Progress report] Final report

WORKING GROUP ON ARCTIC FISHERIES

Final Report to Liaison Committee

1. Participants

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2. Introduction

(a) At the seventh meeting of the Permanent Commission in Dublin, November 1958, the Norwegian delegation expressed concern at recent trends in the Arctic cod fisheries, and proposed a further increase of the mesh size in this area to 130 mm. It was decided to ask the ICES to provide a scientific appreciation of the state of the Arctic fisheries generally, and to assess the immediate and long-term effects of further increases in mesh above 110 mm.

(b) Accordingly, a working group comprising the people listed above was set up under the chairmanship of Mr. Rollefsen. The group met on three occasions; in Bergen in May 1959, in Copenhagen in September 1959, and in Moscow in March 1960. At the first of these meetings the members of the Group submitted all the available statistics and research data relevant to the Arctic fisheries of their country; this combined information formed the basis of the investigations undertaken by the group and the conclusions which are summarised in this report.

(c) At the end of the second meeting in Copenhagen, a full progress report on the findings of the Group concerning the fisheries for cod and haddock was prepared and submitted to the Gadoid Fish Committee during the 1959 ICES meeting. At the third meeting, in Moscow, this report was revised and amended as necessary by inclusion of the data for 1959, although the main conclusions were not thereby altered substantially. By this time the results of the International Arctic Mesh Experiment were also available, and it was possible to prepare assessments of the probable effects of specific increases in mesh size for both cod and haddock.

(d) Owing to the short time elapsing between the Moscow meeting and the meeting of the Permanent Commission in May, it has been possible in this report to give only a summary of the conclusions reached concerning the effects of fishing and of further increases in mesh size on cod and haddock. It is proposed that the full account of the data and analyses on which these findings have been based should form a Special Scientific Report; this will be based on the second progress report prepared in Copenhagen, but supplemented by inclusion of selectivity data and details of the assessments of increase in mesh size.

(e) The Working Group has not been able to consider other Arctic fisheries such as those for redfish, coalfish and plaice, and no reference to these is made in this report.

3. Effects of fishing on the stocks of cod

(a) Having reviewed and analysed the available data for cod, the Working Group concluded that the changes which have occurred in the abundance of the stocks since 1930 have been caused mainly by changes in the amount of fishing during that time, on which have been superimposed increases and decreases due to varying strengths of year-classes. The effects of fishing have been most noticeable in the immediate post-war years when the stocks were abundant after the much reduced fishing during the war, and again in recent years following the marked increase in the amount of fishing during the nineteen-fifties.

(b) It was concluded that at the present time the total mortality rate of cod above six years of age in Regions I and II A (Barents Sea and

Norwegian Coast) is in the region of 65% per year; and not less than this in Region II B (Bear Island-Spitsbergen). Of this total mortality rate it was concluded that between three-quarters and four-fifths is due to fishing.

(c) This high mortality rate during the nineteen fifties provides a satisfactory explanation for the failure of the good 1948, 1949 and 1950 year-classes to have caused more than a temporary increase in the catches of immature fish, and why they have had relatively little influence in recent years on the abundance of the mature fish, even when allowance is made for the hydrographic changes which have occurred in the Barents Sea in recent years.

4. Effects of fishing on the stocks of haddock

(a) Although the data for haddock are less complete than for cod, the Working Group concluded that the effects of fishing on the stocks have been broadly similar to those on cod.

(b) The total mortality rate in Regions I and II A is estimated at about 55% at the present time, of which about three-quarters appears to be due to fishing. In Region II B the fraction of the total mortality due to fishing appears to be higher still, but only a small proportion of the total catch of Arctic haddock comes from this Region.

5. Selectivity of trawl nets for cod and haddock

(a) On the basis of the report of the Arctic Mesh Selection Working Group on experiments carried out by the four countries in the Western Barents Sea in August-September 1959, it was agreed that a selection factor for cod of 3.6 seemed the best working value, this referring to cod-ends made of manila. For haddock it was thought that the evidence indicated a somewhat lower value than was recommended in the report; a factor of 3.3 for manila cod-ends has been used.

(b) The data for cod-ends made of synthetic materials are less extensive, but indicate that polyamide materials have a higher selectivity than those of manila. The assessments given below refer to mesh sizes of manila. The equivalent mesh size for all other materials corresponding to the size for manila is in proportion to their selectivity factors as determined by experiment. For cod-ends made of polyamide fibres (nylon, capron and perlon)

the equivalent mesh size is thought to be about 10% to 15% smaller than for manila cod-ends.

(c) Using the selection factors for manila cod-ends given above, the 50% retention lengths of cod and haddock for various mesh sizes are given in Table I as follows:-

Table I — 50% retention lengths of cod and haddock (manila cod-ends)

Cod-end mesh size (mm)	50% retention length (cm)	
	Cod	Haddock
110	40	36
120	43	40
130	47	43
140	50	46
150	54	50

6. Cod: assessments of long-term effects of increase in mesh size

(a) Long-term effects of increasing the size of trawl mesh above 110 mm have been assessed on the basis of the mortality estimates and selectivity values given above, the growth rate of Arctic cod, the relative fishing efforts exerted by the countries concerned and the size-compositions of the catches of each country. A brief account of the methods used is given in the Appendix to this Report.

(b) It was concluded in the Second Progress Report that increase of mesh size beyond 110 mm would result in improved exploitation of the Arctic cod stocks, and the more detailed assessments made during the Moscow meeting have confirmed this conclusion. Table 2 gives assessments of the probable percentage increase in total long-term catch of cod, to all countries together, resulting from the use of mesh sizes up to 150 mm, taking the period 1950-59 as reference.

Table 2 Cod: effect of increase of mesh size on total long-term catch

Increase of mesh size from 110 mm to:-	Percentage increase in total long-term catch
120 mm	5
130 mm	10
140 mm	16
150 mm	20

(c) The way in which these total gains would be distributed between the various countries and fisheries depends on the relative fishing effort exerted by each, the type of gear used, and the size-composition of the catches taken by each. Table 3 gives estimates of how the increases in total catch shown in Table 2 are likely to be distributed between the trawl fisheries as a whole and those fisheries using other kinds of gear whose selectivity is not affected by a mesh regulation (see also Appendix).

Table 3 Cod: effect of increase of mesh size on total catch by trawl fisheries and by fisheries using other kinds of gear

Increase of mesh size from 110 mm to:-	Percentage increase in total catch to:-	
	Trawl fisheries	Fisheries using other gears
120 mm	4	6
130 mm	9	13
140 mm	14	21
150 mm	17	30

(d) Some idea of what the above percentage increases mean in terms of actual catch can be gauged from the fact that the total catch of Arctic cod over the last five years has averaged about 950,000 tons per year, of which about three-quarters has been taken in the trawl fisheries. On this basis, the 5% increase in total catch given in Table 2 for an increase of mesh to

120 mm represents a gain of nearly 50,000 tons annually, while the 10% increase for a mesh of 130 mm is equivalent to an additional catch in the region of 100,000 tons per year.

(e) Whether actual long-term catches would change in this way if the mesh size were increased depends critically on the strength of the year-classes which will enter the fishery in the future, as well as on other factors, such as the amount of fishing, remaining constant. What the assessments of Tables 2 and 3 show explicity is the probable amount by which the yield obtainable from any year-class, whether good or poor, throughout its life in the fisheries could be increased by the use of larger meshes, at present levels of fishing.

(f) In interpreting the results given in Tables 2 and 3 it will be appreciated that assessments of this kind cannot be made with exactness, but the figures for the effect of meshes of 120 mm and 130 mm are thought to be reliable working assessments which, if anything, may underestimate the gains which would result both in terms of total catch and, more especially, to the trawl fisheries. This is because, in addition to the direct saving of the smallest fish, a larger mesh will tend to encourage trawlers to fish more where the medium and large fish form a higher proportion of the catch. The estimates given in Tables 2 and 3 make some allowance for a change of fishing tactics of this kind, but the full consequences cannot be assessed accurately at present (see Appendix). It can be said, nevertheless, that a shift of fishing pressure towards the larger fish would add to the conservation value of the larger mesh and tend to increase the share of the total catch taken by the trawl fisheries. Assessments of the effect of using meshes larger than 130 mm are necessarily somewhat less reliable on present information, but it is reasonable to conclude that still larger gains could be expected from some further increase of mesh size above 130 mm.

7. Cod: assessments of immediate effects of increase in mesh size

(a) The immediate effect of an increase in mesh size is to cause some loss of catch of the smallest fish compared with what would have been caught at that time with the original mesh. Taking the period 1950-59 as reference, the nominal immediate losses to the various trawl fleets following an increase

of mesh to 120 mm would range from zero to 5%, and from zero to 11% for an increase to 130 mm, depending on the size composition of the catches taken by the fleet in question and its discarding practice. Certain points need to be borne in mind, however, when interpreting these estimates, as set out in the following paragraphs.

(b) These figures give the probable relative loss and not necessarily the actual loss. This latter depends on the magnitude and size composition of the stocks at the time the increase is made, and factors influencing the contemporary success of fishing operations. These causes acting together are responsible for substantially greater year-to-year fluctuations in catches of Arctic cod than would be involved by an increase of mesh from 110 mm to 120 mm or to 130 mm.

(c) In arriving at the above estimates no allowance has been made for the consequences of redistribution of fishing effort towards larger fish, or of increase of fishing power of trawl gear, as mesh size is increased (see Appendix). To the extent that these factors operate, they will both tend to offset the immediate losses resulting from the use of larger meshes.

(d) The above losses refer only to the initial effect of using the larger mesh. Even during the first year in which the larger mesh is used the losses will begin to decrease as fish released by the larger mesh grow into its retention range. During the second year after the increase in mesh size has been made the losses will have fallen to roughly half the above values, and by the third year will have virtually disappeared.

8. Haddock: assessments of long-term effects of increase of mesh size

(a) Long-term assessments for haddock, of which the total catch is roughly one-seventh that of cod, cannot at the present time be made with the same reliability as for cod. Apart from the lesser accuracy of the mortality estimates, information on both the magnitude and size compositions of the commercial catches of haddock by some countries is incomplete.

(b) It is believed, nevertheless, that assessments can be made which give a reasonably reliable indication of the probable long-term gains in total catch of haddock from increase of mesh size. These have been

calculated in a similar way to those for cod, and give percentage increases in total catch of about 6% for an increase of mesh to 120 mm and about 9% for an increase to 130 mm. These conclusions are in harmony with assessments made in a different way, based on the mean age at first capture corresponding to the use of various mesh sizes.

(c) The way in which these total gains would be shared between the trawl and non-trawl fisheries cannot be assessed reliably at present, but the indications are that there would at least be no loss to the trawl fisheries as a whole from increases of mesh to sizes in the region of 125 mm to 130 mm.

9. Haddock: assessments of immediate effects of increase in mesh size

(a) Estimates of the immediate losses resulting from an increase of mesh size from 110 to 120 mm and to 130 mm show that they would be in the region of double those given for cod in paragraph 7 (a). Thus, for the various trawl fleets the initial losses would range from zero to 12% for an increase to 120 mm, and from 5% to 25% for an increase to 130 mm, according to the size composition of catches and discarding practice.

(b) The same qualifications apply to these estimates as set out for cod in paragraph 7, except that the normal range of variation in catch per unit effort of haddock is greater than for cod.

10. Future proposals

(a) The Working Group wishes to suggest that there is a continuing need for scientific advice on the state of the stocks of Arctic cod and haddock, and that it is important to obtain as soon as possible a clearer understanding of the probable effects of increases of mesh size above 130 mm.

(b) The Group is of the opinion that these requirements can be met only by continuing the present co-operation between the scientists of the countries concerned. It is agreed on the necessity for continuing the exchange of statistical and research data and for processing and analysing them so that, in the light of the findings on which this Report is based and which will be described more fully in the Special Scientific Report on Arctic fisheries, it will be possible to obtain an up-to-date appreciation of current trends in the fisheries and of the desirability or otherwise of further regulation.

(c) Special emphasis is attached to the following items for future investigation:-

(i) To undertake further work on the selectivity of nets, with special reference to materials other than manila and to haddock and redfish.

(ii) To follow the relation between total mortality rate and fishing effort, for both cod and haddock, so as to refine the estimates of fishing and natural mortality rates given in this report.

(iii) To investigate further the biology of cod and haddock within the selection ranges of the meshes considered in this report, with special reference to the determination of their natural mortality rate.

(iv) To study further the consequences of changes in fishing tactics on assessments of the effect of increases in mesh size.

(v) To continue investigations on the influence of environmental factors on the distribution of cod and haddock, so as to interpret better the further changes in the fisheries.

(d) To facilitate these co-operative investigations, it is suggested that the Arctic Working Group remains in existence and that arrangements should be made for it to meet together from time to time as may be necessary.

APPENDIX [I]

Notes on the assessment of long-term effects of increase in mesh size

A. The method used for making the long-term assessments presented in this report is that recently developed by J. A. Gulland, a full account of which is being prepared by him for publication. Although similar in principle to the conventional methods of mesh assessment (e.g. Ad Hoc Report), Gulland's method makes full use of the observed length compositions of the commercial catches and is therefore particularly suited for application to complex fisheries such as those for Arctic cod and haddock in which the length composition of catches taken by the various fleets and gears is different. Full details of Gulland's method and of its application to the data of the Arctic fisheries will be presented in the Special Scientific Report which is in preparation; the purpose here is to outline the method and to give some further details of the assessments which have been made.

B. When the size of mesh is increased it will cause a certain number of small fish to be released which would have been caught with the original mesh. The number thus released can be calculated from a knowledge of the original size composition of the catches and the retention curves of the old and new meshes. A small proportion of these released fish will die before they have grown large enough to be retained by the new mesh, but the majority will survive to increase the stock of larger fish. The fraction that will subsequently be caught during the remainder of their life is determined by the ratio of fishing mortality to total mortality in the stock; for Arctic cod this ratio has been estimated as between three-quarters and four-fifths. Their average weight when caught can be estimated from the average weight of fish in the observed catches after applying the selection curve of the new mesh, although this will be a little less than that when the new equilibrium is set up. Thus it is possible to calculate the probable amount of gross gain from the released fish, and also the nett gain by subtracting the original weight of the fish released.

C. In a fishery in which more than one type of gear is used, or the trawl fleets belonging to the various countries have catches with different size compositions, the simplest procedure is firstly to calculate the total gross gain from all the fish released, then to allocate this total gross gain to each component fishery, and finally to calculate the nett gain to each by subtracting the weight of the fish released in that fishery. The main difficulty in applying this method to the Arctic fisheries, in which part of the catch is taken by trawl and part by other gears which are not influenced by mesh regulation, lies in predicting the extent to which the fishing tactics of the trawl fleets may be expected to change as the size of mesh is increased.

D. Minimum assessments of the gain to the trawl fisheries can be made by allocating the total gain according to the ratio of immediate catches with the larger mesh, but this implies that the fleets could not, or would not, redeploy so as to fish more on grounds where fish of sizes above the retention range of the new mesh are relatively more abundant. In most fish stocks, and certainly in Arctic cod and haddock, there is a marked segregation of fish by sizes, especially among the small and medium size ranges; there are, moreover, considerable differences in the observed size compositions of the catches of Arctic cod taken by the various trawl fleets, which demonstrates that differences in fishing tactics already exist between them. It would be unrealistic to suppose that, in practice, vessels would continue to fish those grounds on which a significant proportion of the stock could no longer be retained by the larger mesh.

E. A proper treatment of this question, from which it would be possible to predict the degree of redistribution, and its effects, that would follow a given increase in size of mesh, is complicated and is a matter for further research, but some general statements and provisional assessments can be made of the possible consequence of a change in fishing tactics of this kind. One thing is certain, namely that a tendency on the part of the trawl fleets to redistribute as the size of mesh is increased so as to fish less on predominently small-fish grounds, is in accordance with the principles of good conservation, since it would shift the fishing pressure towards the larger fish and

so add to the gain from the direct releasing action of the larger mesh.

F. If nc allowance is made for any redistribution of fishing by the trawl fleets, the assessments obtained show the gain resulting purely from the releasing action of the larger mesh with the original distribution of fishing. In this case, estimates of the percentage gain to the trawl fisheries, to the fisheries with other gears, and in total catch, are as follows:-

Table A — Cod: effect of increase of mesh size with no redistribution of fishing

Increase of mesh from 110 mm to:-	Percentage increase in long-term catch to:-		
	Trawl fisheries	Fisheries with other gears	Total
120 mm	4	7	5
130 mm	8	15	10
140 mm	13	25	16
150 mm	14	39	20

These assessments can be regarded as showing, more especially, the minimum gains to the trawl fisheries which are to be expected from increase of mesh size. The most marked effect of any tendency by the trawler fleets to redistribute towards larger fish would be to increase the nett gains to them, since they will not only make up thereby some of their loss of fish released by the bigger mesh by increased catches of larger fish, but also obtain a greater share of the gain from those released fish. It is also likely that redistribution by the trawler fleets would reduce to some extent the gains to the fisheries with other gears compared with the figures shown in the above Table.

G. The working assessments given in Tables 2 and 3 of the main report make some allowance for these probable effects of redistribution by the trawler fleets, by the procedure of allocating the total gross gain

according to the ratio of the original catches obtained by each fleet or gear instead of the immediate catches with the larger mesh, as in Table A. In effect, this amounts simply to allocating the total gain from fish released by the larger mesh according to the relative fishing power of each fleet or gear as measured by the ratio of catches before the change in mesh. The resulting assessments are here repeated in Table B for ease of comparison with those of Table 4.

Table B — Cod: effect of increase of mesh size with partial allowance for redistribution of fishing

Increase of mesh from 110 mm to:-	Percentage increase in long-term catch to:-		
	Trawl fisheries	Fisheries with other gears	Total
120 mm	4	6	5
130 mm	9	13	10
140 mm	14	21	16
150 mm	17	30	20

H. Compared with the assessments of Table A, the gains both to the trawl fisheries and to the fisheries with other gears given in Table B are not much different for increases of mesh up to 130 mm, which do not require a degree of redistribution beyond that which is already observed in some of the trawl fisheries. For further increases in mesh, the assessments of Table B show larger gains to the trawl fisheries and reduced gains to the non-trawl fisheries compared with Table A, which is the kind of effect that would be expected from redistribution. It is important to note that the assessments of Table B do not make proper allowance for redistribution because they take no account of the effect on the exploitation of the stock as a whole resulting from the shift of fishing pressure towards the larger fish. This is why the total gains are the same in both tables. It is thought, nevertheless, that the assessments of Table B (see also Tables 2 and 3), which make partial allowance for redistribution, probably give a more realistic appreciation of the relative gain to the trawl fisheries and to the fisheries using other

gears than if no allowance is made for redistribution.

J. It has been thought desirable to include some discussion on methods of assessing the effects of increase in mesh as an appendix to this report, because the special features of the Arctic fisheries and the extensive data available relating to them have brought to light the need for a more dynamic treatment of the influence of mesh regulation on a fishery than has hitherto been attempted. When fishing intensifies in an unregulated fishery it causes the abundance of the larger fish to decline and requires the vessels to fish more on the small-fish grounds in an attempt to maintain their catches, until the process is halted by lack of market demand for the smallest fish. From such a situation the fishery is unlikely, of its own accord, to redistribute towards larger fish, because fishing tactics are determined by immediate effects, and the immediate effect of such a redistribution would probably be a loss of catches, even though the long-term effect would be a gain. In these circumstances the application of mesh regulation has the effect of providing the initial impetus needed to reverse these changes and to promote a better utilisation of the stocks; indeed, in some cases this indirect effect of mesh regulation on fishing tactics may contribute more to the improvement of the fishery than the direct saving of small fish which the larger mesh permits.

27th April, 1960.

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International Council for
the Exploration of the Sea

APPENDIX II

Arctic Fisheries Working Group

Report of Meeting in Copenhagen, March 6-12, 1961

1. Participants

Ju. Ju. Marty (U.S.S.R.)(Convenor)
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S. S. Baranov (U.S.S.R.)
U. Schmidt (Federal German Republic)
A. Hylen (Norway)
R. J. H. Beverton) (U.K.)
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2. Terms of Reference

At the Eighth meeting of the Permanent Commission, in London in May 1960, the Liaison Committee of I.C.E.S. was invited..... "to arrange for the [Arctic Fisheries] Working Group to continue their studies in the light of the investigations by contracting governments, with special reference to the problems of larger minimum mesh sizes in relation to stocks and species of fish in the north-eastern part of the Convention Area other than those dealt with in the [1960] Report of the Working Group", (P.C. 8/126).

3. Scope of this Report

On the basis of data for 1960 submitted by members of the Group, recent developments in the cod and haddock fisheries have been analysed and are reported here. The assessments of the probable effect on these fisheries of increases in mesh size, which were presented in the 1960 report of the Group to the Liaison Committee (27.4.60), have been re-examined in the light of recent data. Since the conclusions of the Group on this question remain substantially unaltered, the remarks given here are supplementary to those of the 1960 Report and are intended to be read in conjunction with that report.

Although there is much less information on species other than cod and haddock, it has been possible to make some appreciation of the probable consequences of increase of mesh size in three other fisheries which are of importance in the north-eastern Arctic, namely redfish, coalfish and plaice.

4. Cod

4.1 Recent trends in the fishery

The total catch of Arctic cod in 1960 was about 640,000 metric tons, which was some 100,000 tons less than in 1959 (figures for Norway are provisional).

In Region I the trawler catch increased by 58,000 tons, but it decreased in Region IIb by 141,000 tons and by 23,000 tons in Region IIA. The catch per unit effort decreased slightly in all three Regions.

The increase in total catch in Region I was due partly to the concentration in the southern part of the region of four to six year old cod, as a result of the rise in temperature there, and partly to a shift of fishing effort to Region I from Region IIb. A considerable part of the catches in Region I consisted of fish in their fifth year of life, i.e. the 1956 year-class, and these were sufficiently abundant to lead to some stabilization of the catch per unit effort at about the level of 1958 and 1959.

The total mortality rate of fish above six years of age in Region I between 1959 and 1960 appeared to be rather higher than would have been expected, even allowing for the increased fishing in 1960. This could have been accounted for, however, by a shift of fishing towards the eastern part of the area where the younger fish are more abundant, and perhaps by a tendency for vessels to concentrate more on haddock than is usual. In general, the conclusions reached by the Group at its previous meetings, namely than the total mortality rate of cod above six years of age is in the region of 65% per year, of which the greater part, perhaps three-quarters to four-fifths, is due to fishing, remain unaltered.

4.2 Assessments of the effect of mesh increase

The basis on which the assessments given in the 1960 Report of the Group were made have been re-examined in some detail. No modification of the selectivity values adopted previously was required, but it was thought necessary to make further allowance for some uncertainty which exists concerning the true numbers of small fish which have been taken in the trawl catches in recent years, and of the reliability with which the ratio of fishing to total mortality can be established. Assessments have also been calculated on the basis of a slightly different period of years, namely 1952-60 instead of 1950-59, which it is thought give a better appreciation of the effect of an increase of mesh size at present levels of fishing intensity. The conclusions from these revised assessments may be summarised as follows:-

(a) Estimates of the immediate loss of landings to the trawl fleets are virtually the same as those quoted in para. 7 of the 1960 Report. Immediate losses would vary very much from one fleet to another, depending on the size composition of fish caught and on discarding

practice. For an increase of mesh from 110 mm to 120 mm, the immediate loss of landings (by weight) would range from zero to about 5% with an average of about 4% for the trawl fleets as a whole. For an increase of mesh from 110 mm to 130 mm the immediate loss of landings would range from zero to 11%, with an average of 8%. In interpreting these results, attention is drawn to the remarks contained in paras. 7(b), (c) and (d) of the 1960 Report.

(b) Revised estimates of percentage long-term gains to be expected from increases of mesh from 110 mm up to 140 mm have been calculated for the trawl fisheries as a whole, for fisheries with other gears, and for the total fishery for Arctic cod. The range of assessments obtained are summarised in the following table:-

Increase of mesh from 110 mm to:-	Percentage long-term gain of landings to:-		
	Trawl fisheries	Fisheries with other gears	Total fishery
120 mm	3-5	7-8	4-6
130 mm	6-9	15-18	8-12
140 mm	8-12	25-31	12-16

(c) No allowance is made in these assessments for factors such as a change in fishing tactics of the trawler fleets or an increased fishing power of the gear, both of which might reasonably be expected to happen after an increase in mesh size. Thus, the above assessments are to be compared with those previously given in Table A of the Appendix to the 1960 Report, which were:-

Table A (of 1960 report). Cod: effect of increase of mesh size with no redistribution of fishing

Increase of mesh from 110 mm to:-	Percentage increase in long-term catch to:-		
	Trawl fisheries	Fisheries with other gears	Total fishery
120 mm	4	7	5
130 mm	8	15	10
140 mm	13	25	16
150 mm	14	39	20

Comparison of the two sets of assessments shows that the earlier figures lie for the most part within the range of the later ones. Although no precise allowance can be made for any change of fishing tactics or increase in fishing power of trawl gear with increase of mesh size, the likelihood is that these would have little effect on the total gain but would increase the share taken by the trawl fisheries compared with that taken by other gears.

(d) In summary, it may be said that the revised assessments give essentially the same conclusions as the earlier ones. Assessments of the effect of a mesh increase cannot, by the nature of things, be given with exactness; but having made what in the opinion of the Group were the most reasonable assumptions where uncertainty exists, the results leave little doubt that an increase of mesh to at least 130 mm, and probably to still larger sizes, would result in long-term gains both to the trawl fisheries and to those using other gears.

4.3 Conclusions for cod

It appears from the most recent data that the stocks of Arctic cod remain at a low level of abundance under conditions of a high fishing mortality rate. This gives the Working Group cause for anxiety concerning the prospects for the fishery in the immediate future. There are indications, however, that the 1959 and 1960 year-classes, which will begin to enter the fishery in 1963, may be rather better than those of recent years. Introduction of a larger mesh would give greater protection to these fish while still small and so would add to the improvement in the fishery which may be expected from them.

5. Haddock

Having examined the 1960 data for haddock, the Working Group found no reason to alter its conclusion stated in the 1960 Report, namely that the effects of fishing on the stocks in the Arctic have been broadly similar to those on cod. The total mortality rate remains in the region of 50% - 55%, of which the greater part appears to be due to fishing.

The smaller growth potential of Arctic haddock compared with cod means that, other things being equal, the haddock fishery cannot be expected to respond to large increases in mesh size as well as would the cod fishery. Nevertheless, it was concluded in the 1960 report that there would be long-term gains in the total catch of haddock of about 6% for an increase of mesh size to 120 mm, and of about

9% for an increase to 130 mm. Revised assessments, bringing in the 1960 data, have not altered these conclusions so far as total catch is concerned but, as anticipated in para 8(c) of the 1960 report, have shown that its partition between trawls and other gears is difficult to predict with any accuracy. On this point our latest assessments have shown that the conclusion reached in the 1960 report, namely that there would at least be no loss to the trawl fisheries as a whole from increases of mesh to sizes in the region of 125 to 130 mm, still remains valid.

6. Redfish

6.1 State of the stocks

Having reviewed the statistical data on the redfish fisheries in the north-eastern Arctic, provided by the U.S.S.R. and West Germany, the Working Group notes that on certain fishing grounds there has been a marked decline in catch per unit effort in recent years. This decline has been most noticeable on the Kapitova Bank (in the deep water between the Bear Island Bank and the Norwegian coast), but substantial declines have also occurred in the area of the Bear Island Bank proper, at Skolpen Bank and at Finmark. Having in mind that similar decreases have occurred on other redfish grounds in the North Atlantic as fishing has intensified, such as on the Rosengarten and on grounds off the coast of Labrador and Newfoundland, it seems probable that these are caused by fishing. So far, however, the accompanying symptoms of heavy fishing which are found in stocks of other species, such as a decline in average size of fish, are not yet apparent in redfish, although this may be the result of the very slow growth rate of this species. Further investigations are needed before the effect of fishing on redfish can be established conclusively.

6.2 Effect of mesh increase

There is not much information on the selectivity of trawls for redfish, but from selectivity tests at West Greenland (von Brandt, 1960) and in the north-eastern Arctic (Saetersdal, 1960) and also from Canadian data, the selection factor of manila cod-ends for redfish may be taken provisionally as 2.6. The 50% selection length for a mesh of 120 mm would then be about 31 cm, and about 34 cm for a mesh of 130 mm. A range of 6 cm between the 25% and 75% retention points is indicated from the available data. It should be noted, however, that these results are from hauls in which the average quantity of fish caught was probably less than is typical of the commercial fisheries. As there seems to be

a fairly definite tendency for the selection factor of redfish to decrease with increasing catch (von Brandt, idem), the above estimates of selectivity, and hence also the immediate losses quoted below, may be too high.

Bearing this qualification in mind, these selectivity results, together with the information available on the size composition of commercial landings of redfish in recent years, enable provisional assessments to be made of the immediate effect of increases in mesh above 110 mm. For the north-eastern Arctic as a whole, the immediate losses to the trawler fleets are estimated to average about 4% by weight for an increase of mesh to 120 mm, and about 12% for an increase to 130 mm.

The Group are of the opinion that the present state of knowledge of the redfish and its associated fisheries is not sufficient to enable any firm assessment of the long-term effect of mesh increase to be made. It can be calculated, however, that the ratio of fishing to total mortality needed to compensate the above initial losses is about 0.6. This ratio is smaller than that which has been established for Arctic cod and probably for haddock also. If the decline in the redfish fisheries noted above is indeed due to fishing, it implies that the ratio of fishing to total mortality is of at least this magnitude. On this basis, it is therefore reasonable to suppose that in the long-term some, and perhaps all, of these immediate losses would be made up.

7. Coalfish and plaice

Judging by the size-composition of coalfish landed by England and Germany from the north-eastern Arctic, the proportion in them of small fish which would be expected to be released by meshes up to 130 mm is very small indeed. Although it is difficult on present evidence to establish the effect of fishing on the stocks of coalfish, it can be said that the landings would be little affected by increases of mesh size up to at least 130 mm.

The number of plaice which would be released by meshes up to 130 mm is also small. In this case, however, the evidence is that the stock of plaice is fairly heavily fished, and it is probable that such fish as would be released by meshes up to 130 mm would result in a long-term gain.

8. Concluding remarks

In their 1960 report, based on decisions reached at their third meeting, in Moscow, the Group listed a series of recommendations for future investigations into the Arctic fisheries. Because of the importance which it attaches to these

proposals as providing the scientific basis for the rational exploitation of the fisheries, the Group wishes to restate them here, together with some further recommendations arising from their recent meeting:-

(a) Data are needed as soon as possible from which assessments can be made of the probable effects of increasing the mesh size above 130 mm. In this connection, it is recommended that the countries concerned should pay special attention to problems such as the effect of mesh size on the fishing power of trawls, and the effect of increased speed of trawling on the size composition of catches.

(b) Special attention should also be given to increasing the precision of assessments of the effect of mesh size on the yield of cod and haddock of the 1959 and 1960 year-classes, which should be a major factor in determining the productivity of the fisheries in the coming decade.

(c) Investigations on redfish should be continued, in order to clarify the influence of natural factors and of fishing on the abundance of the stocks.

(d) Further investigations on the selectivity of nets for haddock and redfish are needed, with special reference to materials other than manila and to the effect of quantity of catch. Some information on the selectivity of coalfish is also needed, if mesh sizes above 130 mm are to be considered.

(e) It is considered that the reporting of commercial statistics of catch and effort in the north-eastern Arctic by smaller sub-divisions of area than the three at present adopted would be a valuable adjunct to future investigations. It is accordingly intended to put forward some proposals in this connection at the next meeting of the Statistical Committee of I.C.E.S.

In the opinion of the Working Group there is a constant need for scientific consultations on the problem of the stock abundance of demersal fish in the north-eastern Arctic. For this purpose it is suggested that the Arctic Working Group should continue its work within the framework of the Gadoid Fish Committee, and be given the opportunity to meet as may be necessary. The systematic work of the Group in the future will make it possible to determine the degree of reliability and the correctness of its general conclusions. Such

an analysis is essential not only for the rationalization of the fishery in this region of the Atlantic, but in order to establish the applicability to other regions of this method of assessment of stock abundance and the state of the fishery.

Ju. Ju. Marty
(Convenor)
24.3.61.