INTERNATIONAL COMMISSION

FOR THE

NORTHWEST ATLANTIC FISHERIES

REDBOOK 1966

PART III SELECTED PAPERS FROM THE 1966 ANNUAL MEETING

Issued from the Headquarters of the Commission
Dartmouth, N. S., Canada

1967

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

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PART III

Note

References on p.205 should be numbered consecutively, as follows:

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1966

PART III

SELECTED PAPERS FROM THE 1966 ANNUAL MEETING

Note

REDBOOK 1966 appears in 3 books. The first book contains Part I, Proceedings of the Standing Committee on Research and Statistics. The second book contains Part II, Reports on Researches in the ICNAF Area in 1965. The third book contains Part III, Selected Papers from the 1966 Annual Meeting.

prepared for printing by Jean S. Maclellan

Issued from the Headquarters of the Commission

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1. Report of meeting of Greenland Cod Working Group[1]

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. Subsequently the Commission adopted a Panel 1 recommendation

(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 Assessment 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.Garrod	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).

[1]Submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/18

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 (Div.1A-1D) and a southern part (Div.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 Div. 1ABCD and 1EF 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 Div.1ABCD 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 1A is negligible but there has been some shift in the distribution of catches between 1B, 1C and 1D. Div.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 Div. 1ABCD in the late 1950s was balanced by the improvement in Div. 1EF 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 (1ABCD) and southern (1EF) 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 Div. 1ABCD. 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 (1965*a*) using a different technique, thus confirming in general 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 Div. 1ABCD was falling at a time when catches in Div. 1EF 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 1ABCD 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 1EF 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 Div. 1ABCD were high in 1954-56, and low in 1957-60. In Div. 1EF, 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 1ABCD, 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 in 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 faily 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 Div.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 Div. 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 Div.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 Div. 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 Div. 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 (1965*b*) 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, 1965*b*) 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 - 1ABCD) 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

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

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 of Subarea 1 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

(continued)

Table 1. (cont'd)

(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 Div. 1A, 1B, 1C and 1D.

Year	Total landings[1] (tons) A	Catch per[2] effort 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:

Portuguese dory vessels (catch per dory hour, June-August)	501-900 t (Sail+Motor) 501-900 t (Motor), 901-1800 t (Motor)
Portuguese trawlers (catch per hour's fishing May-June, August-Sept.)	901-1800 t
Spanish trawlers (catch per hour's 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%	·00.00%	100.00%

Table 4. Average annual numbers ('000s) of each length group of cod landed by trawlers in Div.1B-1F in 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	6	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 in Div.1B-1F in 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, Div.1A-1D, taken with handline 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	.5	0	-0.1	-0.4	-0.8	-1.8	-3.5	-6.7
	gain	.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	.7	0.2	0.6	1.2	2.2	3.4	5.4	8.1
	gain	.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	.5	0	0.1	0.2	0.1	-0.1	-0.5	-0.5
	gain	.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 Subarea 1, and the percentage taken in Div.1B.

Div.	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 1B	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 Div. 1B 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 Div. 1B.

	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

Table 12. Length-weight data on cod from Subarea 1 collected by Federal Republic of Germany.

A. Cod - round fresh - West Greenland

The mean weights for each cm were calculated from a curve of 5,709 weight data. 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 on ice) and multiplied by a conversion factor of 1.24 to get the round fresh weight.

1 Length cm	2 Number of fish	3 Mean weight (if measured to cm below)	4 3 cm group	5 Mean weight (if measured to nearest cm)	6 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	——

(continued)

Table 12 (cont'd)

1 Length cm	2 Number of fish	3 Mean weight (if measured to cm below)	4 3 cm group	5 Mean weight (if measured to nearest cm)	6 3 cm group
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	—	1860	—
60	161	2020		1975	
61	147	2110	2112	1065	1065
62	163	2205	—	2155	—
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	—

(continued)

Table 12 (cont'd)

1 Length cm	2 Number of fish	3 Mean weight (if measured to cm below)	4 3 cm group	5 Mean weight (if measured to nearest cm)	6 3 cm group
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	—

(continued)

Table 12 (cont'd)

1 Length cm	2 Number of fish	3 Mean weight (if measured to cm below)	4 3 cm group	5 Mean weight (if measured to nearest cm)	6 3 cm group
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

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

Length cm below (midpoint o.5)	Number of fish	Mean weight g	Length cm below (midpoint 0.5)	Number of fish	Mean weight g
20	2	70	30	13	215
21	1	80	31	15	240
22	4	92	32	18	265
23	5	105	33	19	295
24	11	120	34	30	325
25	9	135	35	33	355
26	10	150	36	31	385
27	11	165	37	38	420
28	14	180	38	44	455
29	11	195	39	53	490

(continued)

Table 12 (cont'd)

Length cm below (midpoint o.5)	Number of fish	Mean weight g
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

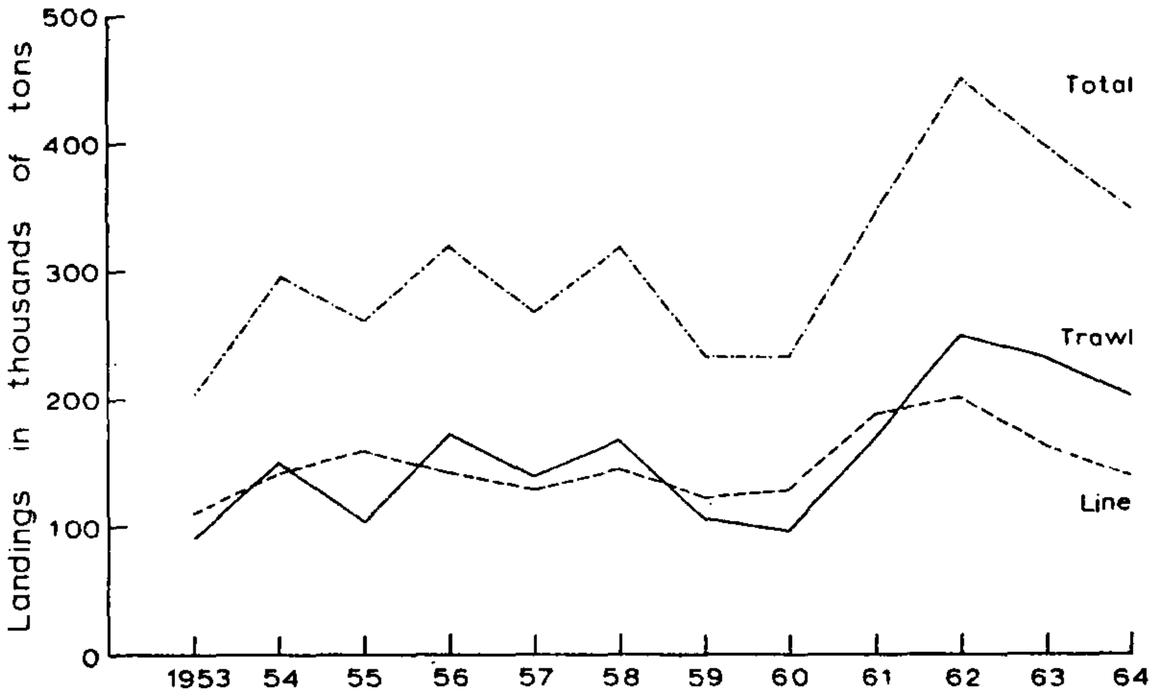


Fig. 1. Trends in total landings of cod from West Greenland (Subarea 1).

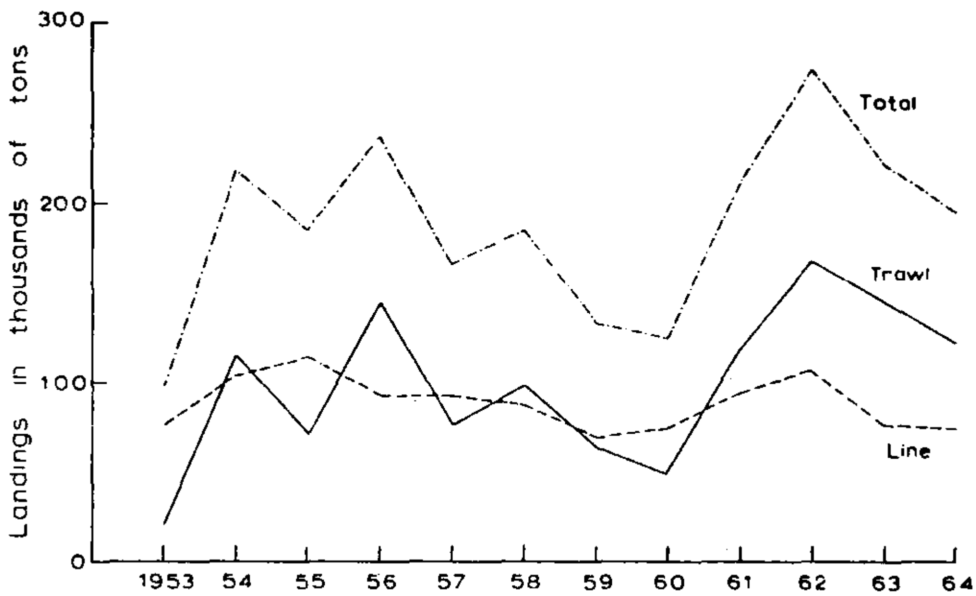


Fig. 2. Trends in total landings of cod from the northern divisions (1A-1D) of West Greenland (excluding landings from "divisions not known").

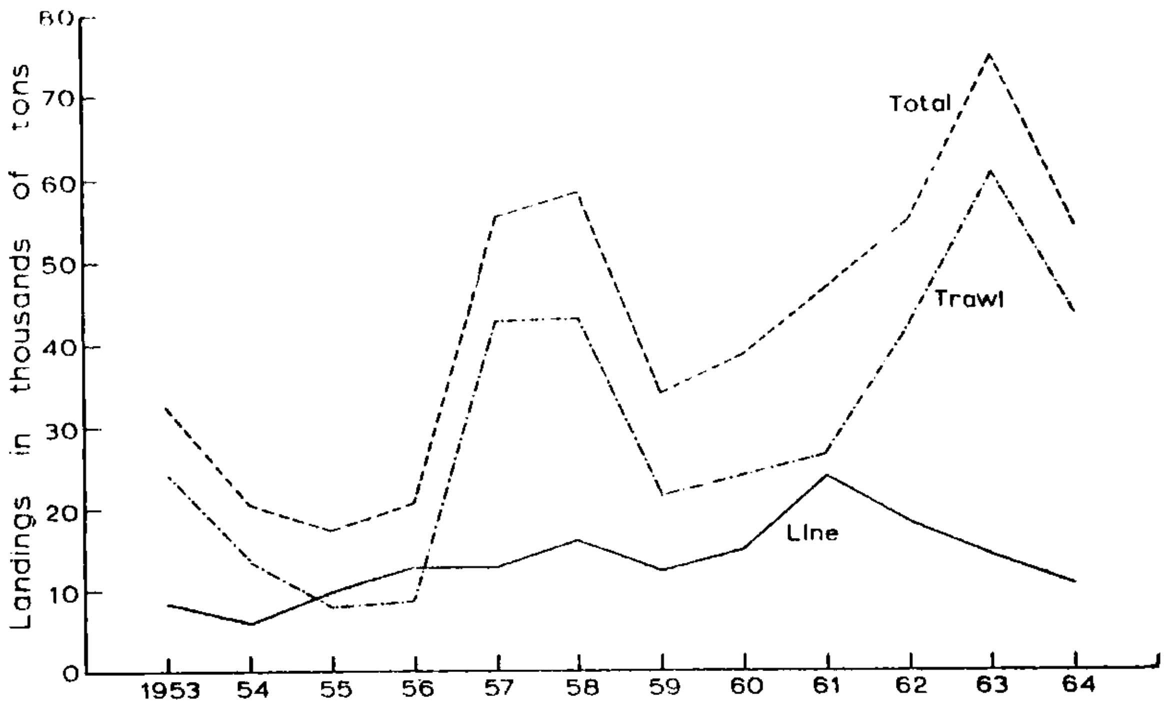


Fig. 3. Trends in total landings of cod from the southern divisions (1E, 1F) of West Greenland (excluding landings from "divisions not known").

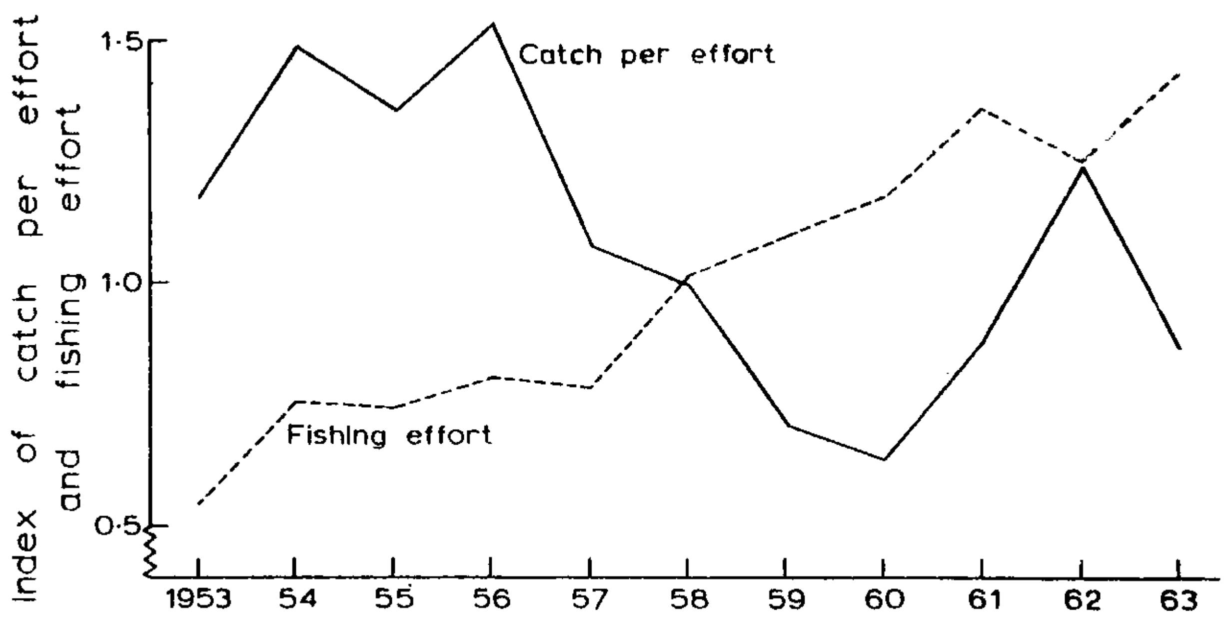


Fig. 4. Trends in catch per unit effort and estimated total effort in the northern divisions (1A-1D) of West Greenland.

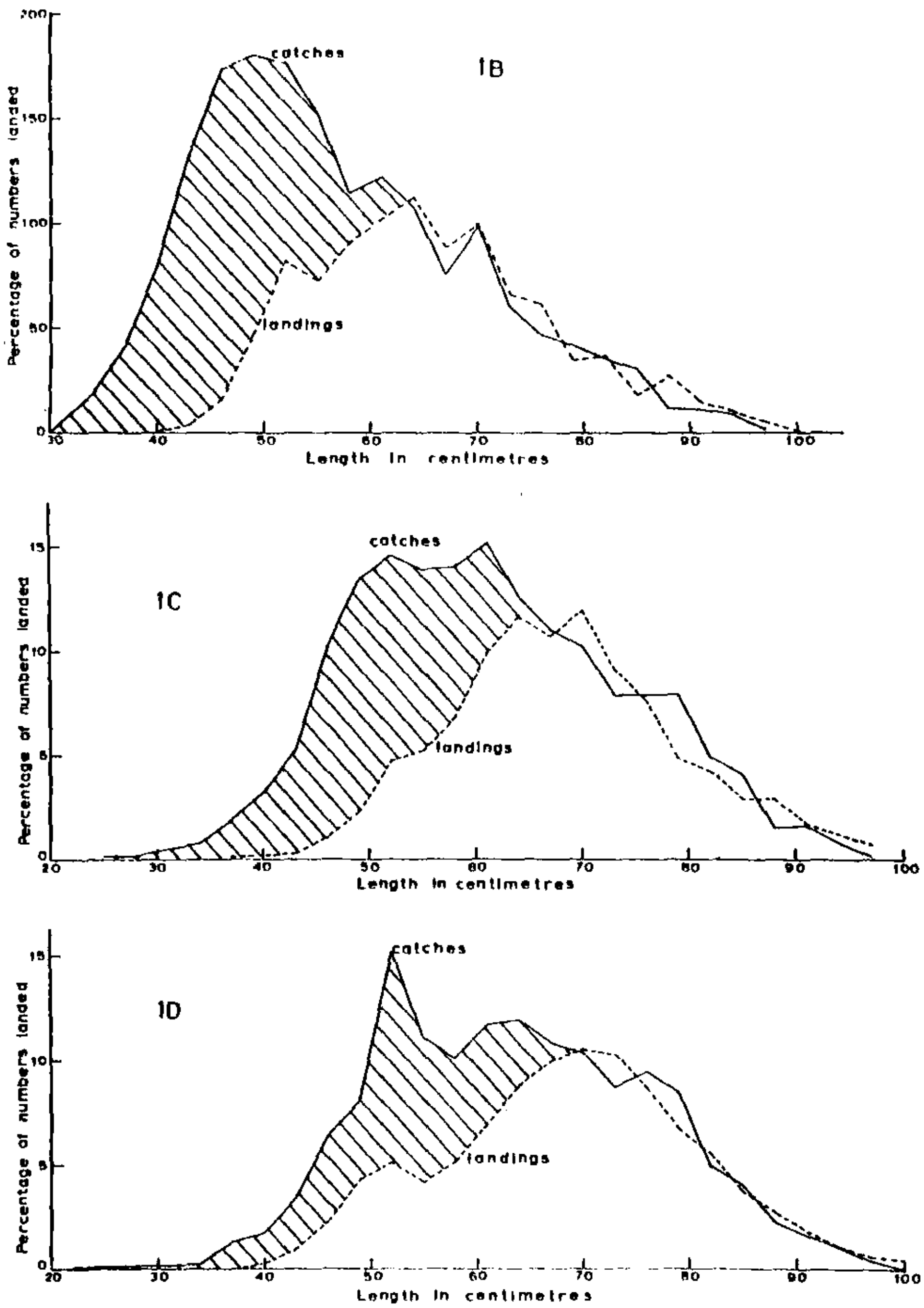
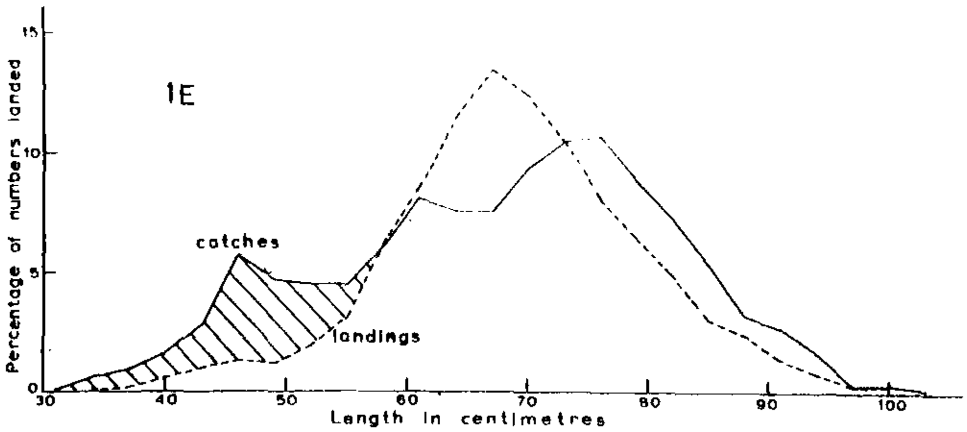


Fig.5a. Length compositions (%) of catches by research trawlers and landings by commercial trawlers in Div.1B-1D. Research data adjusted to make two sets agree for medium and large fish. The shaded area is the estimated discards. The 50% selection length for a 110-mm mesh is shown.



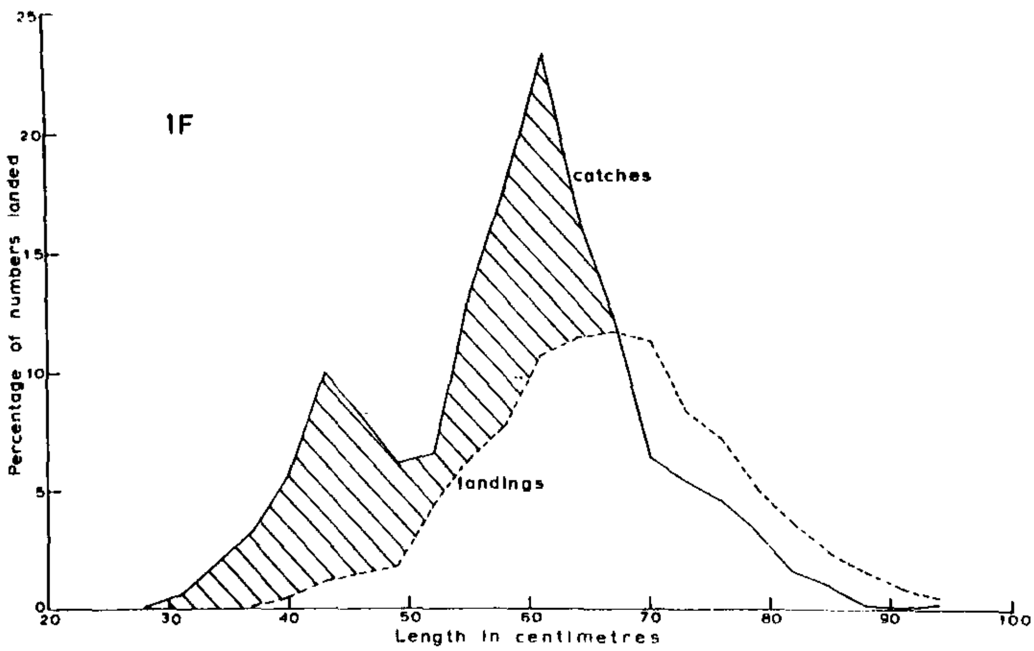


Fig. 5b. Length compositions (%) of catches by research trawlers and landings by commercial trawlers in Div. 1E-1F. Research data adjusted to make two sets agree for medium and large fish. The shaded area is the estimated discards. The 50% selection length for a 110-mm mesh is shown.

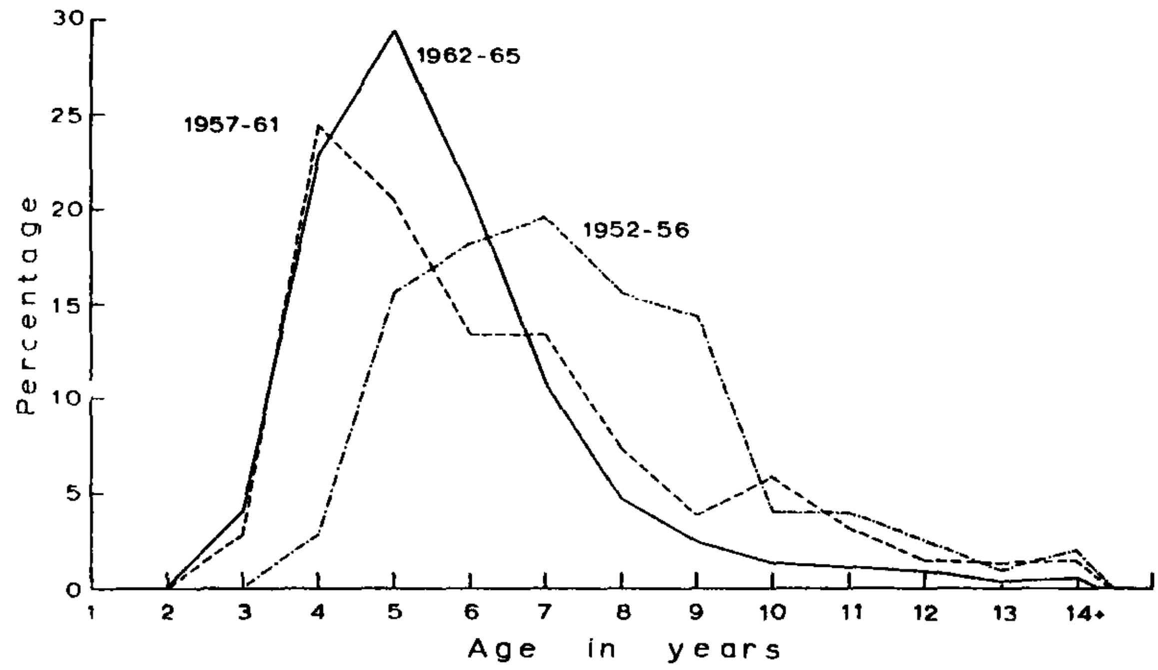


Fig. 6. Age composition of Danish offshore research catches.

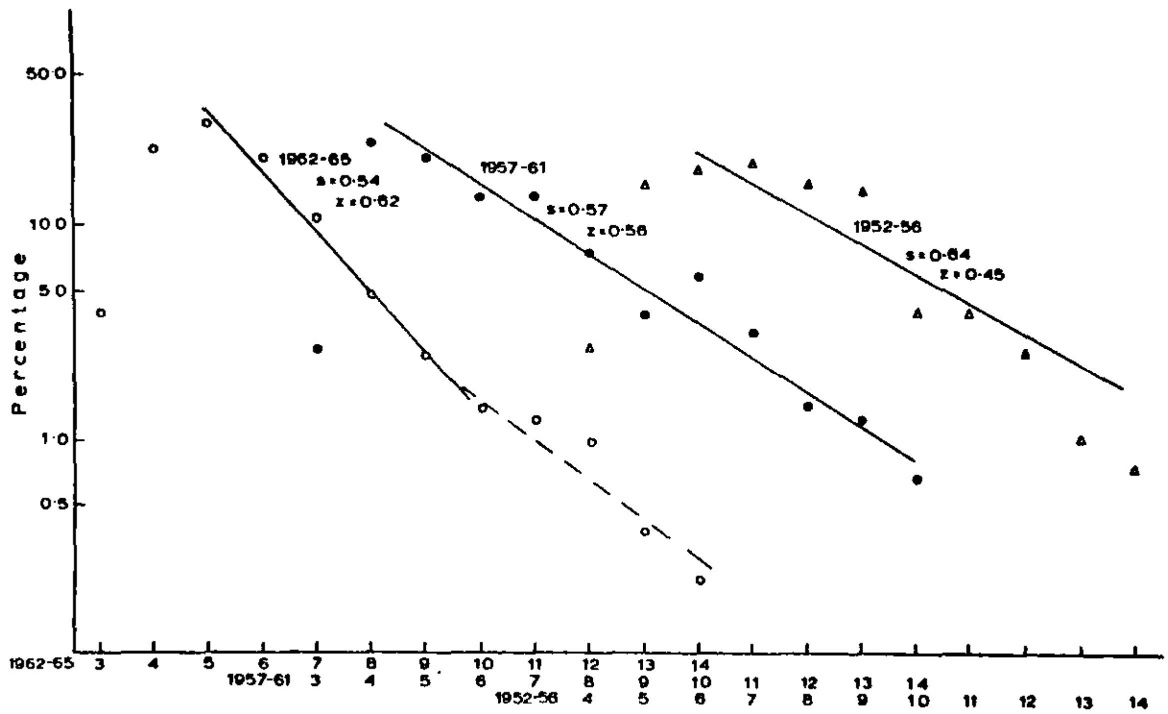


Fig. 7. Age composition of Danish offshore research catches (logarithmic scale), showing estimated mortalities.

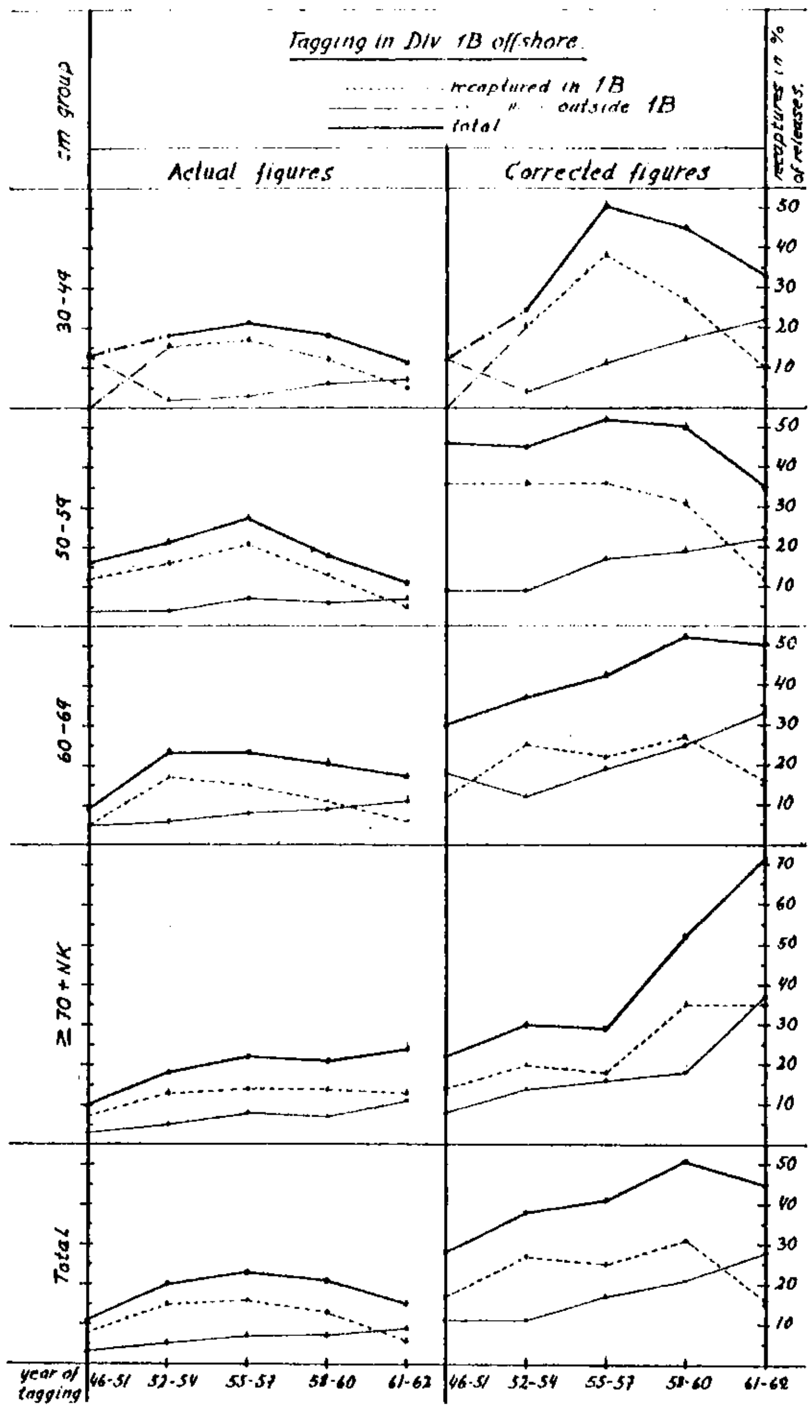


Fig. 8. Returns (left) and estimated recaptures (right) of cod of different sizes tagged in Div. 1B during various periods, expressed as percentages of the initial number tagged. Estimated recaptures in 1961 and 1962 are subject to revision.

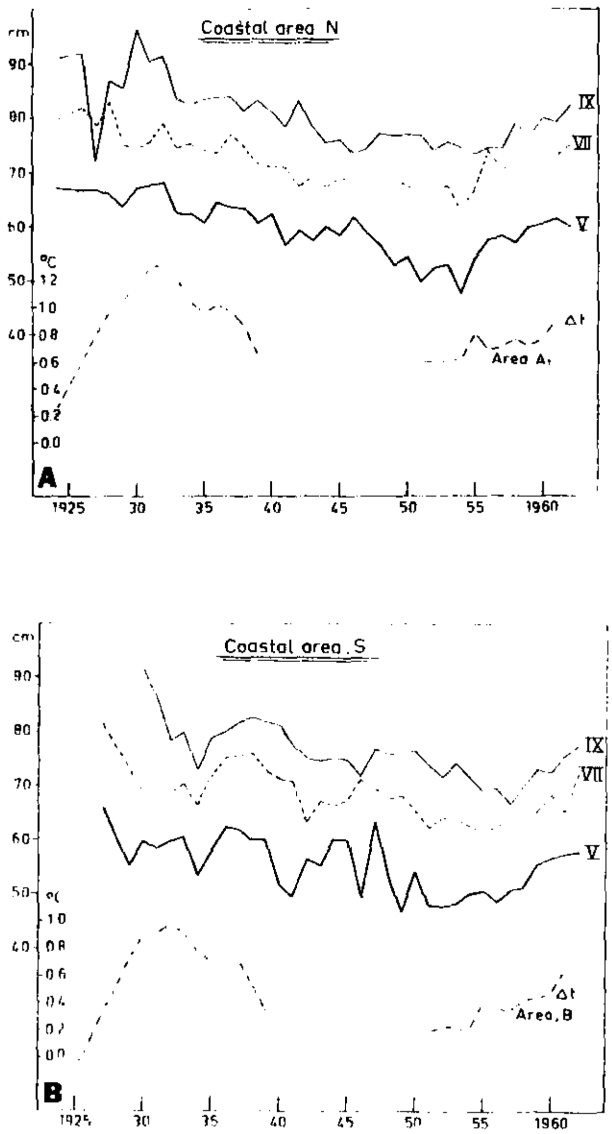


Fig. 9. Average length during each year of sampling of 5-, 7- and 9-year-old cod at West Greenland.

2. Further notes on the effect of possible regulatory measures on catches of Greenland cod[1]

by J.A.Gulland
Fisheries Laboratory
Lowestoft, Suffolk

Introduction

At the meeting of the Working Group on Greenland cod at Copenhagen in February 1966 considerable progress was made in assembling the basic data on catch, effort and size and age composition, and in making some estimates of the effect of possible regulatory measures - specifically increases in mesh size and closure of Div.1B (Store Hellefiske Bank) to fishing. However time did not permit the full discussion and computation of the various effects, and the present paper describes the results of some of the calculations carried out since the Copenhagen meeting. Since it has not been possible to discuss these results with the members of the working group, this report does not appear in its present form as part of the working group's report. It must be emphasized, however, that this paper is based almost entirely on material presented to and compiled by the working group, and on discussions during the group's meeting.

Length Compositions

The working group produced two sets of length composition figures from trawlers, the best estimates of the landings from the commercial trawlers and of the catches by research trawlers. These agreed well for the larger fish, but the research ship samples contained substantially more small fish, even though the gear and mesh size were those normally used commercially. The simplest explanation is that these small fish found in the research ship catches but not in the commercial landings are discarded at sea, and it is known from direct reports from the commercial trawlers that large quantities of fish are, at least on some occasions, discarded. However the quantity discarded, as estimated from the two length compositions, is in terms of the quantity landed (48% by numbers, or 18% by weight), which may be higher than the actual discard rate. The discards can be estimated for each division separately, giving rates of discards (as percentages of the numbers landed) ranging from 80% in Div.1B to 16% in 1E, the rates in 1C, D and F being 52%, 30% and 49% respectively.

The discards may be overestimated through bias in the estimates either of catches or landings. The commercial trawlers may in fact catch fewer very small fish (of the size that would be discarded) than the research vessels because they tend to avoid areas where such valueless fish are most frequent, and concentrate on the areas where the commercially valuable sizes predominate,

[1]submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/56

i.e. the figures in the working group report may give a correct picture of the size composition of the landings, but overestimate the quantity of very small fish which are caught and then discarded. Alternatively, the composition of the landings could be biassed. In the absence of comprehensive data from all types and nationalities of trawlers the working group had to analyse all trawlers together, so that the result is biassed towards those classes of trawlers from which most samples were obtained - that is particularly English and German vessels landing fish on ice. The previous report (Beverton and Hodder, 1962, Figure 4.3) showed that there were considerable differences between the sizes of fish taken by trawlers of different nationalities, with the English, and particularly German, trawlers landing bigger fish. Little up-to-date information is available on the landings of the other countries to show whether these differences still exist in the recent landings, but it is likely that they do. It is known (A. Meyer, personal communication) that the German factory ships which fillet and freeze their catch at sea can use fish that are smaller than is acceptable for the market for fish on ice, so that the size composition of the German fresh fish landings is not typical of the retained catch of the German fleet as a whole. Thus it is possible that the tables of trawl-caught landings in the report underestimate the proportion of small fish in the trawl landings.

With all the uncertainties it is not worth attempting to obtain a single best estimate of the size compositions of trawl catches, landings, and discards, and accordingly four alternative hypotheses were used:

(A) That the working group's estimate of the trawl landings is also the trawl catches, and that there are no discards. This is certainly unrealistic, and gives the least favourable estimate of the effect of any measure to protect the small fish.

(B) That the trawl landings are as for (A), but the commercial <u>catches</u> are the same as the research catches, *i.e.* the discards are 48% by number.

(C) That the trawl landings are as for (A), and that the discards are 20% by numbers, these being the smaller fish among those estimated as discarded in (B). This is possibly the most realistic hypothesis.

(D) That the commercial trawl landings have the same length composition as the research catches, *i.e.* there are no discards, and the recent tendency for commercial markets to accept small fish has been taken to the extreme.

The length compositions of the landings by trawlers and liners, and of the discards by trawlers under hypotheses (B) and (C), are given in Table 1.

Mesh Assessments

These have been made by the same method as in previous reports, using a selection factor of 3.3, and a selection range (25%-75% point) of 10 cm. In estimating the loss due to natural mortality between the times of release and of reaching the retention size of the new larger mesh, it has been assumed that M = 0.3, and that successive meshes from 110 mm up to 170 mm would delay the onset of fishing mortality by 0.1, 0.2, 0.3, 0.5, 0.8 and 1.0 years respectively.

Closure of Div.1B

The original Danish proposal only mentioned closure of the area to trawling. The fishery in 1B is however roughly equally divided between trawl and line (mainly dory vessel) fishing, and, as Tables 4 and 5 of the working group's report show, small fish (under 50 cm) are at least as abundant in the line catches as in the trawl catches; for both gears these small fish are most abundant in the landings from Div.1B, though they occur in smaller numbers in the landings from all divisions of Subarea 1. Thus the closure of 1B and the diversion of the effort to other areas should reduce the proportion of small fish caught, and thus benefit the catches in the long term; this benefit should apply for closure either to trawling or line fishing or both. There is however the possibility that in practice, if the area is closed to only one gear, say trawl, then it will become more attractive to the line fishermen, not only because of possible increase in the stocks, but also due to elimination of direct interference from trawlers; thus the line fishery in 1B may increase if the division is closed to trawling, so that the calculations below, based on the assumption that a closure will cause no change in the pattern of fishing other than a redistribution of Div.1B's present trawling effort, are likely to overestimate the effect of such closure to a single gear.

Some of the general problems involved in assessing the effect of closure of a particular area have been set out in the working group report (*e.g.* the estimation of the size composition of the catches, the movements of the fish, and the redistribution of the fishing effort). The report concluded that the study of the effect of the redistributed effort could be simplified without serious error by assuming that it remained at West Greenland, any overestimate of the effort at Greenland (and hence underestimate of the catch per unit effort) being balanced by an underestimate of the effort elsewhere. The redistribution would result in a reduction in the total landings, the two estimates used being reductions of 5% and 15% of the landings at present taken in 1B.

The estimated catches immediately after the redistribution are given in Tables 2A and 2B for the two assumed values of the loss in redistributing. This shows the reduction in both weight and numbers landed, following closure to either trawl or line, and also the reduction in the numbers discarded (assuming no change in the proportion discarded in each length group) if 1B were closed to trawling. For instance if the division were closed to trawling, and discards were 20% by numbers (hypothesis C), then if there were a 5% loss to the trawlers in redistributing, the numbers landed would be reduced by 4.9 million fish and the numbers discarded by 5.9 million. Ultimately a proportion E of these would be caught, so that the long-term catches, in numbers, would be greater than the landings immediately after closure by a proportion $\frac{E \times 10.8}{N_K}$, where N_K = numbers caught immediately after closure, in millions. The increase in weight caught might not be the same, because the changed distribution of fishing might change the average size of fish caught outside 1B; however, as explained in the working group report, the average size may be assumed, as a first approximation, to remain unchanged (the smallest fish would not be affected, the medium fish would increase, due to better immigration from 1B, while the larger fish would also benefit from the better immigration, but would be reduced by the heavier fishing outside 1B). Thus, the gross long-term change in weight might also be given by $Q = \frac{E \times N_R}{N_K}$, where N_R is the immediate reduction in numbers caught following closure of 1B to trawling (10.8 million in the example above). The net long-term effect G, would, as when assessing the effect of mesh change, be given by

$$(1 + G) = (1 + Q)\ (1 - L)$$

where L = immediate loss, = 0.05 or 0.15 x $\frac{W_B}{W_T}$, where

W_B = landings from 1B by regulated gear

W_T = total landings by that gear.

In this formula there is no correction for loss due to natural mortality, analogous to that in the assessment of mesh change for the mortality of small fish during the period between being released and growing to the size at which they will be retained by the larger mesh. The effect of closure of an area is not so easy to assess - fewer fish are caught, but there is not a discrete group of particular fish which can be considered as being 'released', whose fate can be followed. Certainly the small fish (and in fact fish of all sizes) at present liable to be caught in Div.1B would be reduced by natural mortality before they had moved to other divisions and become liable to capture; however the fish already present in the other divisions would be exposed to a greater fishing intensity (because of the diverted effort), and hence a bigger proportion would be caught. That is, instead of writing

$$Q = \frac{E \times N_R}{N_K}$$

the more correct formula is

$$Q = \frac{E' \times N_R'}{N_K}$$

where $E < E'$ = new exploitation rate in the divisions other than 1B,

$$N_R' = N_R\, e^{-Mt} < N_R,$$

and t = average time for fish to move from 1B to the division open to fishing. The two corrections to E and N_R act in opposite directions, so there may not be too much error involved in ignoring them. Another term should also be introduced for the change in yield from the fish already present outside 1B, following the increased intensity of fishing on these grounds. Again this is likely to be small for a heavily fished stock with a fishing effort around the flat part of the yield/effort curve, and as a first approximation it has been ignored.

Results

The results of the assessments of both mesh change and of closure of Div.1B to trawl or line or both are set out in Table 3. This is presented in four parts, A-D, corresponding to the possible hypotheses regarding the discard rate by trawlers. Each part is given in three sets of columns, corresponding to the range of possible values of E. Thus each set of three columns, giving the estimates of the long-term changes in catches by trawl, line, and total, corresponds to a possible state of affairs at West Greenland, and comparisons between the effects of different regulatory measures should be made for entries in the same column.

An examination of the table shows that nearly all the entries are positive, *i.e.* in most situations there will be some long-term gain to both gears from any of the conservation actions considered. The exceptions are: (a) when there are no discards - the catch by trawlers (and for large meshes, the total catch) would be reduced; (b) for moderate discards, a 170 mm mesh might cause loss to trawlers; and (c) if diversion from 1B caused a large initial loss, there might be a long-term loss to liners if the division was only closed to line fishing. This last situation is of course unaffected by discarding.

When there are no discards, the best mesh size, so far as total landings are concerned, is at least as large as 130 mm (for E = 0.5), and possibly as great as 160 mm (E = 0.8), giving long-term gains of 1-2%; these gains are less than would be obtained from closure of 1B to line fishing, or all fishing, or, if the loss from redistribution was small, from closure to trawling. The gain from total closure might be as much as 5%. Trawl landings might benefit very slightly from a moderate increase in mesh size and the long-term effect (either gain or loss) would be very small (less than 1%) for mesh changes up to 130-140 mm. Losses would be appreciable for very large meshes. Trawl landings would decrease if Div.1B were closed only to trawling, but would gain (up to 4%) from closure to liners only, or to both lines and trawl. Catches by liners would, as usual, benefit from any increase in trawl mesh, or from closure of 1B to trawls (which would give about the same benefit as a mesh size of *ca.* 145 mm).

They would be reduced by closure of 1B to liners.

If there are discards (hypotheses B and C), the likely benefits to all types of gear would be considerably larger, especially as a result of larger mesh sizes. The total landings would increase with increasing mesh size at least up to 150 mm, and probably up to 170 mm, where the benefit might be as much as 15%; closure of Div.1B to either gear would give a benefit; closure to all gears would give about the same benefit (5-10%) as the use of 130-150 mm meshes, and probably considerably less than from the use of a 170 mm mesh. Trawlers also would certainly benefit from the use of larger mesh sizes - up to probably 170 mm if the discard rate is high (up to 10% gain), but if the discard rate is low the gain to the trawlers (2-6%) might decrease for increases in mesh size beyond 140-150 mm. Landings from liners would benefit very greatly from the use of very large meshes (possibly up to 25% from a 170 mm mesh), and the benefit to liners of closure of 1B would be about the same as that from the use of a trawl mesh of about 130 mm.

Finally if discards are ignored, and assessments made of the effect on commercial catches (hypothesis D), the results show that the total catches would increase with increasing mesh size up to at least 150 mm, and probably 170 mm, with gains of probably around 5% for 170 mm. The total catch would also gain from closure of 1B to either trawl or line, the benefit from total closure being greater than from any mesh increase if the fishing rate is low, but about the same as from a 170 mm mesh at the more probable fishing rates. Trawl catches would benefit from mesh increases, probably up to 130 mm (1-2% gain), and would receive about the same benefit from closure of 1B to trawling. They would receive greater benefit from closure to lines, or to both trawl and lines (*ca.* 5% gain). Catches by line would gain from any increase in mesh size (up to 20% from a 170 mm mesh) and, to a smaller extent (about the same as from a 130 mm mesh) from closure of 1B to trawling.

From this it appears that the relative benefits of mesh increase and closure of Div.1B depend on the situation, especially concerning discards. The biggest benefits occur if discarding is heavy; this occurs, to a varying extent, in all divisions, so that the wastage by discarding will not be eliminated by closure of particular divisions, even though, since the proportion discarded is greatest in 1B, the wastage can be reduced by closure. Discarding is most effectively reduced by using larger mesh sizes, even though the spread in the curves of both mesh selection and percentage discarded against length means that the problem is not quite the simple matter of using a mesh size that will release all potential discards, and retain all the rest. However a suitable mesh size will release most of the discards with not too great an initial loss of marketable fish; thus when discards are frequent the best regulatory measure is a larger mesh. When there are no discards a larger mesh involves initially some loss of small fish, and unless this loss is substantial, at least in terms of numbers, the long-term gain cannot be substantial; however it may sometimes be possible to divert fishing from areas of mainly small fish to areas of large fish, with little initial loss. Thus, when there are no discards, and especially when the fishing rate (*i.e.* E) is fairly low, then the most effective regulation may be by diversion from nursery grounds, *e.g.* by closing Div. 1B.

To some extent this analysis exaggerates the difference between the two regulatory measures; the method used for the assessment of the effects of increasing mesh sizes makes no allowance for any resulting change in the distribution of the fleet. Particularly when initial losses are high the trawlers will tend to move away from the small-fish grounds to other areas and so make up at least part of their initial losses even before the released fish grow; this would indirectly achieve much the same effect as the direct closure of the nursery grounds.

The analysis so far has considered the two possible methods (closure and mesh increase) independently; it is quite possible that both could be introduced, either simultaneously or in succession. No precise assessments can be made of the double effect, because, as mentioned in the previous paragraph, mesh increase is likely to change the distribution of fishing, while the closure of one division is likely to change the size composition of the fish in the remaining, fished, divisions. However, to a first approximation the effect of a mesh change after closure of 1B will be given by carrying out an assessment on the present catches or landings from the other divisions, *i.e.* ignoring any change in size composition due to the closure. The results of these calculations showed that, with or without an allowance for discards, the long-term benefits to a fishery in which the size composition (and discard rate, if any) is that of the present fishery in Div.1C to 1F are two-thirds of the benefits to a fishery in which the size composition (and discard rate, if any) is that of the catches in Subarea 1 as a whole (because of the smaller proportion of small fish outside 1B). This, especially when discards are high, still means that benefits could be substantial, and therefore there is a benefit from applying both conservation measures. For instance, taking the most likely present situation, with 20% discards and E = 0.7, the following are the estimated long-term effects:

Conservation Measure	Long-term gain, % Trawl	Line	Total
150 mm mesh	4.9	9.2	6.7
Closure of 1B to all gears (assuming 5% loss)	6.9	6.2	6.6
Extra effect of 150 mm mesh after closure	3.8	6.9	4.9
Total effect of both closure and 150 mm mesh	11.0	13.5	11.8

Summary

The calculations and discussions of the Working Group on Greenland Cod are continued and estimates made of the immediate and long-term effects of

closure of Div.1B (Store Hellefiske Bank) to trawlers and liners, and of the use of larger trawl meshes. Various rates of discards, and ratios of fishing to total mortality are assumed. Under virtually all conditions there will be some gain to both gears through protection of the small fish, either by closure of Div.1B or the use of larger meshes, or both. The magnitude of the gain depends on the precise rate of discards, but this is probably at least moderately high (20% by numbers), in which case closure of 1B to all gears or the use of a 150 mm mesh would give a long-term gain of 6-7%, and both measures together would give a gain of around 12%.

Reference

Beverton, R.J.H. and V.M.Hodder (eds.), 1962. Report of working group of scientists on fishery assessment in relation to regulation problems. Supplement to *Annu. Proc. int. Comm. Northw. Atlant. Fish.*, 11: 1-81.

Table 1. Present catches and landings of cod, in thousands of fish, from Div.1B and other divisions of Subarea 1.

	Div.1B				Other divisions				Total			
	Trawl			Line	Trawl			Line	Trawl			Line
	Land-ings	Discards Hyp.B	Discards Hyp.C	Land-ings	Land-ings	Discards Hyp.B	Discards Hyp.C	Land-ings	Land-ings	Discards Hyp.B	Discards Hyp.C	Land-ings
<24						18	18			18	18	
24-32		105	105	22		296	296	8		401	401	30
33-41	36	2,940	2,940	987	216	2,373	2,373	286	252	5,313	5,313	1,273
42-50	2,748	8,823	4,890	5,038	2,807	8,072	4,474	1,169	5,555	16,895	9,364	6,207
51-59	6,353	4,358	-	6,185	8,365	9,380	-	3,645	14,718	13,738		9,830
60-68	5,246	-	-	5,025	16,820	-	-	626,723	22,066			11,748
69-77	3,546	-	-	3,036	16,039	-	-	7,779	19,585			10,815
78-86	1,520	-	-	1,822	7,534	-	-	5,758	9,054			7,580
87-95	669	-	-	838	2,805	-	-	2,322	3,474			3,160
96-104	119	-	-	292	562	-	-	486	681			778
105+	17	-	-	128	77	-	-	165	94			293
Total	20,254	16,226	7,935	23,373	55,225	20,139	7,161	28,341	75,479	36,365	15,096	51,714
Weight	50,665			56,125	173,225			99,959	223,890			156,084

Table 2. Catches and landings of cod in Subarea 1 immediately after closure of Div. 1B.

Length (cm)	Numbers (thousands)				Change			
	Trawl			Line	Trawl			Line
	Landings	Discards Hyp. B	Discards Hyp. C		Landings	Discards Hyp. B	Discards Hyp. C	
	A. Assuming a 5% loss of catch to diverted ships							
< 24		23	23			5	5	
24-32		378	378	12		-23	-23	-18
33-41	276	3,032	3,032	439	24	-2,281	-2,281	-834
42-50	3,587	10,315	5,717	1,793	-1,968	-6,580	-3,647	-4,414
51-59	10,690	11,987		5,589	-4,028	-1,751		-4,241
60-68	21,494			10,309	-572			-1,439
69-77	20,496			11.928	911			1,113
78-86	9,628			8,829	574			1,249
87-95	3,585			3,561	111			401
96-104	768			745	37			-33
105+	98			253	4			-40
Total	70,572	25,735	9,150	43,458	-4,907	-10,630	-5,946	-8,256
Weight (tons)	221,364			153,277	-2,525			-2,806
	B. Assuming a 15% loss of catch to diverted ships							
< 24		22	22			4	4	
24-32		370	370	12		-31	-31	-18
33-41	270	2,963	2,963	422	18	-2,350	-2,350	-851
42-50	3,505	10,079	5,586	1,727	-2,050	-6,816	-3,778	-4,480
51-59	10,445	11,712		5,384	-4,273	-2,026		-4,446
60-68	21,001			9,931	-1,065			-1,817
69-77	20,026			11,491	441			676
78-86	9,407			8,506	353			926
87-95	3,502			3,430	28			270
96-104	702			718	21			-60
105+	96			244	2			-49
Total	68,954	25,146	8,941	41,865	-6,525	-11,219	-6,155	-9,849
Weight (tons)	216,290			147,665	-7,600			-8,419

Table 3. Estimated immediate and long-term changes in landings from Subarea 1 (as percentages of present landings) following mesh changes, or closure of Div.1B to fishing.

	Long-term changes									Imm. Loss (%)	
	E = 0.5			E = 0.7			E = 0.8				
	Trawl	Line	Total	Trawl	Line	Total	Trawl	Line	Total	Reg. Gear	Total
HYPOTHESIS A (no discards)											
Mesh change											
To 110 mm	0	0.1	0	0	0.2	0	0	0.2	0	0.1	0.1
" 120 mm	-0.1	0.4	0.1	0.1	0.6	0.3	0.1	0.6	0.3	0.5	0.3
" 130 mm	-0.4	0.9	0.2	0	1.2	0.5	0.2	1.4	0.7	1.2	0.7
" 140 mm	-0.8	1.5	0.1	-0.2	2.2	0.7	0.1	2.5	1.0	2.3	1.4
" 150 mm	-1.8	2.5	-0.1	-0.9	3.4	0.9	-0.4	3.9	1.3	4.2	2.5
" 160 mm	-3.5	3.9	-0.5	-2.1	5.4	1.0	-1.4	6.2	1.7	7.2	4.2
" 170 mm	-6.7	5.8	-1.6	-4.6	8.1	0.5	-3.6	9.3	1.6	11.8	7.0
Closure of Division 1B, assuming a redistribution loss of 5%											
Closure to trawl	0.3	1.5	0.7	0.8	2.1	1.4	1.2	2.4	1.7	1.1	0.7
Closure to line	2.5	0.7	1.7	3.5	1.7	2.7	4.0	2.1	3.2	1.8	0.7
Total closure	2.8	2.1	2.5	4.4	3.7	4.1	5.2	4.5	4.9	1.4	1.4
Closure of Division 1B, assuming a redistribution loss of 15%											
Closure to trawl	-1.5	2.0	-0.1	-0.7	2.8	0.7	-0.3	3.2	1.1	3.4	2.0
Closure to line	3.0	-2.6	0.7	4.2	-1.4	1.9	4.8	-0.9	2.5	5.4	2.2
Total closure	1.3	-0.7	0.5	3.2	1.2	2.4	4.2	2.2	3.4	4.2	4.2

Table 3 (continued)

	Long-term changes									Imm. Loss (%)	
	E = 0.5			E = 0.7			E = 0.8				
	Trawl	Line	Total	Trawl	Line	Total	Trawl	Line	Total	Reg. Gear	Total
HYPOTHESIS B (Discards = differences between research and commercial (= 48% by number))											
Mesh change											
To 110 mm	1.1	1.3	1.2	1.6	1.8	1.8	1.9	2.0	1.9	0.2	0.1
" 130 mm	3.5	4.8	4.1	5.4	6.7	6.0	6.4	7.7	7.0	1.2	0.7
" 150 mm	5.0	9.4	6.8	8.6	13.1	10.5	10.4	15.0	12.3	4.0	2.4
" 170 mm	3.8	16.1	8.2	9.6	22.6	14.2	12.5	25.8	17.2	11.6	6.8
Closure of Division 1B, assuming a redistribution loss of 5%											
Closure to trawl	3.5	4.7	4.0	5.3	6.6	5.9	6.4	7.5	6.9	1.1	0.7
Closure to line	2.5	0.7	1.7	3.5	1.7	2.7	4.0	2.1	3.2	1.8	0.7
Total closure	6.0	5.3	5.7	8.8	8.1	8.5	10.3	9.6	10.0	1.4	1.4
Closure of Division 1B, assuming a redistribution loss of 15%											
Closure to trawl	1.8	5.4	3.3	3.9	7.5	5.3	4.9	8.6	6.4	3.4	2.0
Closure to line	3.0	-2.6	0.7	4.2	-1.4	1.9	4.8	-0.9	2.5	5.4	2.2
Total closure	4.6	2.6	3.8	7.8	5.8	7.0	9.4	7.4	8.6	4.2	4.2

Table 3 (continued)

	Long-term changes									Imm. Loss (%)	
	E = 0.5			E = 0.7			E = 0.8				
	Trawl	Line	Total	Trawl	Line	Total	Trawl	Line	Total	Reg. Gear	Total
HYPOTHESIS C (Discards = 20% by numbers)											
Mesh change											
To 110 mm	0.9	1.1	1.0	1.3	1.5	1.4	1.5	1.7	1.6	0.2	0.1
" 130 mm	2.4	3.7	2.9	3.9	5.1	4.4	4.6	5.9	5.1	1.2	0.7
" 150 mm	2.3	6.6	4.1	4.9	9.2	6.7	6.1	10.6	8.0	4.0	2.4
" 170 mm	-0.7	11.1	3.5	3.3	15.6	7.6	5.3	17.8	9.7	11.6	6.8
Closure of Div. 1B, assuming a redistribution loss of 5%											
Closure to trawl	2.1	3.3	2.5	3.5	4.6	3.9	4.1	5.3	4.6	1.1	0.7
Closure to line	2.5	0.7	1.7	3.5	1.7	2.7	4.0	2.1	3.2	1.8	0.7
Total closure	4.6	3.9	4.3	6.9	6.2	6.6	8.0	7.7	7.3	1.4	1.4
Closure of Div. 1B, assuming a redistribution loss of 15%											
Closure to trawl	0.3	3.8	1.8	1.8	5.4	3.3	2.6	6.2	4.1	3.4	2.0
Closure to line	3.0	-2.6	0.7	4.2	-1.4	1.9	4.8	-0.9	2.5	5.4	2.2
Total closure	3.1	1.1	2.3	5.7	3.7	4.9	7.0	6.2	5.0	4.2	4.2

Table 3 (continued)

	Long-term changes									Imm. Loss (%)	
	E = 0.5			E = 0.7			E = 0.8				
	Trawl	Line	Total	Trawl	Line	Total	Trawl	Line	Total	Reg. Gear	Total
HYPOTHESIS D (Commercial landings equal to research-vessel catches)											
Mesh change											
To 110 mm	0.2	1.0	0.5	0.6	1.4	0.9	0.8	1.6	1.1	0.8	0.5
" 130 mm	-0.2	4.0	1.4	1.3	5.6	2.9	2.1	6.4	3.7	4.0	2.5
" 150 mm	-2.7	8.3	1.4	0.3	11.6	4.5	1.8	13.3	6.0	10.2	6.4
" 170 mm	-8.9	15.4	0.1	-4.1	21.6	5.4	-1.6	24.6	8.1	21.1	13.3
Closure of Division 1B, assuming a redistribution loss of 5%											
Closure to trawl	2.1	3.7	2.8	3.6	5.1	4.2	4.3	5.9	5.0	1.5	0.9
Closure to line	2.5	0.7	1.7	3.5	1.7	2.7	4.0	2.1	3.2	1.8	0.7
Total closure	4.6	4.4	4.5	7.0	6.8	6.9	8.3	8.0	8.2	1.6	1.6
Closure of Division 1B, assuming a redistribution loss of 15%											
Closure to trawl	-0.2	4.4	1.7	1.5	6.2	3.4	2.3	7.1	4.3	4.5	2.6
Closure to line	3.0	-2.6	0.7	4.2	-1.4	1.9	4.8	-0.9	2.5	5.4	2.2
Total closure	2.8	1.8	2.4	5.7	4.8	5.3	7.1	6.2	6.8	4.8	4.8

3. Possible effect of a closure of Div. 1B to Trawling judged by tagging experiments and other relevant data[1]

by Sv. Aa. Horsted

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[1]submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/72

I. Introduction

At the 1965 Annual Meeting of ICNAF Denmark proposed that Div. 1B be closed to trawling in order to protect the great quantities of small cod present on the grounds in Div. 1B. Panel 1 considered this proposal and recommended that the Committee on Research and Statistics be requested to examine the desirability of further protection for small cod at Greenland and in particular in this connection the effects of a closure of Store Hellefiske Bank.

A Greenland Cod Working Group (hereinafter called the group) has been established to consider the matter. This group met in Rome in September 1965 and in Copenhagen in February 1966. At these meetings great progress was made in tabulating basic data required for the assessment. The group also had some discussion of the various problems. However time did not permit the group to finish the work. In preparation for the meeting in Madrid 1966, the group asked Mr Gulland to prepare a paper containing assessment of mesh size regulation and of closure of 1B based on data as size composition of catches, discard rate etc. and the present author to prepare a paper on the likely effect of closure of 1B based on the Danish tagging experiments in West Greenland waters. The present paper deals with these tagging experiments, but it is emphasized that a great part of other data used here is based on material compiled and discussed by the group during the Copenhagen meeting and partly given in the report of that meeting (Res.Doc.66/18).

It is also emphasized that the present paper together with the paper to be prepared by Mr Gulland should be fully discussed by the group in Madrid previous to the 1966 Annual Meeting of ICNAF. The present paper is thus prepared more as a working paper for the group than as a document with final conclusions on the question of protecting small cod at West Greenland.

II. Data necessary for the calculations

Some basic data and assumptions are needed for the calculations in this paper. Such basic data are:

1) Natural mortality and mortality due to tagging
2) Growth rate of cod and length-weight relation
3) Fishing effort and fishing intensity in all divisions of Subarea 1
4) Discard rate by gears
5) Proportion between liners' and trawlers' effort in 1B. Proportion between trawlers' effort in 1B and total effort in other parts of Subarea 1
6) Age and size at recruitment in 1B together with gear selection
7) Factors to convert number of tags reported to real number of recaptures.

1) Natural mortality and mortality due to tagging. Estimates of total mortality rate (Z) and of its two components (F and M) are given in previous report from the Assessment Subcommittee (Beverton and Hodder, eds., 1962). These estimates were based mainly from series of age composition data. For the period 1952-57 F was estimated to equal M, both being about 0.18. For the Labrador cod which may have a M similar to that of Greenland cod, the Assessment Subcommittee found M to be between 0.15 and 0.35 and May (1966) proposes the true value to be within the lower half of that range. The group at the meeting in Copenhagen estimated M for Subarea 1 cod to be 0.15 to 0.20.

In the present paper therefore M has been taken as 0.20 for all sizes of cod regarded although it is possible that M is somewhat larger for the smaller cod. For tagged cod it is quite clear that some will die due to tagging or lose their tags. It has not been tried to calculate this extra mortality but very roughly M has been estimated to be 0.35 in the calendar year of tagging. As all tagging experiments dealt with here are from mid-year months this value of M runs for half a year. Thereafter M is taken as 0.20 (t = 1 year).

2) Growth rate of cod and length-weight relation. The growth rate of cod in Subarea 1 has been subject to changes from time to time (Hansen and Hermann, 1965). The Danish samples from 1A-1D offshore, quarter of July, 1953-1965 clearly show that concerning growth rate this period falls into two, *viz.* 1953-59 and 1960-65, the growth rate in the last period being higher than in the former (Table 2, Fig. 1). This corresponds with recent German studies (Meyer, 1966). Applying German figures for gutted weight to these growth curves and looking on 10 cm groups of cod (the -5 cm regarded as mean of the group) this means that *e.g.* a cod of 30-39 cm length with the present growth rate will more than double its weight in one year and that the weight after two years is more than four times the original weight (Table 1). At the same time there is most likely also a considerable increase in value per unit weight.

3) Fishing effort and intensity. Due to the great variation between fishing vessels, between gears and between catchability and distribution of cod at various seasons, it is extremely difficult to get reliable single figures for fishing effort and intensity. The author has tried to estimate the effort on the base of Portuguese dory hours (Horsted, 1965*a*). Garrod (Table 2 in the report of the Copenhagen meeting of the group, Res.Doc.66/18) gives some estimates of total fishing effort based on other fleets. The two sets of figures correspond extremely well with each other. In this paper the figures estimated by the author *(loc. cit.)* have been used.

4) Discarded and industrial fish. Discarded cod and cod processed to fish meal are hereinafter called discards.

It is most essential to know the rate of discarding for each size group of cod, but unfortunately very few data exist. Some figures of total discards are given by Meyer *(loc. cit.)* for the German trawl fishery in Subarea 1 in 1965.

The group has tried to estimate discards for each size of fish by comparing commercial landings with catch of research vessels but points out that this may give an overestimate of discards as the trawlers may prefer to fish on those parts of the grounds where big cod are relatively most abundant.

For the purpose of this paper, it has only been necessary to estimate the discards in 1B.

Assuming that the difference between commercial landings and research catches (Res.Doc.66/18, Fig. 5) expresses the discards, the rate of discarding in percent of numbers caught would for 1B be as given in Table 3. Applying these figures to the average catch of trawlers in 1B as estimated by the group (Res.Doc.66/18, Table 4) gives about 54% discards of total numbers caught by trawlers in 1B. This may, as pointed out, be an overestimate.

For the purpose of this paper, also a completely hypothetical but I hope underestimated discard rate in 1B has been used (discard A) besides the discard rate given in detail in Table 3 (discard B), *viz.*

Discard A		Discard B
trawlers:	length group	
no catch, no discard	32 cm	100% discarded
90% discarded	33-41 cm	100% "
70% "	42-50 cm	84% "
none "	51-59 cm	43% "
none "	60 cm	none "
liners: none "	all	none "

Applying the rate A to the average trawl catch in 1B, as done above for rate B, gives about 21% discards by numbers of trawlers' catch (rate B = 54%).

5) <u>Proportion between liners' and trawlers' effort in Div. 1B. Proportion between trawlers' effort in Div. 1B and total effort in other parts of Subarea 1.</u> Table 4, partly taken from Horsted (1965*a*) gives for various former periods the new effort in 1B and in 1C-1F if the effort of trawlers' fishing in 1B had been diverted to the more southern divisions of Subarea 1. The effort for the year 1964 has been estimated here purely from catch data assuming that catch per effort in 1964 was as in 1963.

The total effort in 1B has, in Table 4, been split up in liners' and trawlers' effort according to the landings from these two fleets. As trawlers are presumed to have more discards than liners, this estimate for the two fleets may be biassed, the effort of the trawlers tending to be too low, that of the liners too high.

When dealing with fishing mortality of different length groups of cod, the effort ought to be split up also according to length groups. This has partly been done when calculating the long-term change by a closure. Using the two rates of discarding (A and B), together with Tables 4 and 5 of the group's Copenhagen report *(loc. cit.)*, it is found that of the total effort in 1B in 1961-64 the following percentages were due to liners and trawlers respectively:

	A		B	
length group	liners	trawlers	liners	trawlers
32-39	75	25	22	78
40-49	40	60	22	78
50-59	48	52	34	66

These figures are used for all periods when calculating the long-term change and referring to the growth rate (Section II, 2). Cod of length group 32-39 cm could next year well be regarded as the 40-49 cm group and this again next year as the 50-59 cm group. For cod outside 1B and for all cod bigger than 60 cm, the figures given in Table 4 are used.

6. Age and size at recruitment. Gear selection. Danish tagging experiments in inshore waters of Div. 1B (Table 5, a-c) have shown that many cod of length group 20-29 cm at tagging are recaptured on Store Hellefiske Bank in the second year after tagging, while many of those of length 30-39 cm at tagging are caught on Store Hellefiske Bank in the first year after tagging.

Trawling with covered codend by German research vessels in 1965 (Meyer, *loc. cit.*) has shown that considerable numbers of the 1962 year-class (3-year-old cod) were present on Store Hellefiske Bank in November, this year-class predominating in the samples. Also the 1963 year-class (2-year-old cod), which is normally regarded as a rather poor one, was fairly well represented.

Judging by this, it is reasonable to believe that cod in 1B are fully recruited at a total length of 40 cm.

In the group's Copenhagen report *(loc. cit.)* a selection factor of 3.7 and a selection range of 10 cm has been used. Recent German investigations (Bohl, 1966) suggest that this factor is too high. A factor of 3.38 was found by Bohl, selection range being 8.7 to 10.3 cm. Applying these last data to a 110 mm mesh size means that selection starts at a total length of cod about 32 cm. For the convenience of the assessment, it has therefore been assumed that cod of length group 30-39 cm (or at least 32-39 cm) are also fully recruited. To judge by the age composition of the samples mentioned above, this may not be an unrealistic assumption.

7. Conversion of number of tags reported to actual number of recaptures. Concerning Danish tagging experiments in Greenland waters, the problem of fishermen's non-returning of tags has been dealt with before by Poulsen (1957) and Horsted (1963 and 1965*b*). The factors given by Horsted (1965*b*, p.3)

have been used for tags released before 1961. The great majority of tags used before 1961 are Petersen tags fixed to the gill cover of the cod.

Various papers presented to the North Atlantic Fish Marking Symposium, Woods Hole, 1961 (ICNAF *Spec. Publ.* No.4) suggested, however, that fixing the Petersen tag dorsally was better than fixing in the gill cover and that also Spaghetti tags fixed dorsally gave relatively many returns. In 1961 and 1962 Danish cod tagging in Subarea 1 was accordingly made partly with Petersen tags fixed dorsally and to the gill cover (1961) and partly with Spaghetti tags and Petersen tags fixed dorsally (1962). The results were, however, very discouraging. It would complicate this paper too much to go into detail. It was found, however, that by small cod (less than 50 cm) Petersen tag fixed to gill cover was clearly much better (5-10 times better) than the same tag fixed dorsally, while with big cod (70 cm or more) the dorsal position was slightly better than the gill cover position. Results varied very much for the medium sized cod. Spaghetti tags seem to be somewhat better than dorsally-fixed Petersen tags, but unfortunately the printed number on some of the Spaghetti tags is washed out.

On the whole, the comparison mentioned is very complicated as the experiments gave most confusing results, and although some conversion factors have been used, the author is not too happy about these factors. Further experiments and analyses will have to be made before such factors should be published.

Complicating the 1961-62 tagging experiments too is the relatively poor Portuguese return of tags in 1962, proposed by Horsted (1965*b*) and later on confirmed and explained by Capt. de Almeida and R. Monteiro (personal communication). All this makes any judging by the 1961-62 experiments most uncertain, also as some returns may still be expected from these experiments.

III. Various assumptions

Having data as given in Section II, it is still necessary for the assessment to introduce also some basic assumptions besides those already mentioned in Section II.

The proposal for closure of 1B to trawling was based on the general theory

1) that the relative amount of small cod is greater on Store Hellefiske Bank than on any other West Greenland fishing bank. This is generally confirmed by the various samples (Copenhagen report of the group, Tables 4 and 5, Fig. 5);
2) that these small cod are more heavily fished by trawl than by line. Discussed in Section II, 4;
3) that small cod when reaching a bigger size begin to emigrate from Div. 1B (analysed in Sections IV and VII, Tables 5, 8 and 11);

4) that the migration of medium-sized and big cod from other divisions to Div.1B is rather small or, if such migration takes place, a great part of these cod will again move out of 1B (analysed in Section VII, Tables 7, 8 and 10).

In the calculations it has further been assumed

5) that migration of cod and distribution of cod after a closure of 1B will still be as shown by the tagging experiments before the closure, including here the basic assumption that tagged cod is evenly distributed in the stock and behave as non-tagged cod;

6) that migration of cod from 1B offshore areas to 1B inshore waters is rather small and not likely to change very much after a closure (analysed in Section IV, 1 and 2, Table 6);

7) that the migration which takes place in a certain year as shown by tagging experiments has been completed at the beginning of that year's fishing season;

8) that trawlers formerly fishing in 1B will fish in other Greenland waters after a closure of 1B;

9) that distribution of liners in Subarea 1 will not change after a closure of 1B to trawling. This assumption may not hold as 1B after a closure may attract liners, partly because at any rate they believe the conservation effect in 1B to be very great and partly because they avoid having their lines spoiled by trawlers. This question needs perhaps further study by the group in Madrid;

10) that as the majority of tagged fish recaptured are caught in the first and second year after tagging, it is proper to assume that the effort which has caught the recaptures from a period's tagging experiments is the effort from the period: 1 year after first experiment started to two years after last experiment started, *i.e.* cod from tagging experiments 1955-57 are assumed to have been recaptured by the effort in the years 1956-59.

Some smaller assumptions are introduced in the calculations because of

11) recaptures from year NK (not known) have been regarded as belonging to first year after tagging. Recaptures from Div. 1NK have been allocated to known divisions according to known recaptures. Recaptures from areas outside Subarea 1 (mainly East Greenland-Iceland) and recaptures from Subarea NK have been regarded as caught in Div.1C-1F. Catch, effort and recaptures from Div.1A have been included in 1B. All this transferring of figures may

sound rather drastic, but has little or no effect on the calculations as only very few recaptures are involved in the transferring.

IV. Migration of cod towards and within Div. 1B

As mentioned in the previous section some study of the migration of cod towards and within 1B is necessary before further assessments of the effect of a closure of 1B can be made.

1) Migration from inshore waters of 1B to offshore waters. Cod have frequently been tagged in inshore waters of Div. 1B, mainly in the harbour of Christianshåb (Disko Bay), in the coastal waters close to Holsteinsborg and in the fjords Amerdloq and Ikertoq just south of Holsteinsborg. The results of tagging experiments from these localities in the period 1955-62 are given in Tables 5a-5c, giving actual number of returns as well as estimated number of recaptures in percent of numbers tagged. Although a full study of migration needs to deal with recaptures per effort instead of just numbers of recaptures the Tables 5a-c nevertheless demonstrate very clearly that there is a considerable migration of cod from inshore of 1B to offshore waters, especially when it is taken into account that all returns from area not known have been taken by nations other than Greenland. In fact, in all experiments and for all sizes of fish, very few tags are returned by Greenland fishermen 3 or more years after tagging, while there are still considerable numbers returned by fishermen of other nations, suggesting that nearly all cod originally present in inshore waters of Div. 1B will migrate to offshore area, and when they have arrived here most likely behave as other cod present in the offshore area.

2) Migration from offshore to inshore waters of 1B. Table 6 summarizes return and estimated recaptures from Div.1A and 1B of cod tagged in 1B offshore waters in various periods. Comparing Greenlanders' percent of returns with Greenlanders' percent of total cod landings in 1A and B, it is quite clear that cod tagged in offshore waters do not mix very much with the stock in inshore waters.

Following this conclusion and the former conclusion, it is therefore assumed that a closure of Div. 1B to trawling will have only minor effect (but this effect is gain) to the inshore cod fishery, and in the assessments migration from offshore to inshore area have been neglected (see also Section III, 6).

3) Migration from more southern divisions into Div. 1B. Proposing the closure of 1B it was assumed that the migration of cod from southern areas into Div. 1B was relatively small, or if such a migration existed the cod moving into Div. 1B would behave as other cod present in 1B, which means that a great part of the inmoving cod would again move out of 1B. Table 7 summarizing tagging experiments for the years 1955-60 in Div. 1B, 1C and 1D offshore area shows that from tagging experiments in 1C 5-15% of the recaptures are taken in

1B, while from tagging experiments in 1D 3-6% of the recaptures are taken in 1B. Although these recaptures also ought to be weighted according to effort in the various regions, these figures by themselves say that the migration from more southern divisions into 1B is rather small. It must also be remembered that cod having moved into 1B are part of the stock in 1B and hence that some of them - and as Table 7 and later assessments show, a good deal of them - again will migrate out of Div. 1B. It is therefore not likely that a closure of Div. 1B to trawling means that any great proportion of the stock found in more southern divisions will avoid being caught by migrating to Div. 1B.

V. Different ways of expressing gain and loss due to closure of Div. 1B to trawling

The effect of a closure of 1B to trawling may be expressed in various ways. By introducing a larger mesh size than hitherto used, the term "immediate loss" is used, but speaking about closure of a certain area one must distinguish between two sorts of loss, *viz.*

a) the loss (or gain) which the banished fleet suffers expressed as the difference between the catch which the vessels would have obtained by staying in the closed area and the catch which they get in the areas to which they move;

b) the loss in output of the stock which was present in the closed area when closing this.

The immediate effect which the banished trawlers feel is the type a) loss, and this loss depends on the possibility of finding another area where catch per effort is as good or very nearly as good as in the closed area. As shown in the group's report, such areas exist throughout the year in the more southern part of Subarea 1. It is very difficult to say anything exact about this loss. The trawlers perhaps chose 1B because catch per effort here was better or thought to be better than in other divisions. On the other hand, some trawlers at the same time fished outside 1B and these presumably thought fishing here to be better than in 1B. In some cases, therefore, the trawlers leaving 1B may find fishing outside 1B to be better than in 1B and therefore get an immediate gain instead of loss. It is, however, essential to remember that the cod in Subarea 1 must be regarded as being so heavily exploited (Assessment Subcommittee reports 1964, 1965) that any increase in effort in any division is supposed not to give any increase in total catch but rather a steady or slightly decreasing total catch, and it is hence most reasonable to think that trawlers moving from 1B will not in the short time after moving get their former catch in 1B fully compensated, and that entering a new division they will also have some influence on the catch of the fleet originally present here. This sort of loss has not been estimated in this paper. The "short time" effect is here taken as the type b) loss, *viz.* the loss in output of the stock present in 1B at the time of closure. This loss will of course be greatest in the first year after closure, but gradually cod will move out from 1B and some of them be caught outside, so that the loss after some years is diminished or even changed to a gain due to the increased weight of the single fish. This short time effect has been calculated for each 10 cm group of cod present in Div. 1B. The total short time loss should be weighted according to the size composition (in 10 cm groups) in 1B.

After some years the cod originally present in Div. 1B at time of closure do not exist any more. From that time only cod recruited after closure are exploited, and the "long-term effect" is here given on a "per recruit" base, the recruits being regarded as the cod in the 40-49 cm group. The long-term effect is here given by the difference in output of 1B cod in 40-49 cm group without a closure and the output which would have been obtained in the same period with a closure, while the "short time effect" is given by the corresponding difference found for cod bigger than 50 cm present in 1B at time of closure.

The net gain or loss for the total fishery in Subarea 1 is then the defined "long-term effect" minus a possible loss in total catch in divisions outside 1B due to the increased effort in these divisions by redistribution of trawlers from 1B.

VI. Model used to calculate "long-term effect" and "short time effect" from tagging experiments

With reference to the various basic data and assumptions mentioned in Sections II and III the "long-term effect" and "short time effect" as defined in Section V is for each length group of fish present in 1B calculated in the following way:

Let N_o be initial number of fish tagged and n_o number of total recaptures in the calendar year (year 0) of tagging. Following Beverton and Holt (1957), the total fishing mortality coefficient F in this year is found from the equation

$$\frac{n_o}{N_o} = \frac{F_o}{F_o + M_o} \left(1 - e^{-(F_o + M_o)\ t_o}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where M = 0.35 and t = 0.5 (Section II.1).

The number of fish present at the beginning of next calendar year (year 1) is then given by

$$N_1 = N_o \ e^{-(F_o + M_o)\ t_o} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

and continuing with equations (1) and (2) (M in the next years = 0.20 and t = 1) the F in each year and the number of tags present at the beginning of each year, N, is calculated.

This F, however, is an overall F, but F may vary between divisions. Knowing the distribution of tagged fish and the returns from each division, it is, however, possible to calculate the separate F in each area. This is done by splitting up n in three groups, *viz.* those caught by lines in 1B, those caught by trawlers in 1B and those caught by all gears outside 1B. Assuming further that the distribution of tags, which takes place during a calendar year, is finished at the beginning of that year (or at the beginning of the fishing season) N can be split up between divisions according to proportions given by

$$\frac{n_B}{f_B} \Big/ \frac{n_C}{f_C} \quad \text{etc., when}$$

n is number of recaptures in each division and f the chance of the tagged fish to be caught in each division as given by Horsted (1965*a*). In this way N is split up in a part staying inside 1B, N_B, and another N_C, having migrated to areas outside 1B. Following equation (1), F can be estimated for these two parts separately, F_B and F_C.

Assuming that a closure took place in the period dealt with, F_B would be reduced in the same proportion as the effort in 1B (given in Table 4) while F_C would be increased. The two new coefficients are called F^1_B and F_C.

The new effort in the two areas would instead of a catch of n_B and n_C give a new catch n^1_B and n^1_C also calculated from equation (1). The total numbers surviving in a year, r, after closure is now given by

$$N^1_{r+1} = N^1_B \; e^{-rF^1_B} + N^1_C \; e^{-rF^1_C} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

This number of survivors again can be split up into two parts. F and F^1 can again be calculated, and new catch and survivors for the next year again estimated.

The gain or loss for each length group in each year is in terms of numbers given by the difference between n and n^1, but the gain and loss has been split up in the calculation so that the gain of remaining lines in 1B and the gain or loss for the total fleet outside 1B (including the trawlers moving from Div.1B) are given separately.

In terms of weight each group of fish must for each year be multiplied by the weight factors given in Tables 1 and 2, and to judge the full gain these again ought to be multiplied by a value factor, which may vary from country to country.

VII. Effect of closure in former periods

The basic material of the tagging experiments on which the calculation are based is given in Tables 8a-c, while an example of the detailed calculations as given in Section VI appears in Table 9. From the other experiments only the final figures for loss and gain are given.

The "short time effect" (defined in Section V) by a closure of 1B to trawling is given in Table 10 a-c as percent change in catch of each length group by numbers and gutted weight (head on). The actual catch without a closure is within each length group the catch per 1000 fish present in 1B at time of closure or when tagging experiment started.

Some of the figures, especially for year 1, may look very unreliable but this is to some degree explained by the fact that all returns from year NK have been allocated to year 1 (Section III, 11).

The "short time effect" for liners in 1B is as expected an immediate raise in catch and an increase in mean size of fish caught, gain in terms of numbers being less than gain in weight.

For the other fleet in Subarea 1, including trawlers formerly fishing in 1B, the total "short time effect" is a decrease in catch but an increase in mean weight of fish, decrease in numbers being less than decrease in weight. This total loss, however, consists of two components, *viz.* a great loss in the first years after closure and later on a gain, but this gain is smaller than the loss in the first years. The gain generally seems to begin in the 3rd year after closure. To estimate "short time effect" for the stock as a whole, it is necessary to weight the effect in each length group with a factor which is the proportion that this length group has in the whole stock. As Table 10 deals with imaginary closure, this has, however, not been found to be worthwhile.

Estimating the "short time effect", it must be borne in mind that the "long-term effect" as defined in Section V begins within the period of the "short time effect", and as the "long-term effect" is an increase in catch this will make the total shore time loss less than shown in Table 10.

The greatest interest, however, has the "long-term effect" of the closure.

The calculation of the "long-term effect" per recruit is based on the 40-49 cm cod. There is, however, a fishery also on the 30-39 cm group, but due to gear selection (trawl as well as line) and possible not full recruitment of these smaller fish, fishing mortality must be less than for the bigger cod. It is impossible to say how big F is for these small cod, but it is supposed not to exceed 0.10. F for the 30-39 cm group has therefore been estimated to 0.00 at the discard rate A (Section II, 4) and to 0.10 for discard rate B, the last estimate to consist of F = 0.02 for lines and 0.08 for trawlers. The true value of discard rate and of F for small fish is supposed to be somewhere between the A and the B theory. Table 2 shows the "long-term effect" (% change in catch per fish recruited in 1B) if a closure had been effective in earlier years and if total fishing effort had remained as in those years.

Clearly the liners remaining in 1B would have a gain, immediate as well as long-term. The other fleets would, with a fishery as on the 1955-57 tagged cod, have had a loss (numbers as well as weight), but with a fishery as on cod tagged in 1958-60 and 1961-62 these other fleets would have had a minor loss in terms of numbers but a gain in terms of weight of 1-4% in the discard rate A and 8-13% in the discard rate B.

As shown in Table 8, the material on which these calculations is based is unfortunately rather poor (119, 76 and 175 cod tagged in the three periods respectively), but regarding also the "short time effect" (Table 10) when medium-sized cod tend to give a gain after 2-3 years after closure it is reasonable to believe that, although the figures for "long-term effect" may be rather uncertain, there is no doubt about the fact that cod recruited in 1B will be best exploited by a closure of 1B to trawling.

VIII. Possible effect of a future closure

When calculations are based on tagging experiments, it is quite clear that the calculations must refer to former situations of fishery and their interest therefore must be academic. In a previous part of this paper, it has only been possible to deal with situations before 1962.

Great change in the efficiency and effort of the trawlers is, however, known to have taken place since 1962. In the Copenhagen report of the group *(loc. cit.)*, it is estimated that $E \left(= \frac{F}{F + M} \right)$ is close to 0.70. The author has therefore tried to calculate the "long-term effect" which may occur by a future closure of 1B to trawling supposing that an overall F in Subarea 1 is 0.40 (E = 0.67) and that effort outside 1B would rise by 20% if trawlers were banished from 1B to 1C-1F. Inside 1B the effort of liners is taken as mentioned in Section II, 5. It is furthermore supposed that growth rate in future remains as in 1960-65 (Fig. 1, Tables 1-2). The migration of cod from 1B southward has been taken as a medium migration of that which the tagging experiments have shown for cod of length groups 40-49 and 50-59 cm.

This assumed migration used here is (in terms of percent of regarded fish found outside 1B)

Year	% found outside 1B
0	0
1	30
2	60
3 or more	80

Referring to Section II, 2 and II, 6 recruits are taken as 40 cm cod which will have a growth of

Year	0	1	2	3	4
cm	40	50	60	69	75
kg (gutted, head on)	0.530	1.020	1.735	2.490	3.165

The calculations are then made after the model given in Section VI and for the two discard theories A and B (Section II, 4).

The results are given in Table 12. It is found that the "long-term effect" by a future closure will be that the exploitation of cod recruited on Store Hellefiske Bank will be much better than now. Liners remaining in 1B will increase their catch of the regarded cod in terms of numbers (25-55%) as well as weight (37-73%) and other fleets in Subarea 1 will also increase their catch of 1B recruits in terms of weight (8-22%) although not in numbers (loss of 28-31%). The long-term gain is thus due to the increase in mean size at which the recruits are caught. The total effect for the fishery of Subarea 1 as a whole depends on the proportion which 1B recruits constitute of the total landings from Subarea 1. Assuming that they constitute at least about 33% of the landings from 1B-1D and nearly nothing of the landings from 1E-1F, and assuming that total catch in Div.1C-1F remains constant after redistribution of trawlers after a closure, this means that the long-term gain for the fishery in Subarea 1 as a whole (based on 1960-63 landings) will be at least between 6% and 12% for discard rate A and B respectively.

The main part of the gain is as mentioned due to increased size of the 1B recruits when these are caught. This increased mean size may mean that also the value of the fish has increased whatever this is in the price paid to fishermen or the price on the different stages of production. This value per weight is therefore different from country to country, but if a value factor can be worked out for each size group this factor could readily be used on Tables 11 and 12.

The Royal Greenland Trade Department (Frølich and Svendsgaard, personal communication) has tried to work out some factors for their frozen products using the formula

$$\text{Value factor} = \text{final market price} - \frac{\text{money paid fishermen and factory workers}}{\text{output by filleting}}$$

and found the following factors for cod of weight (gutted, head on)

600-700 g = 1.65 per unit weight
13-1500 g = 2.03 (= 123% of the 600-700 g)
21-2300 g = 2.15 (= 130% ....)

Applying such factors to Table 12, the "long-term effect" for liners in 1B is increased to 40% and 70% and for other fleets to 13% and 28% for discard rate A and B respectively. For the fishing of Subarea 1 as a whole (with the assumptions mentioned) the gain would increase to 7-13%, but the value factors given will most surely vary between countries and may well be more progressive than those given above, so that the gain for the fishery as a whole may be better than estimated above.

IX. Discussion

The validity of the results given in the previous section depends, of course, on the validity of the data and assumptions used in the calculations. The validity of the data and assumptions has to some extent been discussed in previous sections where data and assumptions are introduced. Furthermore, the paper is, as pointed out, thought as a working paper for the group in Madrid. The author has therefore not found it necessary to go into a detailed discussion on the validity here. It should, however, be pointed out that in all the calculations based on tagging experiments, there has in every case been less than 10% of the tagged fish left after 4 years and in no years more estimated recaptures than estimated tagged fish left. This seems to indicate that natural mortality and estimated number of recaptures are fairly close to the true values and fishing mortality found may accordingly be close to true value too.

The author has in this paper not tried to judge whether the same conservation of small cod could be obtained by an increased mesh size. This may to some extent be the case, but the author is inclined to believe that a closure of Div. 1B to trawling, together with an increased mesh size in other divisions, may be the best method of protecting small cod at West Greenland. This question must be discussed by the group in Madrid.

X. Summary

The effect of closing Div. 1B to trawling is judged by tagging experiments introducing at the same time some assumptions, and to evaluate fully the results given in this paper it is necessary to read all sections of the paper.

It is found that a closure ten years ago would not have been of benefit, partly because of relatively low fishing intensity and partly because of rather slow growth rate of cod at that time. Within the last 7-8 years a closure would, however, have been of some benefit. A closure would at the present time mean a much better exploitation of cod recruited on Store Hellefiske Bank and for the fishery of Subarea 1 as a whole there would possibly be a gain in terms of weight about 6% by a low present discard rate and up to 12% at a high discard rate.

The economical effect would be somewhat higher as the main effect of a closure is a decrease of small cod and an increase of medium-sized cod caught, and these medium-sized cod presumably have a higher value per unit weight than small cod.

The possible effect of a closure of 1B to trawling, together with mesh size regulation, should be studied by the Greenland Cod Working Group in Madrid, 1966.

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Table 1. Mean weight (fresh, gutted, head on) of West Greenland cod of various lengths and - within each length - after various periods. Length based on figures from Table 2 and Fig. 1. Weight based on German figures kindly supplied by Dr A. Meyer.
a = total length (cm below); b = weight (gutted) in gram; c = weight in percent of original weight (when r = 0).

Original length of fish regarded		1953-59					1960-65				
		Length and weight of fish regarded after r years					Length and weight of fish regarded after r years				
	r=	0	1	2	3	4	0	1	2	3	4
25 cm	a	25	36	45	54	62	25	38	49	59	68
	b	135	385	735	1295	1885	135	455	950	1665	2395
	c	100	285	544	959	1396	100	337	704	1233	1774
35 cm	a	35	44	53	62	67	35	46	56	66	73
	b	355	690	1225	1885	2300	355	780	1440	2205	2930
	c	100	194	345	531	648	100	220	406	621	825
45 cm	a	45	53	61	67	72	45	56	65	72	77
	b	735	1225	1810	2300	2815	735	1440	2115	2815	3415
	c	100	167	246	313	383	100	196	288	383	465
55 cm	a	55	62	68	72	75	55	65	72	77	81
	b	1370	1885	2395	2815	3165	1370	2115	2815	3415	3970
	c	100	138	175	205	231	100	154	205	249	290
65 cm	a	65	70	74	76	77	65	72	77	81	84
	b	2115	2595	3045	3290	3415	2115	2815	3415	3970	4440
	c	100	123	144	156	161	100	133	161	188	210
75 cm	a	75	76	77	78	79	75	79	83	85	86
	b	3165	3290	3415	3545	3675	3165	3675	4280	4600	4800
	c	100	104	108	112	116	100	116	135	145	152

Table 2. Mean total length of cod from Danish samples in Div. 1A-1D, offshore areas, quarter of July. Mean of lengths measured to cm below. See also Fig.

Age	1953-59	1960-65
2	27.0	-
3	38.8	40.3
4	45.8	50.2
5	55.6	60.8
6	63.3	70.0
7	68.2	75.5
8	73.0	80.0
9	75.0	83.6
10	77.2	85.6

Table 3. Maximum discard rate by trawlers in Div. 1B (percent of numbers caught) taken from Fig. 5 of the report of the Greenland Cod Working Group, Copenhagen meeting.

cm group	landed	caught	discarded	percent discarded	
33-35	-	17	17	100	
36-38	-	34	34	100	100
39-41	-	70	70	100	
42-44	5	115	110	96	
45-47	20	170	150	88	84
48-50	50	180	130	72	
51-53	80	175	95	54	
54-56	80	150	70	47	43
57-59	91	112	21	24	
60-62	100	120	20	17	

Table 4. Change of effort in Div. 1B and Div.1C-1F if trawlers' effort is diverted from 1B to 1C-1F. Effort given in "Portuguese August trawling hours" (Horsted, 1965*a*).

Period	Effort Div.1B		Effort Div. 1C-1F	New effort in percent of former effort when trawlers are diverted from 1B to 1C-1F	
	trawl	line		1B	1C-1F
1953-56	128,646	117,608	415,900	47.8	130.9
1956-59	110,721	156,014	615,549	58.5	118.0
1959-62	183,833	206,696	851,025	52.9	121.6
1962-63	99,335	115,081	549,455	53.7	118.1
1962-64	140,417	157,730	819,728	52.9	117.1

Table 5 a-c. Returns (corrected and uncorrected) of cod tagged in Div. 1B inshore waters in the years 1955-62. Length is total length to cm below. Year indicates calendar year after tagging. Fish caught more than 4 years after tagging are included in those caught 4 years after tagging. NK = area or year not known. All returns from area NK have been taken by nations other than Greenland.

a

Tagging locality	Length when tagged (cm)	Numbers tagged	Year of recapture	Total returns		Percent of returns uncorrected figures				Percent of returns corrected figures			
				uncorr.	corr.	Recaptured in 1B by Greenland fishermen	Recaptured in 1B by other nations	Recaptured in outside 1B	NK	Recaptured in 1B by Greenland fishermen	Recaptured in 1B by other nations	Recaptured in outside 1B	NK
Disko Bay,			o	16	16	100.0	-	-	-	100.0	-	-	-
harbour of	20 - 39	922	1	9	15	77.8	22.2	-	-	46.7	53.3	-	-
Christians-			2	20	44	20.0	35.0	40.0	5.0	9.1	34.1	50.0	6.8
håb			3	22	54	13.6	40.9	31.8	13.6	5.6	24.1	55.6	14.8
			≥4	7	13	14.3	28.6	57.1	-	7.7	46.2	46.2	-
			NK	2	10	-	50.0	-	50.0	-	50.0	50.0	-
			Total	76	152	40.8	27.6	25.0	6.6	20.4	30.9	41.[illegible]	7.2

(continued)

Table 5 a-c (continued)

Tagging locality	Length when tagged (cm)	Numbers tagged	Year of recapture	Total returns uncorr.	Total returns corr.	Percent of returns uncorrected figures, Recaptured in 1B by Greenland fishermen	1B by other nations	outside 1B	NK	Percent of returns corrected figures, Recaptured in 1B by Greenland fishermen	1B by other nations	outside 1B	NK
*)Holsteinsborg District, Coastal area	2o - 39	783	o	3	3	1oo.o	-	-	-	1oo.o	-	-	-
			1	16	25	75.o	12.5	12.5	-	48.o	24.o	28.o	-
			2	18	51	33.3	16.7	27.8	22.2	11.8	19.6	33.3	35.3
			3	7	16	14.3	28.6	42.9	14.3	6.3	37.5	37.5	18.8
			≥4	12	3o	8.3	8.3	75.o	8.3	3.3	3.3	83.3	1o.o
			NK	2	4	-	5o.o	5o.o	-	-	75.o	25.o	-
			Total	58	129	39.6	15.5	34.5	1o.3	17.8	2o.2	43.4	18.6
	5o or more	12o	o	-	-	-	-	-	-	-	-	-	-
			1	21	31	4.8	38.1	57.1	-	3.2	32.3	64.5	-
			2	8	16	12.5	37.5	5o.o	-	6.3	43.8	5o.o	-
			3	5	13	-	4o.o	6o.o	-	-	15.4	84.6	-
			≥4	5	9	-	-	1oo.o	-	-	-	1oo.o	-
			NK	-	-	-	-	-	-	-	-	-	-
			Total	39	69	5.1	33.3	61.5	-	2.9	27.5	69.6	-

*) 7 cod of length 4o - 49 cm tagged; no returns.

cont/

Table 5 a-c (continued)

Tagging locality	Length when tagged (cm)	Numbers tagged	Year of recap-ture	Total returns uncorr.	Total returns corr.	Percent of returns uncorrected figures: Recaptured in 1B by Greenland fishermen	Uncorrected: 1B by other nations	Uncorrected: outside 1B	Uncorrected: NK	Percent of returns corrected figures: Recaptured in 1B by Greenland fishermen	Corrected: 1B by other nations	Corrected: outside 1B	Corrected: NK
The fjords			o	13	13	100.o	-	-	-	100.o	-	-	-
Amerdloq	20 - 39	461	1	8	16	50.o	37.5	-	12.5	25.o	43.8	-	31.3
and			2	11	19	27.3	36.4	18.2	18.2	15.8	21.1	31.6	31.6
Ikertoq			3	6	16	16.7	50.o	16.7	16.7	6.3	43.8	18.8	31.3
near			≥4	5	11	-	60.o	20.o	20.o	-	27.3	27.3	45.5
Holsteins-			NK	1	5	-	-	-	100.o	-	-	-	100.o
borg													
			Total	44	80	47.7	29.5	9.1	13.6	26.3	26.3	15.o	32.5
			o	31	35	96.8	3.2	-	-	85.7	14.3	-	-
			1	16	20	18.8	62.5	12.5	6.3	15.o	50.o	10.o	25.o
			2	13	22	7.7	69.2	23.1	-	4.5	45.5	50.o	-
	40 - 49	329	3	14	24	42.9	14.3	35.7	7.1	25.o	8.3	45.8	20.8
			≥4	1	1	-	100.o	-	-	-	100.o	-	-
			NK	2	6	-	-	50.o	50.o	-	-	16.7	83.3
			Total	77	108	51.9	29.9	14.3	3.9	37.o	25.9	23.1	13.9
			o	14	14	100.o	-	-	-	100.o	-	-	-
			1	5	5	20.o	80.o	-	-	20.o	80.o	-	-
			2	2	6	-	50.o	50.o	-	-	83.3	16.7	-
	50 or more	79	3	1	1	-	-	100.o	-	-	-	100.o	-
			≥4	1	1		-	100.o	-	-	-	100.o	-
			NK										
			Total	23	27	65.2	21.7	13.o	-	55.6	33.3	11.1	-

Table 6. Relation between total returns from Div. 1B and Greenlanders' returns from Div. 1A+B of cod tagged in 1B offshore areas. Only cod bigger than 40 cm total length when tagged are regarded. Figures in brackets give percent of numbers tagged.

Period of tagging	Numbers tagged	Total returns from 1A + B uncorr.	corrected	Greenlanders' returns from 1A+B(no corr)	Greenlanders' returns in per cent of total returns. uncorr.	corrected	Greenlanders' cod landings in 1A+B in per cent of total cod landings from 1A+B
1952-54	1843	280 (15.2)	489 (26.5)	2 (0.1)	0.71	0.41	6.03
1955-57	1462	252 (17.2)	391 (26.7)	4 (0.3)	1.59	1.02	8.51
1958-60	1631	206 (12.6)	505 (31.0)	12 (0.7)	5.83	2.38	7.85
1961-62	1224	79 (6.5)	290 (23.7)	10 (0.8)	12.66	3.45	5.88

Table 7. Summary of returns and estimated recaptures from Danish cod tagging experiments in Div. 1B, 1C and 1D offshore waters in the years 1955-60, NK = area not known or area outside Subarea 1.

Tagging in Div.	Length when tagged (cm)	Numbers tagged	Total returns and estimated recaptures		Returns in per cent of total returns 1A-B	1C-F	NK	Estimated recaptures in per cent of total estimated recaptures 1A-B	1C-F	NK
1B	30-39	5	0	0	-	-	-	-	-	-
	40-49	195	39	96	77	18	5	71	24	5
	50-59	738	165	379	71	25	4	64	31	5
	60-69	1105	239	528	60	36	4	53	42	5
	≥ 70	1055	245	477	69	29	2	64	33	3
1C	30-39	8	0	0	-	-	-	-	-	-
	40-49	92	19	43	11	74	16	5	65	30
	50-59	207	51	125	12	82	6	14	75	10
	60-69	548	107	213	8	83	8	10	75	15
	≥ 70	2122	436	903	5	90	5	5	85	10
1D	30-39	1	0	0	-	-	-	-	-	-
	40-49	39	6	14	0	100	0	0	100	0
	50-59	434	79	210	6	82	11	4	79	17
	60-69	1245	281	634	2	90	8	2	84	14
	≥ 70	2375	483	973	5	88	7	5	80	15

Table 8. Estimated recaptures (returns corrected) from Danish tagging experiments in Div. 1B offshore waters. Total is given for both estimated recaptures and in brackets actual returns each of them in number as well as in percent of numbers tagged. Length is total length in cm at tagging. Year indicates calendar year after tagging. Those caught more than 4 years after tagging are included in the 4 years' recaptures. NK = division, area or year not known. In the calculations those from Div. 1NK have been allocated to division according to proportion between known recaptures and those from other areas plus area NK have been regarded as taken outside Div. 1B. Those from year NK have been regarded as taken in year 1.

a. Tagging in the years 1955-57.

Length	Numbers tagged	Year	Div. 1B	Div. 1C-1F	Div. 1NK	Other areas + NK
40-49	119	0	6	-	-	-
		1	18	-	-	-
		2	14	5	-	-
		3	3	5	-	-
		≥ 4	5	1	3	-
		NK	-	-	-	-
		Total	46-38.7% (20-16.8%)	11-9.2% (3-2.5%)	3-2.5% (1-0.8%)	- -
50-59	264	0	24	-	-	-
		1	32	15	5	-
		2	30	6	-	1
		3	2	4	-	-
		≥ 4	6	10	3	-
		NK	-	-	-	-
		Total	94-35.6% (55-20.8%)	35-13.3% (16- 6.1%)	8-3.0% (2-0.7%)	1-0.4% (1-0.4%)
60-69	521	0	48	1	1	-
		1	36	71	-	1
		2	21	14	-	-
		3	9	4	-	-
		≥ 4	4	12	-	-
		NK	-	-	-	-
		Total	118-22.6% (79-15.2%)	102-19.6% (40- 7.7%)	1-0.2% (1-0.2%)	1-0.2% (1-0.2%)
≥ 70	558	0	35	-	1	-
		1	49	48	8	6
		2	26	11	-	1
		3	12	2	-	-
		≥ 4	6	6	-	-
		NK	-	5	-	-
		Total	128-22.9% (98-17.6%)	72-12.9% (36- 6.5%)	9-1.6% (3-0.5%)	7-1.3% (3-0.5%)

Table 8 (continued)

b. Tagging in the years 1958-60.

Length	No. Tag-ged	Year	Recaptured in			
			Div.1B	Div.1C-1F	Div.1NK	Other areas + NK
30-39	5	Total	-	-	-	-
40-49	76	0	7	-	-	-
		1	10	-	-	-
		2	5	-	-	-
		3	-	6	-	-
		≥ 4	-	6	-	2
		NK	-	-	-	-
		Total	22-28.9%	12-15.8%	-	2-2.6%
			(10-13.2%)	(4-5.3%)	-	(1-1.3%)
50-59	474	0	61	1	-	-
		1	63	20	-	2
		2	5	23	-	5
		3	3	19	-	-
		≥ 4	10	19	-	5
		NK	5	-	-	-
		Total	147-31.0%	82-17.3%	-	12-2.5%
			(62-13.1%)	(26-5.5%)	-	(3-0.6%)
60-69	584	0	57	1	-	-
		1	68	45	6	-
		2	32	43	3	8
		3	1	20	3	8
		≥ 4	2	10	-	5
		NK	-	-	-	-
		Total	160-27.4%	119-20.4%	12-2.1%	21-3.6%
			(64-11.0%)	(47-8.0%)	(4-0.7%)	(5-0.9%)
≥ 70	497	0	80	5	-	-
		1	46	27	-	-
		2	32	25	-	-
		3	7	14	-	-
		≥ 4	6	14	-	-
		NK	5	-	-	-
		Total	176-35.4%	85-17.1%	-	-
			(70-14.1%)	(35-7.0%)	-	-

Table 8 (continued)

c. Tagging in the years 1961-62.

Length	Numbers tagged	Year	Recaptured in Div. 1B	Div. 1C - 1F	Div. 1NK	Other areas + NK
30 - 39	2	Total	-	-	-	-
40 - 49	175	0	10	-	-	-
		1	3	10	-	-
		2	3	14	3	-
		3	9	5	-	3
		≥ 4	-	-	-	-
		NK	1	10	-	-
		Total	26 - 14.9 %	39 - 22.3 %	3 - 1.7 %	3 - 1.7 %
			(8 - 4.6 %)	(10 - 5.7 %)	(1 - 0.6 %)	(1 - 0.6 %)
50 -59	511	0	57	17	10	23
		1	49	44	22	21
		2	15	36	-	-
		3	2	8	-	-
		≥ 4	-	-	-	-
		NK	1	5	-	-
		Total	124 - 24.3 %	110 - 21.5 %	32 - 6.3 %	44 - 8.6 %
			(26 - 5.1 %)	(22 - 4.3 %)	(4 - 0.8 %)	(6 - 1.2 %)
60 - 69	370	0	31	16	5	5
		1	36	60	7	8
		2	11	32	-	3
		3	-	5	-	4
		≥ 4	-	-	-	-
		NK	-	-	-	-
		Total	78 - 21.1 %	113 - 30.5 %	12 - 3.2 %	20 - 5.4 %
			(23 - 6.2 %)	(33 - 8.9 %)	(3 - 0.8 %)	(5 - 1.4 %)
≥ 70	168	0	39	-	-	-
		1	13	36	5	7
		2	10	3	-	-
		3	-	-	-	2
		≥ 4	-	3	-	-
		NK	-	-	-	5
		Total	62 - 36.9 %	42 - 25.0 %	5 - 3.0 %	14 - 8.3 %
			(22 - 13.1 %)	(14 - 8.3 %)	(1 - 0.6 %)	(4 - 2.4 %)

Table 9. Calculation of a gain - loss by a closure of Div. 1B to trawling based on tagging experiments in Div. 1B 1958-60, length group 50-59 cm by tagging. Symbols see the text, Section VI. Year is calendar year after tagging.

Year	N	N'	n total	n 1B line	n 1B trawl	n_C outside 1B	F	N_B	N_C
0	474.0	474.0	62.0	32.3	28.7	1.0	.31	469.6	4.4
1	340.8	385.2	90.0	36.0	32.0	22.0	.34	244.9	95.3
2	198.6	250.0	33.0	2.6	2.4	28.0	.20	23.4	175.2
3	133.1	164.4	22.0	1.6	1.4	19.0	.20	11.4	121.7
4	89.2	107.4	34.0	5.3	4.7	24.0	.54	21.1	68.1
5	42.6	50.9	-	-	-	-	-	-	-

cont.

Year	N'_B	N'_C	F_B	F_C	F'_B	F'_C	n'_B	n'_C	n'_B-n_B line	$n'_C-(n_C+n_B$ trawl$)$
0	469.6	4.4	.30	.57	.16	.69	33.1	1.2	0.8	-28.5
1	276.8	108.4	.36	.29	.19	.35	43.5	29.2	7.5	-24.2
2	29.4	220.6	.27	.19	.14	.23	3.5	41.2	0.9	10.8
3	14.1	150.3	.34	.19	.18	.23	2.1	28.1	0.5	7.7
4	25.4	82.0	.73	.49	.39	.60	7.5	33.9	2.2	5.2
5	-	-	-	-	-	-	-	-	-	-

Table 10. "Short time effect" (defined in Section V) by a closure of Div. 1B to trawling given as percent change in catch within each length group of fish. Actual figures for catch without a closure are in each length group based on 1000 fish present in 1B when tagging experiment started. Kg is gutted weight. Year is calendar year after closure or after tagging experiment started - Year 0 is only 6 months, tagging experiments starting in mid-year months and closure hence also thought to start in mid-year.

a. if closure had started in the period 1955-57.

Year	Length group	Catch without a closure				% change in catch after closure			
		Liners 1B		Other Subarea 1		Liners 1B		Other Subarea 1	
		numbers	kg	numbers	kg	numbers	kg	numbers	kg
o		53	72.6	38	52.1		o.8		- 1oo.o
1		78	147.o	119	224.3		14.1		- 22.7
2		66	158.1	74	177.2		22.7		- 47.3
3	5o-59	5	14.1	18	5o.7		2o.o		38.9
≧ 4		16	5o.6	56	177.2		37.5		26.8
Total		218	442.4	3o5	~~618.5~~ 651.5	15.3	17.9	- 25.6	- 17.5
o		55	116.3	41	86.7		o.o		- 92.7
1		4o	1o3.8	167	433.4		1o.o		16.8
2		24	73.1	44	134.o		4.2		- 13.6
3	6o-69	1o	32.9	15	49.4		1o.o		- 26.7
≧ 4		4	13.7	26	88.8		25.o		23.1
Total		133	339.8	293	792.3	5.3	5.9	- 4.8	- 2.4
o		38	12o.3	27	85.5		5.3		- 1oo.o
1		56	184.2	152	5oo.1		5.4		2.o
2		27	92.2	41	14o.o		11.1		- 22.o
3	≧7o	13	46.1	13	46.1		7.7		- 61.5
≧ 4		6	22.1	15	55.1		16.7		13.3
Total		14o	464.9	248	826.8	7.1	7.2	- 16.5	- 16.2

(continued)

Table 10 (continued)

b. if closure had started in the period 1958-60.

Year	Length group	Catch without a closure				% change in catch after closure			
		Liners 1B		Other Subarea 1		Liners 1B		Other Subarea 1	
		numbers	kg	numbers	kg	numbers	kg	numbers	kg
o	5o-59	68	93.2	63	86.3		2.9		- 95.2
1		76	16o.7	114	241.1		21.1		- 45.6
2		5	14.1	64	18o.2		4o.o		35.9
3		3	1o.2	43	146.8		33.3		37.2
≥ 4		11	43.7	61	242.2		45.5		18.o
Total		163	321.9	345	896.6	16.o	2o.3	- 18.o	- 3.2
o	6o-69	52	11o.o	48	1o1.5		7,7		- 95.8
1		64	18o.2	139	391.3		15.6		- 25.9
2		29	99.o	113	385.9		27.6		3.5
3		1	4.o	49	194.5		o.o		2o.4
≥ 4		2	8.9	27	119.9		o.o		11.1
Total		148	4o2.1	376	1193.1	14.9	16.o	- 17.3	- 11.1
o	≥70	85	269.o	86	272.2		4.7		- 86.o
1		54	198.5	1o3	378.5		2o.4		- 33.o
2		34	145.5	81	346.7		26.5		- 13.6
3		7	32.2	35	161.o		42.9		2o.o
≥ 4		6	28.8	34	163.2		5o.o		23.5
Total		186	674.o	339	1321.6	16.1	17.8	- 3o.7	- 25.4

Table 10 (continued)

c. if closure had started in the period 1961-62.
(more returns expected to be received).

Year	Length group	Catch without a closure				% change in catch after closure			
		Liners 1B		Other Subarea 1		Liners 1B		Other Subarea 1	
		numbers	kg	numbers	kg	numbers	kg	numbers	kg
0	50-59	67	91.8	97	132.9	6.0		- 54.6	
1		63	133.2	219	463.2	22.2		- 10.5	
2		15	42.2	125	351.9	40.0		15.2	
3		(2)	(6.8)	(17)	(58.1)	(0.0)		(17.6)	
≥ 4		(-)	(-)	(-)	(-)	(-)		(-)	
Total		147	274.0	458	1006.1	16.3	19.0	- 11.8	- 5.7
0	60-69	49	103.6	105	222.1	2.0		- 30.5	
1		56	157.6	217	610.9	19.6		5.1	
2		16	54.6	109	372.2	25.0		7.3	
3		(-)	(-)	(24)	(95.3)	(-)		(29.2)	
≥ 4		(-)	(-)	(-)	(-)	(-)		(-)	
Total		121	315.8	455	1300.5	13.2	14.9	- 1.3	1.4
0	≥70	123	389.3	110	348.2	7.3		- 100.0	
1		44	161.7	349	1282.6	109.0		10.9	
2		32	137.0	46	196.9	12.5		- 56.5	
3		(-)	(-)	(12)	(55.2)	(-)		(25.0)	
≥ 4		(-)	(-)	(18)	(86.4)	(-)		(11.1)	
Total		199	564.7	535	1969.3	30.7	61.1	- 17.4	-15.1

Table 11. "Long-term effect" (defined in Section V) by a closure of Div. 1B to trawling based on tagging of 40-49 cm cod and given for two rates of discarding (rate A and B, see Section II, 4). Actual figures without a closure based on 1000 fish tagged. Kg is gutted weight. Year is calendar year after closure or after tagging experiment started. Year 0 is only 6 months, tagging experiments starting in mid-year months and closure hence also thought to start in mid-year.

a. Low rate of discarding.

Closed in the period	Year	Catch without a closure				% change in catch after closure			
		Liners 1B		Other Subarea 1		Liners 1B		Other Subarea 1	
		numbers	kg	numbers	kg	numbers	kg	numbers	kg
	0	20	14.7	30	22.1	0.0		- 100.0	
	1	72	88.2	79	96.8	16.7		- 100.0	
1955-57	2	69	124.9	91	164.7	30.4		- 36.3	
	3	15	34.5	52	119.6	60.0		23.1	
	≥ 4	34	95.7	41	115.4	55.9		- 39.0	
	Total	210	358.0	293	518.6	29.0	35.4	-49.8	-37.8
	0	37	27.2	55	40.4	2.7		- 100.0	
	1	63	90.7	68	97.9	11.1		- 100.0	
1958-60	2	34	71.9	32	67.7	26.5		- 100.0	
	3	0	0.0	79	222.4	-		49.3	
	≥ 4	0	0.0	105	358.6	-		36.2	
	Total	134	189.8	339	787.0	12.7	15.8	-23.0	4.3
		23	16.9	34	25.0	0.0		- 100.0	
		11	15.8	126	181.4	9.1		7.1	
1961-62		12	25.4	102	215.7	16.7		6.9	
Total up to year 2		46	58.1	262	422.1	6.5	9.8	- 6.9	0.7
Estimated final total		55	83.4	292	506.6	5.5	6.8	- 5.8	1.1

Table 11 (continued)

b. High rate of discarding.

Closed in the period	Year	Catch without a closure				% change in catch after closure			
		Liners 1B		Other Subarea 1		Liners 1B		Other Subarea 1	
		numbers	kg	numbers	kg	numbers	kg	numbers	kg
	0	11	8.1	39	28.7	9.1		- 100.0	
	1	51	62.5	100	122.5	23.5		- 100.0	
1955-57	2	69	124.9	91	164.7	46.3		- 28.6	
	3	15	34.5	52	119.6	73.3		36.5	
	≥ 4	34	95.7	41	115.4	73.5		- 31.7	
	Total	180	325.7	323	550.9	45.0	51.9	-49.2	-34.7
	0	20	14.7	72	52.9	10.0		- 100.0	
	1	45	64.8	87	125.3	20.0		- 100.0	
1958-60	2	34	71.9	32	67.7	47.1		- 100.0	
	3	0	0.0	79	222.4	0.0		69.6	
	≥ 4	0	0.0	105	358.6	0.0		55.2	
	Total	99	151.4	375	826.9	27.3	31.9	-20.8	12.9
	0	13	9.6	45	33.1	0.0		- 100.0	
	1	8	11.5	129	185.8	25.0		14.0	
1961-62	2	12	25.4	102	215.7	25.0		16.7	
Total up to year 2		33	46.5	276	434.6	15.2	19.8	- 3.6	6.6
Estimated final total		42	71.8	306	519.1	14.3	16.7	- 2.0	7.7

Table 12. Possible effect of a future closure of Div. 1B to trawling based on assumption as stated in Section VII, 3 of the text. Actual figures for catch without a closure are per 1000 fish recruited in 1B at a length of 40 cm. Year is calendar year after recruitment. Kg is gutted weight, head on.

Discard rate	Year	Catch without a closure Liners 1B		other Subarea 1		% change in catch after closure Liners 1B		other Subarea 1	
		Numbers	Kg	Numbers	Kg	Numbers	Kg	Numbers	Kg
	o	12o	63.6	181	95.9	11.7		- 1oo.o	
	1	56	57.1	11o	112.2	38.4		- 33.5	
A	2	18	31.2	73	126.7	59.1		25.9	
	3	5	12.5	45	112.1	67.3		55.4	
(low)	≥4	2	6.3	59	186.7	95.5		5o.o	
	Total	2o1	17o.7	468	633.6	+ 25.6	+ 36.8	- 3o.9	+ 8.2
	o	66	35.o	235	124.6	27.8		- 1oo.o	
	1	39	39.8	126	128.5	71.2		- 32.7	
B	2	18	31.2	73	126.7	92.3		51.9	
	3	5	12.5	45	112.1	1o2.o		87.5	
(high)	≥4	2	6.3	59	186.7	145.5		8o.8	
	Total	13o	124.8	538	678.6	+ 54.6	+ 72.8	- 28.2	+ 21.5

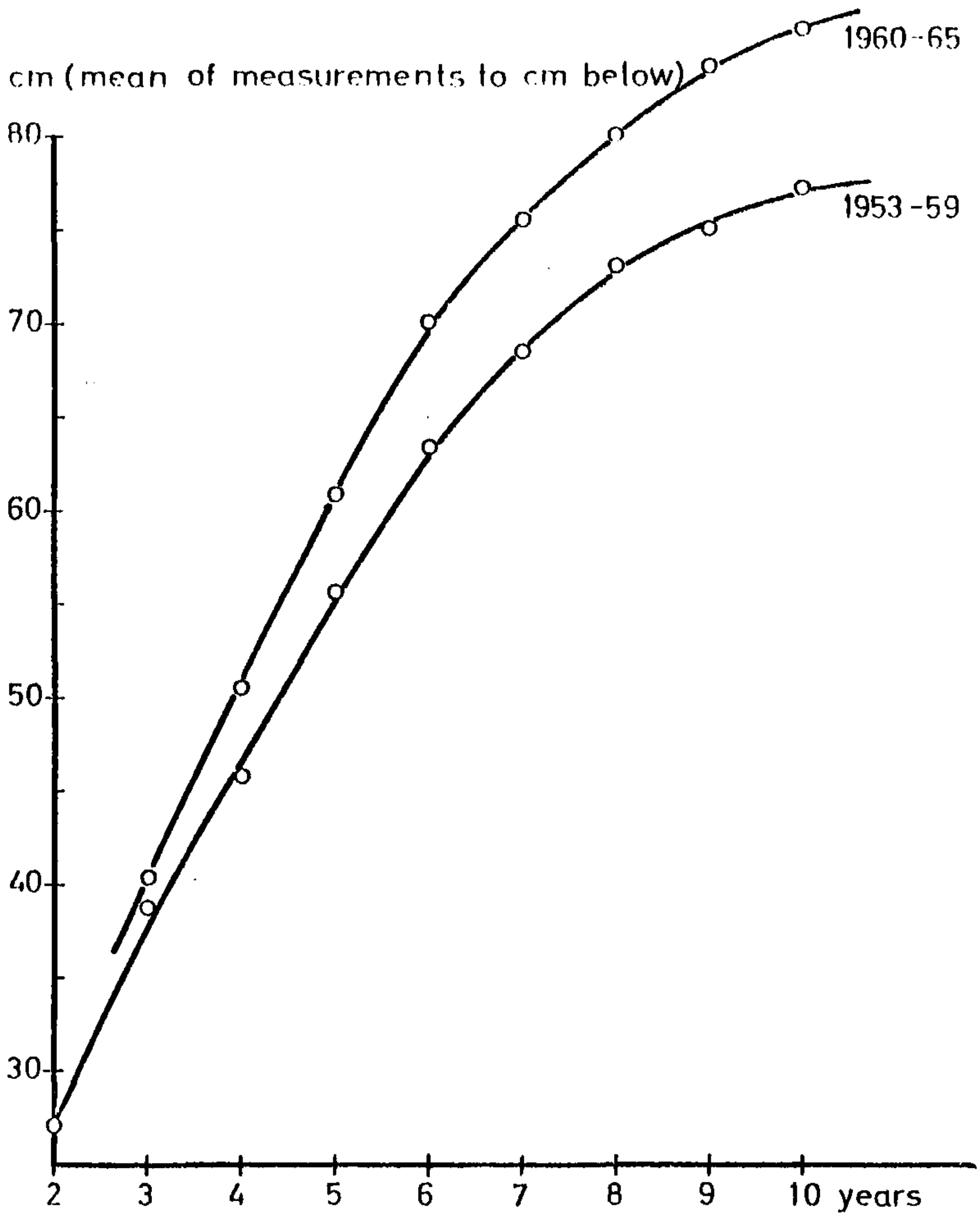

Fig. 1. Growth of cod, Div. 1A-1D offshore, Quarter of July

4. Final Report of the Greenland Cod Working Group[1]

At the 1965 Meeting of ICNAF, 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 to trawling, and

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

Some of the scientists concerned had preliminary discussions at Halifax, and at the mid-term meeting of the Assessment Subcommittee in Rome in September 1965. The main meeting of the working group was held in Copenhagen from 21-25 February 1966, and the report of this meeting is given in ICNAF Res. Doc.66/18. The group could not conclude all the studies and calculations considered necessary, and these were continued by individual members of the working group. The results of the work are given in reports by Horsted and Gulland (Res.Doc.66/72 and 66/56). The group met finally in Madrid on 30 May 1966, when it considered the above documents and other information on the Greenland fishery.

The group was in agreement with the general conclusions reached in the two separate reports prepared since the Copenhagen meeting, and considered that the good agreement on the effect of closure reached by two different methods gave added confidence to the conclusions reached. The detailed assessments are given in the reports, but the general conclusions of the group are as follows:

(a) Small cod at West Greenland are growing so rapidly that in the absence of fishing and with a 20% natural mortality, the total weight of a year-class would increase four times between 2 and 5 years old. Between 5 and 9 years there is little change in the total weight of a year-class. With the present intensity of fishing, the total catch would increase if the small cod were protected until around 4 years old.

(b) Small fish less than 4 years old, though present in all divisions of West Greenland are relatively more abundant in Div. 1B. Because of the nature of the statistical and other material, it was not possible to consider different grounds within 1B separately.

[1] submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/77

(c) The precise quantitative gain from measures to protect small fish depends on the proportion of the catch which is discarded (discards in this sense also include fish used only for fish meal), about which the group did not have as much information as is desirable. It appears that probably at least 20% by numbers and possibly more of the fish caught by trawlers are discarded; some fish are possibly also discarded by liners, but very much less than by trawlers, and some of them may survive.

(d) Closure of 1B to trawling would tend to increase the total landings from West Greenland, but it is likely that fishing by liners in 1B will increase due both to increased stocks and to less physical interference between trawlers and liners.

(e) Total landings would also be increased if Div. 1B were closed to liners, or particularly to both liners and trawlers.

(f) The use of larger meshes by trawlers would also increase landings. All types of gear would probably benefit from meshes up to 150 mm, but for meshes larger than 150 mm trawl landings are likely to decrease, though the total landings may still increase.

(g) The greatest benefit would come from closing 1B and using larger meshes. At a probable discard rate by trawlers of 20% in numbers, and an exploitation rate (E = 0.7) the long-term gains from alternative conservation measures are as follows, as percentages of present landings per recruit:

	Long-term gain %		
Conservation measure	Trawl	Line	Total
150 mm mesh	5	9	7
Closure of 1B to trawlers	4	5	4
Closure of 1B to all gears	7	6	7
150 mm mesh and closure to all gears	11	14	12

In assessing the effect of a given mesh size, it must be emphasized that the calculations have been made in terms of the selectivity of a manila codend without chafers. The same effect would be produced by a smaller codend mesh of more selective material, or a larger codend mesh if chafers are used.

While it is not the group's responsibility to suggest any date of introduction of any conservation, it should be mentioned that at present the two strongest year-classes in the fishery (1960 and 1961) are larger than 50 cm, while the year-classes of 1962 and 1963, which are in the selective range of meshes between 100 and 150 mm are weak. Thus in present conditions introduction of a larger mesh size would cause little immediate loss to the landings.

The group considers that there is a great need for further data on the West Greenland cod fishery, specifically as follows:

(i) data on quantities and sizes of fish discarded or used for fish meal;

(ii) data on the present effective mesh size used by trawlers at Greenland and on the types of chafer used, if any;

(iii) data on the hook size in use by liners, and the selectivity of hooks;

(iv) data on size composition of all landings and catches, particularly for those fleets for which there is at present little material submitted for the Sampling Yearbook;

(v) data on the possible redistribution of ships at present fishing in 1B.

While the individual members of the group should continue their studies of the West Greenland cod stocks, it is not thought that any formal meeting of the group within the next year or two would produce assessments differing to any significant amount from those presented here and in the three more detailed reports. Therefore, it is suggested that the group should not be needed to meet again for perhaps 5 years, unless the Commission has further specific problems to consider, or unless substantial conservation measures, such as closure of Div. 1B, are brought into force.

SECTION B
SELECTIVITY OF CODENDS

1. Comparative selection experiments with polypropylene and polyamide codends[1]

by H. Bohl
Institut für Fangtechnik
Hamburg, Federal Republic of Germany

Introduction

During the 79th cruise of FRV *Anton Dohrn* experiments with a conventional bottom trawl were carried out to obtain further information on the selectivity of polypropylene codends. Some additional hauls conducted on the same occasion with a "perlon" codend made it possible to compare directly the selectivities of polypropylene and polyamide codends. Manila was not used in the trials because nearly all the codends nowadays used in the German deep sea fishery are made of polyamides.

This paper, although dealing with studies prosecuted outside the Convention Area, may be relevant to ICNAF's interest in the selectivity of polypropylene codends.

Methods and Materials

The investigations were conducted between 22-27 June 1964 off Straumnes (northwest Iceland) and on 4 July off Portland (south Iceland). The technique of topside covers and underside blinders was used. Covers, rigged to ICES specification, and blinders were of light nylon (23 tex x 11 x 3 twine) with a mesh opening of about 60 mm.

The codends used in the experiments were to resemble each other as closely as possible but, as shown in the compilation at the top of the following page, several properties differed widely.

Some of the differences could have been diminished easily; for example, using modern polyamide twine with the same runnage, the wet knot strength of both polyamide and polypropylene codends would have been similar. Probably the difference in flexibility resulted from differences in twine construction, in particular the density of plaiting.

The remaining differences are inevitable. The greater thickness of the polypropylene twine results from its lower specific gravity. The relatively low extensibility of the polypropylene twine and the relatively high extensibility of the polyamide twine are well known characteristics of these net materials.

[1] This paper was presented in a provisional form to the ICES Comparative Fishing Committee at the ICES Council Meeting 1964. It was submitted to the 1965 Annual Meeting of ICNAF as Res.Doc.31.

Fibre	polypropylene multifilament	polyamide multifilament
Specific gravity (g/cm^3)	0.91	1.14
Braiding	double twine	double twine
Twine construction	plaited	plaited
R tex	4905	4760
Runnage (m/kg)	204	210
Wet knot breaking strength (kg)	124	104
Diameter, wet (mm)	3.6	3.1
Extension, wet (%) at a load		
of 6 kg	1.7	4.0
12 kg	2.4	6.2
30 kg	4.5	10.7
.. knot breaking strength	15	27
Resistance against deformation wet (Flexibility, g)[a]	50	16

[a] This has been determined by means of the "Lotzener Methode" described by A. v. Brandt and P.J.G.Carrothers in Modern Fishing Gear of the World 2, p.19-20, London, 1964.

Mesh measurements were made along the full length of the codend (47 or 48 meshes), near the mid line of the upper panel, immediately after every haul using an ICES gauge exerting 4 kg pressure. Total length of fish to the nearest centimeter and maximum body girth to the nearest millimeter were taken.

Selection data were collected for haddock and, as occasion arose, also for cod and whiting.

Bad fishing conditions were encountered off Straumnes. The catches were small and very mixed, but uniformly composed during the period of investigations. 8 1/2-17 1/2 baskets[1] of fish (avg. 13 baskets) with the polyamide codend and its cover, and 9-22 baskets (avg. 12 3/4 baskets) with the polypropylene codend and its cover were caught per 2 hours' fishing. A major part of these catches consisted of haddock, as is shown below:

	Haddock (baskets)		
	per haul	average	No. of hauls
Polyamide codend	3-10 1/2	4 3/4	8
cover	1/2-3	1 1/4	
Polypropylene codend	3-10	5 1/2	14
cover	1/2-3 1/2	2 1/4	

The codend catches also contained catfish, cod, coalfish, plaice, lemon sole, dab, rough dab, megrim and small halibut. Small redfish were also prominent in the cover.

[1] 1 basket = 50 kg approximately

Off Portland considerably more fish were available. The total catches (codend plus cover) per one hour's fishing amounted to 46 1/2-63 3/4 baskets (avg. 55 baskets) with the polyamide codend, and to 21 1/2-51 baskets (avg. 34 baskets) with the polypropylene codend. The share of haddock in these catches was as follows:

	Haddock (baskets)		
	per haul	average	No. of hauls
Polyamide codend	14 and 14	14	2
cover	4 3/4 and 5	4 3/4	
Polypropylene codend	3 3/4-11 1/4	8 1/2	4
cover	3/4-2 1/4	1 1/2	

The large by-catches of the codends were composed of cod, coalfish, whiting and flatfish (mainly plaice and dab) and those of the covers of whiting and dab.

Results and Discussion

Due to the small quantities caught off Straumnes, it has not been possible to calculate the selection data for individual hauls. The data obtained from the pooled hauls are given in Table 1.

Table 1. Selection data collected off Straumnes.

	Haddock		Cod
Codend	Polyamide	Polypropylene	Polypropylene
Number of hauls	8	14	11
Avg. duration of tow (minutes)	116	120	120
Number of fish caught (total)	3140	4752	2035
codend	1577	2472	741
cover	1563	2280	1294
25-75% selection range (cm)	8.4	7.0	10.1
No. of fish in sel. range (total)	940	490	461
codend	465	252	208
cover	475	238	253
50% retention length (cm)	47.9	41.6	43.6
Mesh size: mean ± s.e. (mm)	131.5±0.22	125.4±0.09	125.3
range (mm)	122-141	120-132	120-132
No. of fish examined	376	670	528
Selection factor	3.64	3.32	3.48

The haddock data collected off Portland could be analyzed by individual hauls: the selection factors were found to be 3.44 and 3.59 for the polyamide codend (two hauls), and 3.04 (?), 3.22, 3.37 and 3.38 (?) for the polypropylene codend (four hauls). The resulting mean selection factors 3.52± 0.07 for the polyamide codend and 3.25±0.08 for the polypropylene codend do not differ significantly. No special importance, however, should be attached to this finding, because at least two out of the above-mentioned six selection factors could not be determined accurately.

The selection data for the combined hauls are given in Table 2.

Table 2. Selection data collected off Portland.

	Haddock		Whiting
Codend	Polyamide	Polypropylene	Polypropylene
Number of hauls	2	4	4
Avg. duration of tow (minutes)	60	60	60
Number of fish caught (total)	1631	2161	3907
codend	932	1523	1313
cover	699	638	2594
25-75% Selection range (cm)	10.0	7.9	9.3
No. of fish in sel. range (total)	749	720	2122
codend	391	328	927
cover	358	392	1195
50% retention length (cm)	46.7	40.8	45.2
Mesh size: mean ± s.e. (mm)	132.6±0.44	124.4±0.18	124.4±0.18
range (mm)	123-143	119-131	119-131
No. of fish examined	94	192	192
Selection factor	3.52	3.28	3.63

These results indicate that the selection factors for haddock calculated for the polyamide codend were higher than those for the polypropylene codend by 9.6% off Straumnes and 7.3% off Portland. Since selectivity for roundfish by polyamide has been shown to be about 10% higher than for manila, it appears that selectivity for polypropylene and manila is about the same. This conclusion is supported by the fact that the selection factors for the polypropylene codend (3.28 and 3.32) are very similar to the average selection factors for manila codends obtained from the International Iceland Trawl Mesh Selection Experiment 1962 (3.35) as well as from previously available data for the Icelandic area (3.2)(Anon., 1965).

What are the causes of the selectivity difference between polyamide and polypropylene? It may be evident from the differences in the physical properties of the twines as given above. It can be seen there, and more distinctly from the load-elongation curves in Fig. 1, that the polyamide twine is much more extensible than the polypropylene twine. That means that the mesh size of the polyamide codend increases markedly with increasing strain, whereas that of the polypropylene codend increases in a less degree. Thus, during the tow considerably higher pulling forces act on the mesh bars than during the mesh measurement (4 kg), the selectivity difference might be caused to a certain extent by the different extensibilities of the netting twines. As a result of the different twine diameters, the knots of the polypropylene codend are conspicuously thicker than those of the polyamide codend (Fig. 2). This may also help to explain the selectivity difference insofar as the thick knots, which lap into the mesh, reduce the effective mesh opening. The different flexibilities of the netting twines are supposed to be a further source of the selectivity difference. Yet, in this connection it must be recalled that the stiffness of the polypropylene twine was due to the dense plaiting rather than to the net material itself. Therefore, future experiments conducted with polypropylene and polyamide codends of about the same flexibility could possibly result in a somewhat slighter selectivity difference than stated above.

All factors considered, it seems that the selectivity of polypropylene is much more similar to that of manila than to that of polyamide.

Selection data for cod (Table 1), which are considered rather unreliable, and for whiting (Table 2) could be obtained only from the polypropylene codend.

The length-girth relationships of the three species studied are represented as regression equations in Table 3 and as regression lines in Fig. 3.

Table 3. Relation between length and girth.

Species	Area	No. of Measurements	Regression equations*
Haddock	Straumnes	1,419	G=0.531 L + 0.31 (G=0.523 L + 0.4)
Haddock	Portland	854	G=0.578 L - 2.72 (-)
Cod	Straumnes	850	G=0.515 L - 1.46 (G=0.511 L - 1.5)
Whiting	Portland	886	G=0.488 L - 0.42 (-)

*where L = total length in cm and G = maximum body girth in cm
in brackets: *A.T.Cameron*, North Iceland, July 1962

From Table 3 it becomes obvious that the haddock and cod measurements conducted off Straumnes in June 1964, and those carried out on board the Canadian research vessel *A.T.Cameron* off North Iceland in July 1962 (Anon., 1965), yielded practically the same length-girth relationships.

It can be seen from Fig. 3 that, at the time of these selectivity experiments, the small and medium-sized haddock were markedly thicker in the northwest than in the south. This fact, however, is not reflected in the selection results; on the contrary, the selection factors were found to be somewhat higher off Straumnes than off Portland (compare Tables 1 and 2). This suggests that some factors other than girth of fish have given rise to the regional differences in haddock selectivity. As things stand, it is likely that both the relatively large catches and the relatively short duration of tow have favoured the retention of small haddock within the Portland area.

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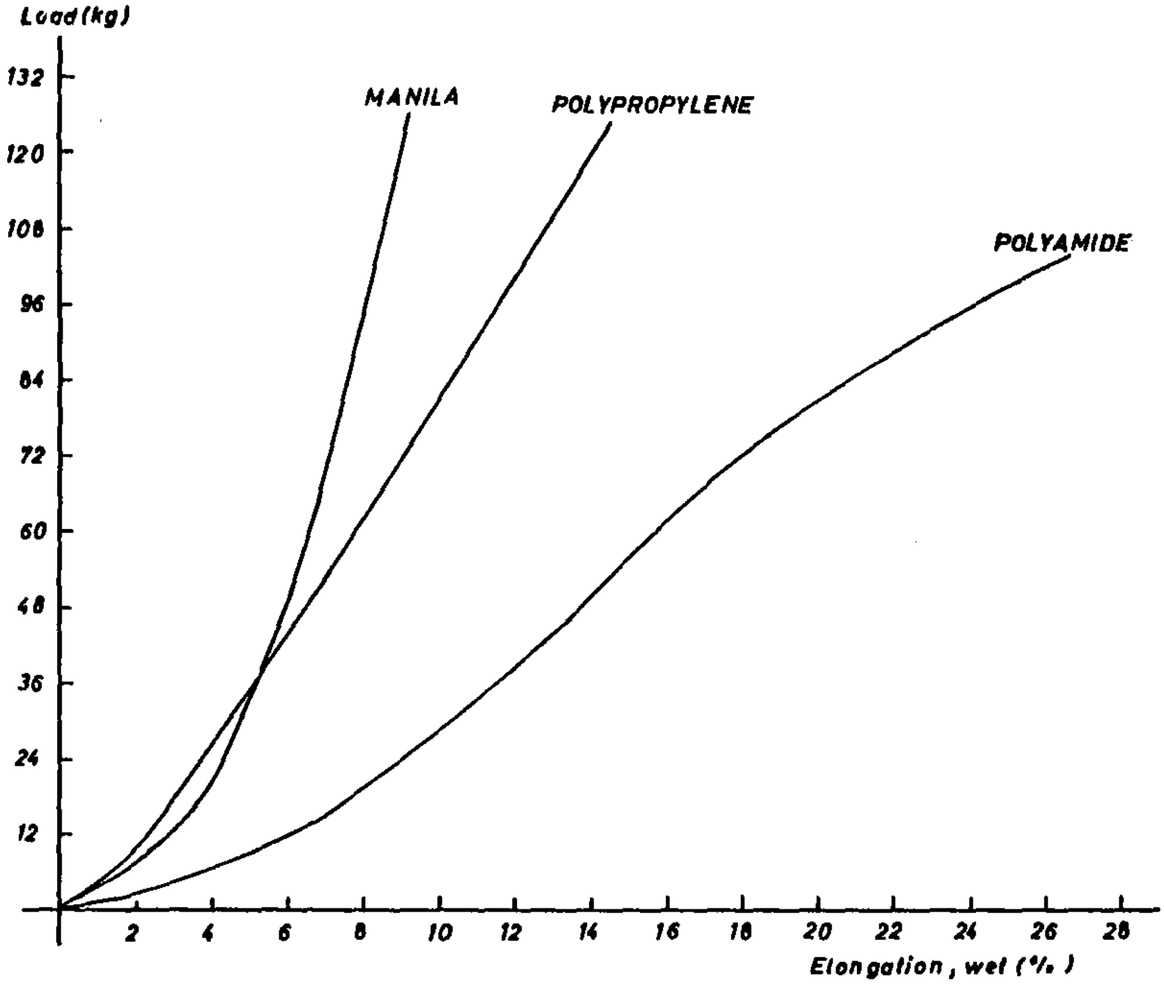

Fig. 1. Load-elongation curves for the twines used and for a comparable manila twine.

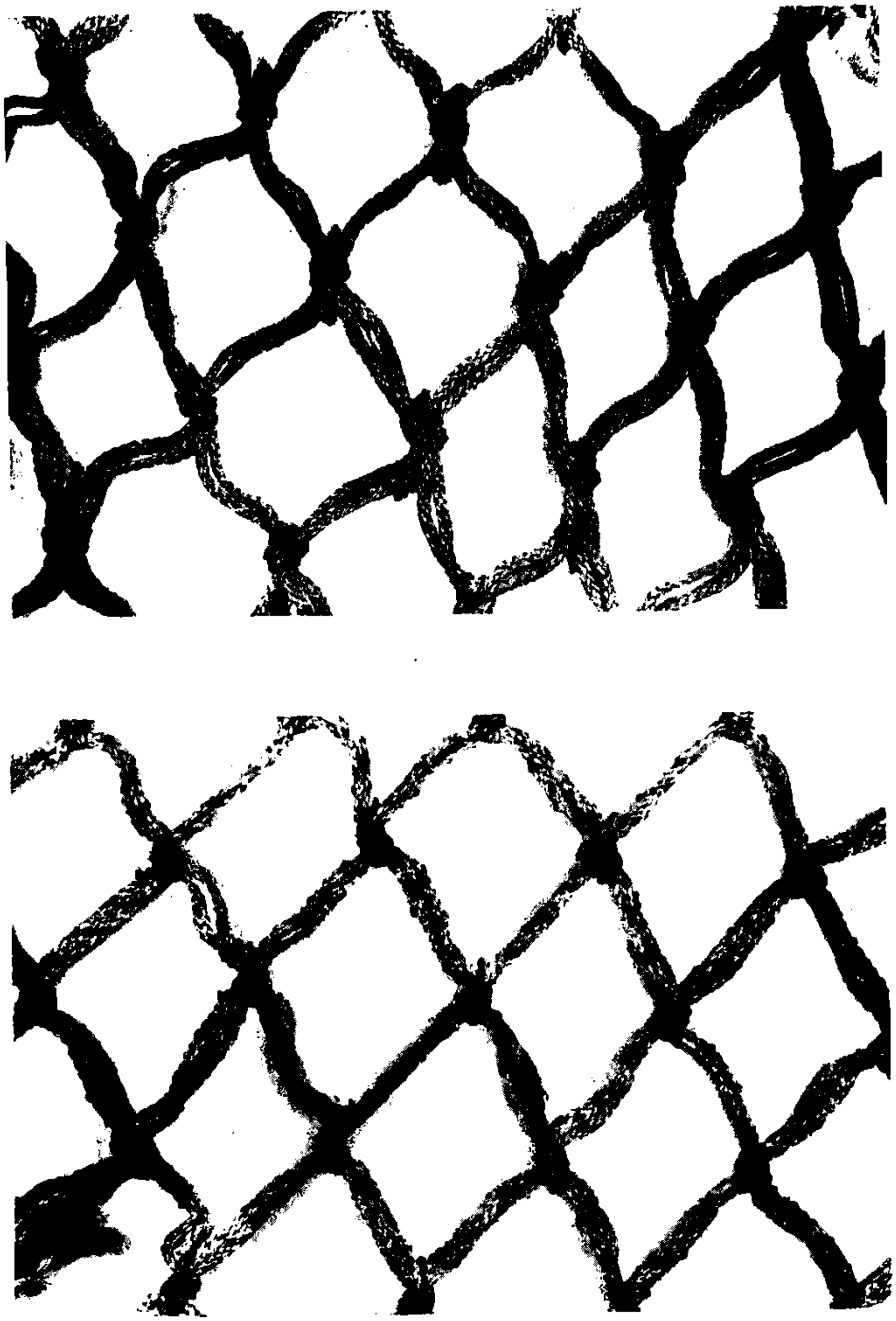

Fig. 2. Photographs of codend nettings used, demonstrating different knot sizes. Above: polypropylene netting; below: polyamide netting (Scale 1:2).

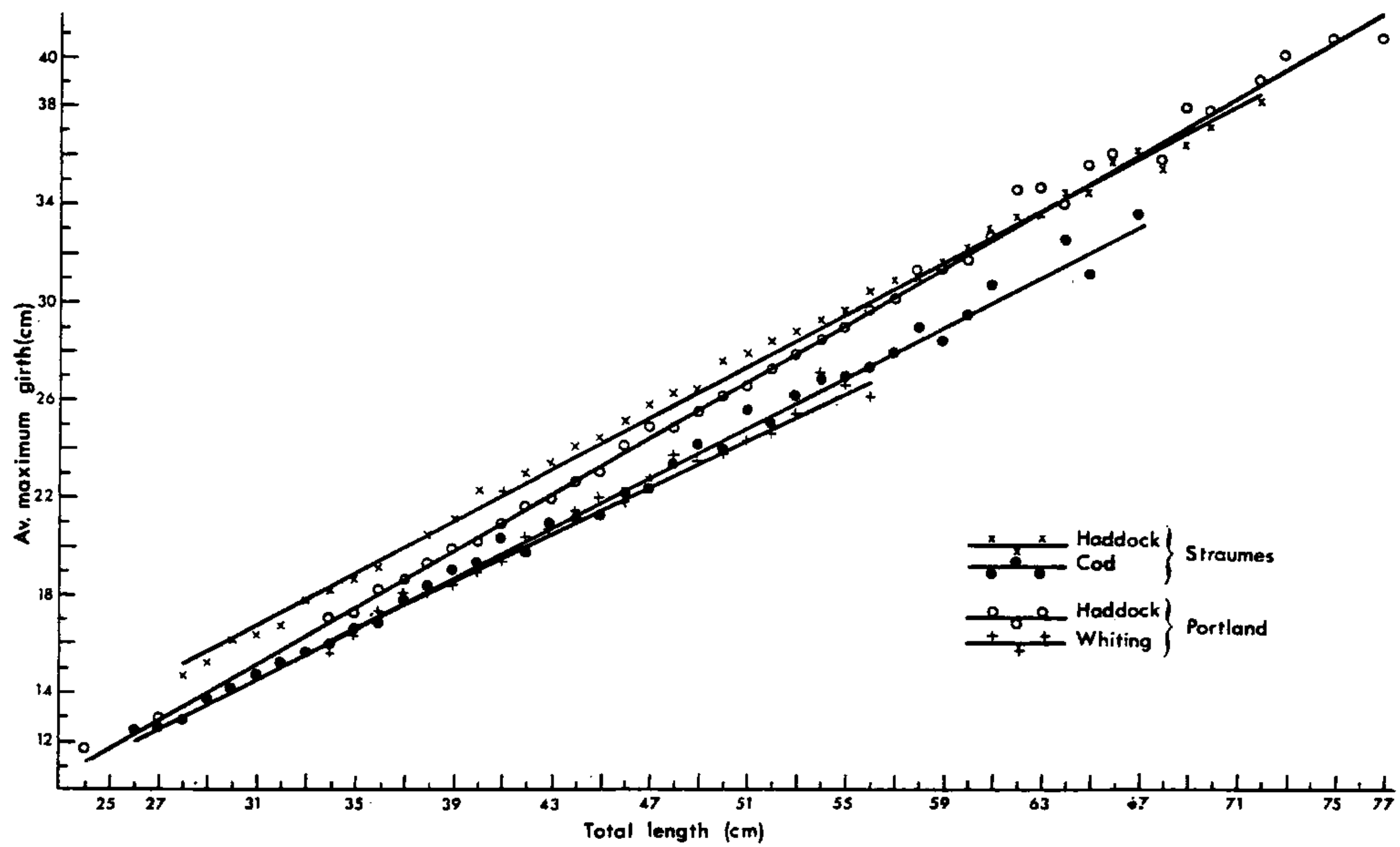

Fig. 3. Length-girth relationship of haddock, cod and whiting.

2. Investigation on selectivity of bottom trawl codend, Type BS-2 in relation to haddock on Georges Bank, 1965[1]

by B. Draganik and Cz. Zukowski
Sea Fisheries Institute
Gdynia, Poland

Introduction

Investigations were carried out on the Nova Scotia and Georges Banks to establish the selection factor for otter trawl codend in relation to haddock. The results may be used as a guide to establishing the minimum mesh size of trawls for commercial fishing of demersal species.

Codend selectivity was determined on a codend marked BS-2, made of double Stylon twine (Polish polyamide fiber) of 3.5 mm diameter. Mean mesh size was 113.7 mm measured wet - mean deviation in size being 2.2 mm. The dimensions of the codend were as follows: length 20 m, and width (across both the upper and lower edges) 5.2 m, in the stretched state. The cover with mesh size of 44 mm, measured wet, was applied over the primary netting of the codend described above. Details of the experiments are included in Table 1. The experiments were conducted aboard R/T *Wieczno*. Fishing was carried out during the daytime only. Length measurements, to an accuracy of 1 cm, were made on the fish which were retained in the codend and which escaped into the cover.

Results

During the cruise 46 hauls were made with the gear to be tested. In view of the low catch per effort for haddock in August on the fishing grounds of the southwestern part of the Great Newfoundland Bank and on the fishing grounds of Nova Scotia, it was not possible to make an accurate estimate of the selection factor. When larger concentrations of haddock were encountered on Georges Bank, 8 good hauls were made. The results of these hauls provide the basis for our calculations.

The selection curve (Fig. 1) was fitted to points representing the percentage of fish retained by the gear at each size interval. From this curve, the length of fish at which 50% are retained (50% point) was established as 41.4 cm for haddock. With the codend of 113.7 mm mesh, the selection factor was then calculated to be 3.64.

The 50% retention length accepted in the ICNAF Area for haddock, with manila codends of mesh size 114 mm, is 37 cm (McCracken, 1964). Using the selection factor for the codend made of double twine 3.5 mm thick and the accepted 50% retention length for haddock, the minimum mesh size was calculated

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[1]submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/28

from the following formula:

$$\frac{L}{m} = c$$

where L = 50% retention length, m = mesh size and c = selection factor. Substituting the selection factor obtained of 3.64 and the 50% retention length of 37 cm, the required minimum mesh size was found to be equal to 101.6 mm.

During experiments it was found that the selectivity of fishing gear depends to a considerable degree not only on the length but also on the condition of the fish. In order to establish such a relationship using other than length measurements, fish weights were also determined.

The results were used to determine the relationship between length and weight, both for fish retained in the codend and for those escaped from it into the cover. This was done by using the formula:

$$W = KL^n$$

where W = fish weight in grams, L = length in centimeters and K and n = coefficients.

Having solved this equation by substitution for coefficients, found by the method of least squares, the curves characterizing the relation were plotted for both groups of fish (Fig. 2). From the spread of the curves it appears that the fish which were retained in the codend, and which were the same length as the fish which escaped, had a greater weight.

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McCracken, F.D., 1964. Minimum mesh sizes and equivalents for different materials to meet ICNAF regulations. *Annu. Meet. int. Comm. Northw. Atlant. Fish.* 1964. Doc. No. 72, Serial No.1368 (mimeographed).

Table 1. Compilation of selection data for grouped hauls, haddock, Georges Bank, 1965.

Ship	R/T *Wieczno*, length 61.0 m, h.p.1,375
Gear	Bottom Trawl Codend, Type BS-2
Date	29 August-21 September 1965
Locality	Georges Bank
Depth range (m)	70-100
Species studied	Haddock
Experimental method	Topside cover
Cover	
Material	Stylon (Polish polyamide fibre)
Mesh size (mm)	44
Codend material	Stylon
No. of hauls	8
Avg. duration of haul (min)	120
Avg. towing speed through water (kn)	4
Type of mesh gauge	ICES gauge (4 kg pressure)
Codend mesh size: mean (mm)	113.7
Range (mm)	107-119
No. of measurements	400
25%-75% selection range (cm)	9.3
No. of haddock in sel. range	
codend	1,853
cover	2,143
Total no. of haddock codend	3,757
cover	7,799
50% retention length (mm)	414
Selection factor	3.64

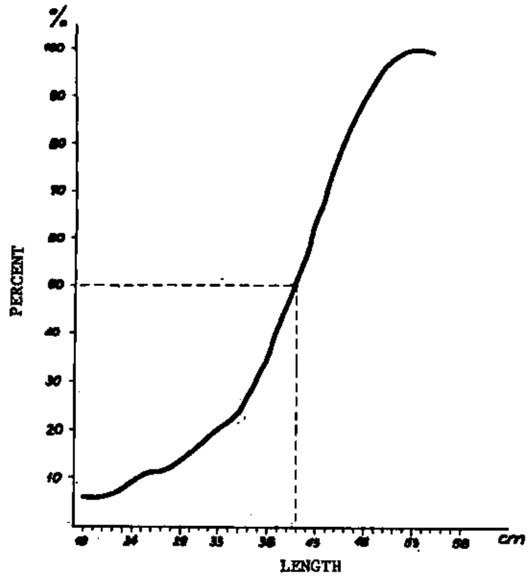

Fig. 1. Selection curve for stylon codend, type BS-2, of 113.7 mm mesh.

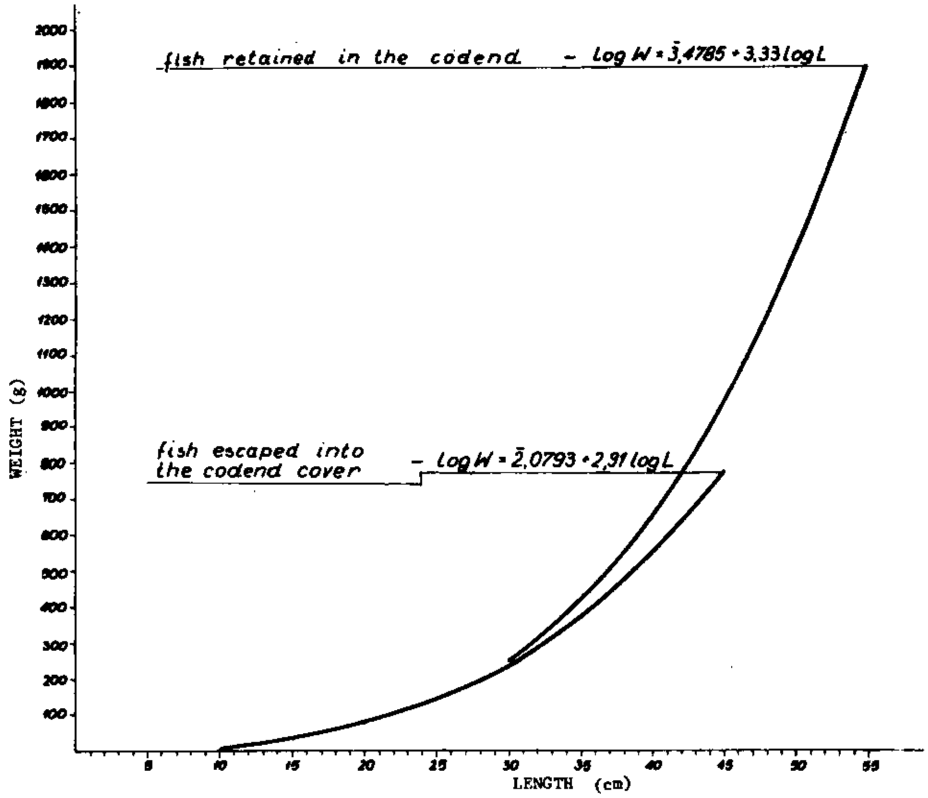

Fig. 2. The effect of codend selectivity on the relation between weight and length of haddock.

3. Selection of cod by bottom trawl codends on Store Hellefiske Bank[1]

by H. Bohl
Institut für Fangtechnik
Hamburg, Federal Republic of Germany

On the 12th cruise of FRV *Walther Herwig* (Nov./Dec. 1965) rather extensive trawl mesh selection experiments were carried out on the southern slope of Store Hellefiske Bank (northern edge of Holsteinsborg Deep, ICNAF Div. 1B).

It was not possible to prepare a final report on these trials in due time. Since, however, the Greenland Cod Working Group has intimated that selection factors for Store Hellefiske Bank cod are urgently needed, no effort has been spared to complete at least this provisional paper.

Four codends of about the same wet knot breaking strength (115-124 kg) and mesh size (114-125 mm) were used. They were made from polyamide continuous, polyethylene monofilament, polypropylene continuous and polypropylene monofilament.

During all of the trials 34 successful hauls were made; 23,710 cod were caught in the codend and 9,466 cod in the cover. The total length of each fish was measured to the nearest centimeter. The relative length composition of the total catch is shown in Fig. 1.

The catches, ranging from about 0.7 to 6.4 metric tons per 65-75 minutes fishing time, were rather heterogeneously composed. Cod were only predominant in the catches made with the polyamide and polyethylene codends. The catches of the two polypropylene codends, however, contained on an average more by-catch (wolffishes, holothurians, American plaice, skates and Greenland halibut) than cod.

The selection curves shown in Fig. 2 for each codend are based on smoothed percentages of retained fish (three-point moving averages). The curves are fitted by eye.

The selection factors obtained from combined hauls are as follows (compare the attached compilation of selection data):

- 3.51 for polyamide continuous (8 hauls)
- 3.38 for polyethylene monofilament (10 hauls)
- 3.28 for polypropylene continuous (8 hauls)
- 3.22 for polypropylene monofilament (8 hauls).

Previous German trials carried out during August 1957 in ICNAF Div. 1D, 1E and 1F (Southwest Greenland) have given markedly higher selection

[1]submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/67

factors, namely 3.7 for manila, 3.9 and 4.0 for two polyamide codends and 3.9 for polyester (v. Brandt, 1957; ICES, 1964). It must, however, be taken into account that the 1957 trials have been conducted by FRV *Anton Dohrn*, an 850 h.p. side trawler with an average towing speed of 4 knots, whereas the 1965 trials were conducted by a large 2,000 h.p. stern trawler with a towing speed of about 4.5 knots. Moreover, in 1957, the catches have been smaller and the cod caught thinner than in 1965. The relationship between maximum body girth (G) and total length (L), obtained from 984 measurements in 1957, has been described by the regression equation $G = 0.42\ L + 2.46$ cm (Messtorff, 1958), whereas the regression $G = 0.56\ L - 2.49$ cm was obtained from 1,490 measurements in 1965 (Fig. 3). These equations imply that, in 1957, cod of the 50% retention lengths (47-53 cm) have been thinner than cod of the same lengths in 1965 by 8-10%.

Norwegian trials carried out during April 1964 in ICNAF Div. 1C and 1D gave the following selection factors: 3.4 for manila, 3.3 for polypropylene and 3.2 for polyethylene (Bratberg, 1965). The value for polypropylene tallies with the recent German findings, while the value for polyethylene is somewhat smaller.

The four selection factors obtained from the *Walther Herwig* trials did not differ very much from each other. In comparison to the selection factor determined for the polyamide codend, the corresponding factors for the polypropylene continuous and polypropylene monofilament codends were found to be lower by 6.6% and 8.3%, respectively. These differences are in line with previous results showing the selectivity of polypropylene similar to that of manila.

In this connection it is noteworthy that, contrary to expectation, no significant difference was found between the selectivity of the both types of polypropylene codends used. The polypropylene monofilament codend made from relatively stiff twine should have, at least theoretically, yielded a markedly lower selection factor than the polypropylene continuous codend made from relatively flexible twine.

Finally, it has to be mentioned that the selection factor for the polyethylene codend was found to be only 3.7% lower than that for the polyamide codend. This result which shows polyethylene to have selective properties similar to polyamide rather than to manila/polypropylene, is in contrast to the above-mentioned Norwegian results (Bratberg, 1965) on the one hand, and in conformity with Canadian results obtained during October 1960 in ICNAF Div.4T (ICNAF Sec., 1962; Parrish, 1963) on the other hand.

Thus, further information on the selectivity of polyethylene codends is urgently needed.

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Compilation of selection data for grouped hauls

Ship	FRV WALTHER HERWIG, length o.a. 83.3 m, 2000 h.p.e.			
Gear	German standard roundfish bottom trawl, 140' groundrope			
Date	21.11. - 5.12.1965 (day and night)			
Locality	Southern slope of Store Hellefiske Bank (66°35'N; 54°25'W)			
Depth range (m)	180 - 220			
Species studied	Cod			
Experimental method	Topside cover			
Cover	ICES specification			
Material	Nylon continuous			
Runnage (m/kg)	1200			
Tex	23 tex x 11 x 3			
Braiding	Single twine			
Twine construction	Twisted			
Mesh size (mm)	60			
Codend material	Polyamide continuous	Polyethylene monofilament	Polypropylene continuous	Polypropylene monofilament
Runnage (m/kg)	252	153	204	208
R..tex	3962	6516	4905	4800
Braiding	Double twine			
Twine construction	Plaited			
Wet knot breaking strength (kg)	119.5	115	124	122
Twine diameter, wet (mm)	2.1	4.5	3.6	3.5
No. of hauls	8	10	8	8
Av. Duration of haul (min)	65	65	70	75
Av. towing speed through water (kn)	4.4	4.5	4.6	4.4
Type of mesh gauge	ICES gauge 4 kg pressure			
Codend mesh size; mean ± s.e. (mm)	125.4 ± 0.2	114.4 ± 0.2	121.6 ± 0.2	121.6 ± 0.2
Range (mm)	103 - 133	104 - 128	114 - 130	114 - 136
No. of measurements	472	590	329	376

(continued)

Compilation of selection data for grouped hauls (continued)

		Polyamide continuous	Polyethylene monofilament	Polypropylene continuous	Polypropylene monofilament
25 - 75% selection range (cm)		11.4	9.3	10.3	8.2
No. of cod in sel. range	codend	1395	2044	1274	850
	cover	1651	1867	1218	850
Total no. of cod	codend	4967	10229	4909	3605
	cover	2765	3023	2015	1663
Av. quantity of cod	codend (baskets[1])	16 1/2 (= 1130 kg)	24 3/4 (= 1695 kg)	16 3/4 (= 1147 kg)	11 (= 754 kg)
	cover (baskets[1])	3 1/4 (= 223 kg)	2 1/4 (= 154 kg)	2 (= 137 kg)	1 1/2 (= 103 kg
of wolffishes [2])	codend (baskets)	7 1/2	6 3/4	14 1/4	5 1/4
	cover (baskets)	+	+	+	+
of other by-catch [3])	codend (baskets)	6 1/4	6 3/4	7 1/2	12 3/4
	cover (baskets)	3	2 1/4	1 3/4	5 3/4
Range of tot. catch/tow	codend (baskets)	8 1/4 - 73 3/4	16 1/2 - 88	16 - 67	10 1/4 - 47 1/2
	cover (baskets)	1 1/4 - 14 1/4	2 1/2 - 7 3/4	2 1/4 - 5 1/2	1/2 - 15
50% retention length (mm)		440	387	399	391
Selection factor		3.51	3.38	3.28	3.22

[1]) Large plastic baskets were used. The average net weight of one basket filled with cod was 68.5 kg

[2]) *Anarhichas denticulatus, A. minor* and *A. lupus*

[3]) Holothurians, *Hippoglossoides platessoides, Raja* spp. and *Reinhardtius hippoglossoides*

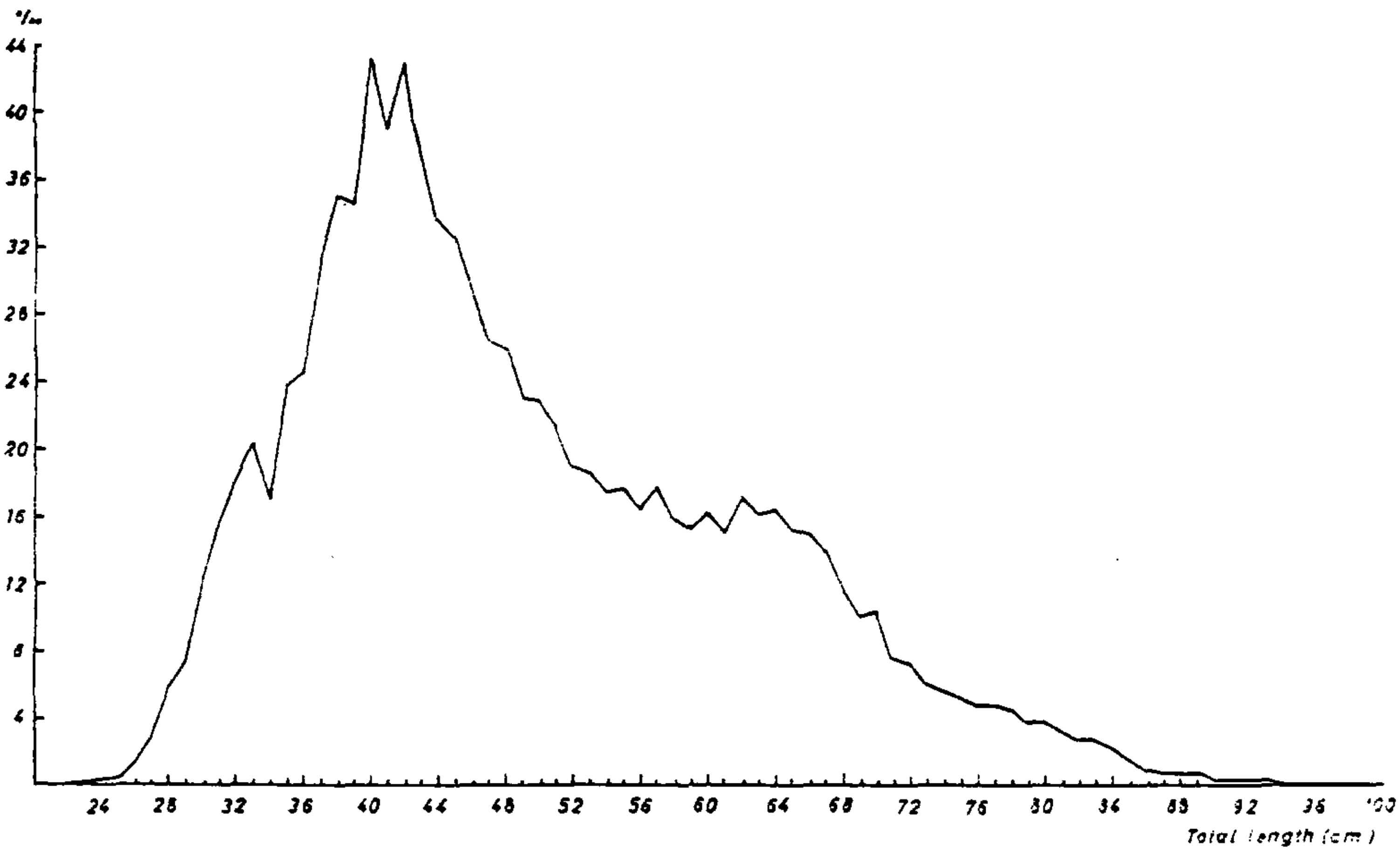

Fig. 1. Relative length composition of cod (codend + cover), 34 hauls; n = 33 176

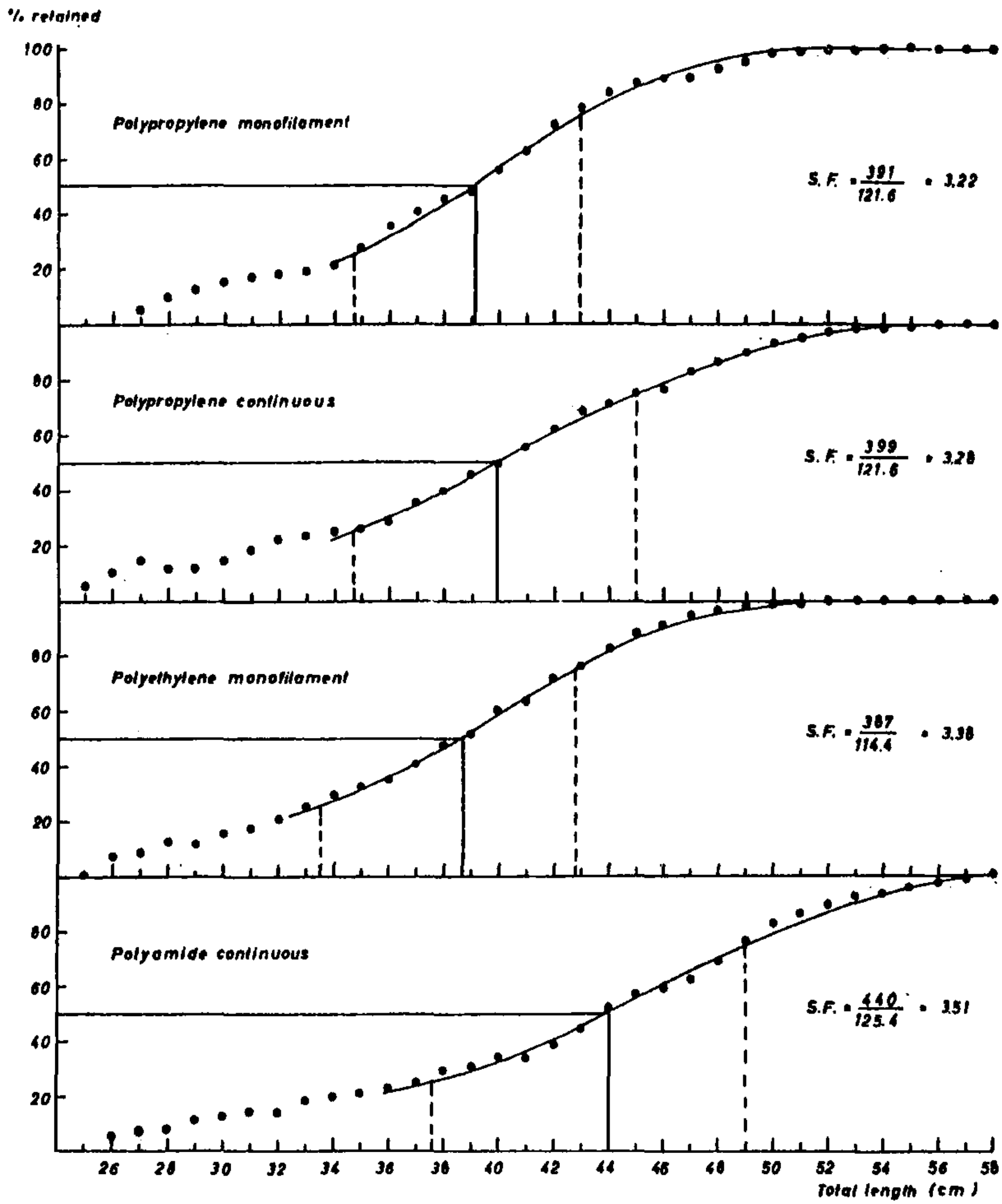

Fig. 2. Cod selection curves for combined hauls.

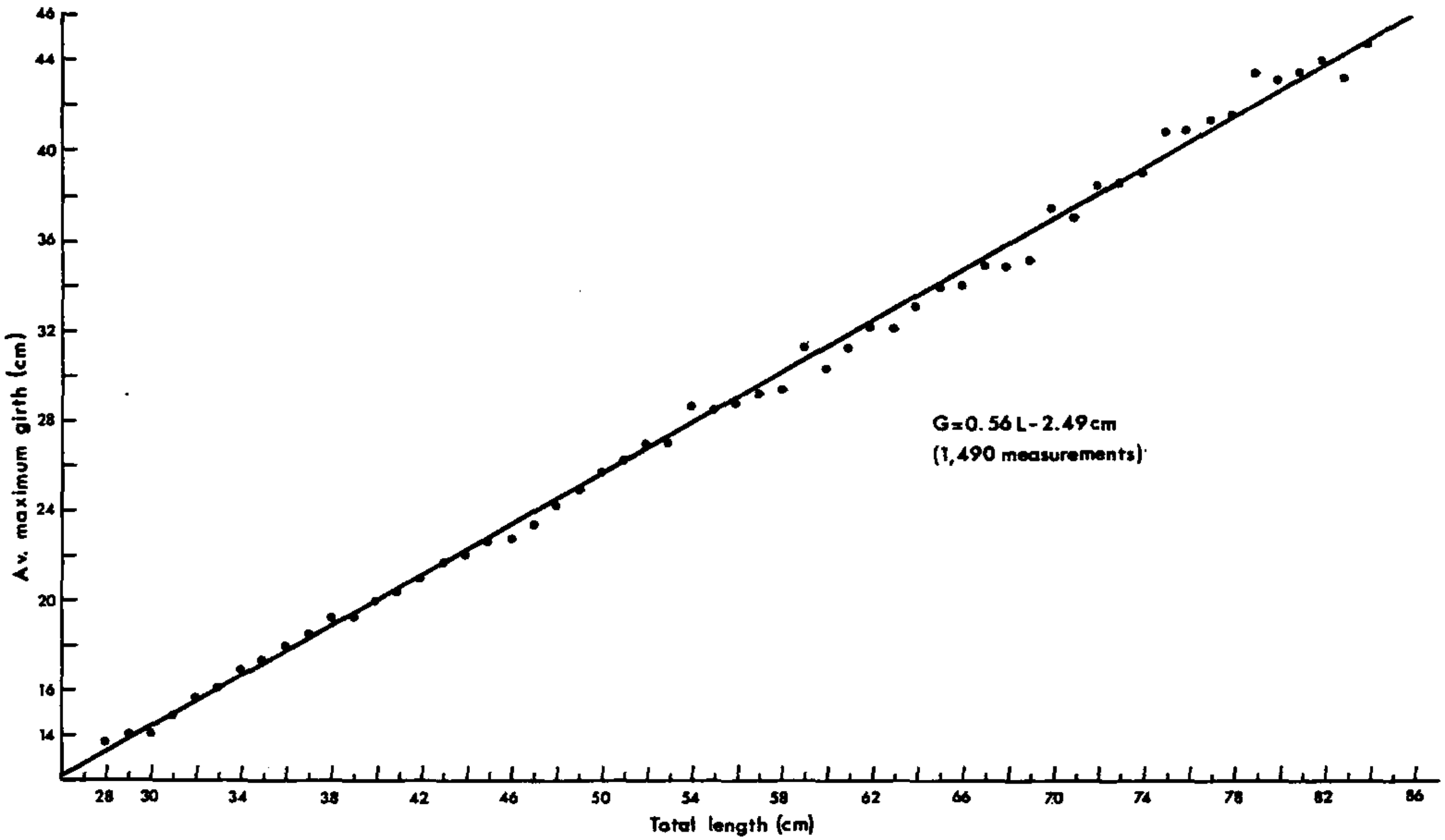

Fig. 3. Cod girth/length relationship at Holsteinsborg in Nov.-Dec. 1965.

SECTION C
SELECTIVITY OF CHAFERS

1. Recent selection experiments with the approved ICNAF topside chafer[1]

by H. Bohl
Institut für Fangtechnik
Hamburg, Federal Republic of Germany

At its 1965 meeting, the *ad hoc* Committee on ICNAF Trawl Regulations requested new information on the effect of the ICNAF topside chafer on codend selectivity (1965 Meeting Proceedings No.13). In compliance with this request, the Institut für Fangtechnik, Hamburg, conducted some appropriate experiments during the 12th cruise of FRV *Walther Herwig* in West Greenland waters.

The investigations were carried out under bad weather conditions (SE 7/8 Beaufört, snow showers) on 6 and 7 December 1965, on the eastern slope of Fyllas Bank (Div.1D), where small immature cod were concentrated in depths between 80 and 110 m (1.7°C).

To find out whether the ICNAF chafer had any effect on selectivity, a series of 4 successful hauls was to be made with a polyamide codend without chafer. Then the chafer was to be attached to the codend, and a further series of at least 4 hauls made. This plan, however, was upset by a tragic accident. While shooting the trawl with the protected codend the third time, a member of the crew fell overboard. The man could not be rescued from the sea. On that the experiments were stopped, and *Walther Herwig* started the homeward voyage one day earlier than originally intended.

Consequently only the results of two hauls with chafer can be compared with those of four hauls without chafer. The small number of hauls certainly reduces the value of the experiments, but not to such an extent that their results should remain unpublished.

During all of the trials 6,594 cod were caught in the codend and 3,794 cod in the cover. The total length of each fish was measured to the nearest centimeter. Fig. 1 shows the relative length composition of the total cod catch. It can be seen that large fish of more than 60 cm were vary sparsely represented. Most abundant were cod between 37 and 55 cm length (mainly year-classes 1961 and 1962) followed by those between about 26 and 36 cm (mainly year-class 1963). This length distribution proved extremely favourable for the experiments, because the selection range of the 122 mm codend used corresponded with the range of well-represented fish lengths. The catches, ranging from 18 1/2 to 40 1/2 baskets[2] per 1 1/4 hours' fishing time, were uniformly composed. Cod were clearly predominant; other fish *(Hippoglossoides platessoides, Anarhichas lupus, Anarhichas minor, Cyclopterus lumpus)* and invertebrates were caught in small quantities (compare Tables 1 and 2).

[1] submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/15
[2] large plastic baskets were used. The average net weight of one basket filled with cod was 68.5 kg.

The chafer was rigged according to the ICNAF specification: a rectangular netting piece made of the same material as the codend (Table 1) was attached with its forward edge across the upper side of the codend and with its lateral edges to the selvedges in such a manner that the codend was covered from 23 meshes ahead of the cod-line (*i.e.* four meshes in front of the splitting strap, if such a strap would have been used) to five meshes ahead of the cod-line mesh (*i.e.* the four aftermost codend meshes were not covered). The width of this netting (7.5 m) was one and a half times the width of the codend. The average mesh size of the chafer (127.5 mm) was slightly larger than that of the codend (122.2 mm).

It is unnecessary to give a detailed description of the experiments in the text of this paper, because all the interesting particulars are included in the tables and figures. One point, however, remains to be mentioned: the selection curves shown in Fig. 2 and 3 are based on smoothed percentages of retained fish (three-point moving averages). They are fitted by eye.

The selection data obtained from combined hauls are compiled in Table 1. Both the set of 4 hauls without chafer and the set of 2 hauls with chafer gave the selection factor 3.38. The selection ranges (9.4 cm without chafer and 8.5 cm with chafer) differed only slightly. The selection curves (Fig. 2) closely resembled one another. In other words, the chafer has not influenced the selectivity of the codend.

Since cod were sufficiently numerous in each catch, reliable selection data could also be obtained from each individual haul (Table 2 and Fig. 3). The selection factors for the 4 hauls made without chafer were found to be 3.28, 3.29, 3.40 and 3.44 (mean selection factor 3.35 ± 0.04). The corresponding selection ranges varied between 8.7 and 10.3 cm. In the two hauls made with chafer, a selection factor of 3.37 was found for each haul. The selection ranges were 8.2 and 8.9 cm. Thus the results presented on a haul-by-haul basis also show that the codend selectivity was unaffected by the presence of the chafer.

According to ICNAF regulations, the mesh size of the chafer may be the same as or larger than that of the codend. In the given instance, the chafer mesh size was larger by 5 mm. It is most unlikely that the experiments would have yielded another result, if the meshes of both the codend and the chafer had been of the same size.

It may be concluded from these experiments, which included catches ranging from 1.25 to 2.75 metric tons, that the ICNAF chafer rigged in the prescribed manner does not impair the codend selectivity for cod.

Table 1. Selection data for grouped hauls.

	Without chafer	With chafer
Ship	FRV *Anton Dohrn*, length o.a.83.3 m, 2000 h.p.e.	
Gear	German standard roundfish bottom trawl, 140' groundrope	
Date	6-7/12/1965	7/12/1965
Greenland time	1645-0145 (dark)	1620-2045 (dark)
Locality	Inner edge of Fyllasbank (63°56'N; 52°28'W)	
Depth range (m)	80-110	
Species studied	Cod	
Experimental method	Topside cover	
Cover	ICES specification, but double as wide as the codend	
Material	Nylon continuous	
Runnage (m/kg)	1200	
Tex	23 tex x 11 x 3	
Braiding	Single twine	
Twine construction	Twisted	
Mesh size (mm)	60	
Codend and chafer material	"Perlon" continuous	
Runnage (m/kg)	200	
R..tex	R 5000 tex	
Braiding	Double twine	
Twine construction	Twisted	
No. of hauls	4	2
Av.duration of haul (min.)	75	75
Av.towing speed through water(kn)	4.6	4.3
Type of mesh gauge	ICES gauge - 4 kg pressure	
Codend mesh size;mean ± s.e.(mm)	122.2±0.2	122.2±0.3
Range (mm)	116-128	115-129
No.of measurements	211	106
Chafer mesh size (mm)	-	127.5
25-75% selection range (cm)	9.4	8.5
No.of cod in sel.range codend	1279	727
No.of cod in sel.range cover	1152	705
Total No. of cod codend	4239	2355
Total No. of cod cover	2246	1548
Av. quantity of cod codend (baskets)	18 (=1233 kg)	19 1/3 (=1324 kg)
Av. quantity of cod cover (baskets)	4 3/4 (= 325 kg)	6 (= 411 kg)
other fish codend (baskets)	4	5
other fish cover (baskets)	1/3	3/4
invertebrates codend (baskets)	1/2	1/2
invertebrates cover (baskets)	+	+
50% retention length (mm)	413	413
Selection factor	3.38	3.38

Table 2. Selection data for individual hauls.

			Without chafer			With chafer	
Haul No.		64	65	66	67	68	69
Duration of haul (min.)		75	75	75	75	75	75
Codend mesh size; mean ± s.e. (mm)		122.1±0.3	122.2±0.3	122.3±0.3	122.2±0.3	121.9±0.4	122.4±0.3
Range (mm)		116–127	116–127	116–127	116–128	115–129	116–128
No. of measurements		53	52	53	53	53	53
Chafer mesh size (mm)		-	-	-	-	127.5	127.5
25–75% selection range (cm)		10.0	9.3	8.7	10.3	8.2	8.9
No. of cod in sel.range	codend	197	452	355	252	381	338
	cover	177	423	315	214	355	353
Total No. of cod	codend	574	1557	1178	930	1447	908
	cover	418	796	658	374	861	687
Quantity of cod	codend (baskets)	9 1/2 (= 651 kg)	27 3/4 (=1900 kg)	19 (=1302 kg)	15 3/4 (=1079 kg)	24 1/2 (=1678 kg)	14 1/4 (= 976 kg)
	cover (baskets)	2 3/4 (= 188 kg)	7 (= 480 kg)	6 (= 411 kg)	3 1/2 (= 240 kg)	6 2/3 (= 456 kg)	5 1/2 (= 377 kg)
other fish	codend (baskets)	5	5 1/2	3	2	5 1/2	4 1/2
	cover (baskets)	1/4	1/4	1/2	1/4	2/3	1
invertebrates	codend (baskets)	1	-	1	-	1/2	1/2
	cover (baskets)	+	-	+	-	+	+
50% retention length (mm)		402	415	421	401	411	412
Selection factor		3.29	3.40	3.44	3.28	3.37	3.37

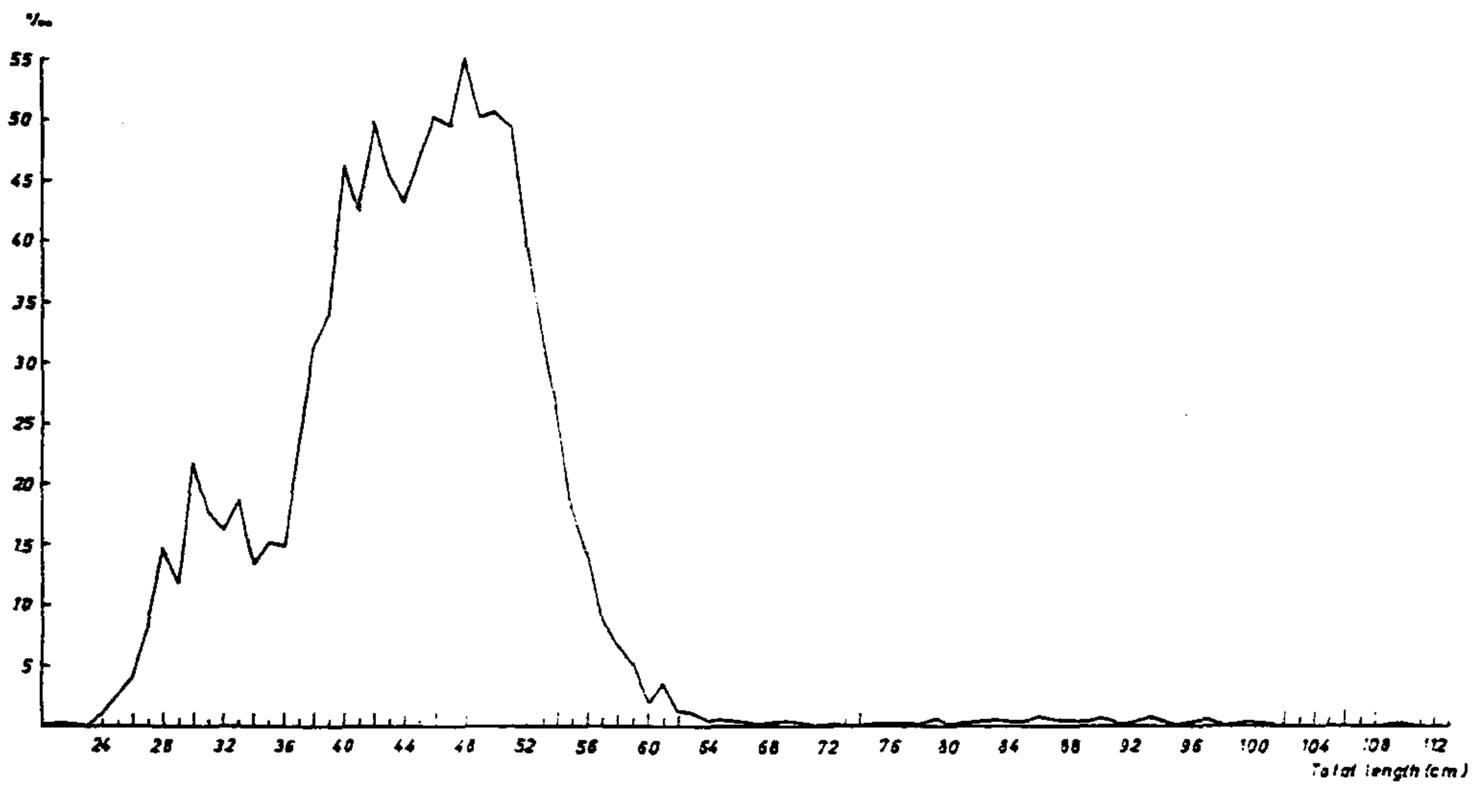

Fig. 1. Relative length composition of cod (codend + cover), 6 hauls; n = 10 388.

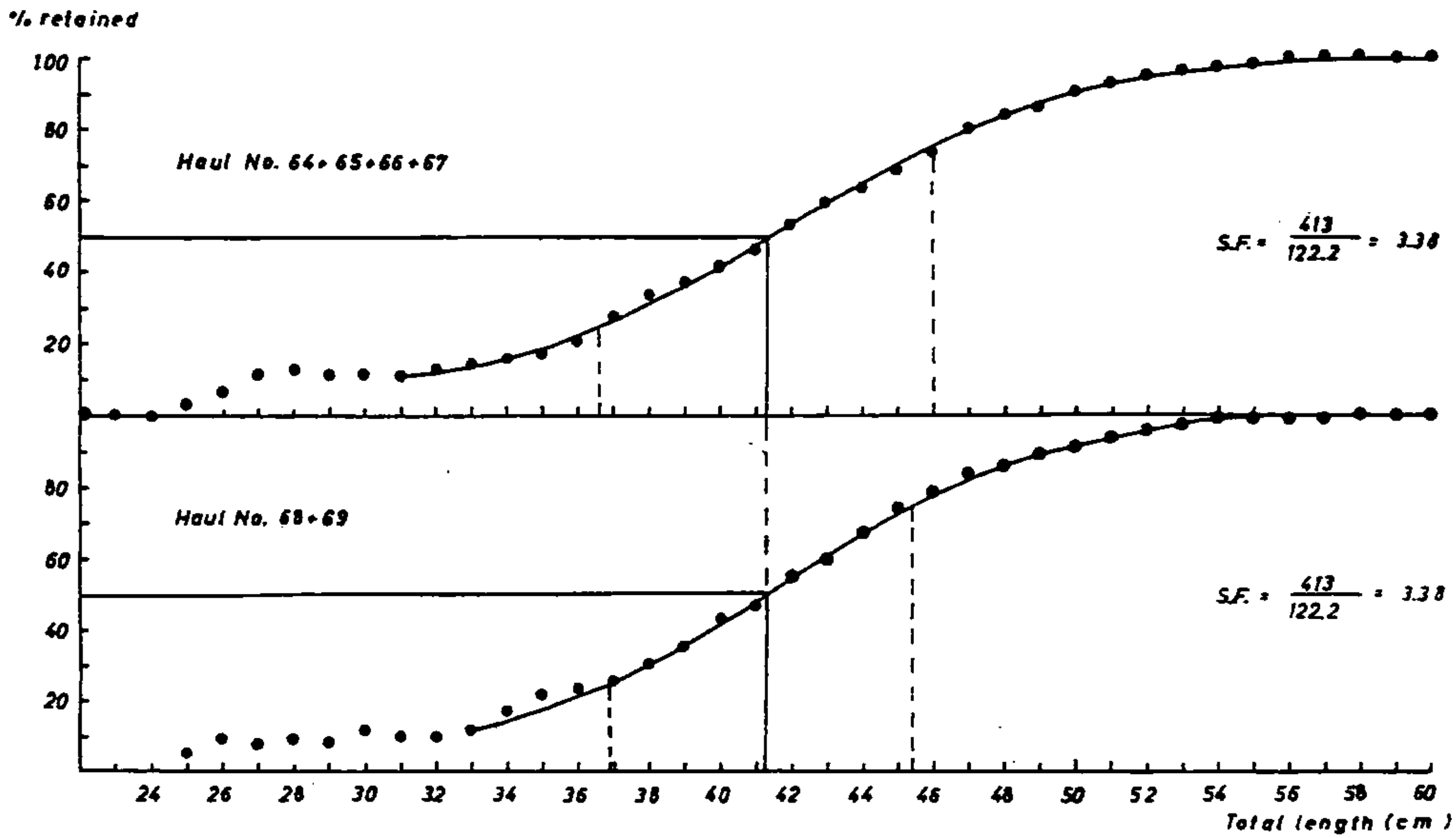

Fig. 2. Selection curves for combined hauls. Above: without chafer; Below: with chafer.

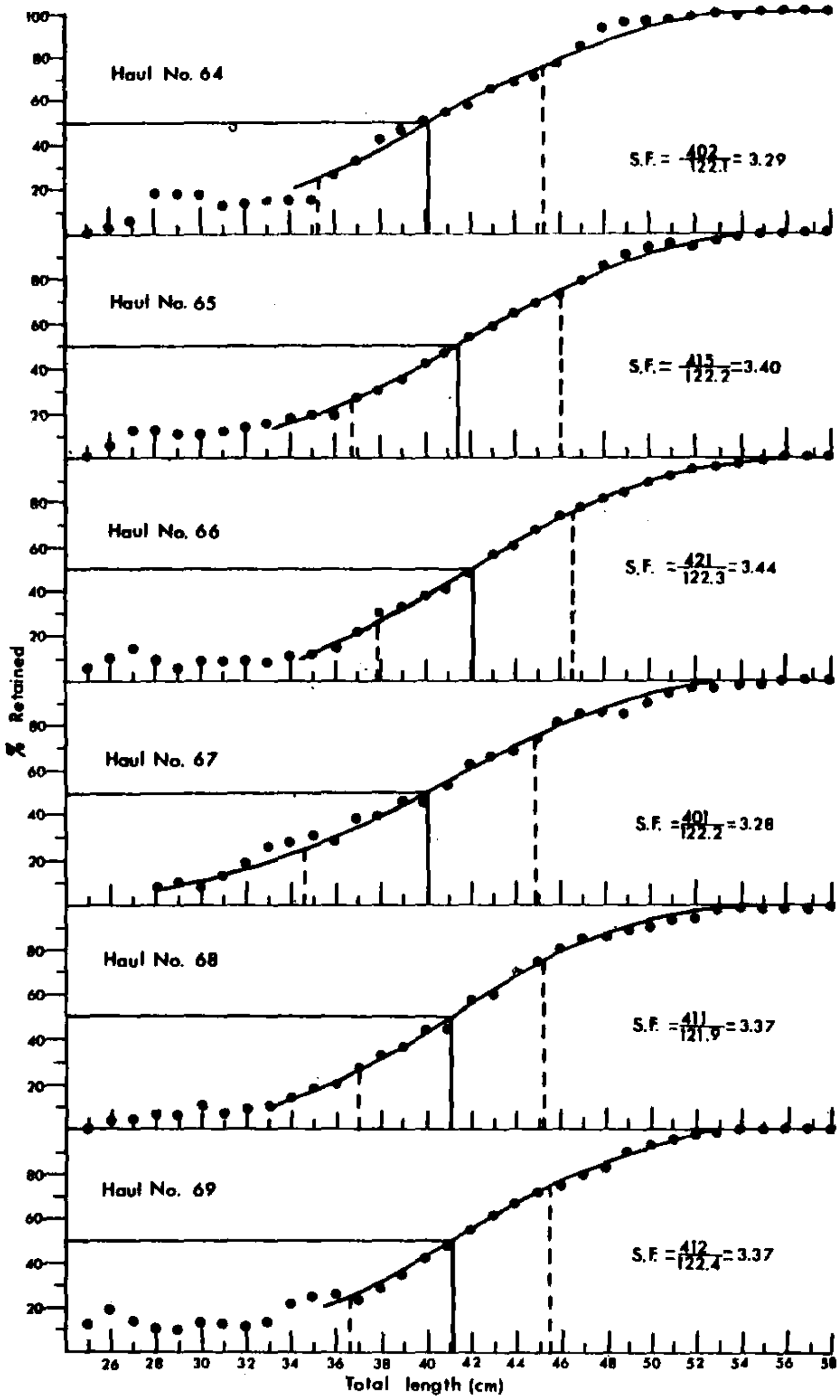

Fig. 3. Selection curves for individual hauls.
Haul No. 64-67: without chafer; Haul No. 68-69: with chafer

2. The Effect of the Use of Chafing Gear on Selection Factor[1]

by Witold Strzyzewski
Sea Fisheries Institute
Gdynia, Poland

Trawl nets used by stern trawlers have to possess more resistance than those used by side trawlers. This requirement is necessary in view of the great weight of fish sometimes lifted aboard in a single haul. The large quantity of fish threatens to break the codend and thus cause the loss of the catch. For this reason the codends have been until now made of double netting, which evidently provided great strength to the net, not ensuring, however, sufficient selectivity. In order to increase the selectivity and simultaneously secure necessary strength of the net, two variant forms of reinforcement of the codend were proposed. One form consisted of fastening a piece of netting with double the mesh size of the codend to its upper side. The other form consisted of a piece of netting fastened in the same manner but with the mesh four times larger than the mesh of the codend. This piece of netting, used for reinforcement, is called "chafing gear" in the present paper. It was rigged over the upper side of the codend in such a manner as to affect the selectivity to a minimum degree and simultaneously prevent possible breaking of the codend netting under the pressure of great weight of fish.

The first form of chafing gear was attached in such a way that each of its meshes covered exactly four meshes of the codend, whereas in the other form each mesh covered 16 meshes of the codend.

Our investigations aimed to find out how the proposed chafing gear affected the selectivity of fishing gear.

Area of Investigation

The investigations were carried out from 4 April to 18 June 1965 in the Convention Area, on fishing grounds from Flemish Cap to Sambro Bank. The trawling depths varied from 60 m to 360 m. The hauls were of 1-2 hours duration and were made only during daytime. The work was performed from the fishing vessel of the Sea Fisheries Institute, R/T *Wieczno*, of length 61.0 m, 797 GRT, 1,375 h.p.

Methods of Measuring Mesh and Some Remarks on the Applied Measuring Gauges

Internal mesh size was measured wet after use, when the codend was hauled on board and fish emptied. Mesh measurements were performed with the standard ICES gauge, made by the Dutch company "Observator". This gauge gives the dimensions of the mesh under a load of 4 kg.

[1]Submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/21

The use of the ICES gauge rather than the ICNAF gauge seemed to be justified for the following reasons:

(1) Though the Polish fishing fleet is operating in both the NEAFC and ICNAF areas, more of its vessels are fishing in the NEAFC area where the ICES gauge is in use;

(2) ICES gauge is based on a single pressure value, not as for the ICNAF gauge on a tolerance between 4.5 kg and 6.8 kg, which in turn affects the interpolation of the results obtained;

(3) The training of controllers for both areas, with equal requirements for both of them, becomes a more practical and easier task.

Fish Measurements

All fish measurements were made with an accuracy of 1 cm. All fish which were retained in the codend, as well as those which escaped from it into the cover, were measured. The following species were included in the investigations: cod, haddock, redfish, American (Canadian) plaice, yellowtail. The selection properties of the codends were established by means of codend covers, which captured fish on their escape from the primary netting of the codend. The weight of fish retained and escaped was determined in each haul.

Codends

The codends used were identical with those used by Polish stern trawlers. The dimensions of the codend were as follows: length 20.0 m, width over upper and lower edge was 5.2 m in stretch. These dimensions were always the same for all codends irrespective of the mesh size used.

Chafing Gear

The chafing gear, applied over the after part of the codend, covered its upper side, while on the lower side a common type of hide was rigged. The dimensions of the chafing gear were as follows: length 12.0 m, width 5.2 m. These dimensions were the same in all experiments. Chafing gear was attached along lateral edges to the joining of both sides of the codend. The upper edge of the chafing gear was fastened mesh-to-mesh to the primary netting of the codend. The lower edge of the chafing gear was fastened to the second row of codend meshes right behind the meshes used for selvage. The meshes of the chafing gear were not joined to the meshes of the codend beyond the lacings, but the netting with large meshes was fastened in such a manner that the twine of large and small meshes stretched over each other.

Covers for selection experiments

The common type of cover was used. Its mesh was 40 mm measured wet. The bag of the cover was wider than the codend proper, commenced at the after part of the belly and was divided into two parts. Its foremost part stretched over the frontal part of the codend, unprotected here by chafing gear. The other part covered the codend with chafing gear.

The fish retained in either of the parts were separately counted and the data brought into the tables refer to this kind of bag.

Kinds of codends and chafing gear used in the experiments

Codends, used in the experiments, were marked with symbols and numbers:

BS-2: - Codend made of double Stylon (Polish polyamide fiber) of 3.5 mm diameter[1]. The mesh size of the codend was 113.4 mm to 114.6 mm. This codend was used as a control to enable the comparison of the influence of chafing gear on decreasing the selective properties of the gear. No chafing gear was rigged on this codend.

BS-3: - Codend made of the same material as BS-2, i.e. of double Stylon twine of 3.5 mm diameter[1]. Its mesh size was 108.9 mm to 114.4 mm and the chafing gear with grate-shaped mesh, made of single twine of 5.0 mm diameter[2], was rigged on it. The mesh size of this chafing gear was four times larger than the mesh of the codend (16 meshes of the codend against one mesh of the chafing gear).

BS-4: - Corresponding to the codends BS-2 and BS-3 (designed by F. Chrzan), but of mesh size 117.6 mm. Chafing gear made of double Stylon twine of 3.5 mm diameter[1], having mesh size two times larger than the mesh of the codend itself (four meshes of the codend against one mesh of the chafing gear).

BS-5: - Codend made of single Stylon twine 5.0 mm in diameter[2] and mesh size of 123.0 mm to 128.5 mm. No chafing gear was used on this codend.

So for the experiments two codends of different materials and without chafing gear were used, and two codends with different kinds of chafing gear were used. The mesh sizes of the codends were 108.9 mm to 128.5 mm.

Results

The results obtained are presented in Fig. 1-5 and Table 1. Table 1 shows that the BS-2 codend (without chafing gear) has the highest selection factor in comparison to other codends.

[1,2]See note at end of paper

Selection factors of this codend for particular fish species were as follows: cod 3.92, haddock 3.78, redfish 2.85, American plaice 2.42 and yellowtail 2.29. In one case only, namely for redfish, the selection factor of BS-3, 2.92, was higher than that of BS-2. However, this might be attributed to chance, since selection factors of the BS-3 codend in relation to other species remained lower than those of the BS-2 codend.

On comparison of the results for BS-2 and BS-5, the codends without chafing gear but with twines of different thickness (BS-2 made of double twine of 3.5 mm diameter and BS-5 of single twine of 5.0 mm diameter), it appears that for BS-2 the factor is higher than for BS-5. This is true for all five species of fish investigated. Expressing these values in percent we can see that for BS-5 the selection factor is lower in comparison to BS-2 (assuming BS-2 to be 100%) by 13.5% for cod, by 15.1% for haddock, 18.9% for redfish, 9.1% for American plaice and by 5.1% for yellowtail.

It seems that the use of twine of comparatively large diameter (5.0 mm) was responsible for lowering the selection properties of the BS-5 codend. The mesh made of this twine was considerably stiffer than the mesh made of double twine. This relatively large diameter of the twine and hence its stiffness most probably influenced the value of the selection factor. Such an assumption is based on investigations on the effect of the thickness of twine upon selection, in which thicker twine reduced the value of selection factor. In these investigations carried out by Cieglewicz and Strzyzewski (1959), the selection factor for the codend made of comparatively thin cotton twine, No. 40/24, was 3.7, whereas that for the codend made of thick cotton twine, No. 20/54, was only 3.1.

According to our recent observations it appears that, not only the thickness of the codend twine but also the thickness of the chafing gear twine influences the selection. It has been found that even large mesh of such chafing gear does not provide the highest value of selection factor when thick twine is used for its netting. Such a conclusion may be drawn from the comparison of selection factors for the codends BS-3 and BS-4. The codends in both cases were made in the same manner of double Stylon of 3.5 mm diameter, However, on the BS-3 codend there was rigged chafing gear made of a single twine of 5 mm diameter with the mesh size four times larger than the mesh of the codend (one mesh of the cover against 16 meshes of the codend), whereas on the codend BS-4 there was rigged chafing gear made of double twine of 3.5 mm diameter with the mesh only two times larger than the mesh of the codend (4 meshes against one mesh of the chafing gear).

Initially it was assumed that the codend with chafing gear of larger mesh size would provide sharper selectivity, but this assumption proved wrong, since the selection factor for BS-3 (with larger mesh size in the chafing gear), calculated on the basis of our experiments, was 3.67, while for the codend BS-4 (with smaller mesh size in the chafing gear) was 3.77.

From these data we have to conclude that the thickness of twine, both in the codend and in the chafing gear, exerts a great influence upon the selective properties of the gear.

We have to add here that the selection factor for the control BS-2 codend is lower in relation to the BS-4 codend by 3.8% only, while for the BS-3 codend it is lower by 6.4%.

The escapement of fish in the frontal part of the codend - as seen from the data given in the tables relating to cod in the BS-4 codend and to redfish in the BS-3 codend - is insignificant in comparison to the escapement in the terminal part of the codend. Hence the conclusion that the terminal part of the codend decides the selection.

Mesh size of investigated codends and chafing gear in relation to manila 114 mm mesh

As already mentioned, in the ICNAF Area the selectivity provided by the size of mesh in the codends should correspond to the selectivity of nets made of manila netting with 114 mm mesh. According to F.D.McCracken (1964), this mesh size relates to cod length of 40 cm. Using the formula

$$\frac{L}{s} = m$$

where L = fish length, s = selection factor, m = mesh size and substituting L = 40 cm and for s the values obtained for selection factors for particular codends, we obtain respective mesh sizes which shall be equivalent to manila mesh 114 mm. Thus for the codends used in our experiments the mesh sizes providing equal selectivity shall be the following:

BS-2 - 102 mm mesh in the codend (no chafing gear)
BS-3 - 109 mm mesh in the codend, 436 mm mesh in the chafing gear
BS-4 - 106 mm mesh in the codend, 212 mm mesh in the chafing gear
BS-5 - 118 mm mesh in the codend (no chafing gear).

It should be noted that these figures refer to the mesh measurements performed in wet state by means of ICES gauge.

Conclusions

The results of our investigations indicate that, in spite of the use of chafing gear different to that recommended by ICNAF, it is possible by proper selection of mesh size in the codend and in the chafing gear to maintain adequate selectivity, for cod and other fish species, equivalent to the selectivity of manila net with mesh size 114 mm.

Hence it can be concluded that it is admissible to use chafing gear other than the ICNAF type, provided that the requirements of necessary selection for captured fish species are fulfilled.

According to our investigations these requirements are best met by the BS-3 and BS-4 codends (with chafing gear) whose selection properties for cod were, in comparison to the BS-2 codend (without chafing gear), decreased only by 6.4% and 3.8% respectively.

If the mesh size, as pointed out above, is 109 mm in the BS-3 codend and 436 mm in its chafing gear, 106 mm in the BS-4 codend and, subsequently, 212 mm in the chafing gear, the required selectivity will be maintained and these types of codends should be approved for practical fishing.

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McCracken, F.D., 1964. Minimum mesh sizes and equivalents for different materials to meet ICNAF regulations. *Annu. Meet. int. Comm. Northw. Atlant. Fish.* 1964. Doc. No. 72, Serial No.1368 (mimeographed).

Note

[1]3.5 mm = Tkt 7; [2]5.0 mm = Tkt 20

Tkt is the weight per unit length of twine expressed in kilo-tex units (kilograms per kilometer).

Table 1. Summary of results of selectivity experiments, Subareas 3 and 4, 1965.

Species	Kind of codend	Hauls (No.)	Mesh size (mm)	Number of fish: escaped	Number of fish: retained	Number of fish: total	Weight of fish: escaped (kg)	Weight of fish: escaped (%)	Weight of fish: retained (kg)	Weight of fish: retained (%)	Weight of fish: total (kg)	50% fish length (cm)	Range 25%-75% (cm)	Selection factors	Decrease of s.f. from BS2="O"
Cod	BS-2	6	114.3	2459	1101	3560	658	25	1929	75	2587	44.9	38,3-48,4	3,92	0,0
	BS-3	9	114.4	5371	5693	11064	1731	16	9053	84	10784	40.9	37,7-46,8	3,67	-6,4
	BS-4	6	117.6	3475	3916	7391	1394	15	7633	85	9027	44.4	39,1-50,3	3,77	-3,8
	BS-5	9	124.4	2476	2470	4946	851	14	5358	86	6209	45.2	39,5-50,2	3,39	-13,5
Haddock	BS-2	5	113.4	2061	827	2888	574	37	997	63	1571	42.9	36,4-45,5	3,78	0,0
	BS-5	3	127.3	2000	1408	3408	841	42	1138	58	1979	40.9	33,6-44,8	3,21	-15,1
Redfish	BS-2	5	114.6	6845	2321	9166	1408	59	982	41	2390	32.7	28,9-35,7	2,85	0,0
	BS-3	3	109.3	5017	4019	036	869	25	2563	75	3432	32.0	29,9-34,9	2,92	+2,5
	BS-5	1	128.5	206	166	372	62	37	105	63	167	29.7	25,7-39,1	2,31	-18,9
American plaice	BS-2	3	113.6	301	610	911	30	12	220	88	250	27.5	24,5-29,2	2,42	0,0
	BS-3	3	108.9	371	670	1041	30	17	144	83	174	25.4	23,1-27,1	2,33	-3,7
	BS-5	2	123.0	735	1490	2225	78	15	437	85	513	27.1	24,4-29,8	2,20	-9,1
Yellow-tail	BS-2	1	114.2	149	760	909	21	9	242	91	263	26.6	24,6-27,7	2,29	0,0
	BS-5	1	127.0	232	1003	1235	35	8	425	92	460	26.6	21,2-28,9	2,15	-6,1

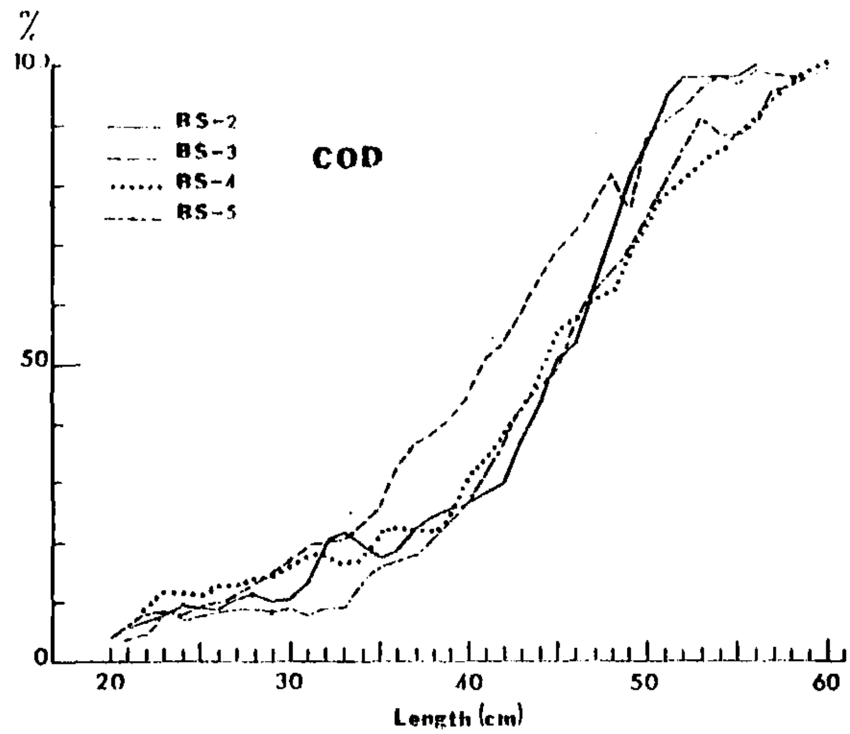

Fig. 1. Selection curves for cod.

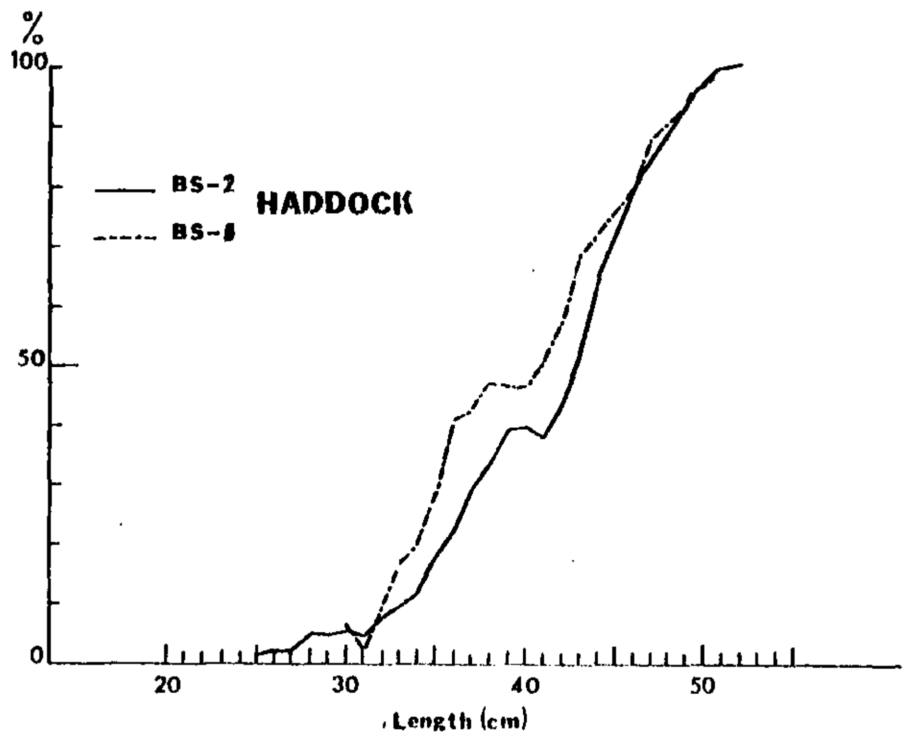

Fig. 2. Selection curves for haddock.

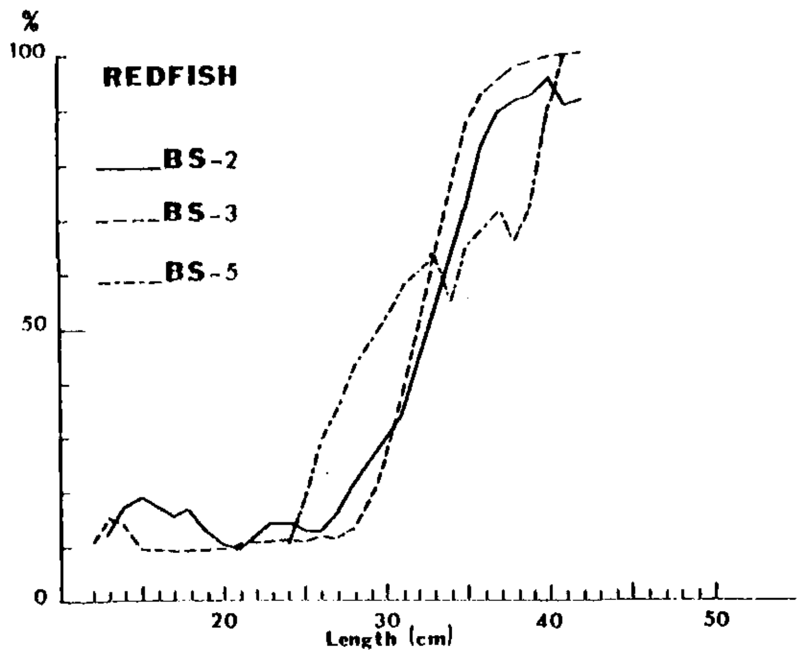

Fig. 3. Selection curves for redfish.

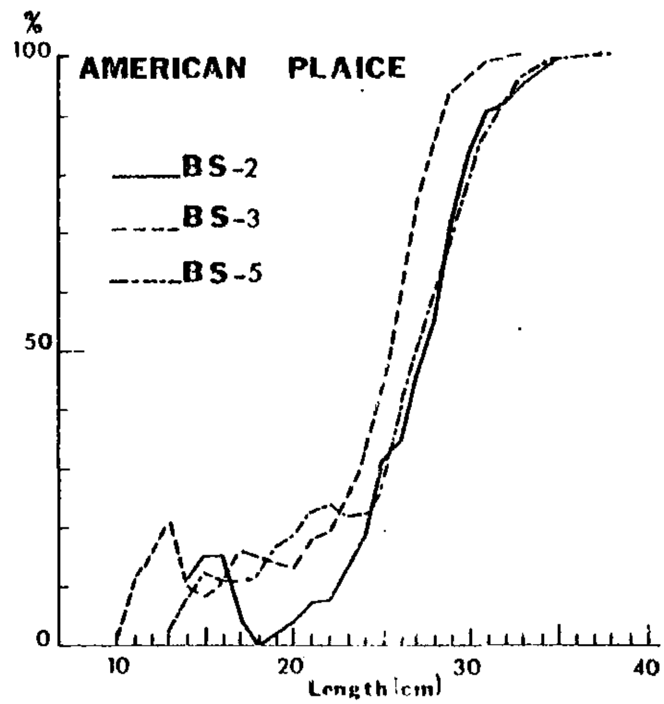

Fig. 4. Selection curves for American plaice.

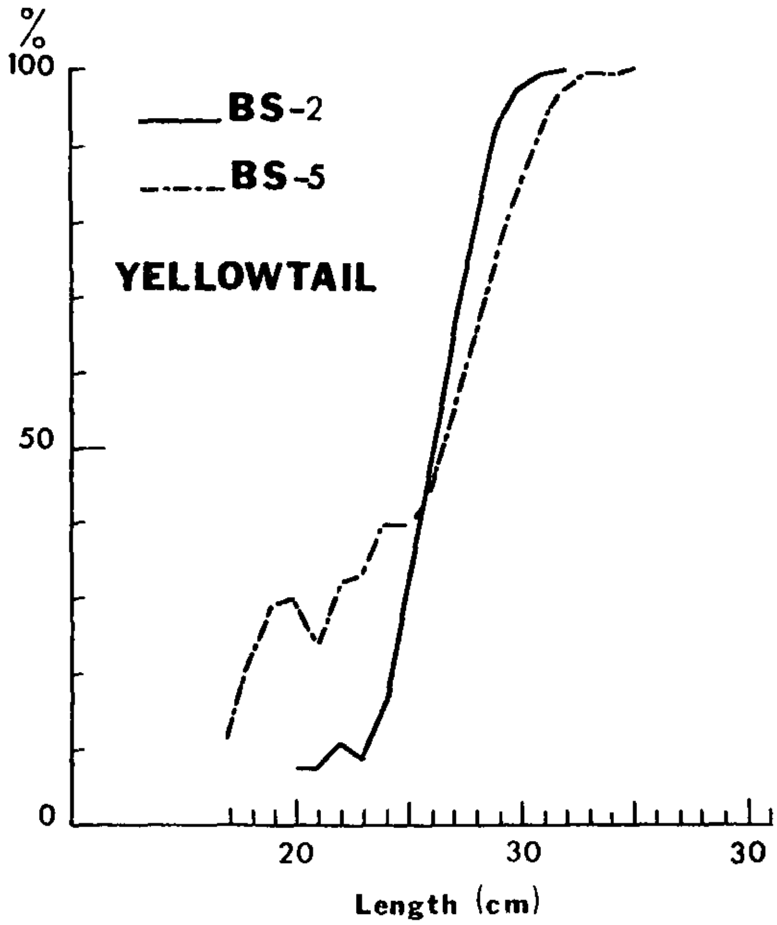

Fig. 5. Selection curves for yellowtail.

3. The effect of the approved ICNAF topside chafer on codend selectivity[1]

by H. Bohl
Institut für Fangtechnik
Hamburg, Federal Republic of Germany

Introduction

At the 1965 Annual Meeting, the Standing Committee on Research and Statistics noted a request by the *ad hoc* Committee on ICNAF Trawl Regulations for new information on the effect of the approved ICNAF topside chafer on codend selectivity (1965 Meeting Proceedings No.13, section 2) and recommended that a review of the available information on this item - including, if possible, an analysis of the effects of catch size on selectivity with the chafer - should be prepared for the 1966 Annual Meeting (*Redbook* 1965, Part I, p.19).

Topside chafer regulations in force

Hitherto regulations regarding topside chafer only entered into force for Subareas 3, 4 and 5. The regulations valid for Subareas 4 and 5 read as follows (ICNAF *Handbook*, 1965, pp.95-98):

> "IV. That the Contracting Governments permit ... (2) a rectangular piece of netting to be attached to the upper side of the codend of the trawl net to reduce and prevent damage so long as such netting conforms to the following conditions:
>
> (a) This netting shall not have a mesh size less than that specified in paragraph I...
>
> (b) This netting may be fastened to the codend only along the forward and lateral edges of the netting and at no other place in it, and shall be fastened in such a manner that it extends forward of the splitting strap no more than four meshes and ends not less than four meshes in front of the cod line mesh.
>
> (c) The width of this netting shall be at least one and a half times the width of the area of the codend which is covered, such widths to be measured at right angles to the long axis of the codend."

The chafer regulations in force for Subarea 3 differ from those for Subareas 4 and 5 only in the wording of the subparagraph IV(b) which reads (ICNAF *Handbook*, 1965, p.93):

[1]submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/29

"IV.

(b) This netting may be fastened to the codend only along the forward and lateral edges of the netting and at no other place in it and shall not exceed 16 meshes in length counted parallel to the long axis of the codend."

Experimental data

In the last decennium a fair number of papers has been written about topside chafing gear and its influence on codend selectivity, but relatively few of them are, in whole or in part, concerned with the approved ICNAF topside chafer. Most of the experimental data relevant to this report are contained in papers by Clark (1958),Saetersdal (1958), Beverton, Parrish and Trout (1959), McCracken (1959 and 1960) and Bohl (1966). The remaining data worthy of consideration are drawn from various sources mentioned below.

To answer the question whether and to what extent codend selectivity is impaired by the ICNAF topside chafer, it is first of all necessary to recapitulate the experimental results available.

Clark (1958) used underwater television equipment to observe the effect of the ICNAF chafer on the escapement of haddock. Two hauls with a 127 mm manila codend were made off Cape Cod in June 1957 by *Albatross III* in 18 fathoms depth at a towing speed of 3 1/2 kn. The number of fish of the escape size taken per hour of tow amounted to 400 specimens (750 pounds). During the first haul the fish were observed inside the codend. The behaviour of haddock did not differ from that observed in codends without chafer under similar conditions. During the second haul the camera was attached to the external upper side of the codend. The chafer "was seen very clearly to flow up away from the codend, allowing about two feet clearance at its after end." The chafer seemed not to be under heavy strain, and its mesh angles varied from 90° at the rear end to 60° at the forward end.

Visual observations of the escape patterns were supplemented by moving picture recordings of the television screen. From a 3 1/2 minute film it could be seen that of the 68 haddock which escaped from the codend, 42 escaped through the chafer meshes (14 after considerable struggling with the chafer meshes and 28 without struggle) and 26 escaped through the rear opening of the chafer (4 after struggling with the chafer and 22 without touching the chafer). Clark came to the conclusion that the chafer "flows up clear of the codend under tow and does not obstruct the codend meshes nor interfere with the escapement of haddock through them." He concluded further that this chafer "does not prevent haddock from completing their escape once they have emerged from the codend. Since fish escaped through the meshes as well as through the rearward opening of the chafing gear, it appears desirable to control both mesh size and degree of clearance."

Saetersdal (1958) reported on chafer experiments conducted by R/V *Johan Hjort* in July 1958 on the East Finmark and Kildin Banks. Using a wide cover 6 hauls were made with the ICNAF chafer (double manila, approximately 110 mm mesh size) attached to a rather new, double-braided manila codend (108-113 mm mesh size). Eight hauls were made without chafer. (The mesh sizes cited for both chafer and codend are not very reliable, since mesh measurements have only been made sporadically and in insufficient numbers.) The length of the chafer was not constant, due to the fact that at first new netting with heavy shrinkage was used. Later on during the experiments this chafer was replaced by a worn-out codend netting having the prescribed dimension. The catches consisted mainly of cod of sizes within the selection range. The quantities caught were small and amounted usually to 20-25 baskets (the net weight of one basket is not stated).

The results of Saetersdal's experiments are shown in the following compilation:

No. of tows	Average mesh size codend/chafer (mm)	(mm)	No. of rearmost codend meshes not covered	Towing speed (kn)	50% length (mm)	S.F.
3	108	110	10 ?	3.60	395	3.66
2	109	110	6	3.75	405	3.72
1	113	110	4	3.47	445	3.94
1*	110	-		3.15	445	4.05
5*	111	-		3.85	405	3.65
2*	112	-		3.78	390	3.48

*Tows without chafer

The average selection factor of the series of hauls with chafer was 3.77 and that of the series of hauls without chafer 3.73. The variability of the results could not be ascribed to variations in catch size or duration of haul, but an indirect relationship was found between towing speed and selection factor. Saetersdal concluded from these experiments that a topside chafer rigged according to ICNAF specifications has no influence on codend selectivity. He stressed, however, that the catches in these trials have been small and that "a complete study of the problem would have to be based on further material, especially from larger catches."

McCracken (1959) reported on chafer studies carried out in September 1958 in Div. 4W. Within 4 days 20 successful tows, each of 45 minutes duration, were made by the R/V *Harengus*. Haddock were taken in good quantities; the catches averaged about 1,000 pounds per tow. A new, double-strand, 5-inch manila codend covered by a small-meshed Nyak netting was used. The chafer made from the same netting as the codend was 50% wider than the codend, whereas the cover used in these trials was only about 33% wider. That means that the width of the chafer was certainly not wholly effective. This fact, however, was not reflected in the selection data obtained: The selection curves derived from 12 tows without chafer and from 8 tows with chafer were shown to be quite similar in shape and position. Both portions of the trials yielded a 50% retention length of about 41-42 cm and a selection factor of about 3.2 or 3.3.

McCracken concluded from these results that "with catches of the size shown, top chafing gear mounted according to ICNAF specifications had no influence on retention within the codend. Since the effective slack of the top chafing gear was less than that specified by ICNAF, the results suggest that netting less than 1 1/2 times the width of the codend might be used."

During September/October 1959 and March 1960 the Canadian chafer experiments were continued in Subarea 4 (McCracken, 1960). On this occasion different types of chafing gear were tested. In the following, however, only that portion of the trials is considered which was concerned with the approved ICNAF topside chafer. Two sets of hauls with chafer and 4 sets of hauls without chafer were conducted by R/V *Harengus* in September 1959 on Sable Island Bank (Div. 4W). Again the covered codend technique was applied. Fishing was carried out with double-braided manila codends having mesh sizes between 114 and 121 mm. The meshes of the manila chafers used were larger than those of the codends by 11 and 15 mm, respectively. Haddock, the species studied, were caught in rather poor quantities; the haddock catches ranged from 1/2 to 26 baskets per tow (1 basket = 38 kg, approximately). The trials gave the following results:

No. of tows	Mesh size codend/chafer (mm)	(mm)	Total catch all species (baskets)	Total no. of haddock (30-50 cm)	Sel. range (cm)	50% length (cm)	S.F.
4*	114	-	45	1,400	5	34	3.0
5	117	132	63	3,500	8	36	3.1
6*	121	-	85	5,100	7	39	3.2
6	121	132	150	7,800	8	39	3.2
4*	121	-	35	2,100	7	40	3.3
6*	121	-	75	3,700	6	42	3.5

*Tows without chafer

The average selection factor for the sets of tows with chafer was 3.15 and that of the sets of tows without chafer 3.25. (The latter is reduced to 3.17, if the last group of tows, which was made about 10 days after the previous series and in a slightly different area, is left out of account). Thus the results show that ICNAF chafers 11-15 mm larger than the codend mesh "did not reduce escapement appreciably".

Beverton, Parrish and Trout (1959) outlined some provisional results of English and Scottish chafer experiments carried out in 1958. As to the English experiments, the general data given by the three authors are supplemented by selection curves contained in the Compilation of Selectivity Data (ICNAF, 1962) as well as by curves and tables in the NEAFC document NC 3/25, 1965. Moreover, additional data on the English experiments were obtained by letter from the Fisheries Laboratory, Lowestoft (Mr R.W. Blacker).

Tests in which double manila codends and double manila ICNAF chafers of about the same mesh size were used, have been carried out by the covered codend technique during two cruises of R/V *Ernest Holt* in June/July 1958 on Sorkapp Bank/Spitsbergen (Cruise IV), and in October 1958 on Hornsund Bank/ Spitsbergen and in the region of Bear Island (Cruise VI). On both cruises mainly cod were caught; the catches were only occasionally mixed with moderate quantities of haddock. The results obtained were as follows:

Cruise	No. of tows	Mesh size codend/chafer (mm)	(mm)	Duration of tow (hrs)	Catch sizes (basket+) only cod range	average	50% length (mm)	S.F.
IV	5	103	105	1	31-66	45	320	3.1
	4*	103	-	1	3-86	42	351	3.4
VI	9	110	105	1 1/2-2	4-63	18 1/3	436	4.0
	6*	110	-	1 - 2	8-82	26	449	4.1

*Tows without chafer + 1 basket = 38 kg approximately

It appears from these data that the ICNAF chafer did impair the codend selectivity on Cruise IV, whereas the same chafer left the selectivity practically unimpaired on Cruise VI. In this context, however, it has to be stressed that the results obtained from Cruise IV are apparently not very reliable. The selection factor of 3.4 for the tows without chafer seems to be over-estimated. Judging from the selection curves published (ICNAF, 1962; NEAFC, 1965), a selection factor of 3.3 or even 3.2 would probably be more adequate. Anyway, really reliable selection factors cannot be given for Cruise IV, because scarcely any cod of the 0-50% retention lengths were caught with the 103 mm codend mesh used. So it remains to be stated that the data of Cruises IV and VI offer no proof that the ICNAF chafer has appreciably reduced the selectivity of the codend.

During Cruise VII of the *Ernest Holt* (Nov.-Dec. 1958; Barents Sea) some experiments were conducted in which a double manila chafer (ICNAF specification) of above 150 mm mesh size was fitted on alternate hauls to a double manila codend of 130 mm mesh size. The cod selection curves for the codend with and without chafer were virtually identical. Both curves gave a 50% retention length of 47 cm (selection factor 3.6).

Finally, it is worth mentioning that on the occasion of Cruise V of the *Ernest Holt* (Aug.-Sept. 1958) tests were made with a chafer having a substantially smaller mesh size (81 mm) than the codend used (105 mm). (The mesh size excepted, the chafer complied closely with the ICNAF specifications.) In this case the codend selectivity for cod was found to be markedly reduced (with chafer: 50% length = 34.6 cm, S.F. = 3.3; without chafer: 50% length = 39.5 cm, S.F. = 3.8). The statement, however, that "the 50% length corresponded, in fact, to what would have been expected if the mesh size of the chafer had been the determining factor for selection" (Beverton *et al.*, 1959), proves to be false, because the authors erroneously believed that a chafer of 95 mm mesh size had been used in these trials.

The preliminary account of the Scottish chafer experiments given by Beverton *et al.* (1959) has recently been completed and partly corrected by a written communication from the Marine Laboratory, Aberdeen (Mr J.A.Pope).

The experiments were carried out by R/V *Explorer* during December 1958 in Faroese waters. Two double-braided manila codends of different mesh sizes were used. A series of hauls was made with each codend, hauls within each series being made with or without a large-meshed double manila chafer (ICNAF type) in a random order. By the covered codend technique the following selection data were obtained, the species referred to being haddock:

No. of tows	Average mesh size codend/chafer (mm)	(mm)	Duration of tow (hrs)	Sel. range (cm)	Total number of haddock in sel. range	50% length (mm)	S.F.
3	82.0	106.5	1	4.9	466	258	3.15
2*	82.0	-	1	5.1	395	225	2.74
6	99.4	131.3	1	4.0	2,152	257	2.59
6*	99.4	-	1	5.7	1,448	283	2.85

*Tows without chafer

The above compilation shows conflicting results. The first portion of the trials revealed no chafer effect; quite the contrary, the tows with chafer gave a markedly higher selection factor than those without chafer. The second portion, however, being based on more tows than the first, pointed to a relatively large chafer effect: A reduction of the selection factor for haddock by about 9% (from 2.85 to 2.59) was found on hauls in which the codend (99 mm) was fitted with a large-meshed chafer (131 mm). The extent to which this difference was possibly caused by factors other than the presence of the chafer (*e.g.* masking effect of the cover), could not be determined from the data.

Bohl (1966) reported on selection experiments with the approved ICNAF chafer which were carried out by FRV *Walther Herwig* (a stern trawler of 83.3 m length o.a.) in December 1965 on the eastern slope of Fyllas Bank (Div. 1D). A double-braided polyamide codend of 122 mm mesh size was fished in conjunction with a small-meshed polyamide cover (ICES specification, but double the width of the codend). The chafer having a mesh size of 127.5 mm was made from the same netting as the codend. The catches, ranging from 1 1/4 to 2 3/4 metric tons per 1 1/4 hours' fishing time, were uniformly composed. Cod were clearly predominant; other fish and invertebrates were caught in small quantities. The selection data for cod, obtained from combined hauls, were as follows:

No. of tows	Average mesh size codend/chafer (mm)	(mm)	Duration of tow (hrs)	Average wt of cod (kg)	Sel. range (cm)	No. of cod in sel.range	50% length (mm)	S.F.
2	122.2	127.5	1 1/4	1,735	8.5	1,432	413	3.38
4*	122.2	-	1 1/4	1,558	9.4	2,431	413	3.38

*Tows without chafer

Both the set of hauls with chafer and the set of hauls without chafer gave the selection factor 3.38. Since cod were sufficiently numerous in each catch, reliable selection data could be obtained from each individual haul. The selection factors for the 4 hauls made without chafer were found to be 3.28, 3.29, 3.40 and 3.44 (mean selection factor 3.35 $\pm$ 0.04). In the two hauls made with chafer, a selection factor of 3.37 was found for each haul. Thus the results represented on a haul-by-haul basis also show the codend selectivity to be unaffected by the presence of the chafer.

An "ICNAF chafer" is reported to have been used in Russian experiments which were carried out at Iceland in July 1962 by the stern trawler *Goncharov* (Treschev, 1965). However, the designation of the chafer is misleading, for it can be taken from the Cooperative Research Report No.3 (ICES, 1965), that the *Goncharov* trials were conducted with a topside chafer "of the same mesh size as the codend, and of the same length, fixed at the forward end and open at the rear, and of a width such that the ratio of perimeter of chafer to perimeter of codend was as 5:4." That is why Treschev's data are omitted from this review.

Discussion

The above results of covered codend experiments carried out between 1958 and 1965 to determine the effect of the approved ICNAF topside chafer on codend selectivity can be summarized as follows: In most of the trials similar selection data were found for chafered and unchafered codends. The selection factors obtained for cod and haddock from tows with chafer were slightly larger than, the same as, or slightly smaller than those obtained from tows without chafer; the maximum difference observed was 0.1. In other words, the majority of the trials revealed no chafer effect.

Differences in selection factors being larger than 0.1 were only found in the following three cases:

(1) During the Scottish experiments (R/V *Explorer*, Dec. 1958, Faroese waters) an 82 mm manila codend was used with and without chafer (107 mm mesh size). The resulting selection factors for haddock were 3.15 for the chafered codend and 2.74 for the unchafered codend. This unexpected result, indicating a better selectivity for the codend with chafer, is not very reliable, because it is based on a small number of hauls with rather poor catches.

(2) On the same occasion *Explorer* also used a 99 mm manila codend with and without chafer (131 mm mesh size). This time the haddock selection factors obtained were 2.59 for the chafered codend and 2.85 for the unchafered codend. That means, a reduction of the selection factor by about 9% was found on hauls in which the chafer was attached to the codend. This result, being based on a sufficient number of hauls, points to a relatively large chafer effect. It should, however, not be left out of account that it is not clear whether and to what extent the reduction of the codend selectivity was due to factors other than the presence of the chafer. So it may have been that the

cover, although being rigged extra-wide, "was having a masking effect, overlaying the chafer and forcing it to lie closer to the codend than it would normally" (Beverton *et al.*, 1959).

(3) On one of the cruises of R/V *Ernest Holt* (English experiments, June/July 1958, Spitsbergen) a 103 mm manila codend was used with and without chafer (105 mm mesh size). The resulting selection factors for cod were about 3.1 for the chafered codend and about 3.4 for the unchafered codend (NEAFC, 1965). Both factors, however, have been shown above to be unreliable: They were obtained from catches in which cod of the 0-50% retention lengths were almost entirely absent. In addition to this it has been pointed out that the selection factor for the codend with chafer was obviously overestimated. Therefore, no special importance should be attached to this portion of the English trials.

With the single exception of that Scottish trial in which a 131 mm chafer was found to reduce the selectivity of a 99 mm codend for haddock by 9%, the experiments reviewed in this report show no chafer effect. So it may be concluded from all the results available that the approved ICNAF topside chafer has little or no influence on the selectivity of the codend for cod and haddock.

It has been supposed that extra large catches may cause the chafer to alter escapement (McCracken, 1960). However, it is not possible to substantiate this assumption by experimental data, because all the data available are based on small or medium-sized catches. Yet it can be seen from the German experiments that catches up to 2.6 metric tons per tow do not cause the chafer to reduce the codend selectivity for cod (Bohl, 1966). The results obtained from the British, Canadian and Norwegian chafer experiments are, in contrast to the German results, not presented on a haul-by-haul basis. Therefore it is in these cases practically impossible to analyse the effects of catch size on the selectivity of chafered codends.

To guarantee an unimpaired codend selectivity, it is necessary that the rigging of the chafer complies closely with the ICNAF specifications. By means of underwater television, Clark (1958) could observe that haddock, once emerged from the codend, complete their escape through the meshes as well as through the rearward opening of the chafer. He concluded from this observation that it would be essential to control both mesh size and slack of the chafer. Selection experiments carried out later with different modifications of the ICNAF chafer led to the same conclusion: Chafers having the prescribed slack of 50% but smaller mesh sizes than the codend reduced the selectivity (*Ernest Holt*, Cruise V/1958, Beverton *et al.*, 1959, etc.). Chafers having the same mesh size as the codend but a slack of only 10-20% affected also the selectivity of the codend (McCracken, 1959; Bohl, 1964).

On the other hand, no reduction in selectivity was detected when a chafer was attached to a codend of the same mesh size with an effective slack of about 33% (McCracken, 1959). Not even a chafer having a slack of 25% and the same mesh size as the codend impaired the selectivity (Treschev, 1965; ICES, 1965). These results indicate that the prescribed 1 1/2 times width of the chafer is more than sufficient and that a chafer somewhere between 1 1/4 and 1 1/2 times as wide as the codend would be adequate. That, however, does not mean that the 1 1/2 times width specified by ICNAF regulations should be reduced. Quite the contrary, as long as there is no more scientific evidence, it is deemed absolutely necessary to maintain this width.

"ICNAF chafers" being applied almost tightly (laceage wider by only 5-8 meshes) had a severe effect on the selectivity of the codend, when the mesh size of the chafer was only slightly larger than that of the codend. However, they had no effect when the size of the chafer mesh (165 mm) was considerably larger than that of the codend mesh (111 mm) (McCracken, 1960). In the light of this evidence it seems to be possible to use tight chafers with extra-large mesh sizes.

Finally, it must be mentioned that not only the width and the mesh size but also the length of the chafer may be relevant to the selectivity of the codend. Canadian trials (Martin, 1957) showed that an excessive length of the chafer reduced escapement appreciably, but Russian experiments (Treschev, 1965; ICES, 1965) gave opposite results.

Conclusions

By the scientific evidence summarized in this report, it is clearly shown that with catch sizes up to 2.6 metric tons the ICNAF topside chafer rigged in the prescribed manner has little or no influence on the codend selectivity for cod and haddock. Improper application of the chafer, however, can seriously reduce escapement. This reduction can be caused by insufficient width, insufficient mesh size and/or excessive length of the chafer.

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4. The effect of chafers on the selectivity, strength and durability of trawls[1]

(a second revised report)

by A.I.Treschev
VNIRO, Moscow

Following the ICNAF recommendation to explore the possibility of elimination of the use of topside chafing gear, investigations have been carried out in the USSR in recent years to evaluate the effect of topside chafers of different types on the selectivity, strength and durability of trawls.

In 1964, at the Annual Meeting of ICNAF, Soviet experts made a verbal statement about the extent and main lines of the research in this field.

In 1965 a special report on the preliminary results of the completed work was presented to the Annual Meeting of ICNAF (1965 Research Document No. 66, Serial No.1534). This revised report comprises the data of the above-mentioned investigations in detail.

1959 Experiments

First experimental data on the comparative selectivity of trawls used with and without chafers were obtained by the USSR in 1959 during a trip of the trawler *Tunets*. During that cruise, experiments were conducted to determine the selectivity of trawls used without chafers and at the same time fishing operations were carried out with a trawl having a tightly-fitted chafer made of the same material as the codend. A comparison of the results of the experimental trawlings showed a certain difference in the size composition of catches obtained. According to data from alternate hauls, the 50% selection length, for a double-braided flax-and-hemp codend made of twine of 5 mm in diameter with the inner mesh size of 110 mm and used without chafer was 39 cm, and for the same codend with chafer was 37 cm.

1962 Experiments

At the time of the international trawl selectivity experiments conducted in Icelandic waters in 1962 (ICES Cooperative Research Report No.3, 1965), experimental hauls were carried out from the large stern trawler *Goncharov* to estimate the effect of a modified ICNAF-type chafer on trawl selectivity in fishing for cod and haddock. The topside chafer used was of the same mesh size as the codend, and of the same length, fixed at the forward end and open at the rear, and of a width such that the ratio of perimeter of chafer to perimeter of codend was as 5:4. These experiments were performed with the use of conventional commercial trawl nets. Duration of the hauls varied from 1 1/2 hours to 3 hours depending on the size of catches. Each successive experiment comprised not less than 5 hauls. For estimation of selectivity, a

[1]submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/58

small-meshed cover was applied.

1963 Experiments

The effect of a chafer on trawl selectivity in the redfish fishery was studied on board the large stern trawler *Kometa* in 1963 in ICNAF Div. 3K and 3T. This chafer, the *Sevryba* type, was made from the same material as the codend. It had the same mesh size and was an equal number of meshes in width. It was located in the rear part of the codend along 207 rows of the codend which had a total length of 441 rows. Attachment of the chafer to the codend was mesh for mesh along the fore and side edges. To prevent displacement of the meshes of the chafer in relation to the codend, the meshes of both were fixed with a lacing running down the middle and forked at the after end. The rear selvages of the chafer and the codend were tucked in together and tied in the usual manner. On the after part of the codend, a protective flap made of bull hide or some other rigid fabric was attached to the underside. (See Circular Letter by Executive Secretary dated 16 January 1964. Chafing gear used by ICNAF countries.) For estimation of the selectivity, the same codend was tried several times with and without a chafer.

1964 Experiments

In 1964, the laboratories of commercial fishing techniques of VNIRO (Moscow) and PINRO (Murmansk) developed and tested a number of experimental Kapron (a polyamide synthetic) codends of a new design with a view to finding a material of greater strength which could be used for making trawl codends. Preliminary laboratory experiments were conducted to choose the most suitable netting twine. The main requirement for those experiments was to ensure the maximum tenacity of webbing when the diameter of the twine is not more than 4.5 mm and the relative length does not exceed that of Kapron trawl nets with normal use. Two types of twisted trawl twine, R8500 tex 80S and R9500 tex 71S, were chosen in the course of laboratory dynamometric tests. The strength of a knot of double webbing made of the twine of the first type was 540 kg, and that of the second type about 620 kg. These webbings were used to make experimental codends which were extensively (until completely worn out) tested on board the large stern trawler *Severnoye siyanie* of the *Pushkin* type. Figure 1 shows a diagram of the experimental codend with its dimensions (also in 1965 Research Document No.66, Serial No.1534). Trials were made under normal fishing conditions with the speed of haul from 3.5 to 4 knots and duration of haul from 1/2 to 3 hours.

During these experiments, observations were made on wear and tear resistance of the material and on changes in the mesh sizes of the experimental codends during their use. The mesh size was measured before using the codends and then at intervals of 10 hauls. The ICNAF wedge-shaped gauge and the ICES spring-loaded mesh gauge were used. In each codend, 30 consecutive meshes, starting at least 10 meshes from the lacings, were measured. To calculate the rate of fatigue of the material used in the codends used without chafers, samples of webbing, 5 meshes by 5 meshes in size, were periodically cut from the codends for analysis. The results of determination of mesh size and strength of meshes are shown in Table 1.

Table 1. Sizes and strengths of meshes of experimental trawl codend "A" (of twine R8500 tex 80S) and codend "B" (of twine R9500 tex 71S).

Indices	A				B			
	Before use (dry)	After 10 hauls	After 20 hauls	Average	Before use (dry)	After 10 hauls	After 20 hauls	Average
Inner size of mesh (mm)	99.9	106.6	114.0	106.8	96.2	102.8	107.2	102.1
Strength (kg)	540	560	507	535.7	620	630	570	606.6

In addition to the above, the experimental codends were tested for their selectivity. For this purpose five hauls were made with each codend rigged with a fine-meshed cover of standard type.

Data obtained from the tests are set out in Annex 1 and Annex 2 to this report.

Table 2 shows a summary of the results of the above-described experiments on the estimation of the effect of chafers on the selectivity of bottom trawls in relation to cod, haddock and redfish.

Discussion and conclusions

The experiments showed (Table 2) that the effect of a flap chafer of the ICNAF type and a tightly-fitted chafer of the *Sevryba* type on the selectivity of codends for cod is approximately the same. The mean value of the selection factors for codends made of double Kapron twine and used with these types of chafers can be taken as equal to 3.7. The difference in selectivity of codends used with and without chafer in this case will be $\frac{(4.0 - 3.7) \times 100}{3.7} = 8.1\%$.

The effect of chafers of the ICNAF type on the selectivity of codends for haddock has proven to be considerably greater: $\frac{(4.0 - 3.45) \times 100}{3.45} = 15.9\%$

It is quite possible that the specific features of the region and the season have contributed to this. The experiments were carried out off Iceland at the end of summer when haddock were feeding heavily. Moreover, a mean value of selection factor (3.45) had been obtained only from two series of tests which differed greatly in their indices of selectivity (0.9).

Table 2 also shows that the use of a chafer of the *Sevryba* type did not have any appreciable effect on the selection factor for redfish. There is

Table 2. Results of experiments on evaluation of the effect of use of different types of chafers on the selectivity of trawls in relation to cod, haddock and redfish. Selection factors calculated in relation to mesh sizes of chafers are shown in brackets.

Vessel and year	Area	Codend	Chafer	Avg catch per haul (kg)	50% selection length (cm)	Selection factor	
			Cod				
Tunets, 1959	Barents Sea	Double flax- and hemp 109.2 mm	Nil	1,420	39.0	3.6	
"	"	"	Double flax- and hemp 109.6 mm	1,350	37.1	3.4	
Goncharov, 1962	Iceland	Double Kapron 108.0 mm	Nil	1,253	44.7	4.1	
Kometa, 1963	Labrador	Double Kapron 104.8	"	2,817	41.9	4.0	4.0
Severnoye siyanie, 1965	Labrador	Double Kapron 102.1 mm	"	7,869	41.4	4.0	
"	"	Double Kapron 107.0 mm	"	4,289	42.2	3.9	
Goncharov, 1962	Iceland	Double Kapron 108.0 mm	modified ICNAF type Double Kapron 127.2 mm	2,027	41.5	3.8 (3.3)	3.65
"	"	Double Kapron 125.0 mm	modified ICNAF type Double Kapron 109.0 mm	1,853	44.0	3.5 (4.1)	
Kometa, 1963	Flemish Cap	Double Kapron 104.0 mm	*Sevryba* type 107.2 mm	3,040	39.8	3.8 (3.7)	
			Haddock				
Goncharov, 1962	Iceland	Double Kapron 108.0 mm	Nil	1,253	43.3	4.0	
"	"	Double Kapron 108.0 mm	modified ICNAF type Double Kapron 127.2	2,027	42.5	3.97 (3.4)	3.45
"	"	Double Kapron 125.0 mm	modified ICNAF type Double Kapron 109.0 mm	1,853	36.7	3.0 (3.4)	
			Redfish				
Kometa, 1963	Flemish Cap	Double Kapron 107.2 mm	Nil	1,970	28.5	2.7	
"	"	Double Kapron 102.8 mm	*Sevryba* type 104.0 mm	1,327	27.5	2.7 (2.6)	

reason to believe that redfish which are being raised from a great depth become very active due to the sharp changes in hydrostatic pressure and escape not only through the codend but also through the meshes of the foreparts of the trawl. This assumption is confirmed by frequent observations of the meshing of redfish in the portions of a trawl ahead of the codend.

Results of mesh measurements in experimental codends showed that the elongation of trawl twine when used without chafer was considerably greater than that when chafer was attached. In codends tested without chafers, stabilization of the meshes did not occur after the tenth haul as usually happens when a chafer is applied. The relative increase in inner size of mesh in codend "A" between the tenth and twentieth hauls was 7% and that in codend "B" was about 4%. The relative increase of mesh size after the tenth haul in comparison with a new webbing measured in dry condition in both cases was the same, *i.e.* approximately 6.5%. The breaking strength of meshes in codend "A" as well as in codend "B" became somewhat greater after the tenth haul as compared with new material. Obviously this can be explained by the fact that the dynamometric measurements were made under different conditions, *i.e.* in the wet and dry state. Mesh strength in both codends decreased considerably between the tenth and twentieth hauls. This decrease caused by fatiguing of the codend material essentially affected the durability of the codends tested. During tests, codend "A" was damaged seven times. It became completely worthless (broken down when the catch was being hauled along the slip) after 53 hours of trawling. Codend "B" was damaged three times. It lifted catches up to 15 tons and broke down when a catch of about 20 tons was hauled on the slip. This codend was used for a total of 77 hours of trawling. The average duration of work with tightly-fitted chafers is 150-200 hours of trawling. Thus, with comparatively great average breaking strength of mesh (606.7 kg), the operations conducted without chafing gear from high-sided stern trawlers are restricted both by the size of catches hauled and the durability of codends.

In these conditions, if it is taken into account that the selectivity depends largely on the relationship between mesh sizes in the codend and in the chafer (see experiments with different mesh sizes in codend and in chafer, *Goncharov*, 1962), the technical solution which would secure an increase in selectivity and which would retain an appropriate strength, would be the use of tightly-fitted chafers made of webbing with mesh size two times the mesh size of the codend. As the experiments showed, such a codend has to be reinforced with transverse wires at intervals of not more than 2 m to prevent mesh displacement.

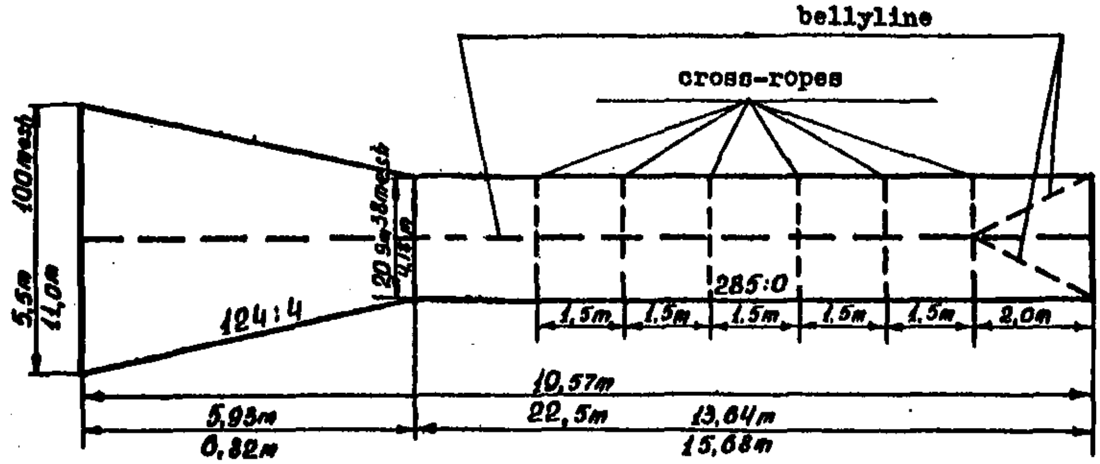

Fig. 1. Diagram of an experimental codend designed to operate without chafer.

Annex 1

Soviet experiment on trawl without chafing gear, *Severnoye Siyanie*, cod, double Kapron

Area	Labrador								
Type of codend	A								
Average mesh size (mm)	107 mm								
	Haul 1			Haul 2			Haul 3		
Length (cm)	Cod-end	Cover	Reten-tion %	Cod-end	Cover	Reten-tion %	Cod-end	Cover	Reten-tion %
< 31		119	0		21	0		59	0
31	8	46	14.8		15	0	2	24	7.7
2	12	135	8.2		36	0	6	63	8.7
3	22	50	30.5	1	8	11.1	5	50	9.1
4	19	80	19.2	1	11	8.3	2	30	6.2
5	27	250	9.7	9	27	25.0	19	100	16.0
6	40	213	15.8	2	10	16.7	6	71	7.8
7	50	201	19.9	4	29	12.1	56	115	32.7
8	53	108	32.9	3	21	12.5	12	74	13.9
9	66	301	17.9	2	13	13.3	40	100	28.6
40	180	200	47.4	5	25	16.7	151	107	58.5
1	200	246	44.8	28	30	48.3	80	165	32.6
2	283	492	36.5	20	54	27.0	120	86	58.2
3	216	180	54.5	26	85	23.4	13	85	13.3
4	320	106	75.1	32	37	46.4	195	69	73.9
5	329	72	82.0	77	10	88.5	192	45	81.0
6	108	10	91.5	23	70	24.7	226	18	92.6
7	233	18	92.8	20	4	83.3	108	2	98.2
8	162	6	96.4	21		100.0	46	5	90.2
9	387	12	96.9	33		100.0	175	12	93.6
50	558	26	95.5	72		100.0	273	6	97.8
1	606	24	96.2	86		100.0	416	3	99.3
2	504	12	97.7	30		100.0	373		100.0
3	288		100.0	29		100.0	264		100.0
4	488		100.0	81		100.0	368		100.0
5	583		100.0	23		100.0	168		100.0
6	369		100.0	23		100.0	336		100.0
7	261		100.0	80		100.0	288		100.0
8	453		100.0	27		100.0	264		100.0
9	261		100.0	78		100.0	152		100.0
60	207		100.0	36		100.0	132		100.0
1	126		100.0	42		100.0	256		100.0
2	471		100.0	18		100.0	104		100.0
3	108		100.0	72		100.0	56		100.0
4	72		100.0	3		100.0	168		100.0
5	27		100.0	13		100.0	32		100.0
6	49		100.0	41		100.0	88		100.0
7	89		100.0				8		100.0
8	45		100.0				104		100.0
9	59		100.0				136		100.0
70				6		100.0	176		100.0
1	72		100.0				96		100.0
2	86		100.0				32		100.0
3	18		100.0				48		100.0
4	9		100.0	23		100.0	8		100.0
5							16		100.0
6							8		100.0
7	9		100.0				24		100.0
8									
9									
80							16		100.0
	8,533	2,907	74.6	1,092	506	68.3	5,864	1,289	82.0

**Annex 1
(continued)**

Soviet experiment on trawl without chafing gear, [illegible], cod, double Kapron

Area	Labrador								
Type of codend	A								
Average mesh size (mm)	107 mm								
	Haul 4			Haul 5			Total		
Length (cm)	Cod-end	Cover	Reten-tion %	Cod-end	Cover	Reten-tion %	Cod-end	Cover	Reten-tion %
< 31		85	0		45	0		329	0
31	7	50	12.3	2	17	10.5	19	152	11.1
2	7	90	7.2	10	47	17.5	35	371	8.6
3	1	35	2.8	4	29	12.1	33	172	16.1
4	4	68	5.5	29	70	29.3	55	259	17.5
5	64	249	20.4	28	100	21.9	147	726	16.8
6	5	60	7.7	45	99	31.2	98	453	17.8
7	10	110	8.3	53	100	34.6	173	555	23.7
8	15	170	8.1	134	315	29.8	217	688	23.9
9	57	154	27.0	131	156	45.6	296	724	29.0
40	83	300	21.7	108	205	34.5	527	837	38.6
1	89	275	24.4	116	142	44.9	513	858	37.4
2	180	139	56.4	260	145	64.2	863	916	48.5
3	35	248	12.4	344	70	83.1	634	668	48.7
4	280	90	75.7	288	120	70.6	1,115	422	72.5
5	240	196	55.0	432	170	71.8	1,270	493	72.0
6	132	95	58.1	378	70	84.4	867	263	76.7
7	419	42	90.9	344	15	95.8	1,124	81	93.3
8	301	39	88.5	295	25	92.2	825	75	91.6
9	222	9	96.1	188	10	94.9	1,005	43	95.9
50	384	21	94.8	459	50	90.2	1,746	103	94.4
1	154	18	89.5	512	15	97.1	1,774	60	96.7
2	340	12	96.6	415	5	98.8	1,662	29	98.3
3	336	3	99.1	216	5	97.7	1,133	8	99.3
4	397	5	98.7	468		100.0	1,802	5	99.7
5	255	3	98.8	558		100.0	1,587	3	99.8
6	357		100.0	423		100.0	1,508		100.0
7	326		100.0	297		100.0	1,252		100.0
8	154		100.0	216		100.0	1,114		100.0
9	234		100.0	117		100.0	842		100.0
60	91		100.0	171		100.0	637		100.0
1	188		100.0	252		100.0	864		100.0
2	289		100.0	279		100.0	1,161		100.0
3	21		100.0	90		100.0	347		100.0
4	140		100.0	144		100.0	527		100.0
5	112		100.0	18		100.0	202		100.0
6	56		100.0	27		100.0	263		100.0
7	182		100.0				279		100.0
8	70		100.0	63		100.0	282		100.0
9	196		100.0	54		100.0	445		100.0
70	28		100.0	36		100.0	246		100.0
1	7		100.0	18		100.0	193		100.0
2				9		100.0	127		100.0
3	21		100.0	9		100.0	96		100.0
4							40		100.0
5	14		100.0	9		100.0	39		100.0
6	7		100.0				15		100.0
7	7		100.0				40		100.0
8	7		100.0				7		100.0
9									
00							16		100.0
	6,524	2,566	71.8	8,049	2,025	79.9	30,062	9,293	76.4

Annex 2

Soviet experiment on trawl without chafing gear, *Severnoye Siyanie*, cod, double Kapron

Area				Labrador					
Type of codend				8					
Average mesh size (mm)				102 mm					
	Haul 1			Haul 2			Haul 3		
Length (cm)	Cod-end	Cover	Retention %	Cod-end	Cover	Retention %	Cod-end	Cover	Retention %
<31		1	0		13	0		7	0
31					3	0		5	0
2		1	0		4	0		6	0
3				1	4	20.0		4	0
4				1	6	14.3	1	25	3.8
5				2	10	16.7		12	0
6		2	0	1	5	16.7	2	26	7.1
7				5	20	20.0	1	19	5.0
8		1	0	2	10	16.7	2	25	7.4
9	1	5	16.7	1	6	14.3	4	36	10.0
40	5	2	71.4	7	43	14.0	22	75	22.7
1	4	3	57.1	4	24	14.3	18	54	25.0
2	2	2	50.0	10	45	18.2	30	75	28.6
3	5	3	62.5	21	48	30.4	46	80	36.5
4	3	2	60.0	19	32	37.2	50	70	41.7
5	25	7	78.1	159	102	60.9	106	42	71.6
6	16	3	84.2	60	20	75.0	81	24	77.1
7	12	5	70.6	82	13	86.3	100	14	87.7
8	24	10	70.6	26	2	92.8	72	6	92.3
9	42	2	95.4	30	2	93.7	68	4	94.4
50	28	8	77.8	62	4	93.9	105	4	96.3
1	26	6	81.2	65	3	95.6	98	4	96.1
2	47	4	92.1	132	8	94.3	84	2	97.7
3	28	2	93.3	49		100.0	142	6	95.9
4	13		100.0	48		100.0	75		100.0
5	85		100.0	72		100.0	51		100.0
6	2		100.0	40		100.0	81		100.0
7	70		100.0	49		100.0	63		100.0
8	5		100.0	24		100.0	61		100.0
9	10		100.0	22		100.0	45		100.0
60	30		100.0	34		100.0	42		100.0
1	1		100.0	10		100.0	6		100.0
2	4		100.0	12		100.0	16		100.0
3	2		100.0	2		100.0	5		100.0
4				12		100.0	22		100.0
5	1		100.0	14		100.0	15		100.0
6	41		100.0	4		100.0	12		100.0
7				4		100.0	26		100.0
8				22		100.0	1		100.0
9	11		100.0				4		100.0
70				6		100.0			
1	2		100.0						
2									
3									
4									
5									
	545	69	88.8	1,114	427	72.3	1,557	625	71.3

Annex 2
(continued)

Soviet experiment on trawl without chafing gear, *Severnoye Siyanie*, cod, double Kapron

Area	Labrador								
Type of codend	B								
Average mesh size (mm)	102 mm								
	Haul 4			Haul 5			Total		
Length (cm)	Cod-end	Cover	Reten-tion %	Cod-end	Cover	Reten-tion %	Cod-end	Cover	Reten-tion %
< 31		26	0		18	0		65	0
31		20	0		8	0		36	0
2	2	27	6.9	2	30	6.2	4	68	5.5
3	2	33	5.7	7	27	20.6	10	68	12.8
4	3	32	8.6	8	40	16.7	13	103	11.1
5	8	89	8.2	20	108	15.6	30	219	12.0
6	8	50	13.8	14	92	13.2	25	175	12.5
7	4	31	11.4	24	26	48.0	34	96	26.1
8	8	69	10.4	144	102	58.5	156	207	42.9
9	24	130	15.6	126	92	57.8	156	269	36.7
40	58	230	20.1	192	78	71.1	284	428	39.9
1	41	198	17.1	398	166	70.6	465	445	51.1
2	95	158	37.5	328	128	71.9	465	408	53.3
3	270	70	79.4	144	96	60.0	486	297	62.1
4	205	94	68.6	420	146	74.2	697	344	66.9
5	290	76	79.2	402	132	75.3	982	359	73.2
6	210	46	82.0	393	59	86.9	760	152	83.3
7	385	70	84.6	336	54	86.1	915	156	85.4
8	270	8	97.1	520	42	92.5	912	68	93.1
9	330	6	98.2	288	22	92.9	758	36	95.5
50	360	32	91.8	576	48	92.3	1,131	96	92.2
1	220	2	99.1	376		100.0	785	15	98.1
2	420	4	99.0	248		100.0	931	18	98.1
3	305		100.0	496		100.0	1,020	8	99.2
4	295		100.0	272		100.0	703		100.0
5	330		100.0	472		100.0	1,010		100.0
6	245		100.0	352		100.0	720		100.0
7	270		100.0	248		100.0	700		100.0
8	350		100.0	280		100.0	720		100.0
9	130		100.0	256		100.0	463		100.0
60	210		100.0	64		100.0	380		100.0
1	125		100.0	162		100.0	304		100.0
2	140		100.0	32		100.0	204		100.0
3	140		100.0	8		100.0	157		100.0
4	20		100.0	104		100.0	158		100.0
5	35		100.0				65		100.0
6	45		100.0	128		100.0	230		100.0
7	10		100.0	184		100.0	224		100.0
8				16		100.0	39		100.0
9				40		100.0	55		100.0
70	5		100.0	48		100.0	59		100.0
1	5		100.0	16		100.0	23		100.0
2				8		100.0	8		100.0
3				16		100.0	16		100.0
4				8		100.0	8		100.0
5				32		100.0	32		100.0
6				16		100.0	16		100.0
7									
8									
9									
80									
	5,873	1,501	79.6	8,224	1,514	84.4	17,313	4,136	80.7

SECTION D
HYDROGRAPHY

1. Hydrographic observations in Subareas 1, 2 and 3, July-August 1965[1]

by W. Templeman
Fisheries Research Board of Canada
Biological Station
St. John's, Newfoundland

Introduction

The 6 monitoring hydrographic sections across the Labrador Current and Continental Shelf from Seal Islands, Labrador, to the southern Grand Bank were occupied 23 July-23 August 1965 by the *Investigator II*.

In approximately the same period, during a cruise of the *A.T.Cameron* 28 July-24 August to West Greenland with the author as scientist-in-charge, temperature sections were taken at fishing locations, often along somewhat scattered lines of stations, along the West Greenland coast and across the eastern half of Baffin Bay and the Labrador Sea (Fig. 1). These West Greenland temperatures were taken for background information for the fishing sets and were by surface thermometer, bathythermograph from surface to 275 m, reversing thermometers at 275 m, at bottom, and at intermediate levels. The temperature profiles appear to show the main features of the water masses, but, from the methods used, no salinities are available between those at the surface and those at 275 m.

West Greenland Area

In the northern sections westward from Disko Bank and Disko Bay across part of the deep water of Baffin Bay to the West Ice (Fig. 2A, 2B), the cold intermediate water of 0°C and lower formed by winter chilling extended from the coastal shelf westward, with the lowest temperatures (-1.5°C) and greatest volume toward the west. Below the cold layer the West Greenland Current was present with highest temperatures (as high as 3.3° to 3.4°C) at the slope of the West Greenland Shelf and lower temperatures westward and deeper. Even at 1,200-1,300 m the effects of this current were evident in temperatures of 0.1° to 0.2°C. Moderately warm water extended into Disko Bay with a small volume above 4°C at 275 m.

In the section extending into Baffin Bay from the northern peak of Store Hellefiske Bank (Fig. 2C), the effects of the West Greenland Current were great enough that the intermediate coldest water below 0°C no longer touched the slope but was situated to the westward, the lowest temperature at the slope being 1.7°C. Westward over Baffin Bay near the West Ice, temperatures of 0°C were present at the surface. A bottom temperature of 4.5°C was found in the shallowest water on the bank and highest temperatures in the West Greenland Current below the intermediate layer were 3.5° to 3.6°C, slightly higher than

[1]Submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/43

in the more northern sections.

In the section extending southward over the eastern side of Store Hellefiske Bank and westward from the southern part of this bank (Fig. 2D), bottom temperatures on the bank were 5.5° and 5.0°C; the lowest temperature of the intermediate water over the slope of the bank was 2.6°C and the highest temperature of the West Greenland Current below the intermediate layer was 4.9°C.

In the section from Lille Hellefiske Bank west over the Davis Strait Ridge (Fig. 3A), the lowest temperatures of the intermediate layer were 1.3° to 1.5°C and lay west of the slope, and the highest temperature of the West Greenland Current below the intermediate layer was 5.1°C.

In the sections from Fylla Bank and Fiskenaes Bank westward (Fig. 3B, 3C), bottom temperatures on the outer parts of the banks were moderately low, 2.0° to 2.1°C (on Banana Bank 1.5°C), and still colder water lay above and presumably coastward. The mixed East Greenland-Irminger Current water of 2° to 5°C, lay near the western shallower parts of the banks and slopes, and was flanked to the west and deeper by relatively unmixed Irminger Current water of 5° to 5.7°C. Temperatures as high as 3.7°C extended to over 1,400 m.

In the Dana Bank section (Fig. 3D), bottom temperatures on the bank increased from 1.2°C toward the coast to 3.5°C at the turn of the seaward slope, and Irminger Current water, 5.0° to 6.0°C, relatively unmixed in the deeper part of the section, lay on or close to the western slope.

In the section extending southward from the seaward edge of the coastal bank west of Cape Desolation (Fig. 4), the effect of the East Greenland Current was evident in temperatures of 0.5° to 2.0°C near surface above the seaward edge of the coastal bank. Deeper and westward, over and close to the slope of the shelf, the Irminger Current or Atlantic component of the West Greenland Current had temperatures of 5.0° to 7.0°C between 100 and 800 m and temperatures as high as 3.4°C to 1,800 m. Southward, over and across the Labrador Sea toward the Northeast Newfoundland Shelf, the depth of the warm 5° and 6°C Atlantic component of the West Greenland Current decreased and such temperatures lay above 75 m.

Considering all the sections (Fig. 2-4), and Fig. 5 the shallowing, loss of volume, gradual cooling, and the lowering of the salinity of the deeper water, higher-temperature portions of the West Greenland Current may be noted as usual with progress northward, especially beyond the Davis Strait Ridge into Baffin Bay.

On the more southern banks - Dana, Fiskenaes and Fylla - the effects of their proximity to the East Greenland Current, the melting ice and icebergs rounding Cape Farewell and their more coastal location produced lower summer temperatures in the shallow water of these banks than are present, due to surface warming and greater mixing, over Lille Hellefiske and Store Hellefiske Banks farther north. Surface temperatures over the outer parts of the coastal banks were considerably higher. In the deep water on the slopes of the banks it was evidently one of the warmer summers.

In the northern, Baffin Bay, sections (Fig. 2A, 2B, 2C) the higher surface salinities due to the influence of the West Greenland Current can be noted to the east and the lower surface salinities toward the melting ice in the west. The gradual decrease in the salinities of the deeper water, due to mixing, can be noted from 35‰ typical of Irminger Current-Atlantic water in the southernmost section to 34.3-34.4‰ in the most northerly sections.

Newfoundland-Labrador Area

In the section from Seal Islands across the southern part of Hamilton Inlet Bank (Fig. 5, 6), there was a much smaller volume than usual of water with temperatures below 0°C and especially below -1.0°C. Temperatures from surface to bottom down to almost 300 m in Hawke Channel and to 200 m over Hamilton Inlet Bank, especially the shoreward edge, were higher than in 1964 and above the average for recent years.

Salinities of the bottom water and for some distance above bottom over the shallower parts of Hamilton Inlet Bank and Hawke Channel were higher than in 1964 and 1963.

In the Bonavista section (Fig. 5, 7), temperatures from surface to bottom over the Northeast Newfoundland Shelf were higher than in 1964 - the surface temperatures being considerably higher. The deeper water to 1,000 m had slightly higher temperatures. On the northern slope of the Grand Bank, also included in this section, surface temperatures were higher and deeper water temperatures on and above the slope not greatly different from those of 1964. The deep slope water of the Northeast Newfoundland Shelf returned to the higher salinity (34.8-34.9‰) condition as in 1963 and did not show the 34.3-34.5‰ salinities present in 1964.

In the St. John's to Flemish Cap section (Fig. 5, 8), the surface water from the coast to the eastern Grand Bank, the coastal deep-water bottom temperatures, the deep water below 250 m on the eastern slope of the Grand Bank, and the water covering the top of Flemish Cap had higher temperatures than in 1964. Otherwise there was little change except that the eastern cold branch of the Labrador Current showed no temperatures lower than -0.8°C in 1965 and some water below -1.0°C was present in 1964. Salinities at the surface were lower shoreward and generally higher seaward above the eastern slope of the Grand Bank than in 1964. Also, above the eastern slope of the Grand Bank the lower salinities, like the temperatures of 3°C and lower, were restricted toward the bank rather than lying above the western part of Flemish Channel as in 1964. Thus, in this section the volume of this colder, lower salinity shoreward portion of the Labrador Current was less than in 1964.

In the section from St. John's to the southeastern slope of the Grand Bank (Fig. 5, 9), temperatures in the deeper water of the Avalon Channel, on the western slope of the Grand Bank, and also on the southeastern slope of the Grand Bank were higher but bottom temperatures on the Southeast Shoal were lower than in 1964. Salinities were generally similar to those of 1964.

In the section at about 75 m, extending along the southwestern edge of the Grand Bank (Fig. 5, 10), surface and eastern slope temperatures were higher than in 1964 but there was little difference in bottom temperatures over the surface of the bank in the two years. Salinities over the surface of the Grand Bank were slightly lower than those of 1964 and slightly higher than those of 1963.

In the section at 275 m, along the southwestern slope of the Grand Bank (Fig. 5, 11), surface temperatures were higher, and temperatures from the upper layers to the bottom in the water of the eastern part of the section, which is derived in large part from the eastern branch of the Labrador Current, were also higher than in 1964. In the western part of the section, lowest temperatures were 0.3°C compared with -1.2°C in 1964. Salinities were generally similar to those of 1964 but the upwelling of higher salinity water to the surface at Station 15 which occurred in 1964 was not present in 1965. The intrusion below 150 m, at Station 13, of water with slightly higher temperatures was evident also in the presence of a very slightly higher salinity at this level. Also, at the edge of the eastern slope of the Grand Bank the intrusion of water with slightly higher temperature than in 1964 near bottom at Station 19 was accompanied by a slightly higher salinity.

At Station 27 near St. John's (Fig. 12), surface temperatures in July-September were slightly higher than in 1964 and for a longer period. Otherwise the temperature picture was very much like that of 1964. In January-February 1966, temperatures throughout most of the water column were higher than usual. Since this station is coastal and the depth is only 176 m, salinities are low, ranging in 1965 between 31.5 and 32.5‰ at the surface and 32.9 and 33.5‰ at the bottom. Lowest salinities in the surface layers were from June to November and at the bottom in late January to early February.

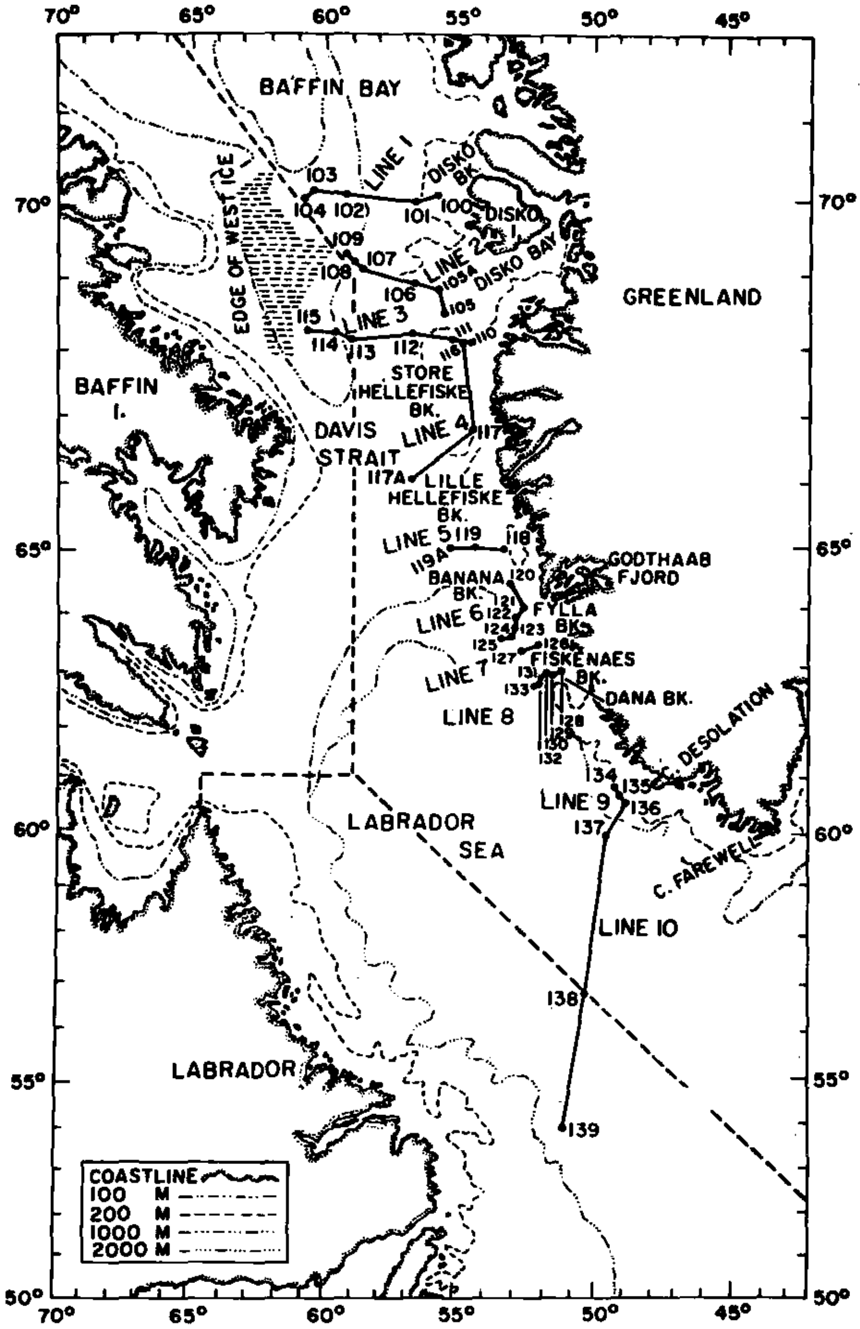

Fig. 1. Locations of the *A.T.Cameron*'s fishing stations at which hydrographic observations of Fig. 2-5 were taken in Baffin Bay, along the West Greenland coast and in the Labrador Sea, July-August 1965.

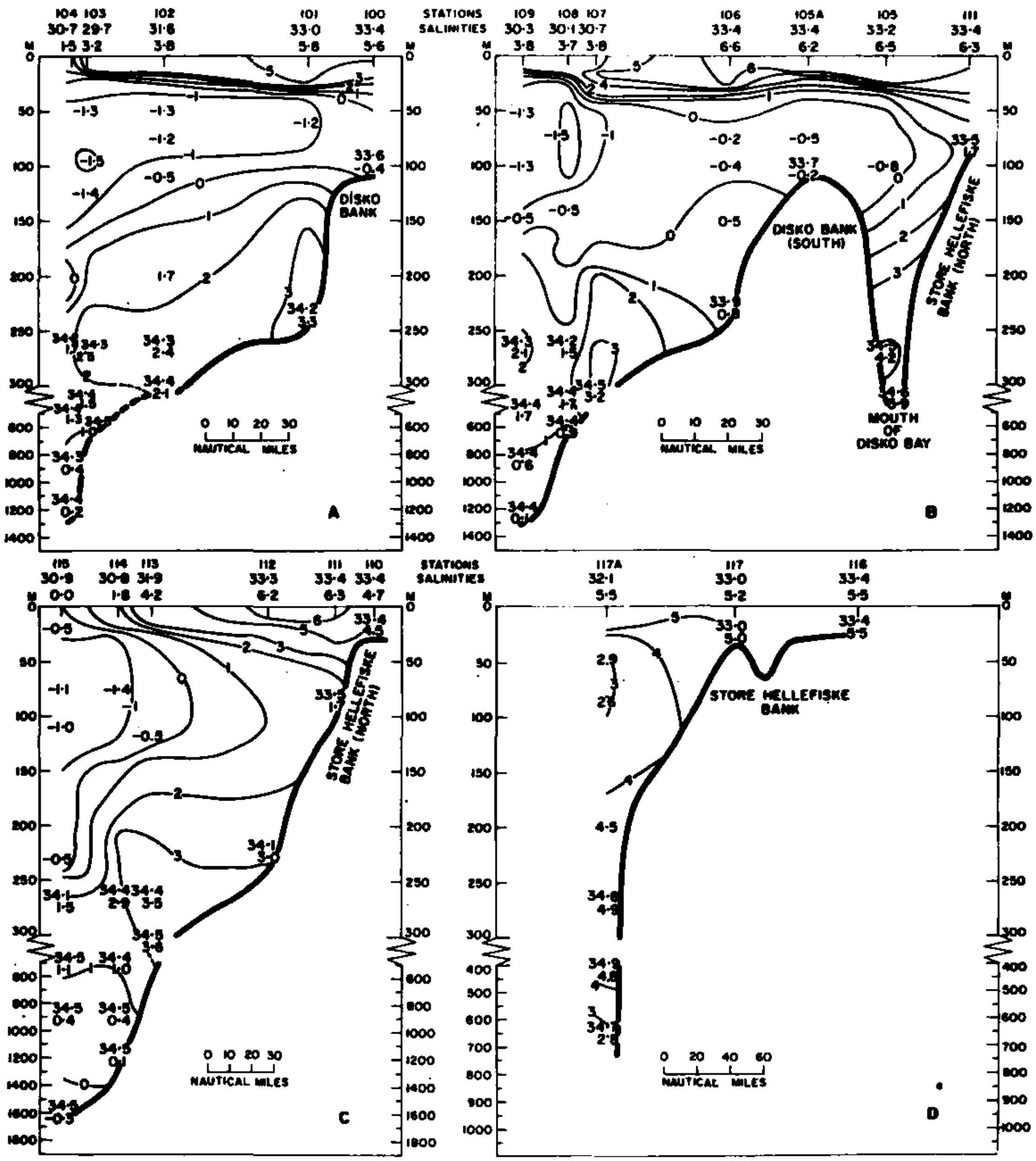

Fig. 2. Temperature sections, °C, 1965 (with individual salinities, ‰, inserted), A, from Disko Bank westward (Fig. 1, Line 1, 28-29 July); B, from northern end of Store Hellefiske Bank and mouth of Disko Bay westward over the southern part of Disko Bank (Fig. 1, Line 2, 30 July-2 August); C, from northern peak of Store Hellefiske Bank westward (Fig. 1, Line 3, 2-4 August); D, from northern peak of Store Hellefiske Bank southward over the eastern side of the bank and southwestward over the Davis Strait Ridge (Fig. 1, Line 4, 5-7 August).

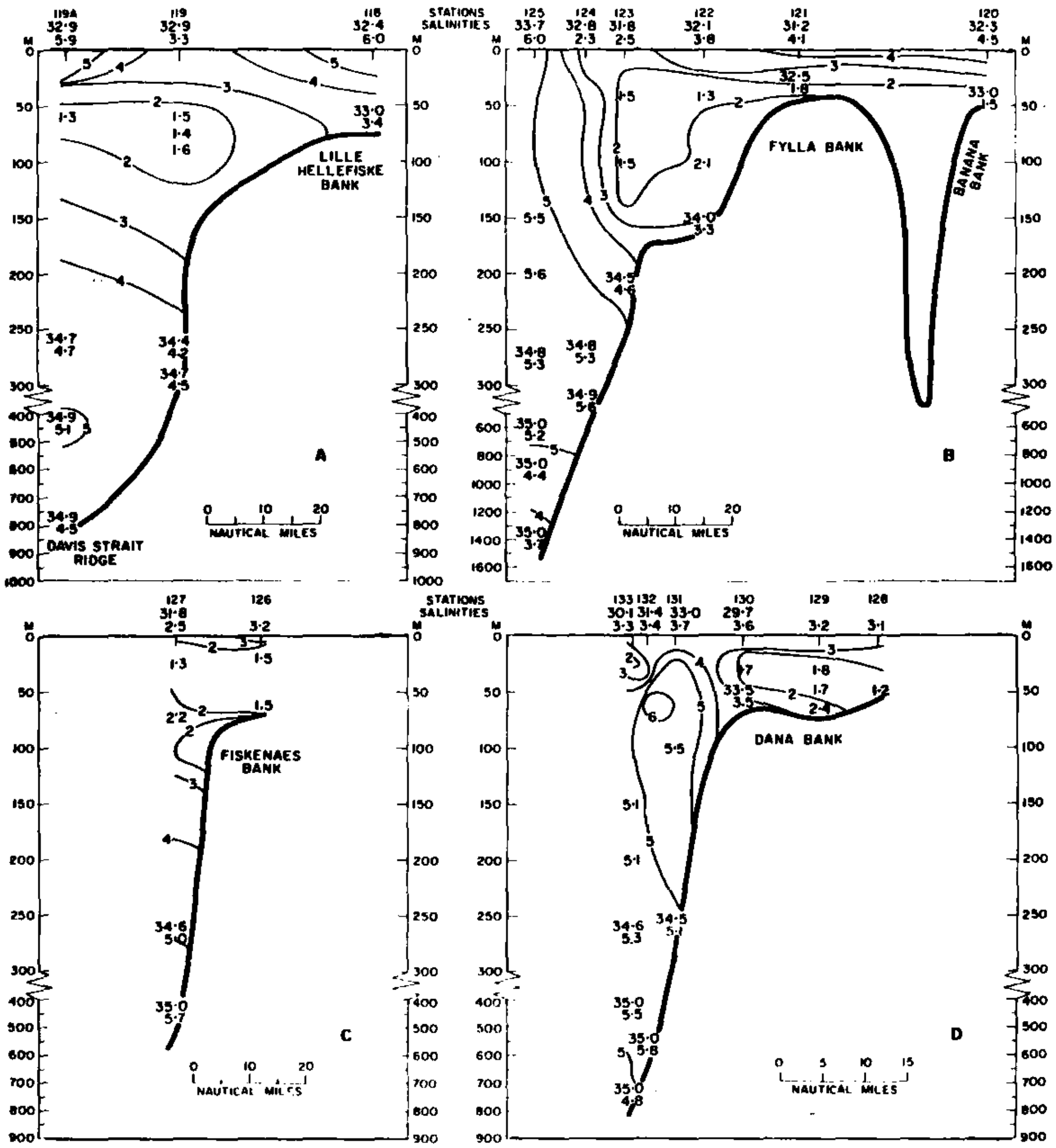

Fig. 3. Temperature sections, °C, 1965 (with individual salinities, ‰, inserted), A, from Lille Hellefiske Bank westward (Fig. 1, Line 5, 8-9 August); B, from Banana Bank southward to Fylla Bank and from Fylla Bank southward and westward (Fig. 1, Line 6, 9-14 August); C, from Fiskenaes Bank westward (Fig. 1, Line 7, 15-16 August); D, from Dana Bank westward and southward (Fig. 1, Line 8, 17-19 August).

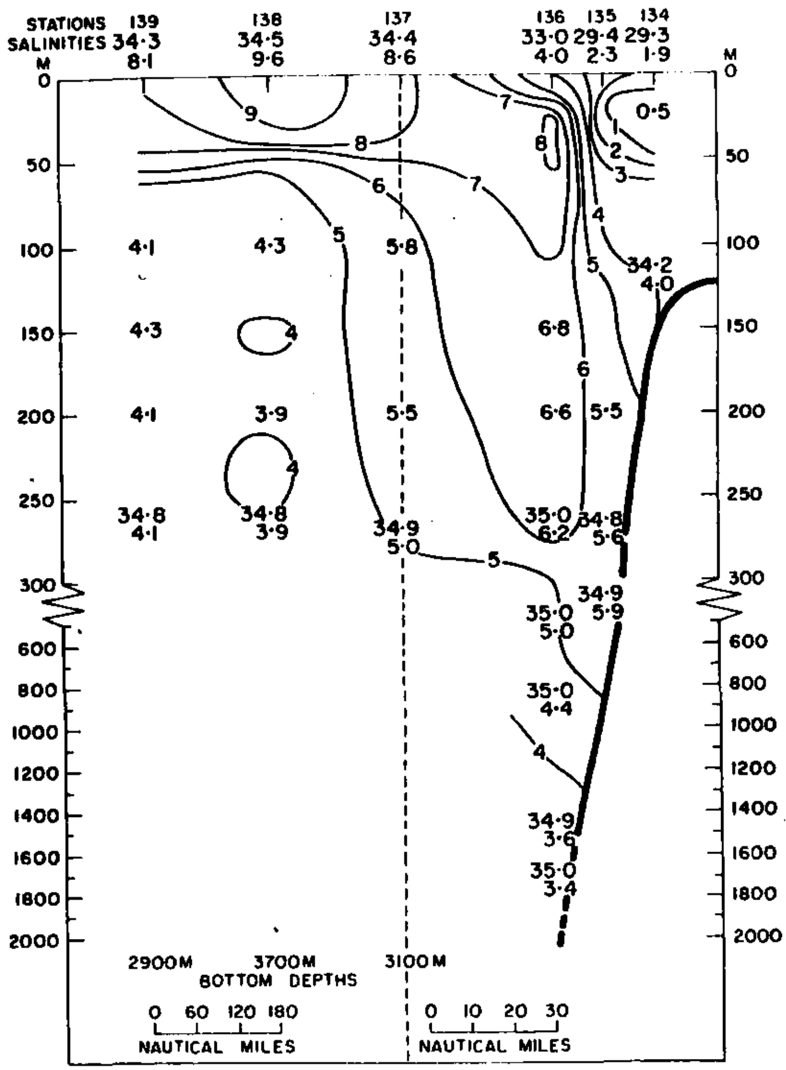

Fig. 4. Temperature section, °C, (with individual salinities, ‰, inserted), from the West Greenland Shelf off Cape Desolation southward across the Labrador Sea toward the Northeast Newfoundland Shelf (Fig. 1, Lines 9 and 10, 20-24 August 1965).

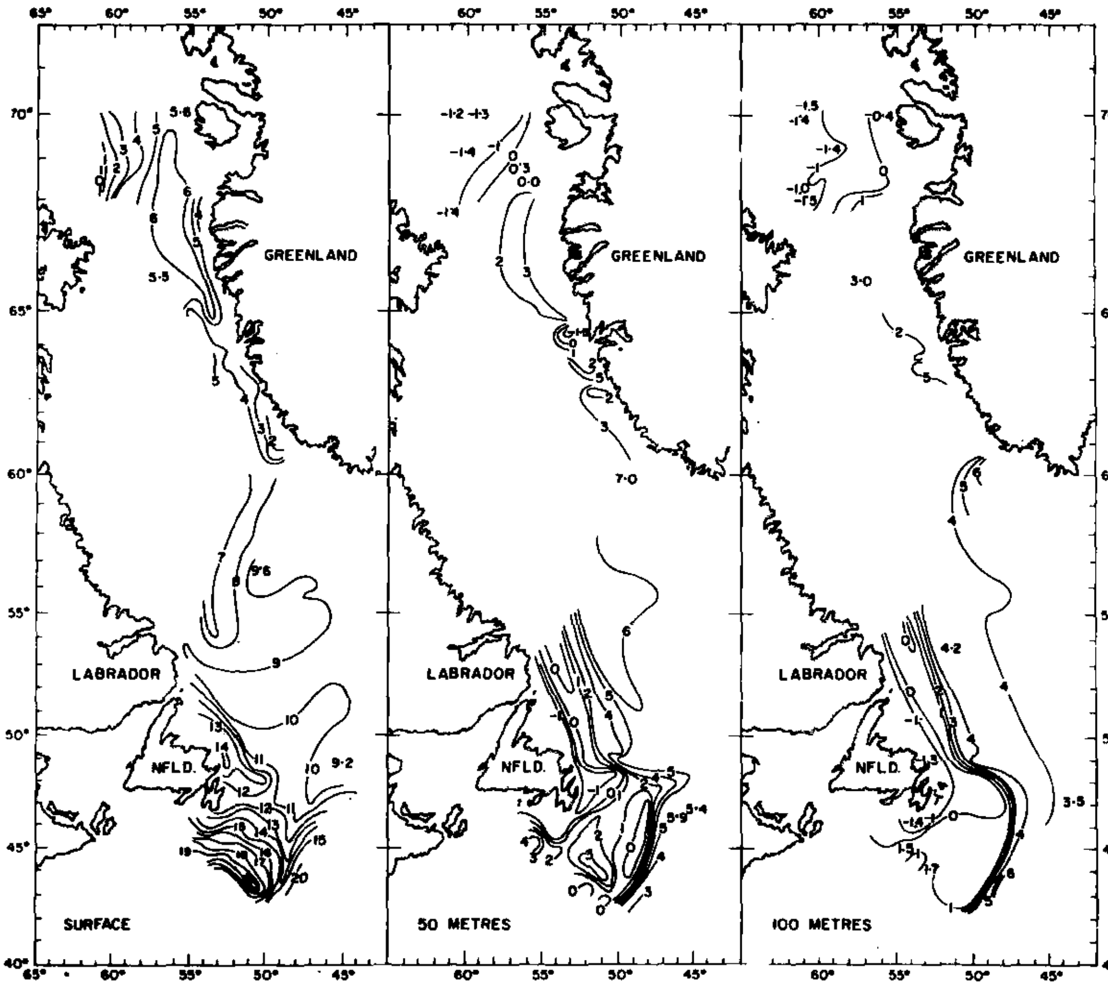

Fig. 5. Temperatures, °C, at surface, 50 m, and 100 m in the West Greenland and Newfoundland areas July-August, 1965. (West Greenland, Baffin Bay and Labrador Sea, 28 July-24 August; St.John's-Flemish Cap northward to off southern Labrador, 23 July-3 August. South of St. John's-Flemish Cap, 17-23 August).

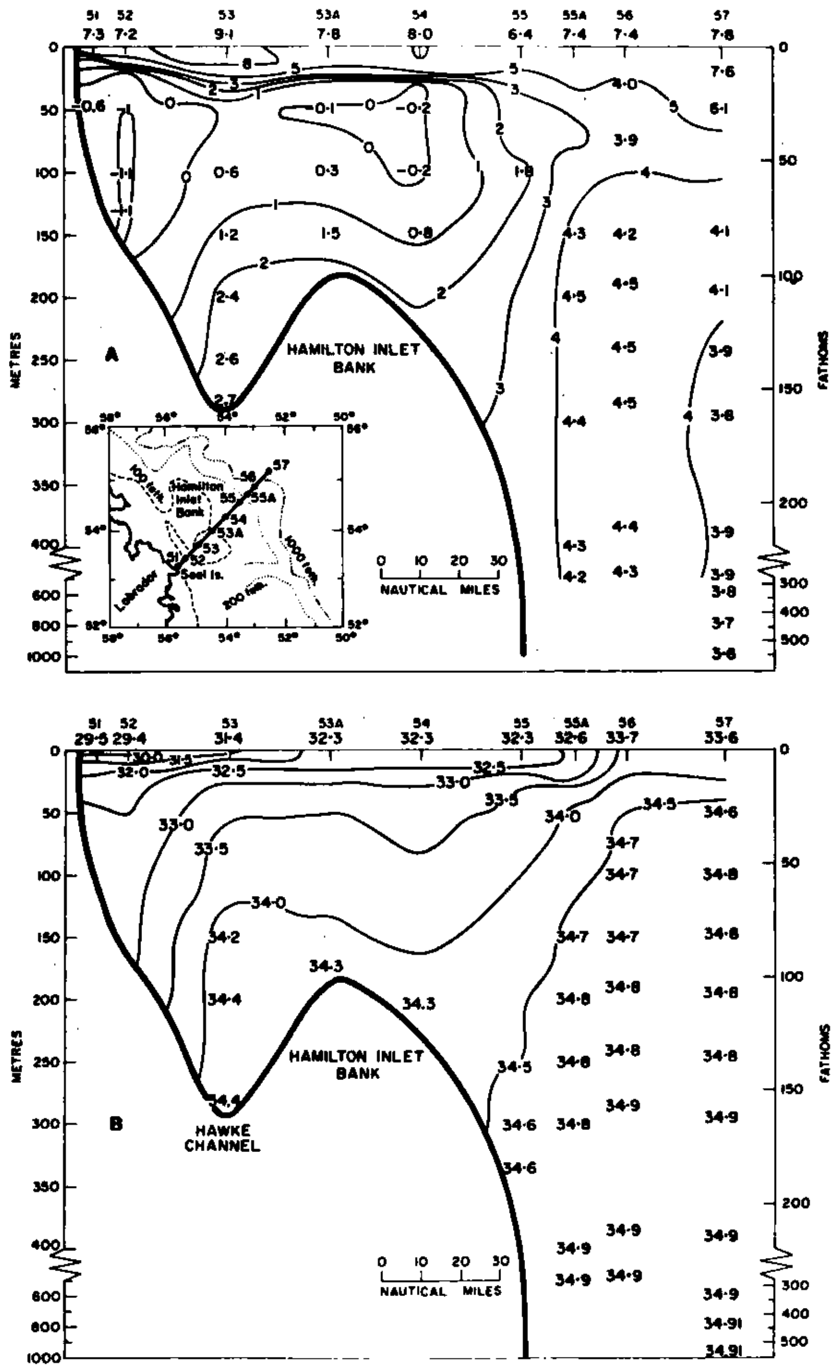

Fig. 6. A, temperature, °C, and B, salinity, ‰, sections, off Seal Islands across Hamilton Inlet Bank, 2-3 August 1965.

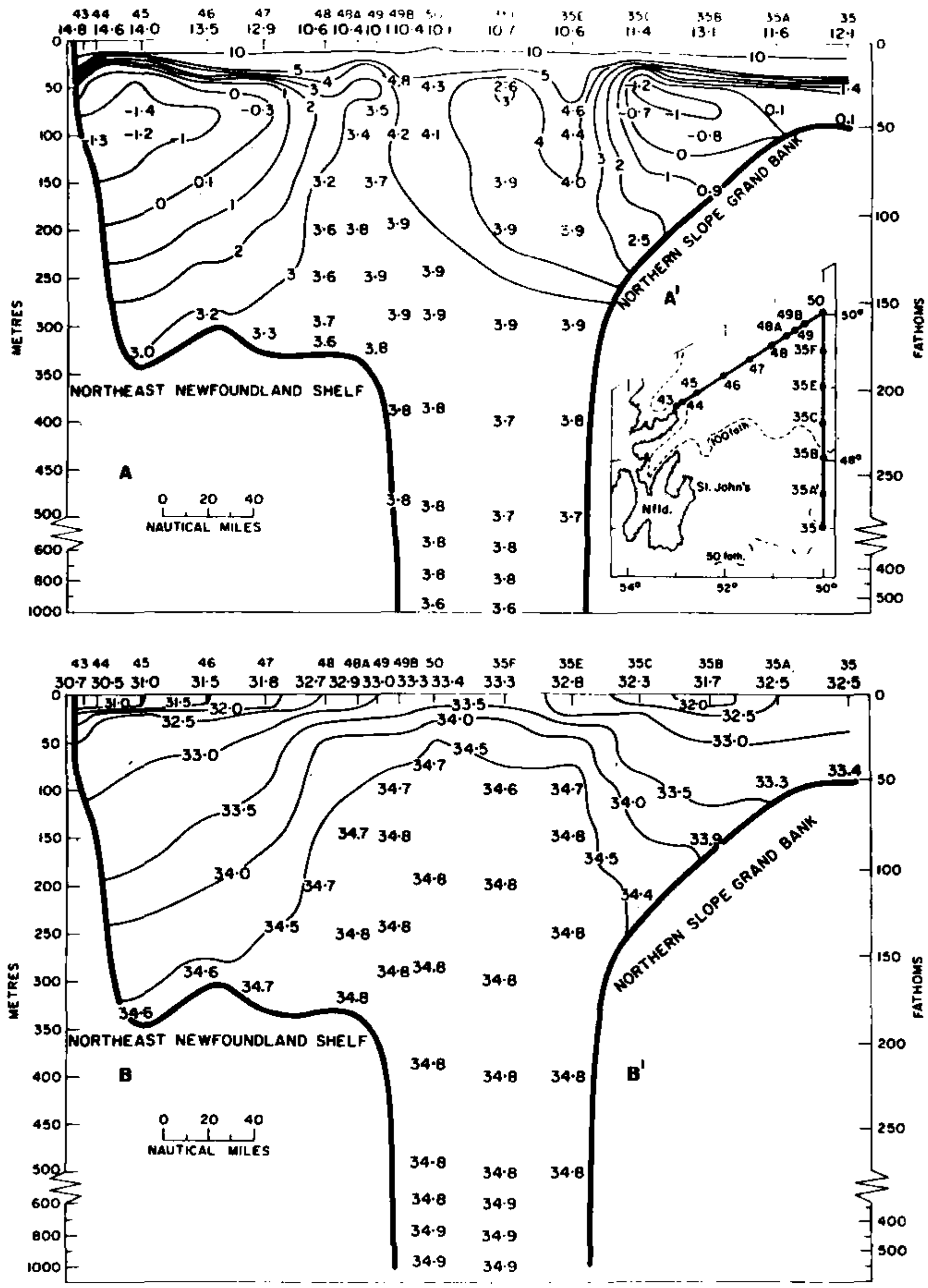

Fig. 7. A, A[1], temperature, °C, and B, B[1], salinity, ‰, sections, over the Northeast Newfoundland Shelf off Cape Bonavista and southward to northern Grand Bank, A, B, 31 July-1 August 1965 and A[1], B[1], 30-31 July 1965.

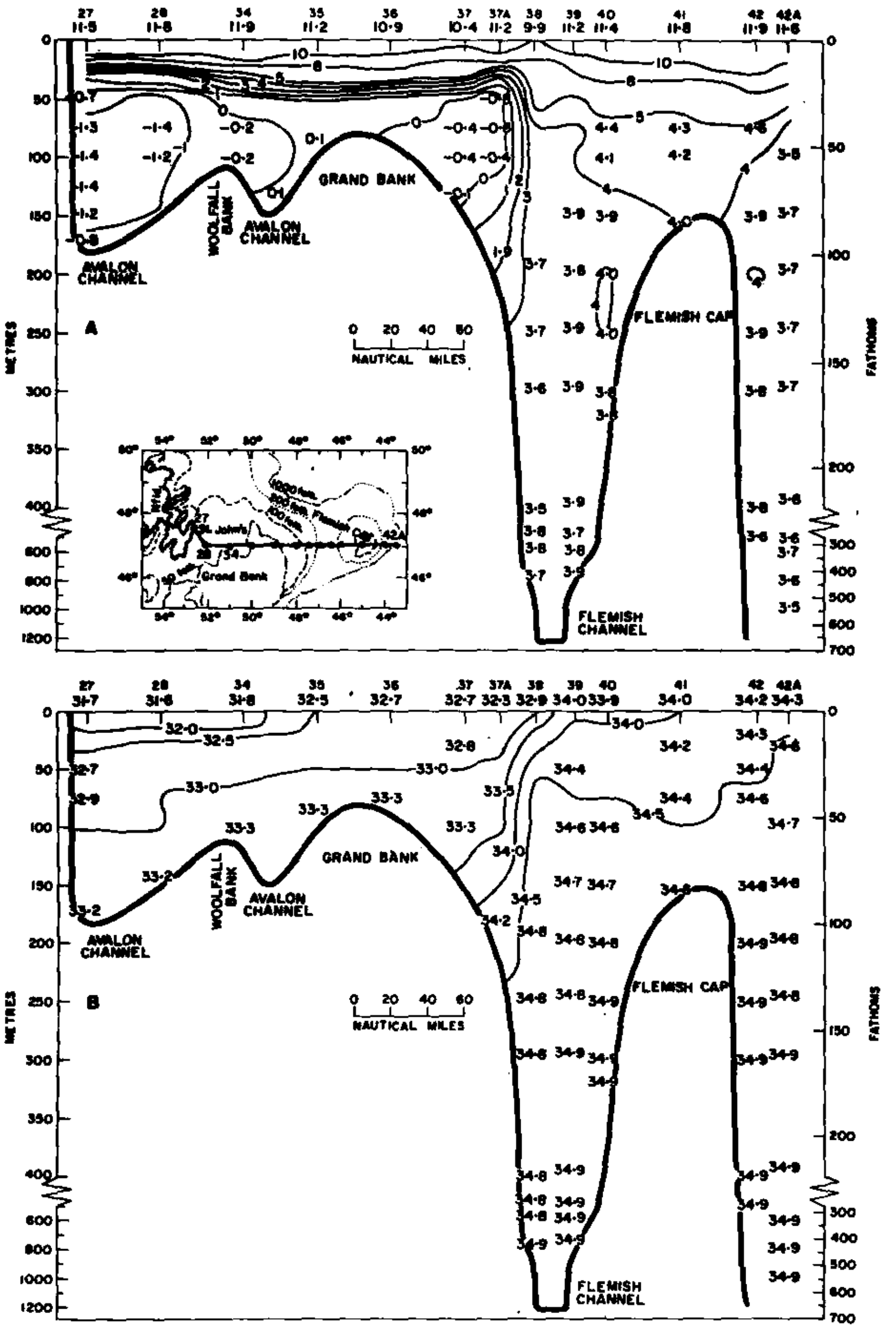

Fig. 8. A, temperature, °C, and B, salinity, ‰, sections, St.John's-Grand Bank-Flemish Cap, 23-25 July 1965.

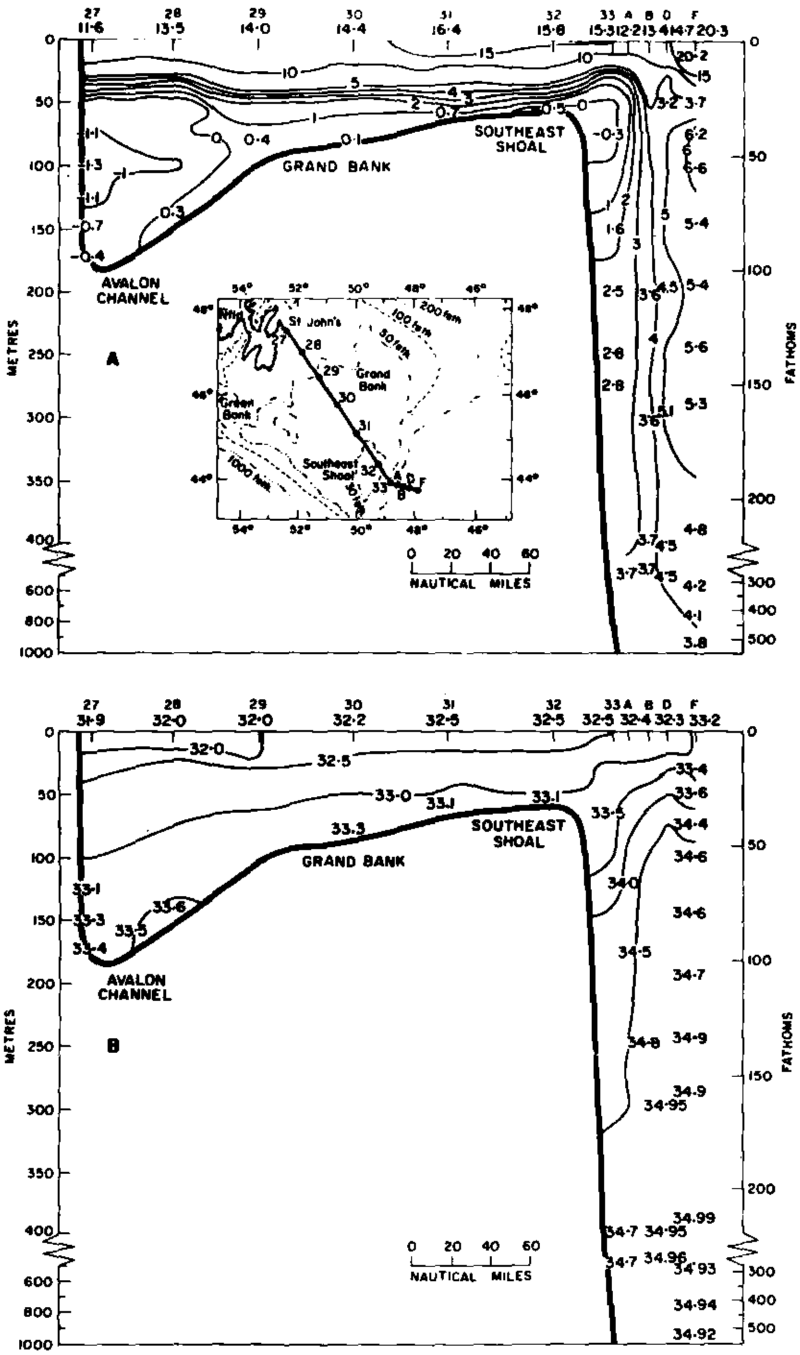

Fig. 9. A, temperature, °C, and B, salinity, ‰, sections, St.John's-SE slope Grand Bank, 17-19 August 1965.

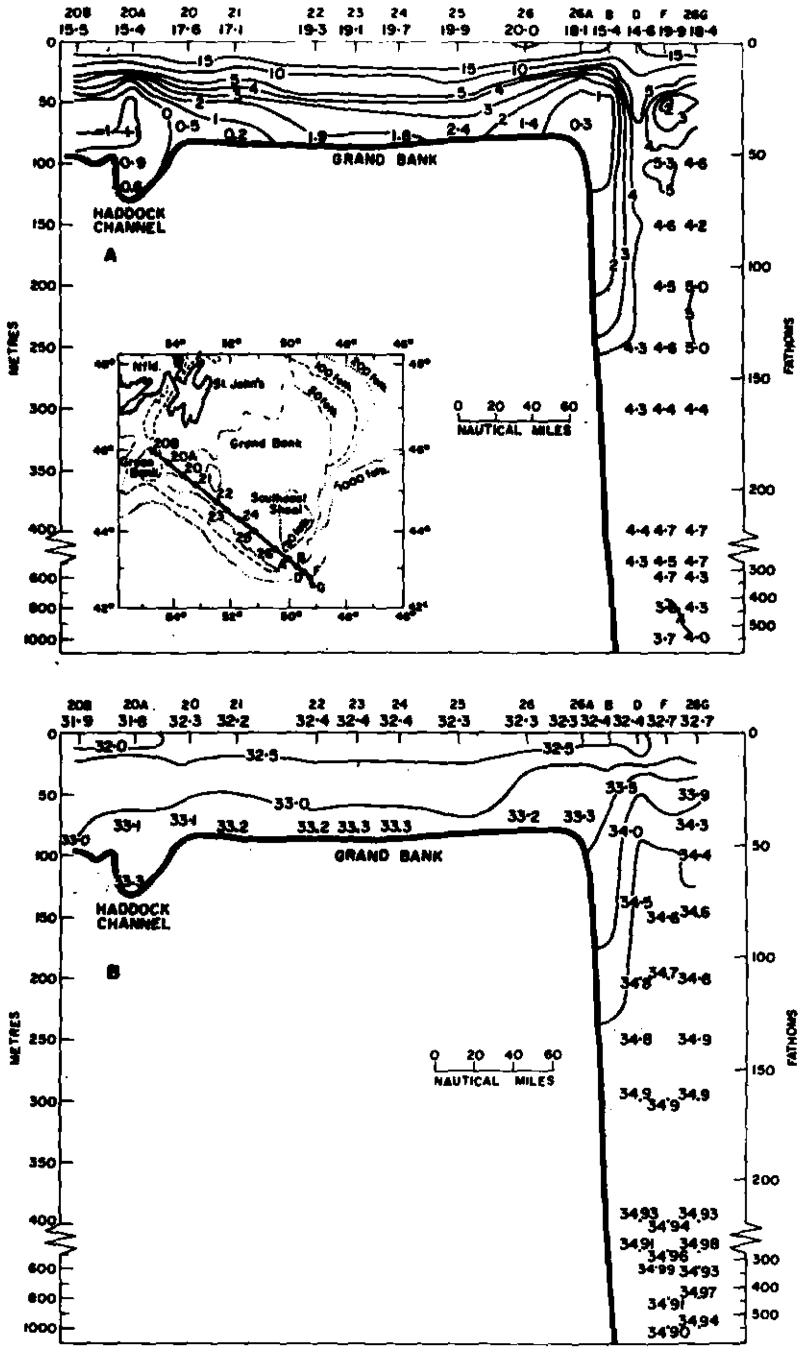

Fig. 10. A, temperature, °C, and B, salinity, ‰, sections, Green Bank-SE Grand Bank, 20-23 August 1965.

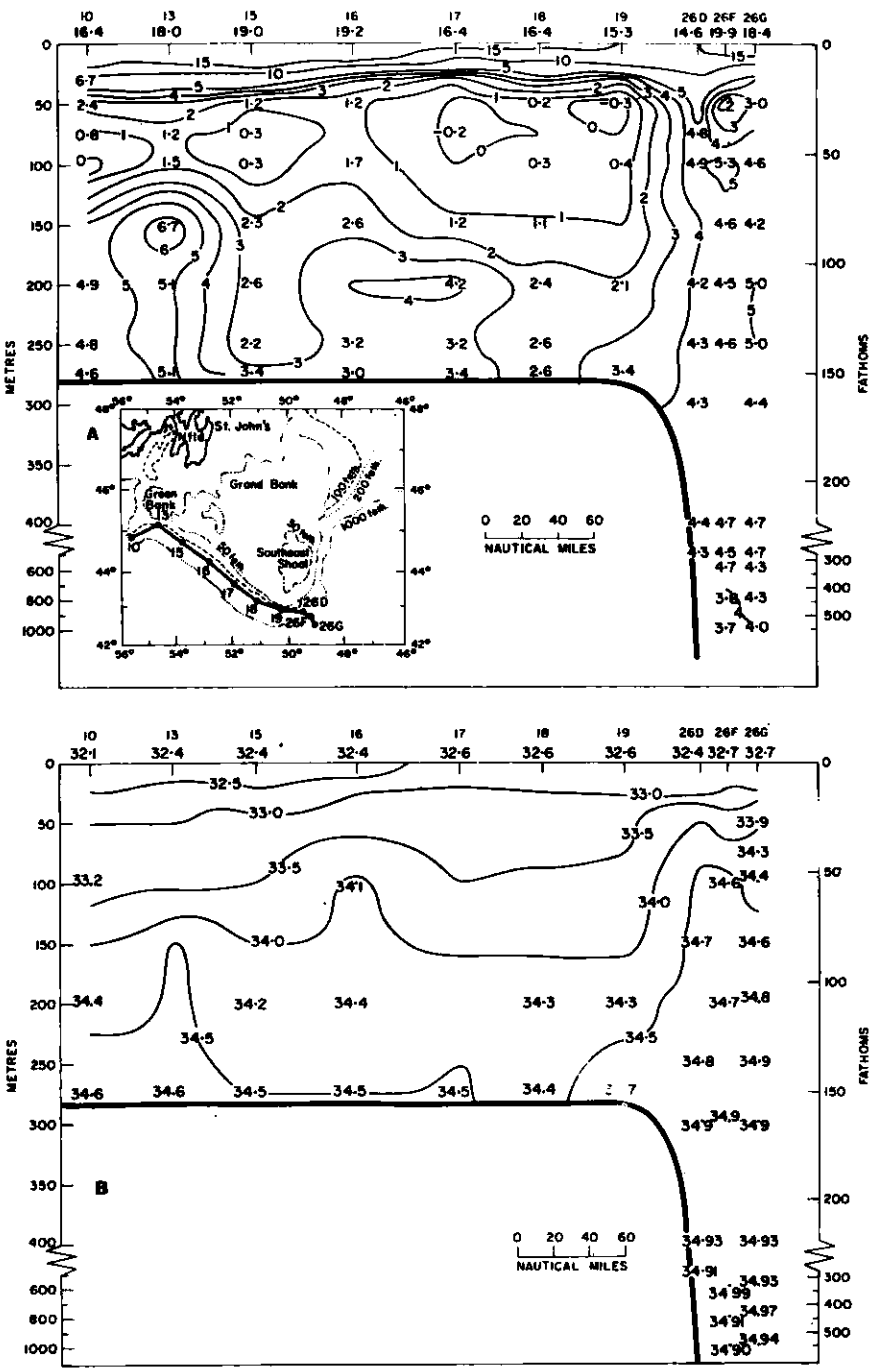

Fig. 11. A, temperature, °C, and B, salinity, ‰, sections, along the SW slope of the Grand Bank, 20-22 August 1965.

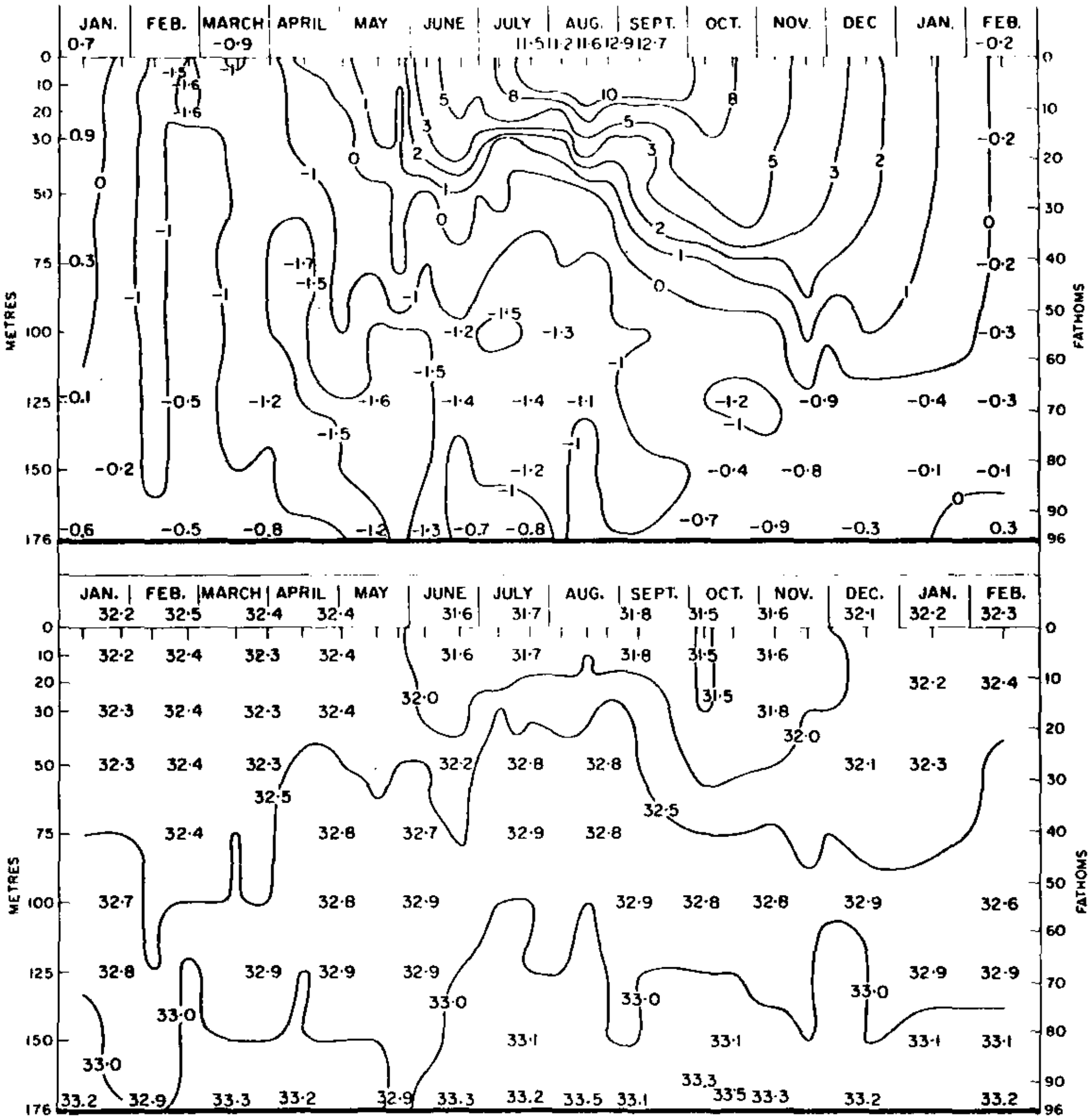

Fig. 12. Above, temperature, °C, and below, salinity, ‰, January 1965 to February 1966, from surface to bottom at Station 27 (see Fig. 8, 9 inset), 2 nautical miles off Cape Spear near St. John's.

SECTION E
NORTH ATLANTIC SALMON

1. A preliminary study of the influence of the Greenland salmon fishery on the salmon stocks and fishery of the Miramichi River system, New Brunswick, Canada[1]

by K. Radway Allen and Richard L. Saunders
Fisheries Research Board of Canada
Biological Station
St. Andrews, N.B.

Introduction

Marking results have shown that an appreciable number of the fish taken in the fishery for Atlantic salmon, which has developed on the west coast of Greenland in the last few years, have originated in Canadian rivers. The fish actually caught at Greenland are obviously no longer available either for capture in Canada or to form part of the spawning stock from which subsequent generations are recruited. We do not yet know definitely, however, whether the fish which visit Greenland are carrying out their normal migration pattern and would, if they survived, return to their home rivers, although there is no evidence at present that they are not. Even if they are, a number of those caught at Greenland would have died from natural causes and never appeared either in catches in their home waters or in the spawning populations. Development of the new fishery, therefore, raises problems affecting the total quantities of salmon caught, the quantities caught in the home waters which are the scene of the traditional fisheries, and the quantities available for the maintenance of future stocks. It is the purpose of this paper to consider the principles involved and to develop methods by which it may become possible to assess the effects of the Greenland fishery using the kinds of data likely to become available. Examination of some of the data already available will, it is hoped, indicate the relative sensitivity of the assessment to the likely errors in the different quantities involved and to suggest where some of the major deficiencies lie in existing data.

The Miramichi River, which drains about 4,000 square miles (about 14% of the area of New Brunswick) in central New Brunswick, flows into the western side of the Gulf of St. Lawrence. Despite the fact that large parts of its catchment area have been sprayed with DDT on one or more occasions in recent years in order to control the spruce budworm, it remains one of the major contributors to Canadian salmon stocks. The catch of the commercial fishery operating traps in the estuary and drift nets off the mouth has recently been about 13% of the total Canadian commercial catch and the Miramichi system makes a very substantial contribution to this catch.

[1] submitted to the ICES/ICNAF Joint Working Party on North Atlantic Salmon, 25-26 May 1966, as ICES/ICNAF Salmon Doc.66/9

For about 15 years the St. Andrews Station of the Fisheries Research Board of Canada has carried out research on the salmon stocks of the Miramichi system. This work has included at various times the operation of traps to take migrating smolts and returning adults, the marking of migrating smolts and the liberation in the Miramichi of marked smolts produced in hatcheries, and the sampling of angling and commercial catches. From data that have been available from the Canada Department of Fisheries on the quantities of fish taken by angling and commercially, it has been possible, as discussed later, to estimate the yield obtained from the Miramichi stock. Much of the more detailed work has been concentrated in one major tributary of the system, the Northwest Miramichi. In studying the possible effects of the Greenland fishery, it was considered that, at the present stage, more useful results would be obtained by examining its influence on the Atlantic salmon stocks of one particular area than on those of Canada as a whole. The Miramichi system is particularly appropriate for this purpose on account both of the relatively large quantities of data available and of the importance of this river as a producer of salmon.

It must be stressed that the main purpose of the present work is the development of methods and the examination of the availability of suitable data, and that any assessments of the influence of the Greenland fishery on the salmon stocks of the Miramichi system or any other Canadian waters must be regarded as highly tentative.

Basic Data

Assuming that the fish visiting Greenland would, if they survive, return to their home rivers in the normal manner, the fundamental questions which have to be examined in determining the effect of catches in Greenland on the catches in home waters and on the maintenance of stocks are those concerning

the proportion of the original population that visits the Greenland area;

the proportion of the fish in Greenland which avoid capture and survive to return to home waters;

the amount of growth made by fish between the time of the Greenland fishery and their return to home waters;

the proportion of the returning fish caught in home waters: and the quantities of spawning fish necessary to maintain stocks at the optimum level.

A comprehensive study of the effects of the Greenland fishery will, of course, involve consideration of the fish from all the areas which contribute to the stock which visits Greenland. It will call for differentiation between the groups of fish originating in the different areas, and separate assessment of their abundance, growth and mortality, and of the rate at which they are being exploited.

The data used in this study are drawn only from Canadian sources, with the addition of those pertaining to the Greenland catch, and correspondingly conclusions can only be drawn as to the effects on Canadian stocks and catches, and, in particular, those of the Miramichi, except where it is assumed for purposes of discussion that similar growth, mortality and exploitation rates apply elsewhere.

The basic data available consist of the quantities of fish taken in the commercial fishery in Greenland and in the commercial and angling fisheries in Canada; the numbers of fish, both smolts and adults, marked in the Miramichi and subsequently recaptured at various points in Canada and in Greenland; the numbers of fish passing through the traps on the Miramichi; and the size and age composition of samples of fish taken from commercial and angling catches and in research operations.

Growth between Greenland and Home Waters

The relative weights which will be taken with the same rate of exploitation (*i.e.*, with the same proportion of the population being caught) at two different stages in the life of a stock of fish depend upon the relation between growth rate and mortality rate during the period between these two stages. It is therefore important to know how much the fish in a group subject to the fishery in Greenland would have grown by the time they return to their home waters if they escaped the Greenland fishery.

This growth can be measured with relatively high accuracy provided that samples of fish of the same group can be measured, both in Greenland and on return to their home waters. The data available indicate that nearly all the fish taken at Greenland are caught at the beginning of their second sea winter. For 799 fish from Greenland whose scales were read by Scottish workers, 781 were maiden one-sea-winter fish, the remainder were almost evenly divided between two-sea-winter fish and previous spawners (K.A.Pyefinch, personal communication). In the present paper, therefore, all other categories have been ignored and the estimates based on the assumption that all fish taken in Greenland have spent one winter in the sea and would return to their home rivers in the following year. The best comparison available between such fish, known to be of similar origin, is between marked fish from the Northwest Miramichi River taken in Greenland after one sea winter and fish of the corresponding age group taken after return to the Northwest Miramichi.

Since some of the tagged fish caught at Greenland have been gutted before weighing and since relatively few weights of fish of known age are available for the same year-classes from the Northwest Miramichi, it is better to make the initial comparison on lengths rather than on weights. The mean length of 14 one-sea-winter Miramichi fish caught at Greenland was 65.9 cm, with a standard deviation of 2.54 cm. These were fish from the 1962, 1963 and 1964 smolt classes. They may be compared with a sample of 139 fish from the 1962 and 1963 smolt classes that returned to the Miramichi as two-sea-winter fish. These had a mean length of 74.2 cm and a standard deviation of 4.58 cm.

When comparing the lengths of fish measured by different workers, it is necessary to be sure that the same "length" was measured in each case or to make a correction for any differences. Enquiries show that both Canadian and Greenland fish were measured as total lengths but that a small difference may nevertheless exist, the Canadian fish being measured with the caudal fin relaxed and Greenland fish with it compressed to give maximum extension (P. Hansen, personal communication). Comparison of regression lines fitted to total-length fork-length data from both sources indicates that in the size range involved, the difference between the two total lengths is 3-4 mm, the Greenland measurement being of course the longer. On the Canadian basis of measurement the mean length of the tagged fish increased from 65.5 cm in Greenland to 74.2 cm in Canada. The mean dates of capture, regardless of year, in Greenland and Canada were respectively 10 October and 21 July. Since the Canadian recaptures occurred in the year following the Greenland recaptures in the life of any year-class, the average interval in which this growth took place was 284 days.

There is, at present, very little comparable data on the weight-length relationship for salmon caught at Greenland and fish of the corresponding age-groups caught in Canada but present evidence suggests that there is no significant difference between the condition factor in Greenland and that on return to Canadian waters. The weight-length relation curve for fresh round fish given by Hansen (1965) in his Fig. 2 corresponds to a condition factor on the centimeter/gram scale of about 97 in the modal size range. A sample of two-sea-winter fish taken in the commercial fishery at the mouth of the Miramichi had an almost identical condition factor. The difference in the method of measuring total length referred to above will only make about 1% difference in condition factor and can be ignored in the present comparison. On this basis, the relative weights of fish taken in Canada and Greenland will be proportional to the cubes of the corresponding lengths. This gives a ratio of 1.46:1. The natural logarithm of 1.46 divided by the time interval in months gives the instantaneous growth rate on a monthly basis (*i.e.*, the proportional weight added in one month) as 0.040.

Natural Mortality Rate between Greenland and Canada

Direct measurement of the mortality rate over this phase of the life history presents considerable difficulties and cannot be attempted on the data now available. J.A.Gulland (*in litt.*) has pointed out that an upper limit of estimate can be obtained by apportioning evenly through the marine life the total mortalities which occur between the time the smolts pass out to sea and the adults return to their native river, and has obtained in this way preliminary estimate of the instantaneous mortality rate on a monthly basis of 0.16.

For the Northwest Miramichi River a number of results are available for the return of marked smolts of both natural and hatchery origin. The highest proportions to return from these have been about 5%. In this system, about 75% of smolts on the average return as grilse after 14 months and about 25% return after 26 months; the 5% return therefore corresponds to an overall natural mortality rate of 0.19 monthly. In these, as in all experiments with marked fish, there is the possibility of tag losses, of additional mortality due to the handling and marking operations, and of failure to report or return tags. These estimates of survival should therefore be regarded as minimal. In other Canadian experiments, Elson (1957*a*) has shown an average return of about 8%.

A great difficulty in estimating the mortality rate during the later part of ocean life lies in the fact that the rate is probably far from uniform during ocean life as a whole. It seems likely that the rate is considerably higher while the fish are in the estuaries and when they first enter the sea. At this time they are in a region where predatory fish are abundant while they are still of small size, and they are also subjected to the osmotic and other stresses associated with the changes from a freshwater to a marine environment. Parker (1965) has shown that in pink salmon 77% out of a total mortality of 95% occurred in the first 40 days out of a total sea life of 450 days. This had the effect of reducing the monthly instantaneous mortality rate from 0.110 for the whole period of marine life to 0.024 for the oceanic period. Atlantic salmon are considerably larger than pink salmon at the time of migration and as a result may perhaps be less susceptible to predation and other causes of increased mortality in the period immediately following migration. It remains likely, however, that the overall estimates given above may substantially exceed the true mortality rate during the time the fish are on the Greenland coast and then returning to their native rivers. On the other hand it is possible that the mortality rate may increase again when the mature fish re-enter coastal water, *e.g.*, due to predation by seals.

A more directly applicable estimate might be obtained from the rate of return as second spawners of salmon which successfully survive the hazards immediately associated with first spawning. The return of fish marked as kelts is generally rather low and this may be due to failure to recover fully after spawning. Quite high rates of return have, however, sometimes been recorded; of 162 kelts tagged in the Indian River in Newfoundland in 1964, 82 were recaptured in 1965, mainly in the commercial fishery. Such a survival rate of more than 50% for a year would correspond to an instantaneous monthly mortality rate of about 0.06. It is possible, however, that these fish spent a good part of the year in the river, and were subjected to some of the causes of natural mortality to a lesser extent than fish on the high seas.

In such an uncertain situation, useful indications can be obtained from other species with similar life histories. The best parallel is probably provided by the salmon of the genus *Oncorhynchus* in the North Pacific, and the problem of marine mortality rates has attracted a considerable amount of attention recently for these fish. Despite this, few good data exist and the values of the instantaneous monthly mortality rate which have been proposed range between 0.02 (Ricker, 1964) and 0.08 (Doi, 1962).

At present, therefore, it seems that all that can safely be stated for Atlantic salmon is that the monthly instantaneous mortality rate lies between the limits of 0.02 and 0.15, and is probably less than 0.10. In the present study, therefore, it is necessary to consider the effect on the conclusions of values of the mortality rate throughout this range.

Exploitation Rate in Canadian Waters

arking experiments have shown that salmon originating in the Miramichi are caught in the commercial fisheries at many points on the Canadian coast, including the east coast of Newfoundland and Labrador. Over two-thirds of the reported commercial captures are, however, taken in the traps in the Miramichi estuary and in the drift-net fishery centred at Escuminac, off the mouth of the estuary. In addition, as they pass up the rivers, the fish are subject to an intensive sport fishery. The best data on the rate of exploitation are available for the Northwest Miramichi where a counting fence has been maintained at Curventon, not far above the head of tide, for a number of years. A fairly accurate estimate can be made of the proportion of fish caught in the river above the fence since the number passing through the fence is known and there are fairly complete records of quantities taken in the various parts of the river. Angling also takes place in the Northwest Miramichi below the fence and the number of fish taken here is also known A proportion of these fish are, however, destined not for the upper Northwest Miramichi but for the Sevogle River, a tributary which enters just below the fence. To obtain an estimate of the actual size of the Northwest Miramichi run, the most satisfactory procedure seems to be to allocate the fish taken by angling below the fence between this river and the Sevogle, in proportion to the respective angling catches in the upper rivers. On this basis, the total escapement from the commercial fishery to the Northwest Miramichi can be estimated and the exploitation rate, due to angling, worked out. This has been done in Table 1 for the years 1964 and 1965, which are the only two years for which the angling catch was divided into grilse and older salmon. The mean exploitation rate is seen to be just over 50% for older salmon. This is appreciably higher than the rate for grilse calculated in the same way; this difference may be significant, but it is assumed that the same exploitation rate applies to all the older classes of salmon.

This exploitation rate may be higher than occurs in a number of Canadian rivers, which are less well known and less heavily fished than the Miramichi. In the Tobique River, a tributary of the Saint John, the fish entering are counted as they pass up a ladder and angling records are maintained. In this case the exploitation rate for all classes of fish was for a number of years between 25 and 35% and although it has been less recently, the rate again appears to be higher for salmon than for grilse. These fish have also been exposed to some angling in the Saint John River before entering the Tobique, the estimate of 25-35% is therefore a minimal estimate of the total angling exploitation rate on the Tobique stock.

Two methods have been used to obtain from the angling exploitation rate an estimate of the commercial exploitation rate. Of fish tagged as smolts in the Miramichi between 1959 and 1963 and subsequently taken as two-sea-year and older fish in fisheries excluding Greenland, 119 were taken in the commercial fishery and 22 by angling. This gives a ratio of commercial to angling catch on older salmon of 5.4:1. The second method is based on the total quantities of fish caught in the two fisheries. In 1964 and 1965, the average number of salmon, as distinct from grilse, caught in all the rivers of the Miramichi system was approximately 4,000. Data are available on the total quantity of salmon landed in Northumberland County and this represents reasonably accurately the commercial catch from the waters of the Miramichi estuary and the adjacent part of the Gulf of St. Lawrence. Those taken in the traps in the estuary are probably all destined for the Miramichi River but it was shown some years ago that about half of those taken in the drift-net fishery are destined for rivers farther north (Belding and Préfontaine, 1939). On the other hand, many Miramichi fish are caught on other parts of the Canadian coast. Of marked smolts native to, or released in, the Miramichi since 1961 and subsequently caught as two-sea-year or older salmon in the commercial fishery, 69 (62%) were taken in the Miramichi area, and 42 (38%) in more distant Canadian waters. The total Northumberland County landings can therefore be regarded as a useful approximation to the commercial take from the Miramichi River stocks. For the years 1964 and 1965, these landings averaged 632,000 lb. Since the capture of grilse in the New Brunswick commercial fishery is prohibited, this catch may be taken to be all larger fish. The mean weight of a sample of two-sea-year fish taken in the Miramichi fishery was exactly 10 lb, so that an estimate of the number of fish taken in the fishery in 1964 and 1965 is 63,000 fish. Thus, the ratio of the total recorded commercial and angling catches for the Miramichi area is approximately 15:1, which is rather higher than the ratio for tagged fish returned. The total catch ratio refers to the whole Miramichi system, while the tagged fish were all of Northwest Miramichi origin. If this is a real difference and not due only to sampling errors, contributory factors could include a higher angling exploitation rate or a lower commercial exploitation rate in the Northwest Miramichi than in the system as a whole. While few precise data are available, the timing of the various fisheries during the season suggests that both commercial and angling exploitation rates are less for late-running than for early-running fish, but that the relative difference is greater for angling than for the commercial fishery and consequently the ratio of angling to commercial exploitation rates tends to be higher for early- than for late-running fish. It is known from trap records that in the Northwest Miramichi the proportion of late to early fish has declined in recent years, apparently as an effect of mining pollution. If the proportions in other parts of the system, which have been less affected in this way, more closely resemble those originally prevailing in the Northwest Miramichi, then the Northwest Miramichi probably now has a higher proportion of early fish than the rest of the system, and consequently may have a higher angling to commercial exploitation ratio. The difference in the estimated ratios of angling to commercial catches may therefore reflect a real difference in conditions. Other factors which could contribute to the difference in the ratios would include: a lower rate of tag reporting from commercial fishermen than anglers; the inclusion of some grilse in the commercial catches; and any excess of Northumberland County landings over the true commercial catch of Miramichi fish. The first of these factors would tend to make the ratio derived from tagging an under-estimate of the true ratio, while the other two factors would tend to make the total catch ratio an over-estimate. Few data are, however, available on the possible magnitude of these factors.

A value of 10:1, which is close to the geometric mean of the two original estimates, has therefore been taken as a basis for estimating total exploitation rate. Combining this with an angling exploitation rate of 0.5 gives a total exploitation rate of about 0.92. While this appears to be a very high exploitation rate, it is supported by the direct estimate which can also be obtained from the tagging data. The number of tagged Miramichi smolts from the 1961 and later smolt years, both wild and hatchery-produced, to be recovered in Canadian waters as two-sea-year fish was 131. Of these, 3 were taken at the counting fence and not subsequently caught in the fishery; the remaining 128 were finally caught either in the commercial fishery or by angling. The resulting estimate of the total exploitation rate is 128/131 or 0.98. This would tend to be an over-estimate if any of the tagged fish survived to spawn below the counting fence or up other tributaries. Normally, errors from these causes could be expected to be small since the fish concerned were either reared in the Northwest Miramichi above the counting fence, or were liberated near it. In recent years, however, metallic pollution from mine wastes has affected the river in the vicinity of the fence and is known to have diverted considerable numbers of fish. The distribution in the system of tagged fish caught by anglers gives some indication of the degree of diversion. Of 17 such fish, 9 were caught in the Northwest Miramichi, 7 in other parts of the Miramichi system, and 1 in a remote river system. The estimate of 0.98 is thus probably too high, and true value may not greatly differ from that obtained earlier.

This estimate of 0.92 for the Miramichi system may be compared with a very tentative estimate which can be obtained in a similar way for the overall Canadian exploitation rate. Elson (1966), from a general review of available data, adopted 0.25 as a typical value of the angling exploitation rate; this included fish of all ages, and accepting a rather lower exploitation for grilse than for older salmon would correspond to a rate of 0.30 for two-sea-year salmon. Data on the proportions of grilse and older salmon in angling catches in the principal areas show that of the 119,000 fish caught by anglers in 1965, approximately 27,000 were two sea years or more. Assuming that the entire commercial catch of salmon in the Maritime Provinces was of two-sea-year and older fish and that two-thirds by weight in Newfoundland and Quebec were of these fish, the weight of large salmon caught commercially in 1965 was about 3.75 million pounds. This corresponds to about 375,000 fish, so that the ratio of commercial to angling catch was about 14:1, which is not significantly different from that obtained for the Miramichi system. The resulting estimate of the total exploitation rate is 0.87. The difference between this and the estimates obtained for the Miramichi system is small and insignificant compared to the errors of sampling and assumption that are involved. In subsequent trial calculations a value of 0.875 has generally been used.

Exploitation Rate in Greenland

The following general analysis provides a method of estimating the exploitation rate in Greenland for a stock of fish if the relative numbers taken at Greenland and in their home waters are known and if estimates of the natural mortality rate between Greenland and home waters and of the exploitation rate in home waters are available.

If E_g = proportion of fish alive at the time of the Greenland fishery which are caught there (exploitation rate)

E = proportion of fish returning to home waters which are caught there

M = instantaneous natural mortality rate between Greenland and home waters

t = average time between presence in the Greenland fishery and presence in the home fishery

N = number of fish in the group at the time of the Greenland fishery

Then, assuming that fish visiting Greenland return in the normal manner if not caught,

Number caught at Greenland $= NE_g$

Number returning to home waters $= N(1-E_g)e^{-Mt}$

Number caught in home waters $= NE(1-E_g)e^{-Mt}$

$$\therefore \frac{\text{Number caught at Greenland}}{\text{Number caught in home waters}} = \frac{NE_g}{NE(1-E_g)e^{-Mt}}$$

$$= R$$

Therefore $$E_g = \frac{REe^{-Mt}}{1 + REe^{-Mt}}$$

An estimate of R is available from the recaptures of tagged fish. Since the amount of effort expended annually in either fishery can vary from year to year and would affect the value of R, it is necessary to adopt some means of standardizing the effort. In the present study it has been assumed that in Canadian waters effort has remained constant over the four years concerned, 1961-64. This manifestly does not apply to the Greenland effort; for this fishery it has been assumed that the chances of capturing Canadian fish in any season have been proportional to the total quantity of salmon taken in Greenland in that year. This, in effect, assumes that the Greenland catch has been proportional to the effort, *i.e.*, that the stock at Greenland has remained approximately constant over this period. Values of R, and therefore of E_g, have then been calculated for a standardized Greenland catch of 1,000 metric tons; this standardized level of catch is appropriate since it is close to the mean for the two biggest years in the fishery. The estimation of R for each year, and a final pooled value, is shown in Table 2. The pooled value (0.26) is obtained by dividing the ratio of total Greenland to total Canadian two-sea-year recaptures by the average Greenland catch for the four years. Greenland recaptures for 1965 cannot, of course, be used, since the corresponding Canadian recaptures will not be made until the 1966 season.

Table 3A shows the values of E_g corresponding to the above estimated values of R and E for the range of natural mortality rates which has been shown to be likely to include that applying between Greenland and Canada. It appears, therefore, that E_g is likely to be between 0.05 and 0.16 and most probably between 0.08 and 0.16.

Values of E_g for a wider range of combinations of R, E and M are shown for comparative purposes in Table 3B.

The method which has been used in this section provides an estimate of the rate of exploitation by the Greenland fishery on the whole stock of fish concerned (in this case the Northwest Miramichi fish) and not the rate applied to that part of the stock which enters the area of the Greenland fishery. If only a part of the fish which spend two winters at sea reach the Greenland area, the estimated rate of exploitation within the Greenland area will be correspondingly higher, but it is the exploitation rate on the whole stock which is significant in assessing the effects of the Greenland fishery.

Proportional Reduction in Canadian Catch

The previous section has developed an estimate (E_g) of the proportion of Miramichi fish entering their second winter in the sea, which are caught in the Greenland fishery.

If only part of this stock move to the Greenland area and are exposed to the fishery there, it is strictly the home-water exploitation rate and the natural mortality rate for this part of the stock which should be considered in assessing the effect of the Greenland fishery on home-water catches and on ultimate escapement. At present, however, there is no evidence that the rates for this part differ from those applicable to the stock as a whole, although it is possible that further studies may provide such a basis. It may, for example, be found that the fish going to Greenland, if they travel further, tend to return later in the season and are therefore exposed to the home-water fishery for a shorter period with consequently a lower exploitation rate. Similarly, it might be that the greater distance travelled led to a higher natural mortality rate or a greater tendency to stray. In the present analysis, however, it is assumed that the mortality and exploitation rates are the same for the fish visiting Greenland as for the rest of the stock at the same age.

The value of E_g developed above is an estimate of the proportionate reduction in the stock and catch of two-sea- year fish in the Miramichi per 1,000 tons taken in Greenland. This proportion will apply to both the number and weight of fish caught. Since the landings of grilse by the commercial fishery is illegal in New Brunswick, the commercial catch in the Miramichi area will be reduced by the same proportion. The angling catch in this area, however, includes many grilse and these are apparently not affected by the Greenland fishery. In recent years the average catch of grilse by angling in the Miramichi system has been greater than the average catch of older salmon and the proportion has been increasing. The proportional reduction in the total number of fish caught by angling in the Miramichi system due to catches in Greenland will therefore be substantially less than the reduction in large fish.

Effect of Greenland Catches on Total Catch of Salmon

Using the same notation as before and with K equal to the instantaneous growth rate during the period between the Greenland and home-water fisheries, then

for unit number of fish caught in Greenland the number caught in home waters will be reduced by

$$Ee^{-Mt}$$

and for unit weight of fish caught in Greenland the weight caught in home waters will be reduced by

$$Ee^{(K-M)t}$$

Therefore for unit captures in Greenland the total catches (both Greenland and home water) will be increased by

$1 - Ee^{-Mt}$ in number

and $1 - Ee^{(K-M)t}$ in weight

Since E and e^{-Mt} must both be less than 1, the expression for increase in numbers must be positive, but, if K sufficiently exceeds M the expression for increase in weight may be negative, so that the Greenland fishery will produce a decrease in total catch.

Table 4A shows for the estimated values of E and K, the reduction in the weight of the Canadian catch, and the increase in the weight of the total catch, per 1,000 tons of Canadian fish taken at Greenland. Any catch at Greenland will, of course, cause some reduction in the home-waters catch but the effect on total catch is very dependent on the value of M and for the probable range of M may vary between a small reduction and an increase by 50% of the Greenland catch or even more.

Table 4B shows the effect on home-water and total catches of a range of combinations of E and M. As a general principle, which is independent of the values of any of the parameters involved, the greater the loss to the home-water fishery the less will be the overall benefit from an increase in the total catch in both Greenland and home waters. The lower the natural mortality rate is ultimately found to be, the higher will be the home-water loss, and the less the overall benefit.

Since the effect of a Greenland fishery on the total catch is influenced by the rate of exploitation (E) in the home fishery, it is possible to define a critical home-water exploitation rate (E_c) as that at which the Greenland fishery has no effect on the total catch. Table 5 shows the values of E_c for various combinations of K and M. Where the actual home exploitation rate is less than the critical value, the Greenland fishery will produce an increase in total catch, but if E is greater than E_c the Greenland fishery will cause a reduction. The lower left half of the table corresponds to the conditions under which M is greater than K and the Greenland fishery will always produce an increase in total catch.

Proportion of Fish of Canadian Origin in Greenland Catches

The two preceding sections have developed estimates, per 1,000 tons of salmon taken in Greenland, of the proportionate reduction this will produce in the home-water catch, and of the actual reduction in the weight of the home-water catch. These have used estimates of growth, natural mortality, and exploitation rates which have been obtained for the Miramichi fishery and are believed to be reasonably representative of Canadian conditions generally. If it is assumed that not only K and M but also E are similar for Canada and for other salmon-producing areas which contribute to the Greenland catches, it is possible to estimate the proportion of the fish in the Greenland catches which are derived from Canadian stocks. This is done in Table 6, taking 3,750,000 lb (1,700 metric tons) as the average total Canadian catch for the last two years. This ratio is much less sensitive to the value of M than any of the other parameters examined, and for the entire range of possible values of M varies only between 0.22 and 0.25.

In this case the largest source of error may lie in the sampling errors associated with R. This is based ultimately on the recapture of 13 fish in Greenland and 91 in Canada and the ratio under consideration is proportional to it. If such numbers occurred in a simple sampling process, the 95% confidence limits for the ratio of Greenland to Canadian tag recoveries would be about 0.13-0.21 to 1; this would correspond to confidence limits for the ratio of Canadian to total catch reduction of 15-45%.

In recent years Canadian catches have made up 15-18% of the total recorded commercial catch of Atlantic salmon (data drawn from FAO Year Books), or about 20-23% if Baltic catches are excluded. Allowing for sampling errors and for the differences in home-water exploitation rates in different areas, these preliminary estimates do not indicate any significant difference between the proportion of Canadian fish in Greenland catches and the proportion either in world catches or in world stocks. There is therefore no reason to assume at this stage, that the proportion of Canadian fish visiting Greenland differs greatly from the proportion in fish from other areas.

Effect on Spawning Escapement

Few good data are available regarding the relation between the size of spawning runs and the number of smolts produced for Atlantic salmon or for the exploitation rate that will produce optimum spawning escapement for maximum smolt production. Elson (1957*b*) has estimated the spawning density required to produce 10 large parr per 100 square yards of stream, which appears to be about the quantity required in many streams to give maximum smolt production. The exploitation rate estimated for two-sea-year salmon in the Miramichi (92%) is so high as to be likely to be close to the maximum which will give optimum escapement if it does not actually exceed it. The calculations outlined in previous sections led to an estimate of exploitation rate in the Greenland area of 5 to 15%. Superimposition of this on the home-water exploitation rate will reduce the survival, which is already probably less than 10%, by a similar proportion.

In addition to the escapement of two-sea-year and older fish, there is of course also a spawning run of grilse and these in many Canadian waters probably make a greater contribution to the next generation than do the older fish although their individual egg production only averages about 0.4 to 0.5 that of the older fish. This part of the population is not at present affected by the Greenland fishery.

The question of the extent to which the return of fish as grilse or salmon is genetically determined is one which is attracting considerable attention but the answer remains uncertain. It is therefore not yet possible to determine the extent to which additional exploitation on the older fish could affect the age composition of future runs and thus the size of succeeding runs of two-sea-year and older fish.

Summary and Conclusions

1. This paper is primarily an attempt to develop methods of analyzing the problems arising from the Greenland fishery and to assess the availability of suitable data.

2. Canadian data, particularly referring to the Miramichi system, have been used for this purpose because they were the most comprehensive available to the authors; the conclusions regarding the effects on Canadian stocks and catches must, however, be regarded as very tentative and requiring amendment or

confirmation as other data become available.

3. The Greenland fishery takes almost entirely fish nearing their second sea winter, and it has been assumed that they would, if not caught, return to their parent streams as two-sea-year fish in the normal manner; the analysis is further based on the assumption that two-sea-year fish constitute all the catch.

4. Reasonably good data exist on the rate of growth between Greenland and the return to home waters. The monthly instantaneous growth rate (K) is about 0.04.

5. No precise estimate of the natural mortality rate during this period is possible; the monthly instantaneous rate (M) almost certainly lies between 0.02 and 0.15 and probably between 0.02 and 0.10.

6. The exploitation rate on two-sea-year fish in Canadian waters is high, being commonly over 0.8 and in the Miramichi system over 0.9. A value of 0.875 is used in the trial calculations.

7. The exploitation rate at Greenland on fish of Miramichi origin, based on the numbers of marked fish recaptured at Greenland and in Canada is estimated at 0.05 to 0.16, and probably between 0.08 and 0.16, depending on the value of M used. These values are for a standardized Greenland catch of 1,000 tons.

8. The proportionate reduction in the Canadian commercial catch, which consists mainly of two-sea-year and older salmon, will be only slightly less than the Greenland exploitation rate. The angling catch, because it contains a large component of grilse, will be reduced by a smaller proportion.

9. The proportion of fish of Canadian origin in the Greenland catches is estimated at 0.22 to 0.25; this is relatively independent of the value of M selected although it is subject, like all other estimates, to substantial errors of sampling and assumption. This proportion is close to the proportion of Canadian in world Atlantic salmon catches (0.15 to 0.18). This fairly close agreement does not suggest that the fraction of Canadian fish entering Greenland waters differs greatly from the fraction of fish from other areas which do so.

10. The spawning escapement to Canadian rivers will be reduced by the Greenland fishery in a proportion similar to the Greenland exploitation rate. For the older salmon, which are subject to the Greenland fishery, the local exploitation is already high and the spawning escapement correspondingly low. The grilse, which are less heavily exploited locally, are also not affected by the Greenland fishery. The effect of this selective pressure on the older fish on the ultimate proportion of grilse and salmon in the stocks cannot as yet be assessed.

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Table 1. Computation of angling exploitation rate for salmon other than grilse in the Northwest Miramichi River.

	Angled below trap	Trap catch	Angled above trap	Angled in Sevogle	Catch below allocated to Northwest Miramichi	Catch above and allocated catch	Trap and allocated catch	% caught
1964	84	132	52	65	37	89	169	52.7
1965	461	113	23	127	71	94	184	51.1
Total	545	245	75	192	108	183	353	51.8

Table 2. Computation of ratio between number of salmon caught in Greenland, and number, from the same group, caught as two-sea-year fish in Canadian waters per 1000 tons annual catch in Greenland. Results for Miramichi fish tagged as smolts.

A	B	C	D	E	F	G
Year of Greenland fishery	Smolt year	Weight of Greenland catch (tons)	Tagged 1 year earlier	Re-captured in Greenland	Re-captured as two-sea-year salmon	E/CF x 1000
1961	1960	115	750	1	6	1.449
1962	1961	220	5871	0	20	0
1963	1962	420	5611	2	45	.106
1964	1963	1400	8832	10	20	.357
Total		2195	21,264	13	91	.260

Table 3 A. Computation of the exploitation rate (E_g) of the Greenland fishery on Miramichi salmon entering their second winter at sea, from the equation

$$E_g = \frac{REe^{-Mt}}{1 + REe^{-Mt}} ;$$

trial calculations for a series of values of M, using the estimated values of R, E and t as listed.

R = .26	E = .875	RE = .227	t = 10
M	e^{-Mt}	REe^{-Mt}	E_g
.02	.819	.185	.156
.03	.741	.168	.143
.04	.670	.152	.131
.05	.607	.137	.120
.06	.549	.124	.110
.07	.497	.112	.100
.08	.449	.101	.091
.09	.407	.092	.084
.10	.368	.083	.076
.11	.333	.075	.069
.12	.301	.068	.063
.13	.273	.061	.057
.14	.247	.056	.053
.15	.223	.050	.047

Table 3 B. Values of E_g for a range of values of R, E and M.

R	E	M	.02	.04	.06	.08	.10	.12	.14
.1	.5		.038	.032	.026	.021	.017	.014	.011
	.75		.057	.048	.039	.031	.026	.021	.017
	.85		.065	.053	.043	.036	.030	.024	.019
	.9		.068	.057	.046	.038	.031	.026	.021
	.95		.072	.060	.050	.041	.034	.028	.023
.2	.5		.075	.063	.052	.042	.034	.029	.023
	.75		.109	.091	.075	.062	.052	.043	.035
	.85		.122	.102	.085	.070	.058	.048	.039
	.9		.128	.107	.089	.074	.061	.051	.042
	.95		.135	.113	.094	.079	.065	.054	.045
.3	.5		.109	.091	.075	.062	.052	.043	.035
	.75		.155	.130	.109	.091	.075	.062	.052
	.85		.172	.145	.122	.102	.085	.070	.058
	.9		.181	.153	.128	.107	.090	.074	.061
	.95		.189	.160	.135	.113	.095	.079	.066
.4	.5		.140	.118	.098	.081	.068	.056	.046
	.75		.197	.167	.140	.118	.099	.082	.068
	.85		.218	.185	.156	.131	.111	.092	.076
	.9		.227	.194	.164	.138	.116	.097	.080
	.95		.238	.203	.173	.146	.123	.103	.086

Table 4 A. Computation of reduction in tons in home-water catch and increase in total catch per 1000 tons additional catch taken in Greenland.

Reduction = $Ee^{(K-M)t}$

Increase = $1 - Ee^{(K-M)t}$

Values of E, K and t as listed.

	E = .875	K = .05	t = 10
M	$e^{(K-M)t}$	Reduction in home-water catch	Increase in total catch
.02	1.350	1181	-181
.03	1.221	1068	- 68
.04	1.105	966	34
.05	1.000	875	125
.06	.905	791	209
.07	.819	716	284
.08	.741	648	352
.09	.670	586	414
.10	.607	531	469
.11	.549	480	520
.12	.497	434	566
.13	.449	392	608
.14	.407	356	644
.15	.368	322	678

Table 4 B. Reduction of home catch and increase of total catch for unit catch in Greenland for a series of values of M and E, taking K = .04 and t = 10.

M	Reduction in home catch				Increase in total catch			
E	.50	.75	.85	.90	.50	.75	.85	.90
.02	.610	.915	1.037	1.098	.390	.085	-.037	-.098
.03	.552	.828	.939	.994	.448	.172	.061	.006
.04	.500	.750	.850	.900	.500	.250	.150	.100
.05	.452	.678	.769	.814	.548	.322	.231	.186
.06	.409	.614	.696	.737	.591	.386	.304	.263
.07	.370	.555	.629	.666	.630	.445	.371	.334
.08	.335	.502	.569	.603	.665	.498	.431	.397
.09	.303	.455	.515	.546	.697	.545	.485	.454
.10	.274	.411	.466	.494	.726	.589	.534	.506
.11	.248	.372	.422	.447	.752	.628	.578	.553
.12	.224	.336	.381	.404	.776	.664	.619	.596
.13	.203	.305	.345	.366	.797	.695	.655	.634
.14	.184	.276	.312	.331	.816	.724	.688	.669
.15	.166	.248	.282	.294	.834	.752	.718	.706

Table 5. Tabulation of critical exploitation rate (E_c) in home waters at which an additional catch in Greenland does not alter the total catch, for various values of K and M; using the equation

$$E_c = e^{-(K-M)t}$$

M	K .02	.03	.04	.05	.06	.07	.08
.02	1.000	.905	.819	.741	.670	.607	.549
.03	-	1.000	.905	.819	.741	.670	.607
.04	-	-	1.000	.905	.819	.741	.670
.05	-	-	-	1.000	.905	.819	.741
.06	-	-	-	-	1.000	.905	.819
.07	-	-	-	-	-	1.000	.905
.08	-	-	-	-	-	-	1.000

Table 6. Estimation of the proportion of the total Greenland catch taken from Canadian stocks by multiplication of the estimated proportional reduction in Canadian catch, and absolute reduction in total home-water catch per 1000 tons taken in Greenland: results for a series of values of M.

M	Proportional reduction in catch	Reduction in Canadian catch	Total reduction in home catch	Proportion of total catch from Canada
.02	.156	265	1181	.224
.03	.143	243	1068	.228
.04	.131	223	966	.231
.05	.120	204	875	.233
.06	.110	187	791	.235
.07	.100	170	716	.237
.08	.091	155	648	.239
.09	.084	142	586	.241
.10	.076	130	531	.243
.11	.069	118	480	.245
.12	.063	107	434	.246
.13	.057	97	392	.248
.14	.053	88	356	.249
.15	.047	81	322	.251

2. Recaptures of tagged Atlantic salmon in Greenland waters in 1965 and some remarks about the Greenland salmon fishery[1]

by Paul M. Hansen
Grønlands Fiskeriundersøgelser
Charlottenlund, Denmark

The Greenland Salmon Fishery in 1965

The total catch of Atlantic salmon in Greenland waters in 1965 was 716 tons (gutted, head on) which is about half of the output in 1964.

Table 1 gives the catches in tons per division in 1965 in different months. In the tables Div. 1B is divided into two subdivisions, 1Ba and 1Bb. The limit between the two subdivisions is 67°30'N Lat. The reason for this partition is that there is a big difference between the catches in these two subdivisions.

September and October, as in 1964, were the best months. The salmon catches have decreased in all Greenland districts except in 1Ba, where the catch rose from 48 tons in 1964 to 142 tons in 1965.

There is reason to believe that the decrease in the salmon fishery is partly a result of the lower prices for salmon paid to the Greenland fishermen and partly because of the higher prices for cod in 1965.

Table 2 shows the prices paid by the Royal Greenland Trading Company for salmon in 1964 and in 1965, and for cod in 1964, 1965 and 1966.

The increase in the prices for cod in 1965 just when the salmon fishery started, together with the much lower prices for salmon compared with 1964, probably had the effect that many Greenland fishermen abandoned the salmon fishery in favour of the cod fishery. Further the gill-net fishery for salmon requires much more work than the cod fishery because it is very difficult to clean from the nets dead seaweed which flows in the sea in large amounts in the autumn.

Size of Salmon

The sizes of the salmon were very much like those in 1964 and in 1963. Figure 1 shows the length distributions in samples of salmon from Div. 1D (Fiskenaesset 1963 and 1964 and Godthaab 1965) and Div. 1C (Sukkertoppen 1965). The sample from 1C contains bigger fish than the other samples possibly because it has been taken a little later (early November) than the other

[1] submitted to the ICES/ICNAF Joint Working Party on North Atlantic Salmon, 25-26 May 1966, as ICES/ICNAF Salmon Doc.66/13

samples. The measurements are given in fork length. The relationship between total and forked lengths are shown in Fig. 2.

The weights of salmon taken in different divisions are shown in Table 3. In the whole catch, the largest numbers of salmon lie between 3 and 5 kg (57%). The biggest salmon are caught in 1A, 1Ba and 1Bb where the percentages of salmon of more than 5 kg are 17.0, 33.8 and 22.6 respectively. In 1C and 1E the corresponding percentages are only 12.2 and 7.4. Div.1F cannot be compared with the other divisions as the whole catch was only 9.6 tons. In 1964 95.4 tons were obtained in Div. 1F.

Recaptures of Salmon tagged in Foreign Rivers

Thirty recaptures of tagged salmon were reported from West Greenland in 1965. In 1964 the number of recaptures was 37. One recapture of a salmon tagged in Luleaa in Sweden in 1962 and recaptured off Angmagssalik in East Greenland in March 1965 has been mentioned in the addendum to ICES paper CM 1965, Salmon and Trout Committee, No.17. Details about the taggings and recaptures are given in Table 6.

Table 1. Catch of salmon (gutted, head on) in tons per division in 1965.

Div.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	%
1A	-	2	15	-	-	17	2.3
1B a	-	9	101	32	-	142	19.8
1B b	-	11	43	14	1	69	9.6
1C	1	101	83	51	11	247	34.5
1D	12	37	23	5	-	77	10.8
1E	39	83	29	4	-	155	21.6
1F	-	5	4	-	-	9	1.3
Tons	52	248	298	106	12	716	99.9
%	7.3	34.6	41.6	14.8	1.7		100.0

Table 2. (a) Prices (D.Kr.) for salmon of different weights (gutted, head on)

Weight (kg)	1964	1965 (to 25 Oct.)	1965 (from 25 Oct.)
1	5.75	1.50	2.00
2	11.50	3.00	4.00
4	28.00	18.00	22.00
5	47.50	25.00	30.00
6	72.00	30.00	36.00

(continued)

Table 2 (cont'd). (b) Price (D.Kr.) per kg of cod for freezing.

Year	1 May-31 Aug.	1 Sept.-30 Apr.
1964	0.42	0.52
1965	0.40	0.65
1966	0.45	0.69

Table 3. Catch in tons of salmon of different weights per division (except Div. 1D)

		Weights in kg							
Div.		1.0-2.5	2.5-3.0	3.0-4.0	4.0-5.0	5.0-7.0	7.0-9.0	9.0	Total
1A		0.2	0.9	7.0	5.7	1.4	1.0	0.4	16.6
1Ba		0.4	3.0	38.1	52.0	26.1	18.1	3.7	141.4
1Bb		3.4	8.5	24.7	16.8	8.4	5.8	1.3	68.9
1C		10.2	22.4	42.8	17.0	6.9	5.2	0.8	105.3
1E		24.0	45.5	62.0	13.1	6.9	3.4	0.2	155.1
1F		0.2	0.7	2.4	1.5	1.8	1.9	1.1	9.6
Total	t	38.4	81.0	177.0	106.1	51.5	35.4	7.5	496.9
	%	7.7	16.3	35.6	21.4	10.4	7.1	1.5	

Table 4. Distribution of recaptures of tagged salmon by divisions and countries where they were tagged.

Div.	Canada	Ireland	England	Scotland	Total
1Ba	-	1	-	1	2
1Bb	1	-	-	1	2
1C	3	-	6	2	11
1D	1	-	-	-	1
1E	3	1	3	-	7
1F	2	-	-	2	4
NK	3	-	-	-	3
Total	13	2	9	6	30

Table 5. The distribution of recaptured salmon by stages when tagged.

Country	Smolt	Kelt	Big Salmon	?	Total
Canada	8	-	1	4	13
Ireland	-	2	-	-	2
England	7	1	-	1	9
Scotland	5	-	1	-	6
Total	20	3	2	5	30
%	66.7	10.0	6.7	16.7	

Table 6. 1965 recaptures in Greenland waters of salmon tagged in Scottish, English, Irish and Canadian rivers.

Tagging	Recapture
Tagged in Scotland:	
17. Small green circular plastic tag No.K 72 April 28, 1964 smolt trapped on River Bran and transported to the River Conon and released there Pitlochry	September 1, 1965 off Tigssaluk 61°20'N 49°10'W
18. Square silver tag Sc 4496 May 6, 1964 River North Esk 14.5 cm 2+ years old	September 11, 1965 South of Avigait 62°10'N 49°55'W
19. Silver tag No. Sc 6825 May 9, 1964 River North Esk Smolt, 19 cm	December 4, 1965 off Sukkertoppen 65°25'N, 53°00'W 73 cm, 3 kg ♂
20. Circular green plastic tag No. J 97 April 28, 1964 River Bran (Ross-shire) Smolt	Letter dated October 22, 1965 Ekalugarssiut, Julianehaab 60°38'N 45°55'W
21. Square silver tag No. Sc 5834 May 9, 1964 River North Esk Smolt, 11.5 cm 2+ years	October 24, 1965 off Itivdloq 66°33'N 53°25'W 70 cm, 4.1 kg ♂
22. Red plastic double tag No. 1597 November 28, 1964 River North Esk (estuary) 57.5 cm 2.1+ years, (ripe to spawn)	October 22, 1965 Egedesminde 68°45'N 52°40'W 77 cm, 4.3 kg
Tagged in England:	
19. Small square silver tag No. E7 5895 March 25, 1964 River Usk, Pant-y-Goitre, Monmouthshire Smolt	September 18, 1965 off Sukkertoppen 65°25'N 53°00'W 73 cm, 2.9 kg ♀

(continued)

Table 6 (cont'd)

Tagging	Recapture
Tagged in England (cont'd)	
20. Small square silver tag No. E 6 9285 April 14, 1964 River Axe, Colyford, Devon Smolt, 14.7 cm	September 18, 1965 off Sukkertoppen 65°25'N 53°00'W 74 cm, 3.1 kg ♂
21. Small square grey plastic tag No. 7429 May 8, 1964 River Severn, Gloucester Smolt	September 13, 1965 off Sukkertoppen 65°25'N 53°00'W 76 cm, 3.5 kg ♂
22. Small square silver tag No. E 9 5930 April 21, 1964 River Wye at Brockhampton, near Hereford Smolt	September 19, 1965 off Kangamiut 65°49'N 53°21'W 77 cm, 3.5 kg ♀
23. Small square silver tag No. E 8 0583 April 15, 1964 River Usk at Pant-y-Goitre, near Abergavenny Smolt	October 17, 1965 off Sukkertoppen 65°49'N 53°00'W 77 cm, 3.7 kg ♀
24. Circular silver tag No. E 1 1710 April 25, 1964 River Severn, Tewkesbury Smolt	November 4, 1965 off Sukkertoppen 65°25'N 53°00'W 71 cm, 2.5 kg ♂
25. Yellow plastic flap E 0475 May 4, 1965 River Axe, Devon Kelt	September 14, 1965 off Frederikshaab 62°00'N 49°50'W 82 cm
26. Circular silver tag No. E 1 1737 April 25, 1964 River Severn, Tewkesbury Smolt	September 23, 1965 off Frederikshaab 62°00'N 49°50'W 66 cm, 3 kg ♀
27. Square silver tag No. E 10 4577 April 23, 1964 River Severn, Tewkesbury	September 11, 1965 South of Avigait 62°10'N 49°55'W

(continued)

Table 6 (cont'd)

Tagging	Recapture
Tagged in Ireland:	
5. L. Lea No. 4648 March 22, 1965 River Corrib Kelt, 69 cm, 2.3 kg	 October 16, 1965 Akunak, Egedesminde 68°43'N 52°12'W
6. L. Lea No. 3715 January 6, 1965 Parteen Rearing Installation on the Shannon Kelt, 60 cm, 1.8 kg	 September 13, 1965 Kangerdluarssuk, Frederikshaab 62°05'N 49°35'W
Tagged in Canada:	
24. Plastic tag No. 72331 May 20-22, 1964 NW Miramichi River Smolt	 August 31 off Frederikshaab 62°00'N 49°50'W
25. Plastic tag No. 62966 May 20-22, 1964 NW Miramichi River Smolt	 August 29, 1965 off Qagssimiut 60°45'N 47°20'W 65 cm, 2 kg
26. Plastic tag No. 56507 May 23, 1964 NW Miramichi River Smolt	 Handed to Mr Saunders Sukkertoppen in September 1965 no further information
27. Plastic tag No. 76237 May 25, 1964 NW Miramichi River Smolt	 September 9, 1965 off Ravn Stoeø 62°40'N 50°25'W 1.5 kg
28. Plastic tag No. 79307 June 3, 1964 NW Miramichi River Smolt	 Letter dated November 16, 1965 off Kangamiut 65°49'N 53°21'W 2 1/2-3 kg gutted, head on
29. Plastic tag No. 74419 May 22, 1964 NW Miramichi River Smolt	 September 16, 1965 off Arsuk 61°10'N 49°35'W 65 cm, 2.6 kg

(continued)

Table 6 (cont'd)

Tagging	Recapture
Tagged in Canada (cont'd)	
30. Plastic tag No. 80950 October 11, 1964 NW Miramichi River 89 cm	Letter dated December 16, 1965 found on a frozen salmon Vendsyssel Packing Co.
31. Plastic tag No. 59291 May 26, 1964 NW Miramichi River Smolt	October 2, 1965 off Sydprøven, Kinalik 60°25'N 45°40'W 69 cm, 2.5 kg. ♀
32. Plastic tag No. 31242 June 7, 1963 Cain's Stream, Prince Edward Island Smolt	September 16, 1965 Amerdloq Fjord 66°53'N 53°10'W 6.1 kg
33. Silver wire with a white and green bead	August 25, 1965 Nurutussok, Frederikshaab 62°00'N 49°50'W
34. Silver wire with a white and green bead	August 27, 1965 at Pá, Sukkertoppen district 66°00'N 53°25'W 68 cm, 2.5 kg ♀
35. Silver wire with a white and green bead	Autumn 1965 The tag was found in a lot of salmon at a fishmonger who bought the salmon in Greenland
36. Silver wire with a white and green bead	November 28, 1965 Entrance to Ameralik Fjord 64°00'N 51°40'W weight about 3 kg

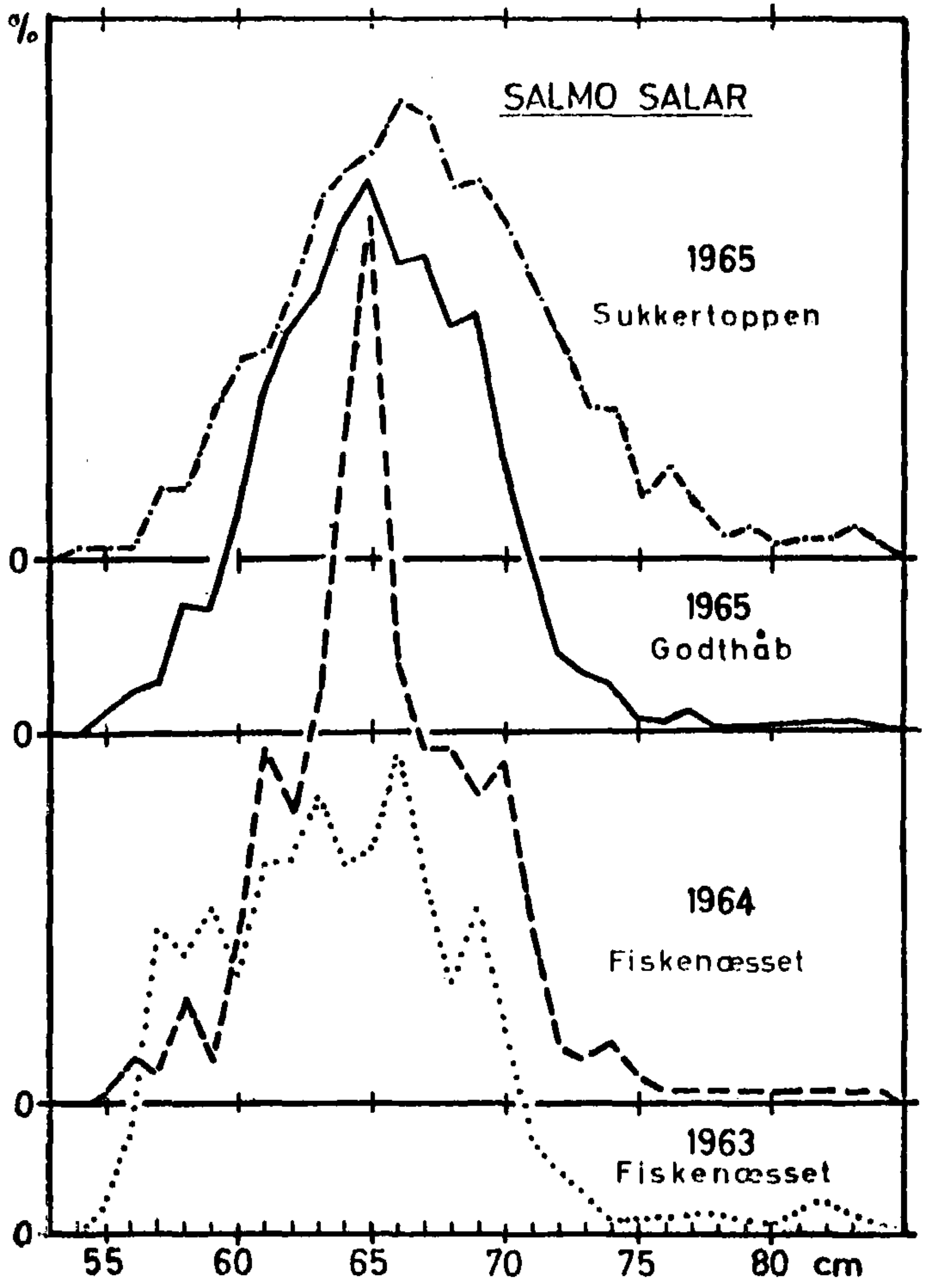

Fig. 1. Length distribution (cm) of salmon sampled in Div.1D (Fiskenaesset 1963 and 1964 and Godthaab 1965) and Div.1C (Sukkertoppen 1965).

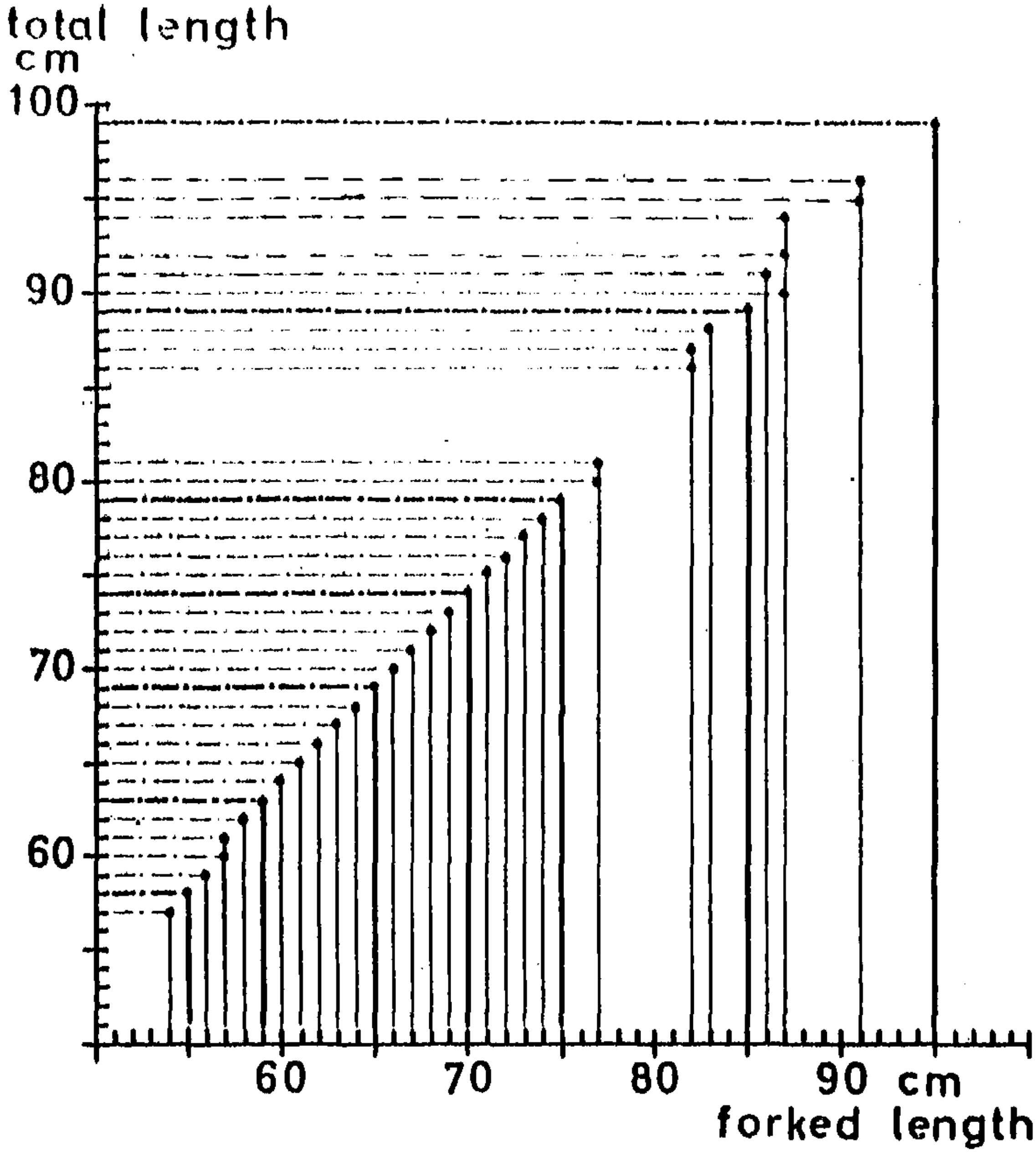

Fig. 2. Relationship between total to fork lengths of salmon.

SECTION F
TRAWL MATERIAL AND MESH SIZE SAMPLING

Size Sampling Summary Form" completed by member countries and which represent the number of codends with average mesh size of codend in each mesh size group (12.5 mm range for each mesh group in 1964 and 4 mm range for each mesh group in 1965), are reorganized into three major divisions around the mesh size group which contains the 114 mm (4-1/2 inch) mesh size adopted by the Commission for regulation of the ICNAF fisheries in Subareas 3, 4 and 5 in 1955 and for Subareas 1 and 2 in 1961. Thus the paper presents the number of codends with average mesh size greater than (>), equal to (=) and less than (<) in the 108-121 mm (4-1/2-4-3/4 inch) mesh size group in Part A for the 1964 data and in the 110-114 mm (4-2/5-4-3/5 inch) mesh size group in Part B for the 1965 data.

(c) The type of mesh gauge used in measuring the meshes of codends sampled is presented in Parts A and B by country in most cases. Where different types were used for measuring the meshes of codends sampled in fisheries for different species, the type has been recorded by species.

(d) All data presented in Parts A and B are based on measurements of meshes of codends after use.

(e) The proportion of codends which were using topside chafing gear (ch) to those codends measured (ce) is presented for each gear, species or group of species and subarea.

(f) Abbreviations for the net materials used for the codends are as follows:

PA - polyamides
PES - polyesters
PE - polyethylenes
PP - polypropylenes
Ma - Manila or sisal
O - Other materials

(g) Abbreviations for the species of fish are as follows:

Cod - Cod
Had - Haddock
Red - Redfish
Hak - Hake
Sil - Silver hake
Pol - Pollock
Flo - Flounders
Mac - Mackerel
Yel - Yellowtail flounder
Fla - Flatfish
Mix - Mixed species
Ind - Industrial species

(h) Abbreviations for the gear types are as follows:

OT - Otter trawl
DaS - Danish seiner

Part A. Trawl Material and Mesh Size Sampling Summary for 1964

The Summary is based on data submitted in 1964 by Canada (Maritimes, Quebec and Newfoundland), France (St. Pierre & Miquelon), Germany, Fed. Rep., Iceland, Portugal, USSR, UK and USA on the form "Trawl Material and Mesh Size Sampling Summary" (ICNAF/Gear & Selectivity/14.10.64) (*Redbook* 1964, Pt.I, pp. 42 and 45) and presented to the 1965 Annual Meeting of the Commission as Research Document No.52.

CANADA - 1964
(ICNAF gauge)

Species	Gear	Mesh Size Gp (108-121 mm)	No. of codends measured														
			Subarea 3					Subarea 4					Subarea 5				
			PA PES	PE	PP	Ma	O	PA PES	PE	PP	Ma	O	PA PES	PE	PP	Ma	O
Cod	OT	>	-	-	-	-	-	8	2	-	1	-	-	-	-	-	-
		=	4	-	-	-	-	99	33	-	3	2	1	-	1	-	-
		<	1	-	-	-	-	80	15	-	-	1	-	-	-	-	-
		ch/ce			5 / 5					10 / 244					2 / 2		
	DaS	>	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	4	11	-	-	-	-	-	-	-	-
		<	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-
		ch/ce								0 / 20							
Cod Pol	OT	>	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
		=	26	5	7	40	-	-	-	-	-	-	-	-	-	-	-
		<	8	-	1	9	-	2	-	-	-	-	-	-	-	-	-
		ch/ce			97 / 97					2 / 2							
Had	OT	>	-	-	-	-	-	8	1	-	-	-	-	1	-	-	-
		=	2	-	-	-	-	34	7	5	-	-	8	-	-	-	-
		<	1	-	-	-	-	22	-	-	-	-	-	-	-	-	-
		ch/ce			3 / 3					18 / 77					9 / 9		
Had Pol	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		=	6	-	8	6	-	-	-	-	-	-	-	-	-	-	-
		<	6	-	2	5	-	-	-	-	-	-	-	-	-	-	-
		ch/ce			33 / 33												
Red	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	23	8	1	-	-	1	-	-	-	-
		<	2	-	-	-	-	36	9	-	4	3	1	-	-	-	-
		ch/ce			2 / 2					8 / 84					2 / 2		
Red Pol	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		=	9	-	1	14	-	-	-	-	-	-	-	-	-	-	-
		<	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-
		ch/ce			28 / 28												

(continued)

CANADA - 1964 (cont'd)
(ICNAF gauge)

Species	Gear	Mesh Size Gp (108-121 mm)	No. of codends measured Subarea 3 PA PES	PE	PP	Ma	O	Subarea 4 PA PES	PE	PP	Ma	O	Subarea 5 PA PES	PE	PP	Ma	O
Fla	OT	>	-	3	-	-	-	2	2	1	-	-	-	-	-	-	-
		=	6	5	5	1	-	14	6	-	-	-	-	-	-	-	-
		<	1	-	-	-	-	10	3	-	-	-	-	-	-	-	-
		ch/ce	21 / 21					10 / 38									
	DaS	>	-	-	-		-	1	2	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	5	4	-	-	-	-	-	-	-	-
		<	1	-	-	-	-	9	-	-	-	-	-	-	-	-	-
		ch/ce	0 / 1					0 / 21									
Flo Pol	OT	>	-	-	-	1	-	-			-	-	-	-	-	-	-
		=	92	31	23	23	-	-			-	-	-	-	-	-	-
		<	39	1	7	22	-	-	-	-	-	-	-	-	-	-	-
		ch/ce	239 / 239														
Pol	OT	>	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
		=	-	-	-	-	-	13	2	-	-	-	-	-	2	-	-
		<	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-
		ch/ce						15 / 21					2 / 2				
Hak	OT	>	-	-	-	-	-	3	1	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
		<	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		ch/ce						0 / 7									
Mac	DaS	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
		ch/ce						0 / 1									
All Species	OT	>	-	3	-	2	-	22	6	2	1	-	-	1	-	-	-
		=	145	41	44	84	-	186	56	6	3	2	10	-	3	-	-
		<	59	1	10	39	-	154	27	-	4	4	1	-	-	-	-
	Total		204	45	54	125	-	362	89	8	8	6	11	1	3	-	-
		ch/ce	428 / 428					63 / 473					15 / 15				
All Species	DaS	>	-	-	-	-	-	2	3	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	9	15	-	-	-	-	-	-	-	-
		<	1	-	-	-	-	12	1	-	-	-	-	-	-	-	-
	Total		1	-	-	-	-	23	19	-	-	-	-	-	-	-	-
		ch/ce	0 / 1					0 / 42									

FRANCE (St Pierre & Miquelon) - 1964
(gauge not reported)

Species	Gear	Mesh Size Gp (108-121 mm)	No. of codends measured Subarea 3 PA PES	PE	PP	Ma	O	Subarea 4 PA PES	PE	PP	Ma	O	Subare PA PES	PE	PP	Ma	O
Cod	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Had		=	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-
Fla		<	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red		ch/ce	0 / 8														

(continued)

GERMANY, Fed. Rep. - 1964
(ICES gauge at 4 kg pressure)

Species	Gear	Mesh Size Group (108-121 mm)	No. of codends measured Subareas 1-2				
			PA PES	PE	PP	Ma	O
Red	OT	>	-	-	-	-	-
Cod		=	6	1	-	-	-
Had		<	42	1	-	-	-
		ch/ce	37 /50				

ICELAND - 1964
(ICES gauge)

Species	Gear	Mesh Size Group (108-121 mm)	No. of codends measured Subareas 1-2-3				
			PA PES	PE	PP	Ma	O
Cod	OT	>	-	10	-	-	-
Red		=	-	1	-	-	-
		<	-	-	-	-	-
		ch/ce	11 / 11				

PORTUGAL - 1964
(Flat gauge)

Species	Gear	Mesh Size Group (108-121 mm)	No. of codends measured Subareas 1-2-3-4				
			PA PES	PE	PP	Ma	O
Cod	OT	>	-	-	-	-	-
		=	22	12	27	-	-
		<	-	-	-	-	-
		ch/ce	0 / 61				

USSR - 1964
(ICNAF gauge)

Species	Gear	Mesh Size Group (108-121 mm)	No. of codends measured Subareas 1-2-3-4-5				
			PA PES	PE	PP	Ma	O
Cod	OT	>	2	-	-	-	-
Had		=	21	-	-	-	-
Fla		<	7	-	-	-	-
Red		ch/ce	0 / 30				
Sil							

(continued)

UK - 1964
(NEAFC wedge gauge)

Species	Gear	Mesh Size Group (108-121 mm)	No. of codends measured									
			Subarea 1					Subarea 2, 3, 5				
			PA PES	PE	PP	Ma	O	PA PES	PE	PP	Ma	O
Cod	OT	>	-	-	-	-	-	-	-	-	-	-
Red		=	-	-	1	-	-	-	-	-	-	-
		<	-	-	-	-	-	-	-	-	-	-
		ch/ce	0 / 1									
Cod	OT	>	-	-	-	-	-	-	-	-	-	-
Had		=	-	-	-	-	-	-	-	1	-	-
Red		<	-	-	-	-	-	-	-	-	-	-
Fla		ch/ce						0 / 1				

USA - 1964
(ICES and ICNAF gauge)

Species	Gear	Mesh Size Gp (108-121 mm)	No. of codends measured														
			Subarea 3					Subarea 4					Subarea 5				
			PA PES	PE	PP	Ma	O	PA PES	PE	PP	Ma	O	PA PES	PE	PP	Ma	O
Red	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(ICES		=	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
gauge)		<	30	-	-	-	-	35	-	-	-	-	37	-	-	-	-
		ch/ce	0 / 30					3 / 35					3 / 37				
Cod	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Had		=	-	-	-	-	-	55	-	-	-	-	68	-	-	10	-
(ICNAF		<	-	-	-	-	-	13	-	-	-	-	19	-	-	-	-
gauge)		ch/ce						19 / 68					29 / 97				
Yel	OT	>	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-
(ICES		=	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-
gauge)		<	-	-	-	-	-	-	-	-	-	-	30	-	-	-	-
		ch/ce											0 / 45				
Sil	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(ICES		=	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
gauge)		<	-	-	-	-	-	-	-	-	-	-	87	-	-	-	-
		ch/ce											24 / 87				
Ind	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(ICES		=	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
gauge)		<	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-
		ch/ce											0 / 8				
All	OT	>	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-
Species		=	-	-	-	-	-	55	-	-	-	-	79	-	-	10	-
		<	30	-	-	-	-	48	-	-	-	-	181	-	-	-	-
	Total		30	-	-	-	-	103	-	-	-	-	264	-	-	10	-
		ch/ce	0 / 30					22 / 103					56 / 274				

Part B. Trawl Material and Mesh Size Sampling Summary for 1965

The Summary is based on data submitted in 1965 by Canada (Maritimes, Quebec and Newfoundland), France (Mainland), Germany, Fed. Rep., Iceland, Portugal, USSR, UK and USA on the form "Trawl Material and Mesh Size Sampling Summary" (ICNAF/Gear & Selectivity/23.11.65) (*Redbook* 1965, Pt.I, pp.62-63).

CANADA - 1965
(ICNAF gauge)

Species	Gear	Mesh Size Gp (110 -114 mm)	No. of codends measured														
			Subarea 3					Subarea 4					Subarea 5				
			PA PES	PE	PP	Ma	O	PA PES	PE	PP	Ma	O	PA PES	PE	PP	Ma	O
Fla	OT	>	11	9	9	5	-	2	-	5	-	-	-	-	-	-	-
		=	54	12	66	8	-	23	16	6	-	-	-	-	-	-	-
		<	77	6	9	8	-	30	10	2	1	-	-	-	-	-	-
		ch/ce	271 / 274					25 / 95									
Had	OT	>	2	-	1	-	-	46	8	8	-	-	10	3	2	-	-
		=	2	-	3	1	-	-	-	-	-	-	8	-	-	-	-
		<	-	-	2	1	-	17	2	1	-	1	-	-	-	-	-
		ch/ce	12 / 12					10 / 83					21 / 41				
Cod	OT	>	3	1	4	3	-	102	30	15	3	6	5	1	-	-	-
		=	13	4	5	4	-	24	15	18	10	-	5	-	-	-	-
		<	8	-	1	3	-	93	63	6	-	4	-	-	-	-	-
		ch/ce	49 / 49					88 / 383					8 / 11				
Red	OT	>	3	-	2	4	-	-	-	1	-	-	-	-	-	-	-
		=	1	-	6	3	-	13	10	1	-	-	-	-	-	-	-
		<	2	-	3	-	-	78	20	1	-	-	-	-	-	-	-
		ch/ce	24 / 24					9 / 124									
Pol	OT	>	-	-	-	-	-	7	2	3	-	-	1	-	1	-	-
		=	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-
		<	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
		ch/ce						9 / 15					2 / 4				
Hak	OT	>	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		ch/ce						1 / 1									
All Species	OT	>	19	10	16	12	-	158	40	32	3	6	16	4	3	-	-
		=	70	16	80	16	-	60	41	25	10	-	14	-	1	-	-
		<	87	6	15	12	-	221	95	10	1	5	-	-	-	-	-
	Total		176	32	111	40	-	439	176	67	13	11	30	4	4	-	-
		ch/ce	356 / 359					142 / 706					31 / 56				

(continued)

FRANCE - 1965
(Flat gauge)

Species	Gear	Mesh Size Group (110-114 mm)	No. of codends measured Subarea 1, 2, 3, 4				
			PA PES	PE	PP	Ma	O
Cod	OT	>	175	-	-	-	-
		=	-	-	-	-	-
		<	-	-	-	-	-
		ch/ce	0 / 175				

GERMANY, Fed. Rep. - 1965
(ICES gauge)

Species	Gear	Mesh Size Group (110-114 mm)	No. of codends measured Subarea 1, 2, 3				
			PA PES	PE	PP	Ma	O
Cod		>	9	8	-	-	-
Had		=	9	1	-	-	-
Red		<	21	3	-	-	-
		ch/ce	0 / 51				

ICELAND - 1965
(ICES gauge)

Species	Gear	Mesh Size Group (110-114 mm)	No. of codends measured Subareas 1, 2, 3				
			PA PES	PE	PP	Ma	O
Cod	OT	>	-	-	-	1	-
Red		=	-	5	-	-	-
		<	-	1	-	1	-
		ch/ce	0 / 8				

PORTUGAL - 1965
(Flat gauge)

Species	Gear	Mesh Size Group (110-114 mm)	No. of codends measured Subareas 1, 2, 3, 4				
			PA PES	PE	PP	Ma	O
Cod	OT	>	27	26	-	-	-
		=	-	28	-	-	-
		<	-	-	-	-	-
		ch/ce	0 / 81				

(continued)

USSR - 1965
(ICNAF gauge)

Species	Gear	Mesh Size Gp (110 -114 mm)	No. of codends measured														
			Subarea 3					Subarea 4					Subarea 5				
			PA PES	PE	PP	Ma	O	PA PES	PE	PP	Ma	O	PA PES	PE	PP	Ma	O
Cod	OT	>	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Had		=	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red		<	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		ch/ce	0 / 55														
Sil	OT	>	-	-	-	-	-	55	-	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	14	-	-	-	-	-	-	-	-	-
		<	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-
		ch/ce						0 / 73									
Her		>	-	-	-	-	-	-	-	-	-	-	59	-	-	-	-
Sil		=	-	-	-	-	-	-	-	-	-	-	22	-	-	-	-
		<	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-
		ch/ce											0 / 85				

UK - 1965
(Wedge gauge)

Species	Gear	Mesh Size Group (110-114 mm)	No. of codends measured				
			Subareas 2, 3				
			PA PES	PE	PP	Ma	O
Cod	OT	>	2	3	-	-	-
Had		=	-	1	-	-	-
Fla		<	-	-	-	-	-
		ch/ce	2 / 6				

(continued)

USA - 1965
(ICES gauge at 10 lb)

Species	Gear	Mesh Size Gp (110-114 mm)	Subarea 3 PA PES	Subarea 3 PE	Subarea 3 PP	Subarea 3 Ma	Subarea 3 O	Subarea 4 PA PES	Subarea 4 PE	Subarea 4 PP	Subarea 4 Ma	Subarea 4 O	Subarea 5 PA PES	Subarea 5 PE	Subarea 5 PP	Subarea 5 Ma	Subarea 5 O
Had	OT	>	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-
		=	4	-	1	-	-	4	-	-	-	-	-	-	-	-	-
		<	112	-	6	1	-	75	-	5	1	-	-	-	-	-	-
		ch/ce			13 / 125					12 / 87							
Red	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<	24	-	2	-	-	37	-	5	-	-	37	-	5	-	-
		ch/ce			0 / 26					0 / 42					0 / 42		
Sil	OT	>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		=	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<	-	-	-	-	-	-	-	-	-	-	73	-	10	-	1
		ch/ce													28 / 84		
Fla	OT	>	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
		=	-	-	-	-	-	-	-	-	-	-	21	-	-	-	-
		<	-	-	-	-	-	-	-	-	-	-	90	-	-	-	-
		ch/ce													2 / 114		
Mixed	OT	>	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
		=	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
		<	-	-	-	-	-	-	-	-	-	-	50	-	3	2	1
		ch/ce													4 / 58		
All Species	OT	>	1	-	-	-	-	2	-	-	-	-	4	-	-	-	-
		=	4	-	1	-	-	4	-	-	-	-	22	-	-	-	-
		<	136	-	8	1	-	112	-	10	1	-	250	-	18	2	2
	Total		141	-	9	1	-	118	-	10	1	-	276	-	18	2	2
	ch/ce				15 / 211					12 / 129					34 / 298		

2. Synthetic net materials and their trade names[1]

by G. Klust
Institut für Fangtechnik, Hamburg
(with the cooperation of P.J.G.Carrothers
Fisheries Research Board of Canada, St. Andrews, N.B.)

1. Kinds of synthetic fibres

The following chemical groups of synthetic fibres are used for fishing nets:

Polyamide	Symbol: PA
Polyester	" : PES
Polyethylene	" : PE
Polypropylene	" : PP
Polyvinyl alcohol	" : PVA
Polyvinyl chloride	" : PVC
Polyvinylidenechloride	" : PVD

This classification does not include all kinds of synthetic fibres produced by chemical industries. For example, one of the most important groups for textile industry is not mentioned, the polyacrylonitriles, known, among others, by the trade marks Orlon, Dralon, Acrilan. These fibres seem not to be used for fishing nets. In the fishing industries of most countries not all of the seven kinds of fibres mentioned above are to be found as net material. Which kind of fibre is preferred in a country does not always depend on its qualifications for fishery purposes, but often on the supply of the netting industry.

The polyamide fibres are manufactured in several types, differing in the chemical components and also in some properties, *e.g.* the melting point. The two most important polyamides are:

polyamide 66, with the components hexamethylenediamine and adipic acid,

and

polyamide 6, made from caprolactam (= aminocaproic acid). ("Polyamides are frequently described by a numerical shorthand. The numbers used refer to the numbers of carbon atoms in the diamine, the dibasic acid, or the amino acid. Thus, a polyamide from a diamine and a dibasic acid will have two numbers giving, respectively, the number of carbon atoms in the amine and the acid, such as 66, ... whereas those from amino acids have only one number, such as 6 ..."). (9)

[1]submitted to the 1966 Annual Meeting of ICNAF as ICNAF Res.Doc.66/73

The first fibre from polyamide 66, made in the USA, was called "nylon", the first fibre from polyamide 6, made in Germany, has the trade mark "Perlon". The term "nylon" is no longer a trade name but has become a generic term which applies to all polyamide fibres. It may be used as a synonymous word for polyamide, such as nylon 66, nylon 6, nylon 11.

Polyester fibres were developed in the United Kingdom; the first trade mark was "Terylene".

Polyethylene and polypropylene fibres are often collectively designated as polyolefins. Because of their different properties with regard to fishing nets, we quote them as two separate groups. The first polypropylene fibre, made in Italy, is known by the trade mark "Meraklon".

These four groups, polyamide, polyester, polyethylene and polypropylene, are the most important synthetic fibres used for fishing nets in the ICNAF Area.

Netting yarns made of polyvinyl alcohol fibres and polyvinyl chloride fibres (both first discovered in Germany) are now mainly produced in Japan. Polyvinylidene chloride fibres are usually a co-polymer of vinylidene chloride and a small amount of a vinyl derivative. "Saran" is a name given to a wide variety of co-polymers of vinylidene chloride (9 and 10). It is not only used as a trade name but also as a generic term, similar to the term "nylon".

These three kinds of fibres, polyvinyl alcohol, polyvinyl chloride and polyvinylidene chloride, are used quite extensively in Japanese fishing gear, but probably only to a small extent in the ICNAF Area.

2. Basic forms of synthetic net material

Netting yarns[1] of synthetic fibres can be manufactured in four basic forms (7):

1. spun yarns, consisting of staple fibres (fibres of short length), bound together by twist,
2. filament yarns, composed of fine, silk-like, continuous fibres, that run the whole length of yarn, also called "multifilament" yarns;
3. monofilaments, (synthetic wires), continuous filaments which have greater diameter and stiffness than those used in filament yarn;
4. synthetic film tapes, which are broken down into fibrous material by twisting under tension.

[1]Netting yarn = "General term for any kind of yarn construction, such as single, plied or cabled yarn, monofilaments or combination of yarns usable for the manufacture of netting"
(Draft 61 of ISO Subcommittee 38/9, November 1965

Polyamide is used as net material in the forms 1, 2 and 3, though in marine fishing gears preference is given to the second form, *viz.*, the twines made of fine, continuous filaments. The same is true of netting yarns made from polyester. Netting yarns based on polyethylene are made of monofilaments. At present polypropylene netting yarns for marine fishing are mostly manufactured in form 2 (continuous filaments). A rather recent development is the production of yarns from synthetic films "which actually fibrillate in spinning under standard conditions of tension, speed and twist level" (3). Polypropylene is the most suitable for producing such fibrillating film tapes, followed by polyethylene (6). It is possible that, in future, the new film twines made from these two kinds of synthetic material will appear more and more on the net market.

3. Remarks to the list of trade names of ICNAF given in the ICNAF Circular Letter 65/1 dated 24 November 1965:

(a) BNS (British Nylon Spinners), DuPont, Fabelta, Rhodiaceta, Toray, Celanese are not names of fibres but of companies manufacturing fibres;
(b) "Rilsan" (not Rislan, as in the letter) and "Tergal" are no longer used for fibres but as trade marks for specially manufactured webbing or finished textile products (4);
(c) "Nyak" is the name of a combination twine and therefore mentioned in Table 2 of this paper;
(d) The name of the polyester fibre "Lanon" has been changed into "Grisuten";
(e) "Anzolon" seems to be a mis-spelling. Two similar trade names are known: "Anzalon" and "Anzylon", both polyamide fibres;
(f) "Celanese" is, as already mentioned, the name of a big company, but also the registered trade mark for cellulose man-made fibres produced in the USA, Great Britain, Columbia and Venezuela. "Celanese PP" is a polypropylene fibre in the USA (4);
(g) "Hizex", a registered Japanese trade mark, is written: "Hi-Zex".
(h) "Hostalen" is not the name of a fibre but the trade mark for the basic chemical from which polyethylene fibres are made;
(i) The list contains a number of names of fibres which certainly are not used in ICNAF fisheries. They should be deleted. On the other hand, trade names of some fibres made of PVA, PVC and PVD should be added;
(j) The names of the countries are neither complete nor exact in all cases. Some examples are given: Nylon is not only used in Denmark, USA and West Germany, but probably in all fishing countries of the world, and it is manufactured in many industrial countries, *e.g.*, Canada, France, Germany, Italy, Japan, Spain, Switzerland, UK, USA. "Lilion" is made in Italy, Spain and USA, "Terylene" not only in the United Kingdom but also in the Argentine, Australia, Canada and India. "Nymplex" in the Netherlands and in Denmark, "Meraklon" not only in Italy but

also in the USA. The polyamide fibre "Perlon" is made under this trade mark only in West Germany. "Corfiplaste" is produced in Portugal and not in Iceland (4).
Such fibres as Nylon, Terylene, Meraklon, Perlon, Nymplex, Corfiplaste and some others are not only used by the fishing industries of the fibre producing countries but are exported to many other fishing countries too. Therefore it is proposed that the names of the countries should be removed from the list. For fisheries purposes, it is necessary to identify the chemical group of the fibre trade names and to know the main properties of the chemical groups.

4. Trade names of synthetic net materials

About 600 trade names of synthetic fibres (most of them registered trade marks) are known. In Table 1 a selection is made based on a former ICNAF paper by A. v. Brandt (2), on comments kindly given by Mr P.J.G.Carrothers, and on information gained by the author. Fibres, whose names in the list are underlined, are supposed to be certainly used in marine fishing gears. Combined trade names consisting of the generic name of the fibre and the name of the manufacturing company have not been listed in Table 1, *e.g.* Asahi-Saran, Bolta-Saran, Bri-Nylon, Chemstrand-Nylon, Dawbarn-Nylon, Dawbarn-Saran, Draka-Saran, DuPont-Nylon, Eastman-Polypropylene, Emmenbrücke-Nylon, Enka-Nylon, IGG-Saran, Imperial-Nylon, Kurashiki-Vinylon, Nichibo-Vinylon, NRC-Nylon, Nylon-BNS, Nylon-Deutsche Rhodiaceta, Nylon-Fabelta, Plate-Nylon, Polyäthylen-Draht-Hoechst, Polymers-Nylon, Polypropylen-Draht-Hoechst, Richmond-Saran, Teijin-Nylon, Teijin-Teteron, Toray-Nylon, Toray-Tetoron.

It is not possible to give a list of trade names, which is in conformity with the actual situation in all details. Year by year new names are introduced by the manufacturers of synthetic fibres. Though the development of the modern extruders, by which the production of monofilaments and fibrillating films from polypropylene and polyethylene has become relatively simple, the number of manufacturers is increasing more and more and with them the number of trade names for these materials will increase likewise.

A second category of trade names for net materials is listed in Table 2, containing names of combination twines, specially made for use in fishing gears. With the exception of "Nyak" (UK) they all are of Japanese origin. The best known names are underlined.

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Table 1. List of the trade names of synthetic net materials.

POLYAMIDE 66

Anid
<u>Enkalon</u>
<u>Kenlon</u>
<u>Knoxlock</u>
Lamonyl
Nailon
Nylex
<u>Nylon</u>
Nylsuisse
Platil
Roblon
Tynex

POLYAMIDE 6

<u>Amilan</u>
<u>Anzalon</u>
<u>Caprolan</u>
Celon
Dayan
<u>Dederon</u>
<u>Enkalon</u>
<u>Forlion</u>
<u>Grilon</u>
<u>Kapron</u>, <u>Capron</u>
Lilion
Nopalon
<u>Perlon</u>
<u>Steelon</u>

POLYVINYL ALCOHOL

<u>Cremona</u>
<u>Kanebian</u>
<u>Kuralon</u>
<u>Kuremona</u>
<u>Manryo</u>
<u>Mewlon</u>
<u>Trawlon</u>
<u>Vinylon</u>

POLYESTER

<u>Dacron</u>
<u>Diolen</u>
Enkalene
Grisuten
Terital
Terlenka
<u>Terylene</u>
<u>Tetoron</u>
<u>Trevira</u>

POLYPROPYLENE

Akvaflex PP
<u>Courlene PY</u>
<u>Danaflex</u>
<u>Drumfil</u>
<u>Drylene 6</u>
Herculon
<u>Meraklon</u>
<u>Movlon</u>
<u>Multiflex</u>
<u>Nufil</u>
Propylon
<u>Pylen</u>
Trofil P
<u>Ulstron</u>
Velon PS

POLYVINYL CHLORIDE

<u>Envilon</u>
Krehalon S
<u>Nip</u>
<u>Ramelon</u>
Rhovyl
<u>Teviron</u>
Vinyon

POLYETHYLENE

Akvaflex
<u>Argon</u>
<u>Bellex</u>
<u>Corfiplaste</u>
<u>Courlene</u>
<u>Drumlene</u>
<u>Drylene 3</u>
<u>Echylon</u>
<u>Gunlene</u>
<u>Hi-Zex</u>
<u>Kanelight</u>
<u>Laveten</u> (Lavaten)
Marlex 50
Norfil
Northylen
<u>Nymplex</u>
<u>Plachylon</u>
<u>Polyfa</u>
<u>Pylen E</u>
Trofil
Velon LP
<u>Vetex</u>
Wirilene
Wynene 18

POLYVINYLIDENE CHLORIDE

Clorène
<u>Daran</u>
<u>Krehalon</u>
<u>Kurehalon</u>
<u>Saran</u>
Velon

Table 2. Trade names of combination netting yarns (Twines of dissimilar components).

Trade name			made of yarns from
Kyokurin	: PA	filament	and saran
Livlon	: PA	filament	and saran
Marlon A	: PA	filament	and PVA staple
Marlon B	: PA	filament	and saran
Marlon C	: PA	filament	and PVC filament
Marlon D	: PP	filament (?)	and saran
Marlon E	: PA	staple	and PVA (or PVC) staple
Marumoron	: PA	filament	and PVA staple
Nyak	: PA	filament	and acetate staple
Polex	: PE		and saran
Polysara	: PE		and saran
Polytevye	: PE		and PVC filament
Polytex	: PE		and PVC filament
Ryolon	: PES	filament	and PVC filament
Saran - N	: PA	filament	and saran
Tailon (Tylon-P)	: PA	filament	and PA staple
Tevimew	: PVA	staple	and PVC staple