the mortality applies make it difficult to use this information to get a precise separation of fishing and natural mortalities, but there is good agreement with the estimate for the earlier period that fishing and natural mortality were about equal, i.e.

$$F_1 - M = 0.15 \text{ to } 0.20,$$

and for 1960

$$F_2 = 0.30 \text{ to } 0.50$$

$$M = 0.15 \text{ to } 0.20$$

so that in 1960 fishing accounted for about two-thirds of the total deaths, i.e.

$$E = 0.6 - 0.7.$$

There is also fair agreement with the results of tagging experiments. Those in Division 1B are analyzed in more detail in a later section; in this Fig. 8 shows that the percentage recaptured has been increasing during the last 20 years, agreeing with the increased effort and increased mortality, and that in the last few years this percentage has reached about 50%, and rather more for the bigger fish. This percentage should be equal to E, the ratio of fishing to total mortality, but is likely to be an underestimate due to uncorrected losses.

Since the present (1965) effort is probably above that for the period to which the above estimates refer, it is likely that the present value of E is above 0.7. Accordingly, in the assessments of the effects of mesh change etc. a most probable value of 0.7, and bounding values of E = 0.5 and 0.8, within which the true value probably lies, have been used.

Growth

The Group did not examine the growth of cod in any detail. Data from Danish experimental fishing were presented by Dr Hansen. The average length of certain ages of fish each year are given in Fig. 9 (figures 1A and 1B from Hermann and Hansen, 1965). Over the whole period for which these data are available, there have been fluctuations, amounting to up to ca. 20% in length each side of mean; most recently the average lengths have tended to

increase, possibly due to increases in temperature. An important consideration as far as this report is concerned is that any recent decrease in the stock cannot be due to changes in the growth rate; also that a faster growth means that small fish will be exposed to losses from natural causes for a shorter time before growing to a good size, so that the benefits from protecting the small fish are likely to be increased.

The average growth of Greenland cod is given in Table 7. This gives, as well as the average length and gutted weight of fish of each age in December (at the end of December), the percentage increase in weight during each year. Allowing for the natural mortality of around 15-20%, it is clear that the total weight of a year-class doubles between 3 and 4 years old, and is still increasing up to 6 or 7 years old. The estimated changes in the abundance of a group of 1,000 fish, in the absence of fishing and with a natural mortality of 20%, is given in the last rows of Table 7 in terms of numbers and weight. This shows in general terms the desirability of protecting three year old fish, and catching them, on the average, at about 6-8 years old (compared with about 5-6 years old at present - see Fig. 6).

Mesh Changes

Assessments of the effects of increasing the mesh size have been made in the same way as in the earlier Assessment Group's report, i.e. by calculating an immediate loss of the fish in the present landings which will be released by the larger mesh, and the long-term effect on the landings when the fish released have grown big enough to be retained by the larger mesh.

In the calculations a selection factor of 3.7 (for meshes as measured with an ICES gauge, as used for scientific purposes) and a selection range of 10 cm has been used. The effective mesh-size at present in use (as measured with an ICES gauge) was assumed to be 100 mm - the selectivity of the nets used by several countries being reduced by the use of chafers - though so far as the effect on the landings, which contain few fish in the selection range of the 100 mm mesh, are concerned, this assumption is not very critical. The calculations have been based on the average landings for 1961-64, and it must be emphasized again that these are landings, not catches. Since appreciable quantities of small fish are discarded, most of which would be released by a suitably large mesh, the estimates given are distinctly underestimates of the likely benefits from using larger meshes.

Results of Mesh Assessment

Calculations, using the method of Gulland (1961) have been made of the effect of using mesh sizes from 110 mm to 170 mm, with no allowance for discards, and of the effect of a 150-mm mesh for two probable rates of discards - 10 and 20% by numbers. For the latter calculations it was assumed that a 150-mm mesh would release all the discarded fish. The results are given in Table 8. This table shows that, ignoring discards, the total catches will increase, even at the lowest likely value of E for increases of mesh size up to 130 mm. For the most probable value of E the total catch increases up to at least 170 mm. The benefits are, as usual, not equally shared between different gears, with the catches by other gears increasing substantially for any mesh size increase, while, if no allowance is made for discards, the trawl landings would appear to decrease for mesh sizes greater than 130 mm. However, if allowance is made for discards, then both groups of gears will benefit at least from the use of 150-mm meshes. For a 10% discard rate the gain in total catch is about 5%, and if the discards are 20% the gain in total catch is 7-9%. The corresponding gains to the trawlers are 2-3%, and 6-7% respectively.

Closure of Store Hellefiske Bank: General

The proposal to close this bank to trawling was put forward with the specific objective of protecting small cod, and would be expected to have broadly similar conservation effects as the use of a larger mesh size. The assessment of the likely effects require a considerably wider range of data than the assessment of the effects of mesh change; these include the size distribution of the catches both on Store Hellefiske Bank and in other parts of West Greenland; the movements of cod of all sizes from the closed area into the areas where they can be caught; and the probable redistribution of the trawlers previously fishing on Store Hellefiske Bank.

Since most of the data available has been grouped according to ICNAF divisions, the Working Group could not adequately separate the data concerning Store Hellefiske Bank from those for other parts of Division 1B; however, the majority of the catches from 1B are taken on Store Hellefiske Bank. In this report, therefore, assessments have been made of the effect of closing the whole of 1B, rather than of Store Hellefiske Bank only.

Redistribution of Fishing

The long-term effect of closure of 1B will be influenced by how the fishing diverted from 1B is redistributed - the benefit from better protection of the fish in 1B might be more than balanced by the losses due to increased fishing on other grounds already heavily fished. The trawlers at present fishing in 1B are large vessels, including factory trawlers, which could fish in a wide range of alternative grounds, including outside the ICNAF area. A full assessment of the effect should, therefore, include analysis of all possible alternatives. However, most of the alternative grounds, with the possible exception of Labrador, are probably as heavily fished as Greenland, and it has been assumed that the fishing effort diverted from 1B will be redistributed within the Greenland area; this simplifies the assessments, though it may overestimate the future effort (and hence underestimate the future catch per unit effort) in Greenland waters, but only to the extent that the effort outside Greenland is underestimated (and the catch per unit effort overestimated).

The catches by trawlers in each month of 1962 (the recent year with the highest catches in 1B) and in each of the other divisions are given in Table 9. This shows that even in the months when fishing in 1B is greatest, there is also a considerable fishing in other areas; in fact, in no month do the catches in 1B amount to more than 55% of the total trawl catch. Thus if the grounds in 1B, including Store Hellefiske Bank, are closed, there will remain alternative grounds on which the trawlers can fish. Presumably, however, ships fish in 1B because catches there are better, or at least are believed to be better, so that there may be some immediate loss of catch if trawlers are diverted from 1B. In the following calculations, therefore, it has been assumed that they will catch 5% or 15% less by weight; this catch will be distributed in the southern Divisions 1C-1F in the same proportion as the present trawl catch in those areas, and will have the same length composition. The immediate effects of closure of 1B to trawling in terms of numbers of fish of each length caught can therefore be calculated, and the results, based on the average trawl landings in 1961-64 are shown in Table 10. This gives the present landings, in total and for 1B and other divisions separately, and the landings outside 1B immediately following the change. As expected, the total numbers of small cod landed decrease, while there is an increase in the numbers of larger cod.

The actual degree of redistribution required in any one year will depend on the likely proportion of fishing in 1B in the absence of regulation; this varies from year to year, being influenced partly by the strength of the young year-classes present in 1B. Disruption will be least when the youngest year-classes are weak.

Movements of cod from Store Hellefiske Bank

Danish scientists have tagged cod on Store Hellefiske Bank, as well as in other Greenland waters, over a long period. These show that fish disperse from 1B into the other parts of West Greenland, especially 1C and 1D, with rather smaller numbers moving into the southern divisions (1E and 1F), and outside the ICNAF area to East Greenland and Iceland. This dispersion is mainly confined to the offshore banks, and few tagged fish have been recaptured in the inshore fishery in 1B. The pattern of returns is shown in Fig. 8, which gives for each 10-cm length group (length at tagging) the returns from 1B and outside 1B at different periods of tagging. The left-hand part shows the actual percentage of tags returned; this will be a considerable underestimate of the percentage of fish present on Store Hellefiske Bank which are ultimately caught - tags may come off the fish, fish may die when tagged, and in particular not all the tagged fish recaptured may be returned.

Horsted (1965b) has shown how a correction for incomplete returns can be made, based on an assumption of complete returns by the best country (Portugal). This gives an estimate which may still be an underestimate of the actual number recaptured; this estimate is plotted on the right-hand side of Fig. 8. Apart from a drop for the tagging experiments in 1961-62, which may well be due to an unusually low rate of returns from Portuguese fishermen in 1962 (Horsted, 1965b) and a recent fall in returns from the smaller fish due probably to a change in the type of tag used, the estimated percentage recaptured increases for most sizes over the period 1946-62, reaching a value of some 70% for the biggest fish, and over 50% for the fish of all sizes taken together. Over the same period the proportion returned from outside 1B has increased, and recently more than half the recaptures occur outside 1B. Figure 8 shows that there is no very marked difference in the pattern of returns of fish of different sizes. In considering the returns according to the time since tagging, data for all sizes of fish were grouped together. The results are given in Table 11. This shows that little dispersion takes place in the season of tagging, but by the next year considerable mixing has taken place; the degree of dispersion increases in the following years. After 3 years 50% of the total number of returns come from outside 1B. This is less than the proportion of the total catch (either from West Greenland as a whole, or from the northern part - ABCD) which comes from outside 1B, which suggests that the tagged fish are still to some extent relatively more abundant in 1B than elsewhere. However, the increasing proportion of returns coming from outside 1B suggests that it is reasonable to assume that all the stock protected by a closure of 1B will ultimately become available to the fishery in the more southern divisions. That most of the adult fish must move out, at least temporarily, is shown by the fact that there is little or no spawning inside 1B.

Effects of Closure

Two methods of assessing the effects of the closure of 1B were discussed. The most direct is to calculate directly the probable yield in other areas of the fish present in 1B, using the tagging and other data to determine what proportion will be caught, and after what time and at what size; this yield can then be compared with the present catch in 1B. The effect on the stocks outside 1B of the extra effort diverted from 1B must also be taken into account; however, since these stocks are heavily fished it is likely that moderate changes in effort will cause only small changes in total catch. As the calculations needed for this method are relatively long, with the effect on each size of fish being calculated separately, there was not time to carry out this method of assessment during the Copenhagen meeting, though it is hoped to make some of the necessary calculations before or during the Madrid meeting.

The other method discussed is similar to that used for mesh assessment. The calculations of the immediate effect of the redistribution of effort

show that there will be fewer fish caught; thus more fish will be available for capture in future years, and if the proportion of the extra fish left alive which are ultimately caught is known, then the increase in the number caught can be directly calculated.

Mathematically, if N_1 = original catch in numbers

N_2 = catch in numbers immediately after redistribution

E = proportion caught = ratio of fishing to total mortality

then $N_1 - N_2$ = immediate reduction in numbers caught, and

$\frac{E(N_1 - N_2)}{N_2}$ = proportion gross long-term increase in numbers caught.

These extra fish will, however, not have precisely the same length distribution as the present catches. Thus the numbers of the very smallest fish in the catches will not change much, as the fish protected in 1B will be rather larger by the time they have moved into the other divisions. The immediate reduction in numbers caught is greatest among the small sizes, which when they have moved out of 1B will give the greatest long-term increase to the medium fish. The long-term catches of large fish will tend to be increased by the immediate reduction in catches of small fish, but be reduced by the immediate increase in the catches of medium fish.Overall the numbers of larger fish caught may not change much. Thus the numbers of both small and large fish do not change much, and the long-term increase is mainly among the medium fish, so that the average weight may not change much. Therefore, as a first approximation, the long-term changes in the weight caught may be taken as being the same as the long-term changes in the numbers.

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TABLE 1. Total catch of cod by ICNAF Divisions and gears 1953-1963 (metric tons round fresh)

(a) Trawl fisheries

Year	A	B	C	D	Sub-total ABCD	E	F	Sub-total EF	NK	Total trawl
1953	206	8,898	816	11,657	21,377	6	23,981	23,987	48,652	94,216
1954	330	43,178	7,793	64,142	115,443	31	14,206	14,237	21,331	151,011
1955	9	11,606	19,577	40,067	71,259	635	7,236	7,871	27,647	106,777
1956	-	19,633	29,716	94,515	143,854	5,347	2,615	7,962	26,865	178,681
1957	-	18,709	22,074	35,413	76,196	26,664	15,688	42,352	21,172	139,720
1958	1	23,066	32,197	43,016	98,461	19,361	23,526	42,887	30,268	171,616
1959	-	40,437	2,977	20,989	64,403	10,905	10,574	21,479	22,539	108,421
1960	-	19,831	7,012	23,320	50,163	15,091	8,951	24,042	25,369	99,574
1961	507	43,666	31,096	43,702	178,971	13,157	13,182	26,339	25,535	170,845
1962	1,017	65,846	66,258	35,208	168,329	25,090	16,609	41,699	37,208	247,236
1963	66	31,175	63,063	50,217	194,521	45,056	15,528	60,584	29,718	234,823
1964	72	29,712	34,607	57,046	121,437	30,879	12,918	43,797	41,252	206,486

(b) Line fisheries

Year	A	B	C	D	Sub-total ABCD	E	F	Sub-total EF	NK	Total line
1953	4,603	35,559	11,961	25,197	77,320	3,566	4,908	8,474	25,234	111,028
1954	3,431	54,529	13,643	31,121	102,724	2,537	3,750	6,287	36,553	145,564
1955	1,355	44,023	16,447	51,321	113,146	5,891	4,033	9,924	38,441	161,511
1956	490	42,094	11,887	38,867	93,338	6,671	5,893	12,564	37,000	142,902
1957	277	45,917	13,802	31,950	91,946	6,809	5,880	12,689	24,585	129,220
1958	186	38,718	12,653	35,507	87,064	6,238	9,689	15,927	45,123	148,114
1959	1,223	40,285	13,576	14,274	69,358	5,422	6,905	12,327	43,359	125,044
1960	223	46,220	11,406	17,344	75,193	6,681	8,158	14,839	46,418	138,450
1961	601	40,921	21,378	31,357	94,257	9,204	11,162	20,366	62,416	177,039
1962	315	64,351	15,441	26,588	106,695	5,884	12,205	18,089	78,688	203,472
1963	295	43,938	13,260	19,912	77,405	4,392	9,949	14,341	69,901	161,647
1964	299	22,648	16,972	34,643	74,562	4,615	5,907	10,522	58,186	143,270

(c) All gears

Year	A	B	C	D	Sub-total ABCD	E	F	Sub-total EF	NK	Total
1953	4,809	44,457	12,777	36,854	98,897	3,572	28,889	32,461	73,886	205,244
1954	3,761	97,707	21,436	95,263	218,167	2,568	17,956	20,524	57,884	296,575
1955	1,364	55,629	36,024	91,388	184,405	6,526	11,269	17,795	66,088	268,288
1956	490	61,717	41,603	133,382	237,192	12,018	8,508	20,526	63,865	321,583
1957	277	64,626	35,876	67,363	168,142	33,473	21,568	55,041	45,757	268,940
1958	187	61,784	44,850	78,523	185,344	25,599	33,215	58,814	75,391	319,549
1959	1,223	80,722	16,553	35,263	133,761	16,327	17,479	33,806	65,898	233,465
1960	223	66,051	18,418	40,664	125,356	21,772	17,109	38,881	71,787	236,024
1961	1,108	84,587	52,474	75,059	213,228	22,361	24,344	46,705	87,951	347,884
1962	1,332	130,197	81,699	61,796	275,024	30,974	28,814	59,788	115,896	450,708
1963	361	75,113	76,323	70,129	221,926	49,448	25,477	74,925	99,619	396,470
1964	371	52,360	51,579	91,689	195,999	35,494	18,825	54,319	99,438	349,756

TABLE 2. Relative changes in total catch, catch per unit effort and fishing effort in Divisions A, B, C, and D

Year	Total landings[1] (tons) A	Catch per effort[2] B	Catch per effort from Horsted 1965	Fishing effort A/B x 10^{-2} C	Relative change in effort	
					From C	Horsted 1965
1953	154,526	1.18	1.20	1,310	0.55	0,54
1954	271,073	1.49	1.29	1,819	0.76	0.88
1955	244,677	1.36	1.34	1,799	0.75	0.76
1956	295,948	1.53	1.59	1,934	0.81	0.78
1957	202,597	1.08	1.12	1,876	0.79	0.76
1958	242,566	1.00	0.91	2,426	1.02	1.12
1959	186,348	0.71	0.79	2,625	1.10	0.99
1960	180,129	0.64	0.79	2,815	1,18	0.95
1961	285,348	0.88	0.87	3,243	1.36	1.38
1962	370,175	1.24	1.09	2,985	1.25	1.42
1963	296,441	0.87	0.89	3,407	1.43	1.43

1) Included an estimated share of landings from "division not known."

2) Based on relative changes in catch per effort of:

Portuguesedory vessels (catch per dory hour, June-August)	501-900 t (Sail + Motor), 501,900 t (Motor), 901-1800 t (Motor)
Portuguese trawlers (catch per hours' fishing May-June, August-Sept.)	901-1800 t
Spanish trawlers (catch per hours' fishing, May-June, August-Sept.)	901-1800 t
German trawlers (catch per day fished, May-July, 1D only).	501-900 t

TABLE 3. National shares of the cod fishery in Subarea 1

Years		1953	1959	1963
Total catch of cod (tons)		202,422	233,542	405,771
% of total catch	Denmark (G)	10.43	11.80	5.73
	Denmark (F)	14.07	16.40	19.17
	France	9.73	13.00	8.92
	Germany	-	7.45	33.71
	Iceland	6.66	0.20	0.96
	Norway	15.33	11.40	7.88
	Portugal	26.53	28.58	15.57
	Poland	-	-	0.07
	Spain	1.43	5.88	0.12
	United Kingdom	15.89	5.23	6.63
	USSR	-	0.04	1.25
		100.00%	100.00%	100.00%

TABLE 4. Average annual numbers ('000s) of each length group of cod landed by trawlers 1961-64

Length	1 B	1 C	1 D	1 E	1 F	Total
33-35	8			4		12
36-38	8	8	11	17	5	49
39-41	20	28	63	53	27	191
42-44	228	51	181	92	68	620
45-47	811	194	467	106	100	1,678
48-50	1,709	390	852	116	190	3,257
51-53	2,167	808	1,012	171	326	4,484
54-56	2,059	932	834	309	472	4,606
57-59	2,127	1,309	1,022	640	530	5,628
60-62	1,915	1,921	1,342	870	664	6,712
63-65	1,829	2,216	1,720	1,290	662	7,717
66-68	1,502	1,948	1,976	1,550	661	7,637
69-71	1,504	2,130	2,081	1,454	656	7,825
72-74	1,044	1,548	2,059	1,209	514	6,374
75-77	998	1,296	1,739	888	465	5,386
78-80	628	826	1,352	710	354	3,870
81-83	586	720	1,097	506	259	3,168
84-86	306	527	731	291	161	2,016
87-89	334	527	531	238	115	1,745
90-92	209	301	344	134	63	1,051
93-95	126	229	201	86	36	678
96-98	71	102	118	45	18	354
99-101	19	49	92	23	13	196
102-104	29	49	37	13	3	131
105-107	12	2	28	7	3	52
108-110	5	6	15	-	1	27
111-113	-		11	3	1	15
Total	20,254	18,117	19,916	10,825	6,367	75,479

TABLE 5. Average annual numbers ('000s) of cod landed by vessels using lines 1961-64

Length (cm)	1 B	1 C	1 D	1 E	1 F	Total
24-26						
27-29						
30-32	22	8				30
33-35	190	35	8	1		234
36-38	337	58	23	1		419
39-41	460	108	48	1	3	620
42-44	933	88	26	16	1	1,064
45-47	1,759	170	205	36	25	2,195
48-50	2,346	183	308	80	31	2,948
51-53	2,141	240	462	99	117	3,059
54-56	2,064	278	561	111	242	3,256
57-59	1,980	345	656	128	406	3,515
60-62	2,026	405	945	158	514	4,048
63-65	1,676	518	957	227	529	3,907
66-68	1,323	545	1,062	319	544	3,793
69-71	1,099	448	1,128	418	558	3,651
72-74	1,044	410	1,216	390	498	3,558
75-77	893	448	1,306	374	585	3,606
78-80	632	448	1,147	359	426	3,012
81-83	705	443	959	264	293	2,664
84-86	485	327	713	142	237	1,904
87-89	308	217	669	159	134	1,487
90-92	305	148	432	102	62	1,049
93-95	225	90	230	27	52	624
96-98	144	40	170	10	16	380
99-101	93	22	102	28	10	255
102-104	55	20	63	3	2	143
105-107	44	8	56	2	2	112
108-110	38	15	12	5	3	73
111-113	15	8	18	3		44
114-116	8	2	10	2		22
117-119	8		8	2		18
120-122	15		-	2		17
123-125			3			3
126-128			2			2
			2			2
Total	23,373	6,075	13,567	3,469	5,290	51,714

TABLE 6. Age composition of Danish offshore samples, Divisions 1 A-1 D, taken with hand line and/or trawl

Age Group \ Year:	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
III	-	-	-	-		-	-	-	-	6.7	3.7	2.9	1.4	12.3	1.8	0.3
IV	7.4		1.7	0.6	8.5	2.9	0.2	20.5	11.5	17.2	11.6	61.2	12.3	15.0	37.7	26.7
V	33.3		46.0	5.9	2.5	21.4	2.3	10.7	44.1	13.8	16.6	17.3	36.5	14.3	15.2	52.3
VI	9.9		5.7	56.6	8.1	3.3	17.3	12.0	10.2	31.3	8.7	5.1	30.9	35.3	11.1	6.0
VII	6.2		26.3	4.9	46.8	13.1	7.1	24.4	5.4	6.0	27.9	3.2	4.8	11.8	23.2	3.7
VIII	22.2		3.3	17.8	5.3	45.5	6.5	5.6	14.5	5.2	5.8	5.9	2.1	3.4	4.6	9.1
IX	-		2.8	1.7	12.5	2.7	51.8	4.6	2.1	7.7	4.3	1.0	6.5	1.3	1.5	0.8
X	3.7		8.6	1.8	0.8	5.9	2.8	17.2	1.2	1.0	9.2	0.4	0.9	3.4	0.8	0.5
XI	1.2		1.1	7.4	2.6	0.9	8.0	1.6	9.8	2.2	0.9	1.4	1.1	0.7	3.0	0.2
XII	6.2		0.5	0.7	10.4	0.9	0.4	2.3	0.1	3.2	1.6	0.1	2.9	0.5	0.2	0.3
XIII	2.5		0.9	0.4	0.8	2.7	0.4	0.3	1.1	0.7	3.8	0.3	0.4	0.7	0.3	0.1
XIV	1.2		0.2	0.3	0.4	-	2.8	0.2	-	1.5	0.4	1.1	0.4	0.1	0.4	-
XV	1.2		0.2	0.2	-	0.3	0.2	0.5	-	-	1.2	-	0.2	0.2	-	-
XVI	4.9		1.3	0.1	0.1	-	0.4	0.1	-	-	0.5	-	-	0.9	0.1	-
XVII	-		-	1.5	-	-	-	-	-	2.7	-	-	-	-	0.1	-
XVIII	-		1.2	-	0.2	-	-	-	-	-	0.2	-	-	-	-	-
XIX	-		0.2	-	0.2	-	-	-	-	-	-	-	-	-	-	-
XX	-		-	0.1	0.1	0.1	0.2	-	-	-	-	-	-	-	-	-

TABLE 7. Growth of Greenland cod.

Age	2+	3+	4+	5+	6+	7+	8+	9+	10+
Length (cm)	32	44	54	64.5	71.5	76.5	80.5	84	85.5
Weight (gm)	250	670	1,260	2,035	2,705	3,290	3,820	4,360	4,600
Increase in wt %	168	88	62	33	22	16	14	6	
Total abundance) Numbers	1,000	800	640	512	410	328	262	210	168
of year-class) Weight	250	536	806	1,042	1,109	1,079	1,001	916	773

TABLE 8. Mesh assessment for Greenland.
Percentage change in landings
(a) No allowance for discards

Gear	E	110	Changing from 100 mm to 120	130	140	150	160	170
Trawlers: Imm. Loss		0.1	0.5	1.2	2.3	4.2	7.1	11.8
Long-term gain	.5	0	-0.1	-0.4	-0.8	-1.8	-3.5	-6.7
	.7	0	0.1	0	-0.2	-0.9	-2.1	-4.6
	.8	0.1	0.1	0.2	0.1	-0.4	-1.4	-3.6
Other Gears:	.5	0.1	0.4	0.9	1.5	2.5	3.9	5.8
Long-term gain	.7	0.2	0.6	1.2	2.2	3.4	5.4	8.1
	.8	0.2	0.6	1.4	2.5	3.9	6.2	9.3
Total: Imm. Loss		0.1	0.3	0.7	1.4	2.5	4.2	7.0
Long-term gain	.5	0	0.1	0.2	0.1	-0.1	-0.5	-0.5
	.7	0.1	0.3	0.5	0.7	0.9	1.0	1.6
	.8	0.1	0.3	0.7	1.0	1.3	1.7	2.7

(b) Effect of 150 mm, allowing for discards.
Long-term gain, as percentage of present landings

Gear	E	Discard rate by trawlers (by numbers) 0%	10%	20%
Trawlers	0.5	-1.8	0.6	3.0
	0.7	-0.9	2.5	5.9
	0.8	-0.4	3.5	7.4
Other Gears	0.5	2.5	5.0	7.6
	0.7	3.4	7.0	10.6
	0.8	3.9	8.0	12.1
Total	0.5	-0.1	2.4	4.9
	0.7	0.9	4.3	7.8
	0.8	1.3	5.3	9.3

TABLE 9. Monthly catches (tons) of cod by trawlers in each Division of West Greenland, and the percentage taken in Division 1 B

Divisions	Month												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
A	-	-	-	-	-	-	9	144	198	666	-	-	1,017
B	3,138	1,137	207	1,245	2,013	2,011	4,275	14,492	13,150	10,584	6,485	7,429	66,166
C	4,653	14,212	15,304	4,120	895	1,460	3,087	4,408	1,460	3,168	6,729	6,712	66,208
D	1,836	815	3,181	1,384	542	1,016	6,896	7,092	3,272	3,560	5,256	358	35,208
E	731	505	2,293	1,938	2,889	7,892	6,419	3,136	200	926	579	582	25,090
F	2,190	413	1,163	224	2,441	1,850	1,333	1,380	535	1,757	1,387	1,934	16,607
NK	1,269	751	239	-	488	9,557	4,106	3,371	5,119	4,701	4,124	3,488	37,208
Total	13,812	17,833	22,387	8,911	9,268	20,786	26,125	34,023	23,934	25,362	24,560	20,503	247,509
% in 1 B	22.7	6.37	9.24	13.98	21.72	9.67	16.36	42.60	54.95	41.74	26.40	36.23	26.73

TABLE 10. Immediate effect on the numbers of fish landed, of closure of Division 1 B to trawling
(a) if loss in weight by diverted trawlers = 5%
(b) if loss in weight = 15%

(thousands of fish)

Length (cm)	Present landings			Immediate after closure		Change	
	1 B	Others	Total	a	b	a	b
< 44	264	608	872	781	765	-91	-107
45-59	8,873	10,780	19,653	13,843	13,520	-5,810	-6,133
60-74	7,794	28,471	36,265	36,560	35,708	+295	-557
75-89	2,852	13,333	16,185	17,121	16,722	+936	+537
< 90	471	2,033	2,504	2,611	2,550	+107	+ 46
Total	20,254	55,225	75,479	70,916	69,265	-4,563	-6,214
Weight	50	169	214	211.5	206.5	-2.5	-7.5

TABLE 11. Actual number of tags returned from different divisions of fish tagged in 1 B

	1 A	1 B	1 C	1 D	1 E	1 F	Other areas	Not known	% outside 1 B
Year of tagging	-	229	7	3	2	-	-	6	5
1 year after tagging	-	372	65	81	20	3	6	20	31
2 years after tagging	1	141	36	43	17	2	8	7	41
3 or more years after tagging	-	104	32	54	14	4	6	10	50

Fig. 1. Trends in total landings of cod from West Greenland

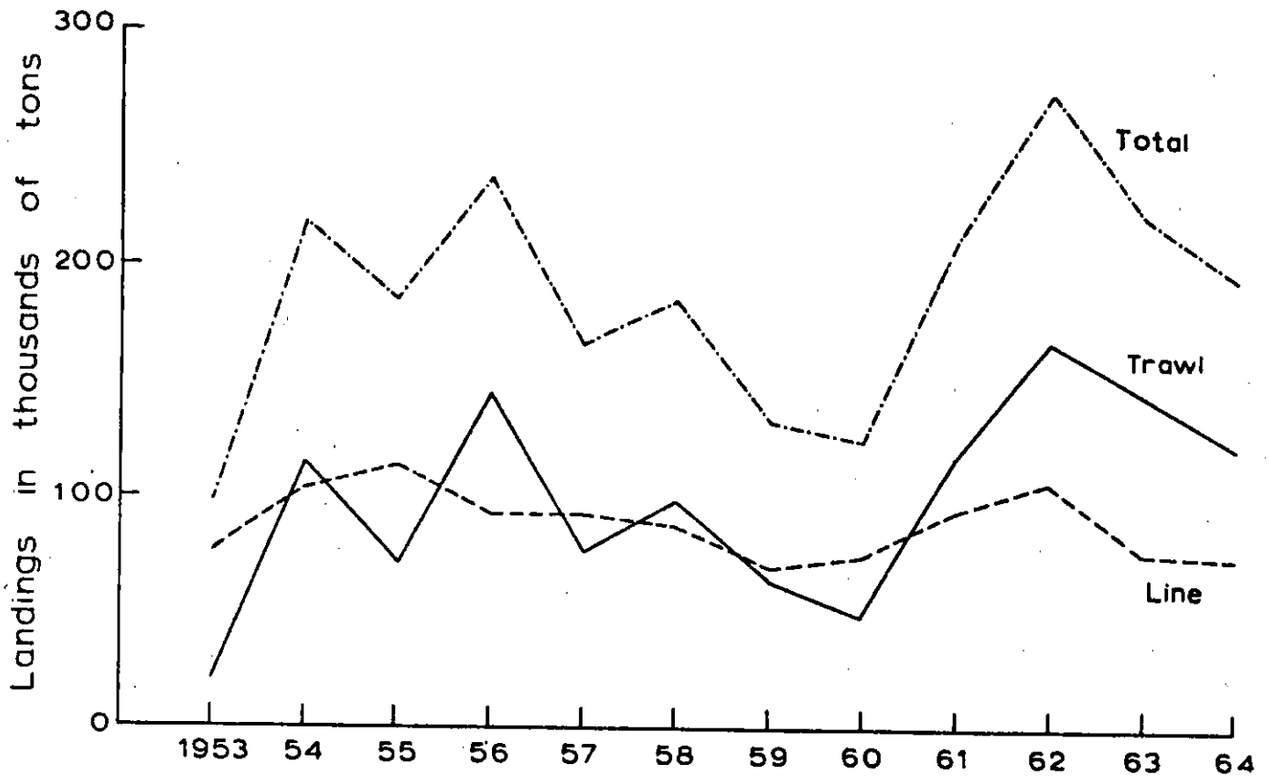

Fig. 2. Trends in total landings of cod from the northern divisions (1A-1D) of West Greenland (excluding landings from "divisions not known").

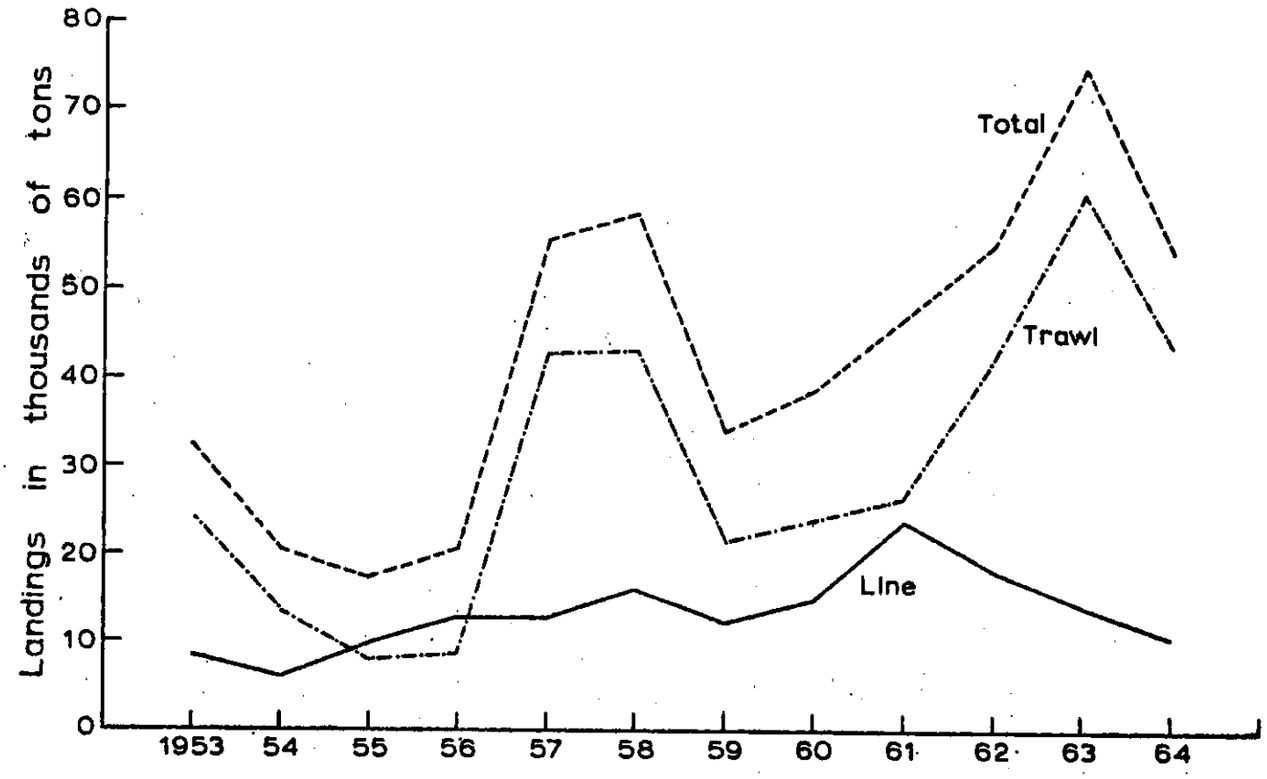

Fig. 3. Trends in total landings of cod from the southern divisions (1E, 1F) of West Greenland (excluding landings from "divisions not known").

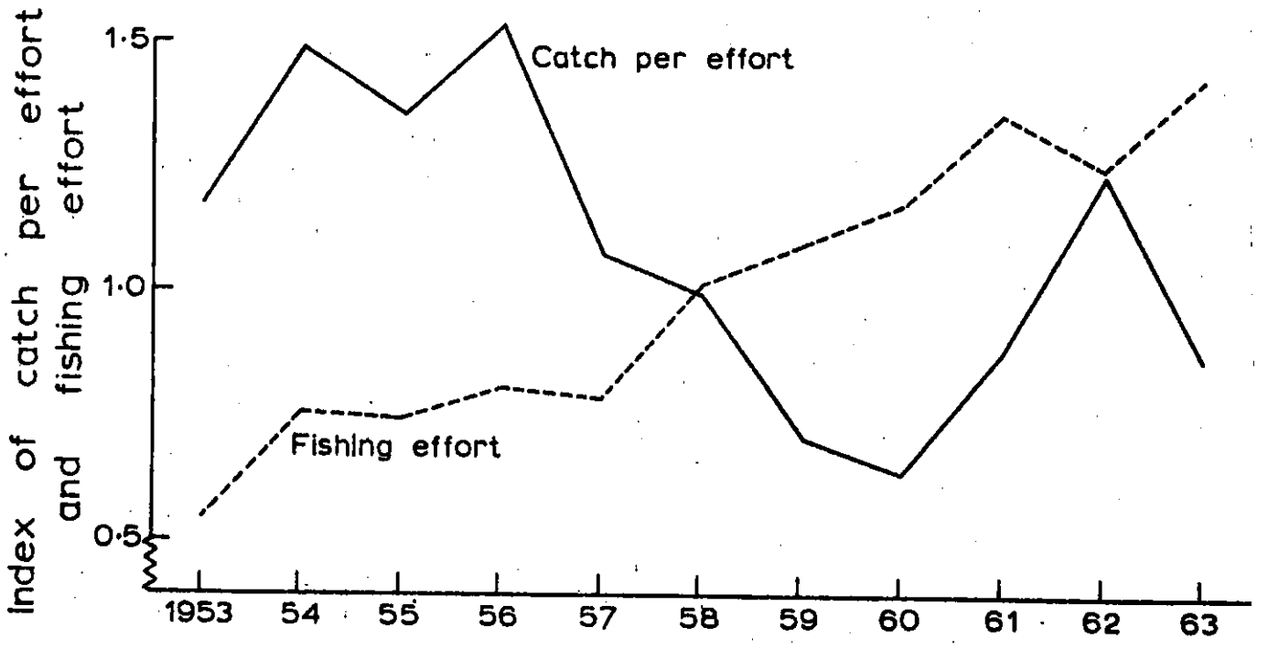

Fig. 4. Trends in catch per unit effort and estimated total effort in the northern divisions (1A-1D) of West Greenland.

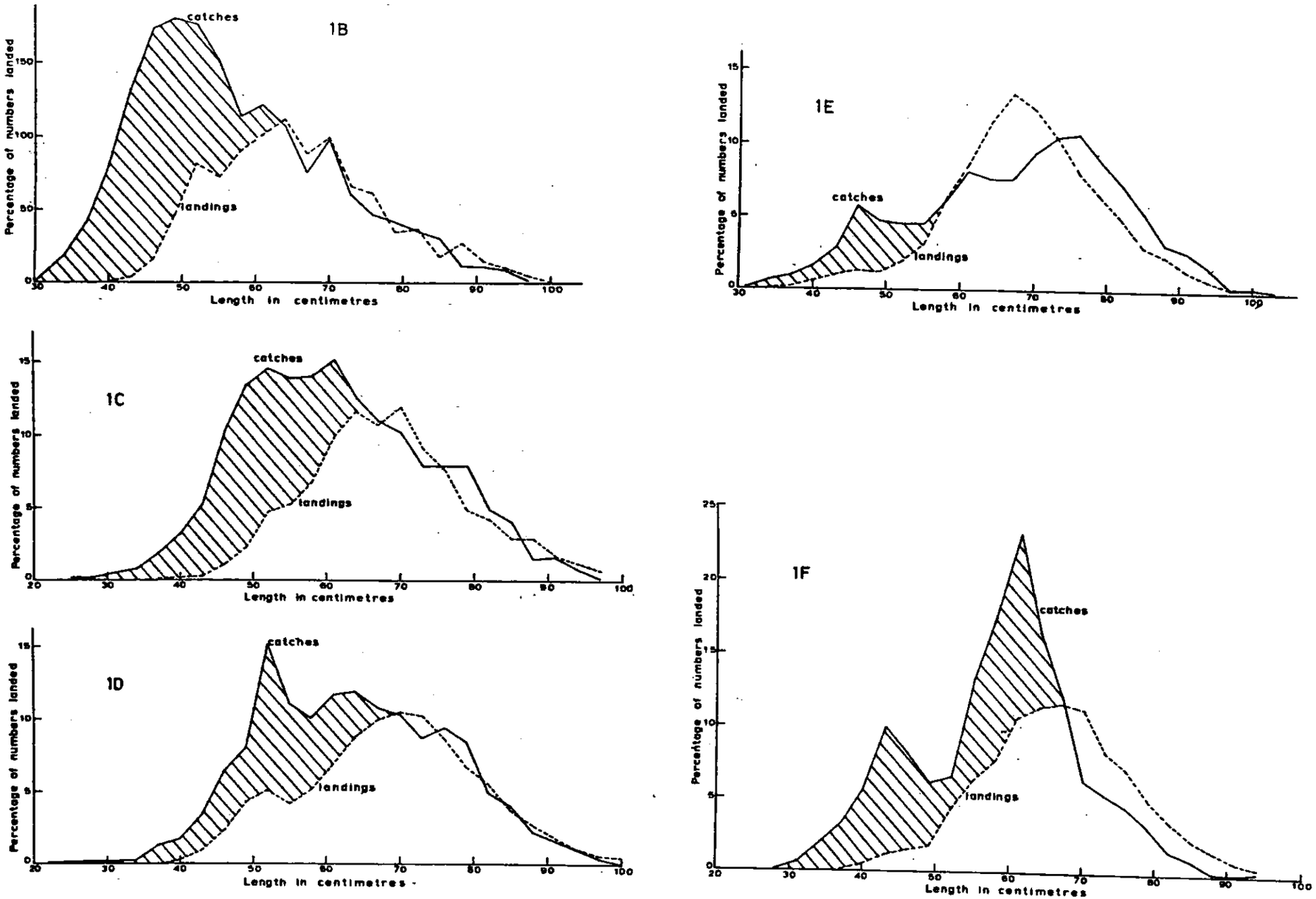

Fig. 5. Length compositions (percent) of catches by research trawlers and landings by commercial trawlers. Research data adjusted to make two sets agree for medium and large fish. The shaded area is the estimated discards. The 50% selection length for a 110-mm mesh is shown.

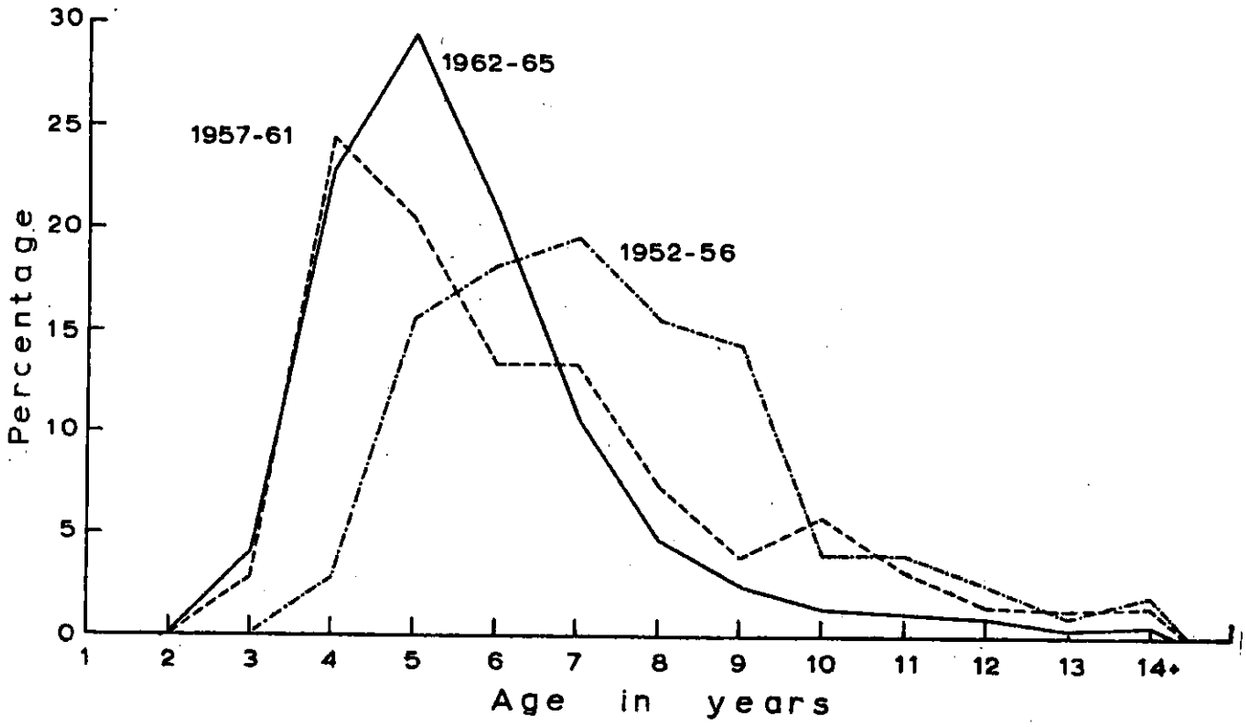

Fig. 6. Age composition of Danish offshore research catches.

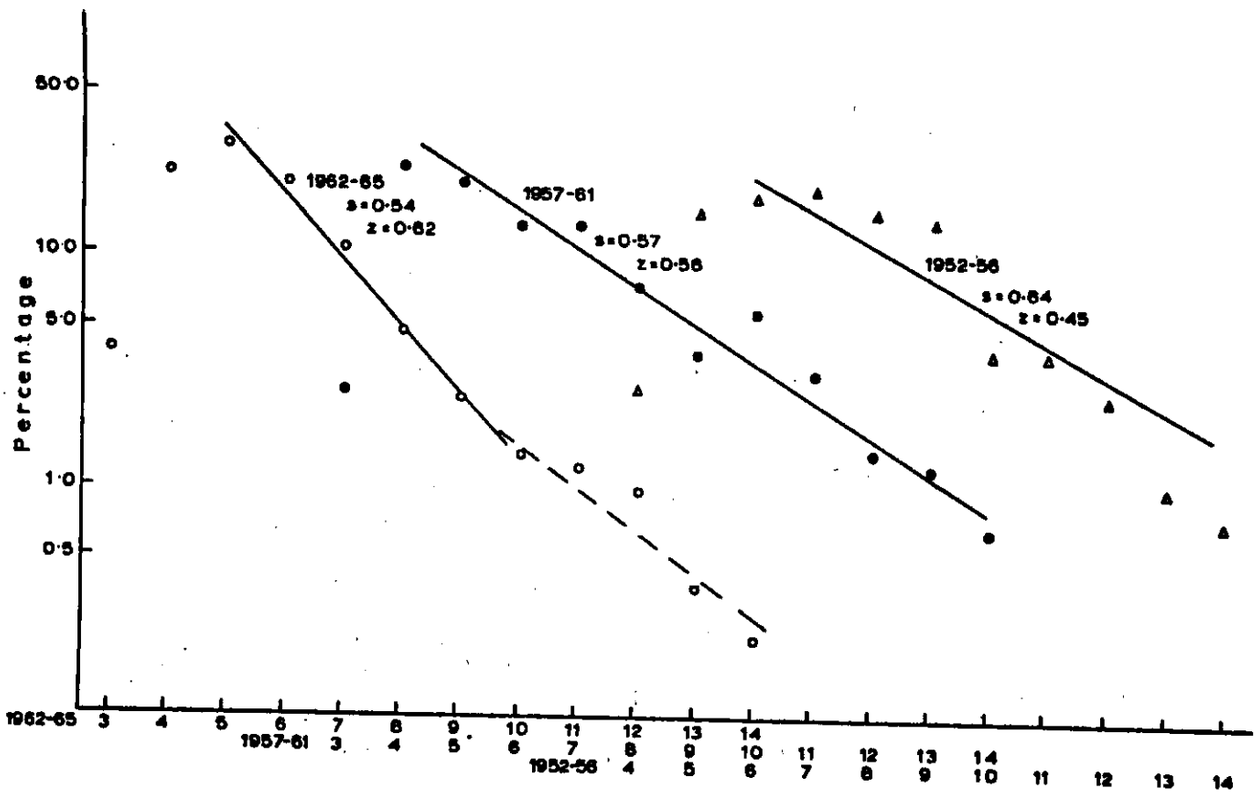

Fig. 7. Age composition of Danish offshore research catches (logarithmic scale), showing estimated mortalities.

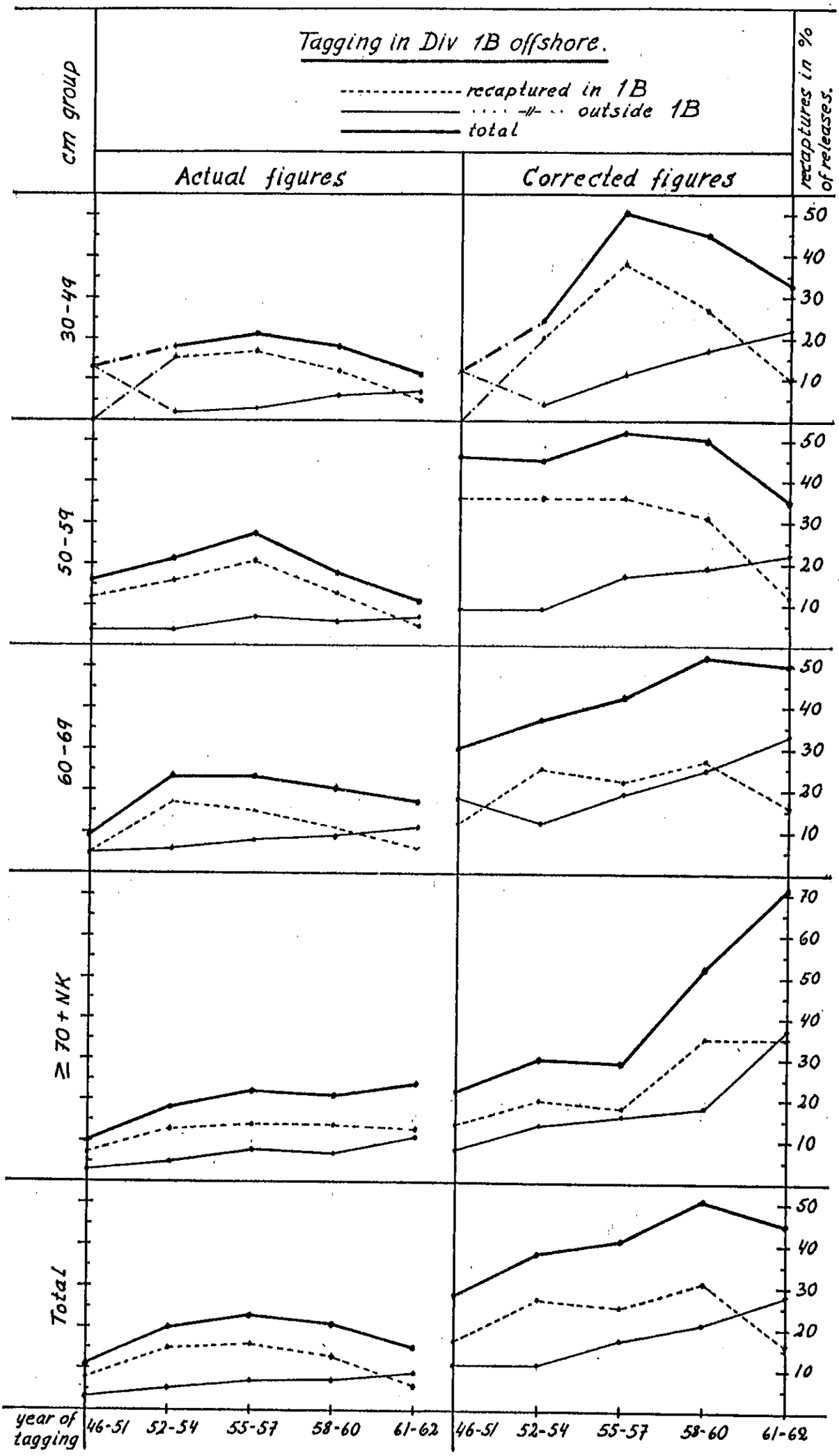

Fig. 8. Returns (left) and estimated recaptures (right) of cod of different sizes tagged in 1B during various periods, expressed as percentages of the initial number tagged. Estimated recaptures in 1961 and 1962 are subject to revision.

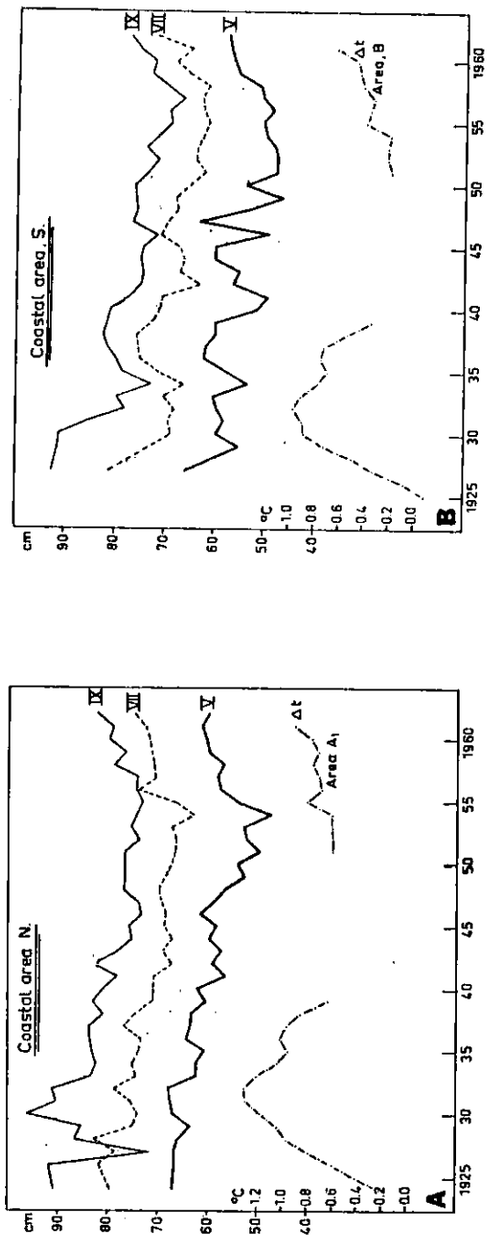

Fig. 9. Average length during each year of sampling, of 5-, 7- and 9-year-old cod at West Greenland.

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

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Appendix

ANNUAL MEETING - JUNE 1966

Report of meeting of Greenland Cod Working Group
Copenhagen, 21-25 February 1966

German Length-Weight-Data

A. Cod - round fresh - West Greenland

The mean weights for each cm were calculated from a curve of 5709 weight datas. The weight-samples are from the following months of the years 1953-1958, 1965 and 1966: February 2, March 1, April 2, May 5, June 3, July 2, August 2, September 1, October 1, November 2 and December 1 sample. The weights of 20 to 50 cm cod are the real live weights. The weights of all cod bigger than 50 cm were taken from gutted cod landed on ice (5 % mean loss of weight by pressure during 6 to 15 days storage in ice) and multiplied by a conversion factor of 1.24 to get the round fresh weight.

1	2	3	4	5	6
Length cm	Number of fish	Mean weight (if measured to cm below)	3 cm group	Mean weight (if measured to nearest cm)	3 cm group
20	2	75		70	
21	1	90	———	80	———
22	4	105	105	95	95
23	5	120	———	110	———
24	11	135		125	
25	9	155	153	145	143
26	10	170	———	160	———
27	11	195		180	
28	14	205	208	200	200
29	11	235	———	220	———
30	13	255		240	
31	15	280	282	265	267
32	18	310	———	295	———
33	19	340		325	
34	30	370	370	355	355
35	33	400	———	385	———
36	31	440		420	
37	38	480	480	460	460
38	44	520	———	500	———
39	53	560		540	
40	50	605	605	580	582
41	49	650	———	625	———
42	50	695		670	
43	54	740	742	715	717
44	55	790	———	765	———
45	53	840		810	
46	40	895	895	860	863
47	47	950	———	920	———
48	35	1015		980	
49	26	1090	1090	1050	1053
50	40	1165	———	1130	———
51	17	1240		1200	
52	32	1325	1325	1285	1285
53	36	1410	———	1370	———
54	44	1495		1450	
55	46	1580	1582	1540	1538
56	51	1670	———	1625	———
57	57	1755		1710	
58	50	1840	1842	1795	1795
59	58	1930	———	1880	———
60	161	2020		1975	
61	147	2110	2112	1065	1065
62	163	2205	———	2155	———

1	2	3	4	5	6
63	143	2300		2250	
64	151	2395	2400	2345	2348
65	146	2505	———	2450	———
66	142	2610		2555	
67	152	2725	2725	2665	2668
68	149	2840	———	2785	———
69	137	2960		2900	
70	138	3080	3082	3020	3022
71	146	3205	———	3145	———
72	130	3335		3270	
73	127	3470	3470	3400	3402
74	139	3605	———	3535	———
75	140	3740		3670	
76	126	3880	3887	3810	3813
77	118	4040	———	3960	———
78	145	4200		4120	
79	127	4370	4370	4280	4283
80	138	4540	———	4450	———
81	111	4710		4620	
82	131	4880	4880	4790	4790
83	150	5050	———	4960	———
84	135	5220		5135	
85	144	5395	5395	5305	5307
86	137	5570	———	5480	———
87	119	5765		5665	
88	103	5950	5952	5855	5855
89	113	6140	———	6045	———
90	86	6330		6235	
91	36	6530	6533	6430	6432
92	31	6740	———	6630	———
93	28	6960		6845	
94	24	7220	7223	7090	7095
95	22	7490	———	7350	———
96	14	7770		7620	
97	12	8060	8063	7910	7913
98	12	8360	———	8210	———
99	8	8670		8520	
100	13	8980	8980	8830	8830
101	6	9290	———	9140	———
102	1	9605		9455	
103	4	9930	9933	9775	9778
104	3	10265	———	10105	———
105	6	10610		10445	
106	1	10965	10967	10795	10797
107	2	11325	———	11150	———
108	1	11690		11510	
109	5	12060	12065	11875	11880
110	-	12445	" "	12255	" "
111	-	12840	———	12645	———
112	4	13240	13240	13040	13042
113	1	13640	———	13440	
114	1	14050		13850	
115	1	14465	14465	14260	14263
116	2	14880	———	14680	———
117	2	15320		15100	
118	2	15770	15773	15540	15540
119	-	16230	———	15980	———
120	3	16690		16440	
121	1	17150	17163	16920	16923
122	1	17650	———	17410	———
123	3	18180		17920	
124	1	18720	18720	18450	18453
125	1	19260	———	18990	———

B. Cod - fresh gutted - West Greenland

Datas from weighings at sea (cod less than 50 cm) and on land (cod more than 50 cm). For during storage in ice the cod loose in the mean 5 % of their weight, the datas of the gutted landed weight were raised to get the fresh gutted weight.

Length cm below (midpoint 0.5)	Number of fish	Mean weight g
20	2	70
21	1	80
22	4	92
23	5	105
24	11	120
25	9	135
26	10	150
27	11	165
28	14	180
29	11	195
30	13	215
31	15	240
32	18	265
33	19	295
34	30	325
35	33	355
36	31	385
37	38	420
38	44	455
39	53	490
40	50	530
41	49	570
42	50	610
43	54	650
44	55	690
45	53	735
46	40	780
47	47	830
48	35	885
49	26	950
50	40	1020
51	17	1090
52	32	1160
53	36	1225
54	44	1295
55	46	1370
56	51	1440
57	57	1515
58	50	1595
59	58	1665
60	161	1735
61	147	1810
62	163	1885
63	143	1960
64	151	2035
65	146	2115
66	142	2205
67	152	2300
68	149	2395
69	137	2490
70	138	2595
71	146	2705
72	130	2815
73	127	2930
74	139	3045
75	140	3165
76	126	3290
77	118	3415
78	145	3545
79	127	3675
80	138	3820
81	111	3970
82	131	4125
83	150	4280
84	135	4440
85	144	4600