ANNUAL MEETING - JUNE 1967

Report of the Working Group on Joint Biological and Economic Assessment of Conservation Actions[1]

The Group was established at the 16th Annual Meeting of the Commission to "...carry out an examination of the problems of assessing the economic effects of possible conservation measures in time for the 17th Annual Meeting of the Commission..." It was directed to "...utilize available biological and economic information and to supplement this by clearly stated assumptions...taking into account the possible redistribution of fishing effort..." This action stemmed from a recommendation of the Assessment Subcommittee of the Standing Committee on Research and Statistics (R&S) that "...the Chairman of R&S and the Executive Secretary arrange for a joint assessment by biologists and economists of the effects of possible conservation actions in the Convention Area...(which) should be made in collaboration with any other appropriate international body willing to contribute..."

The Subcommittee's recommendation for a joint or interdisciplinary approach to this subject, culminating intermittent discussion of it in the Commission since 1962 or thereabouts, was based on the ground that "...collaboration (between biologists and economists) is desirable because economic consequences are an important feature of the results of regulatory measures and because biological assessments constitute an essential background for economic analysis, in that they provide the necessary information on the actual and potential output from the resources."

The Group met twice, from 17-21 October 1966, and from 3-8 April 1967, both times in London, with the following in attendance:

Name	Affiliation
Mr P. Adam	OECD, Paris, France
Mr O.V.Bakurin	Ministry of Fisheries, Moscow, USSR
Dr A.S.Bogdanov	VNIRO, Moscow, USSR
Dr J.A.Crutchfield	University of Washington, Seattle, USA
Mr L.R.Day	ICNAF Secretariat, Dartmouth, Canada
Mr J.A.Gulland	FAO, Rome, Italy
Mr R.C.Hennemuth	BCF, Woods Hole, Mass.
Mr E.S.Holliman	FAO, Rome, Italy
Mr S.A.Horsted	Greenland Fisheries Investigations, Charlottenlund, Denmark
Dr W. Krone	OECD, Paris, France
Mr A. Laing	British Trawlers' Federation, Hull, England
Mr W.C.MacKenzie	Department of Fisheries, Ottawa, Canada
Mr B.B.Parrish	Dept. of Agriculture & Fisheries, Aberdeen, Scotland
Mr F.E.Popper	FAO, Rome, Italy
Dr G.F.M.Smith	FRB, Ottawa, Canada
Mr L. Van Meir	BCF, Washington, D.C., USA

The Group was equally divided between biologists and economists. Mr MacKenzie acted as chairman for the meetings and Mr Day as secretary. The Group's report was drafted chiefly by Dr Crutchfield, Mr Gulland, Dr Krone, Mr Parrish and Mr Van Meir.

As indicated, the Group was charged with the examination, and biological and economic evaluation, of alternative conservation measures that might be applied in the fisheries of the Northwest Atlantic. At the first meeting it was decided to study a few stocks or a few closely associated groups of stocks selected according to the criteria, a) that they were understood to be exploited to a point where maximum physical yield could be attained with a significant reduction in total

1) The Working Group was established by ICNAF with participation by FAO, NEAFC and OECD.

effort and b) that reasonably adequate statistical data were available for their assessment. As a result of discussion, however, it became evident that, although individual stock assessment is the proper approach for biological analysis of exploited fish populations, in the present case both the biological and the economic effects of catch regulation must be assessed on the basis of the ICNAF and NEAFC areas combined.

The reason for this is that certain vessels, or fleets of vessels, operate throughout both areas. A conservation measure in a particular convention area or subarea would be likely to cause a redeployment of fishing pressure to other areas. Such a redeployment would nullify any potential economic gain from fishery management and might even result in lower aggregate physical yield. In short, no conservation measures aimed at enhancing economic returns or protecting physical yields in the cod and haddock fisheries of the North Atlantic could be effective unless they applied to the entire area over which mobile high-seas fishing vessels range.

The Group decided a) to undertake an evaluation of the possible economic gains from curtailment of the fishing mortality rate (intensity) in three areas where this appeared to be desirable on biological grounds and b) to undertake a preliminary assessment of the short and long-term effects on physical yield of a curtailment of fishing intensity throughout the cod and haddock fisheries of the ICNAF Area plus Region 1 of the NEAFC Area. These projects were assigned as follows:-

a) Bio-Economic Assessments -

1. Georges Bank cod and haddock stocks -
   Mr Hennemuth and Mr Van Meir

2. West Greenland cod stocks -
   Mr Gulland and Dr Krone

3. Northeastern Arctic cod stocks -
   Mr Parrish and Mr Laing

b) "Global" Biological Assessment of cod and haddock stocks -
   Mr Parrish, Mr Gulland, Mr Hennemuth and Dr Smith, with assistance of the ICNAF Assessment Subcommittee and the ICES Liaison Committee.

In addition, OECD undertook to prepare a projection (to 1970) of fishing-fleet development in the North Atlantic.

The papers produced on each of these subjects are attached as appendices to this report. They formed the basis for discussion at the second meeting of the Working Group. The factual content is summarized below, together with a review of the implications and the conclusions of the Group thereon.

A. STATE OF NORTH ATLANTIC COD AND HADDOCK FISHERIES

General Aspects

Since 1945, fishing intensity in the major groundfish fisheries in the North Atlantic, especially those for cod and haddock, has increased greatly. This has been particularly noticeable in the northern part of the Northeast Atlantic (Region 1 of NEAFC Area) and throughout the Northwest Atlantic (ICNAF Area). The number of large and highly mobile vessels in these areas has increased substantially since the mid 1950s and especially during the 1960s. A striking feature of the cod and haddock yields from each of the main fishing areas is that, except for a rapid growth in the initial stage of the fishery, they have failed to increase at the same rate as the increase in fishing activity. This has been apparent since the mid 1950s in the major cod fisheries in the Northeast Arctic, at Iceland and West Greenland and more recently in the Labrador-Newfoundland area. These areas together contribute three-quarters of the total yield of cod from the North Atlantic.

Biological Assessment

Detailed biological assessments of the exploited stocks in these areas, based on population models currently used by ICNAF scientists, have shown that, with the increase in total fishing intensity, the total mortality rates of the exploited age-groups have increased and that fishing now accounts for two-thirds to three-quarters of the numbers of fish dying each year. Examples of such assessments for the Northeast Arctic and West Greenland cod and the Northeast Arctic and Georges Bank haddock are given in Appendices I-III.

These assessments all give the same important result that, at the high level of fishing intensity reached in the period 1962-1965, the fishing mortality rate was higher than that necessary to give the maximum sustainable catch per recruit. In these fisheries, therefore, the catch could be sustained over the long term and perhaps increased as much as 10% with a reduction in the fishing mortality rate of 30-40%. In addition to the achievement of the same or a slightly greater catch with this reduction, there would be a substantial increase in the catch per unit fishing intensity, less year-by-year variability in total catches and an increase in the average size of fish in the catches.

Although the examples dealt with above are ones in which the effects of increased exploitation have been the most severe amongst the North Atlantic groundfish fisheries, the results of biological assessments on other cod and haddock stocks in this region show most of them to be in the same general state. The assessments indicate that, for the main stocks of these species in the ICNAF Area and Region 1 of the NEAFC Area, the fishing mortality rate is at or beyond the level giving the maximum sustainable catch. Consequently, in these cases, no sustained increase in catch can be expected from further increases in fishing intensity. Indeed, in most cases, a sustained reduction in the fishing mortality rate (fishing intensity) of 10-20% would not result in a decrease in average long-term catches and might result in a slight increase.

It must be recognized that the effects described above refer to the long-term situation which would be achieved after the exploited stocks had become adjusted to a reduced fishing mortality rate. There would be inevitably a transition period for this adjustment during which the catch, under conditions of average recruitment, would first fall and then build up to a higher level. For the cod and haddock stocks in the North Atlantic, this transition period would last for 4-6 years while a return to the original catch level would be effectively achieved in 3-4 years (see examples in Appendices I-III). In practice, owing to annual fluctuations in recruitment, it may be possible to minimize the transitional decrease in catch if the reduction in fishing mortality rate is made at a time when recruitment is high.

The above assessments have been made on the basis of the present situation as regards the mesh sizes in use in the trawl fisheries. As indicated in recent reports by the R&S Committee to the Commission, some long-term increases in cod and haddock catches in the ICNAF Area would accrue from further increases in mesh sizes, especially in the cod fisheries in the northern subareas. However, such measures alone would not solve the major economic problems resulting from the increased fishing intenstiy in recent years. Though the larger meshes would change the shape of the yield/effort curve, the fishing mortality rate in most stocks is so high that, even with the largest practicable meshes, a moderate decrease in fishing would not result in a decrease in sustained catch and might well result in a slight increase. Although it is desirable, therefore, that larger meshes be used in several fisheries, their use would not alter the conclusions of this report.

Economic aspects

It is impracticable to define the objectives of a regulatory program involving several species, wide geographic distribution of fishing effort and multi-nation participation, in terms of an <u>optimum</u> level and composition of catch.

If an average curtailment of total fishing effort of 10 to 20% could yield - after the transition period - the same or even slightly increased physical output, it follows that excessive capital and manpower are currently employed. It likewise follows that the resultant increase of 10 to 25% in the average catch per unit of effort reflects the extent of the economic benefits to be gained by curtailment.

The Group therefore accepts the view that the maintenance, at least, of total output (physical yield), accompanied by a reduction in inputs constitutes an appropriate target for a management program.

According to the stock assessments dealt with in this report, the long-term equilibrium catch curve is rather flat over a considerable range of effort. This means that long term benefits would be mainly in terms of reduced costs and not in terms of increased landings. It is estimated that costs of about $50 to $100 million annually could be saved if effort were reduced 10 to 20% in the North Atlantic cod and haddock fisheries, with additional economic benefits from improved size composition of the catch. Moreover, a management program that provided some assurance of long-run stability of output from international fishery resources would remove a condition of uncertainty that surrounds decision-making (by firms and agencies) at present.

To illustrate the economic implications and problems of a reduction in effort, two case studies have been undertaken (see the economic sections of Appendices I and II). These show that there would be economic advantages to be gained from reducing fishing effort on Georges Bank haddock and West Greenland cod. It is also demonstrated, however, that the total benefits will depend partly upon the manner in which fishing effort is curtailed. The investigation of the United States operations on Georges Bank haddock reveals this very clearly: if the number of days fishing per vessel is reduced by 30%, leaving the number of vessels and manpower unchanged, only very small long-term benefits would be achieved and the short-term effects on annual earnings for both vessel owner and crew would involve serious initial losses. If, however, the amount of input is adjusted to the reduced number of fishing days to allow full utilization of the remaining capacity, an immediate and substantial improvement of the economic situation is certain and in the long run this industry would become highly remunerative. Stock conditions (and thus physical yields) would improve equally under either method of reducing mortality; hence the anticipated economic results would determine the action to be taken.

The West Greenland exercise provides an example of how cost savings differ depending on which types of vessel and operation are affected by the cut in effort. It must be emphasized that the eventual outcome, within the range indicated, would depend upon the individual owners' decisions as to the operation of their fleets in a regulated fishery.

A difficult problem is to evaluate the means and impact of diverting or removing the excess capacity. It may be assumed that no alternative superior to its present utilization exists for the capacity (fish fleets) now employed in the North Atlantic cod and haddock fisheries. In some cases a country might be able to redeploy vessels and manpower into fisheries for other species in the North Atlantic that are not now fully exploited or to shift them to other waters. In some instances, however, this would necessitate the retiring of vessels.

For some countries this might not pose too serious a problem, since part of the fleet is obsolete. Assuming that the "freed" manpower could be absorbed easily in other occupations, the elimination of capacity would involve slight loss to the industry itself and would even represent a gain from the viewpoint of public welfare.

In regions with employment difficulties, however, the manpower considerations would have important economic, social and political implications. This applies particularly to those remote areas where fisheries provide practically the only means of subsistence. To be effective, an international management program must enable each country to deal with these problems as it sees fit, while protecting the ability of others to adopt different national policies.

There are several, albeit limited, ways in which redundant fishing capacity could be handled by an individual country. Some North Atlantic stocks to which excess capacity might be diverted are herring, blue whiting, capelin, squid, sand eels and redfish. Among areas outside the North Atlantic to which surplus vessels might be sent are the Central and South Atlantic areas, including the hake fishing grounds off South America and South Africa. Other alternative uses for surplus vessels might also be found in the future, e.g. in connection with oil prospecting. It is possible, in the last resort, to reduce costs simply by holding vessels idle. Moreover, the speed with which excess capacity is diverted or removed from fishing could be adjusted to the particular situation of a national fleet

In summary, harvesting the North Atlantic stocks of cod and haddock with reduced inputs could result in economic benefits of considerable extent. The actual extent of the benefit realized by each country would depend to a significant degree upon the way in which the problem of reduction and/or redeployment of excess fleet capacity is dealt with.

B. PROJECTED DEVELOPMENTS IN FISHING ACTIVITY

In the preceding paragraphs it has been shown that, by 1965, fishing intensity on cod and haddock in the North Atlantic had reached the stage where the cost of harvesting the annual catches was substantially greater than necessary. Unless restrictions are imposed, this situation appears likely to persist and indeed to increase in severity. A recent enquiry by OECD into the development (to 1970) of fishing fleets in countries prosecuting the groundfish fisheries of the North Atlantic indicates that fishing capacity may be expected to increase (see Appendix IV). The additional capacity coming into existence will not necessarily eliminate older capacity to an equivalent extent. The fact that a comparatively high proportion of total costs consists of unavoidable costs, on the one hand, and the existence of governmental support programs, on the other, precludes the operation of any self-adjusting mechanism to maintain capacity at any given level. It is unlikely, therefore, that economic forces alone can prevent further increases in fishing effort in these fisheries. The evidence suggests that, at a conservative estimate, fishing effort on the North Atlantic cod and haddock stocks may increase as much as 15-30% by 1970. This would probably result in a decrease in the total catch of these species and reduce the catch per unit of effort considerably below the 1963-1965 level.

Outside the North Atlantic a similar situation is developing. The fleets of long-range vessels are steadily increasing. More and more countries in all parts of the world are starting to operate such vessels. Up to the present the problems which might have arisen from this increasing capacity have been mitigated by the development of fisheries on hitherto lightly exploited grounds, e.g. the Bering Sea, Northwest Africa and Southwest Africa. Several of these grounds are now showing signs of depletion. There are few alternative grounds where fish of a suitable type are likely to be caught in economically attractive quantities.

As pointed out, the present state of the North Atlantic stocks is such that effort regulation of one area alone should not be considered because the surplus effort is likely to be directed to another equally heavily fished stock. At present, it is reasonable to consider a regulation for the cod and haddock stocks of the North Atlantic alone, and to assume that the surplus effort diverted to other areas would go to stocks which are still relatively lightly fished, and which are capable of producing an increased sustained yield following an increase in effort. It is likely that such an assumption will be much less reasonable in the future, when any policy of reducing fishing mortality on the cod and haddock stocks in the North Atlantic would have to take into account the problems of a restriction of fishing on a world-wide scale with the vastly greater scientific and administrative complications that this would involve. The need for taking positive steps toward effort limitation in the North Atlantic demersal fisheries before the problems become still more complex is therefore urgent. In addition, the development of a workable regulatory program in the North Atlantic would make it easier to anticipate and deal effectively with the problem of excessive fishing effort in other regions.

C. TYPES OF REGULATORY MEASURES

Various methods of limiting the fishing mortality rate have been reviewed in previous papers presented to ICNAF, e.g. the Templeman-Gulland statement[2] to the 1965 meeting and the UK Commissioners' Note[3] for the 1966 meeting. In these documents it was made clear that methods which in practice reduce the efficiency of fishing, e.g. restriction or banning of improved types of gear, closed areas or closed seasons (at least as the only method of regulation), waste the potential economic benefits of regulation. The only reasonable alternative is direct limitation of either total catch or total effort.

Direct limitation of total catch on a "global" scale, with all countries, fleets and enterprises continuing to fish until the prescribed quota is reached, would lead to a situation in which every unit strove to maximize its share. This situation, experienced in several fisheries where an overall quota has been in effect, e.g. the Pacific halibut and the Antarctic whale fisheries, causes most of the potential benefit of reducing mortality to be lost. A similar situation would obtain under a direct limitation on total effort. Mortality would be reduced but total costs would be increased, and the value of the product may be decreased. The overall quota, therefore, whether in terms of catch or effort should be allocated among participants in the fishery. In the case of fisheries under international management, this means first of all allocation among countries.

Within a national fishing industry there would still be a scramble if control stopped at the imposition of a quota for the country as a whole. A country, however, may regulate the utilization of its quota in the manner best suited to internal conditions, e.g. to provide maximum net income, full employment to the greatest number of fishermen or fish at the lowest price to consumers. The method by which a country administers a quota assigned to it is unlikely to affect the stock involved or the fisheries of other countries.

Fishing effort (input) limitation

In principle, direct limitation of effort permits the maximum saving in costs. However, there are serious difficulties in effort regulation. These lie in the need for expressing effort in a standard form and in taking account of the continued improvement in fishing methods. This means that the effort quota would have to be frequently revised and that frequent recalibration would be required. In fact, a number of scientific problems, e.g. measurement of the effect of using more powerful echo-sounders, are not yet solved.

Moreover, if for any reason the customary distribution of fishing in space or time were disturbed, the relation between fishing effort, e.g. hours fishing, and the fishing mortality rate would be changed. In the Labrador cod fishery, for example, an hour's fishing in March on the average catches substantially more (perhaps two or three times as much) fish and causes a greater mortality rate than an hour's fishing by the same vessel in October. Regulation of catch or effort may well alter the seasonal pattern of fishing, e.g. when there is a scramble for a quota, and therefore standardization of fishing effort must take into account the time of fishing.

Further complications arise in the application of effort regulation by reason of the multi-national character of the cod and haddock fisheries of the North Atlantic. In these fisheries, agreement on the weighting factor to be used for changes in the gear used by some of the countries concerned are likely to be very difficult. At present many of the basic statistics, which would be necessary to compute total effort in standard terms, are not available. As pointed out in the United Kingdom Commissioners' paper (see footnote 3), when effort regulation is in force, the only real check on whether each country is exerting the correct mortality rate would be obtained from the record of catches. If a country's share of the total catch is increasing, so is the proportion of the total fishing mortality rate that it is exerting whatever the statistics of fishing effort may show.

Catch limitation

National catch quotas involve few problems of standardization among countries. Both ICNAF and ICES (NEAFC) statistics of catch are expressed as live

---

[2] W. Templeman and J. Gulland. "Review of possible conservation actions for the ICNAF Area." Annu. Proc. int. Comm. Northw. Atlant. Fish., 15: 47-56.

[3] United Kingdom Commissioners to ICNAF. "Note by the United Kingdom Commissioners on the Regulation of Fishing Effort." ICNAF Comm.Doc.66/17, 1966.

(round fresh) weight. For cod and haddock landed as wet or whole frozen fish, factors for conversion to live weight are available and the landed weight is well known. The area of origin is less certain. Cod and haddock are landed from areas in the North Atlantic outside the area defined in this report but the vessels fishing in the Baltic, the North Sea and west of the British Isles are generally different from those fishing the northern part of the North Atlantic. The same vessels may fish at Faroes and Iceland, or at Faroes and in the North Sea, but cod from Faroes are relatively easy to identify on the market.

Factory trawlers, handling processed (filleted and frozen) fish, present greater problems in establishing the species, the area of fishing (though such vessels are most unlikely to catch cod or haddock outside the defined area) and the live weight. These difficulties, however, should not be insuperable. Fish below marketable size which are either discarded at sea or converted into fish meal are a greater problem. Probably there is no way of including rejects (discards) in any catch quota, desirable though this would be. So far as the future stock is concerned, the removal of these small fish has a greater influence than the capture of the same weight of larger fish. Fish used as fish meal should be included in the quota, although this will raise problems of determining the live weight, the species and of distinguishing between fish meal made of whole fish and that made from the residue of processed fish. Most of the relevant statistics are already available.

The chief disadvantage of setting catch quotas is that the relation between catch and the fishing mortality rate is not constant over time, but varies with changes in the stock abundance. Thus the catch quota would have to be regularly adjusted to maintain the fishing mortality rate at the desired level. If the catch quota were set too high, the excessive fishing mortality rate would reduce the stock, so that the discrepancy in the following year would be greater. Without adjustment of the quota, the stock would continue to decline and the fishing mortality rate would increase, as happened between 1950 and 1962 in the Antarctic baleen whale fishery, where the quota set initially was only a little too high.

Variations in year-class strength are an important cause of fluctuations in stock abundance. There may be a difference of as much as 100:1 between the best and worst year-classes but the resultant fluctuations in the abundance of the stock, which contains several year-classes, are much less. In many fisheries estimates of year-class strength can be obtained, e.g. from research surveys of 0-group fish one or two years before the year-class enters the fishery. Further estimates of the strength of a year-class can be made after it enters the fishery, a year or two before it makes its biggest contribution to the catches. Thus it would be possible for estimates of stock abundance to be made 3 years, 2 years and 1 year in advance and in the current year. The accuracy increases with each estimate. Such estimates might be used to establish a catch quota in the following manner: a) in 1970, for example, a forecast could be made of a quota for 1972, b) in 1971 a preliminary quota could be set for 1972, with participating countries being guaranteed say 90% of their eventual share, and c) in 1972 a definite quota could be established for the current season equal to 90% at least of the provisional quota.

Whether this scheme is feasible depends on the degree of adjustment to the current year's quota that is acceptable to countries and industries, as well as to the precision of the scientists' forecasts. Although it is desirable to have much better knowledge of the state of the stocks and of year-class fluctuations, in the opinion of the majority of the Working Group enough information is available to permit meaningful estimates of annual overall catch quotas being made. The validity of this opinion might be tested by estimating a) the stock abundance for 1968 and subsequent years and b) the resulting quotas corresponding to given levels of the fishing mortality rate (perhaps those corresponding to the average 1963-65 level and 10 or 20% below that level), such estimates to be accompanied by an indication of their probable precision. The Group consider that such an exercise would be highly desirable. It would also be desirable to expand research on a) the abundance of young fishes and their influence on stock magnitudes, and b) on rates of total and fishing mortalities.

If a total catch quota were adopted as the international method of management, individual countries might still wish to exercise control of their own fishing operations by other methods. By itself a catch limit is likely to be a most inefficient method of control within a country. Direct control of input, e.g. by the licensing of fishing vessels, would give much better economic results. Given reasonable estimates of stock abundance, such as those used in setting the catch quotas, the number of vessel licenses that should be issued to obtain the desired catch quota could be estimated quite closely. A country that relied on input limitation usually might approximate its catch quota by adjustment of licensing as the season progressed. It might be preferable, however, to carry over moderate deviations from the annual quota (up to 10 or 20% of the total, for instance) to the next year. As an example of how such deviations might be discouraged, a country could be credited with 90% of a shortfall and debited with 110% of an excess. Thus, if a country took 1,000 tons less than its quota in a given year, its quota for the subsequent year would be increased by only 900 tons. Similarly, if an extra 1,000 tons were taken in any year, the quota would be reduced by 1,100 tons in the succeeding year.

The problem of several stocks

In the North Atlantic there are a number of distinct stocks of both haddock and cod. These stocks differ in their natural characteristics of growth rate, natural mortality, etc., as well as in the degree to which they are exploited. If the full potential from each stock is to be obtained, then the fishery on each should be separately regulated in terms of mesh size and of fishing mortality rate. Discussions of the practical problem of regulating the mortality rate on separate stocks brought out so many complications and difficulties of enforcement that it seemed preferable to consider first an overall restriction for much of the North Atlantic. The area covered should include all the stocks fished by the mobile fleet of large European vessels, with reference to which the problem of separate control by areas is most acute. The Group therefore believe that first consideration should be given to a single restriction or quota covering the cod and haddock stocks of the entire ICNAF Area and of Region 1 of NEAFC, i.e. East Greenland, Iceland and the Northeast Arctic. The Faroes might or might not be included.

Such an overall quota in terms of catch could be established by simply adding the catch quotas for each area. The establishment of an overall effort quota on the other hand would be very difficult since an hour's fishing at Labrador is not equivalent to an hour's fishing on Georges Bank in terms of either cost or catch.

Year-class fluctuations in different stocks are to a large extent independent. Thus the fluctuations in a total catch quota are less than the fluctuations in the individual quotas. The differences in the occurrence of good year-classes encourage the switching of fishing operations from one stock to another. However a theoretical study suggests that the resultant deviations from the optimum level of fishing mortality do not lead to any appreciable loss in catch. In fact, there may well be a gain in overall efficiency from operating each year on the stocks and grounds which, during that period, are the most productive.

Appendix V describes a method by which an overall quota can be modified, either when first introduced or later when some of the operational problems have been solved, to ensure a better allocation of fishing among different stocks. The method is to declare closed seasons of suitable length for those stocks which, even under a correct total quota, may still be too heavily fished. This closure would apply particularly to the mobile fleets which could be diverted to other, underfished areas. As indicated in Appendix V this technique would contribute to the desired allocation of effort to different stocks without imposing hardship on those nations whose fleets are largely limited to one or two areas.

Another method would be to apply a weighting factor to each stock in a manner similar to that of the Whaling Commission which uses weighting factors of 1:1/2:1/6 for blue, fin and sei whales, respectively, to obtain a total catch in terms of Blue Whale Units. Thus, for example, if the Northeast Arctic was being fished too heavily and Labrador not heavily enough, then 1 ton of cod from the Arctic might count as 1.2 'standard' tons and a ton of Labrador cod as 0.8 'standard' tons. Such a scheme might involve, though in a less extensive form, the problems of enforcement and identification of area of capture encountered in considering separate regulation of each stock.

D. SUMMARY

Biological assessments based on population models currently used by ICNAF scientists were presented to the Working Group. These showed that most of the cod and haddock stocks in the North Atlantic are now so heavily fished that a moderate reduction in the fishing mortality rate would not result in a decrease in sustained catch and probably would result in an increased catch.

Cost studies were made of the effects of such a reduction in the fishing mortality rate for two areas, viz. Georges Bank and West Greenland. These showed that the economic benefits could be very large. A rough estimate of the effect of curtailing the fishing mortality rate on all North Atlantic cod stocks suggests a possible saving of 50 to 100 million dollars in costs, with the average annual catch remaining constant or increasing slightly. However the studies showed that the actual reduction of costs depends critically on how reduction of the fishing mortality rate is achieved.

Of the methods of reducing the rate of fishing mortality available to the international commissions, there are only two that would enable member countries to reduce their production costs, i.e. an allocation of definite shares of an agreed total amount of fishing expressed in terms of either a) catch or b) standard units of fishing effort. It would be necessary for countries individually to restrict fishing operations to the assigned limit. The method adopted for this purpose may be chosen to suit national objectives and would be irrelevant to the general effectiveness of the management program.

The use of fishing effort, e.g. days on the ground, as a measure of the amount of fishing under quota control would raise very great problems of inter-gear calibration and the like and, for that reason, may be set aside for the present. The use of catch in a similar way would require reasonably precise forecasts of fish stock abundance several years in advance, but a considerable quantity of data is available for this purpose and quota estimates corresponding to various levels of fishing, might be prepared for 1968 and subsequent years.

Separate regulation of the amount of fishing for each of the stocks in the North Atlantic, while desirable, would be impracticable. It follows, therefore, that any restriction of fishing should first be considered for the combined cod and haddock stocks of the northern part of the North Atlantic, i.e. the whole of the ICNAF Area and Region 1 of NEAFC, possibly excluding the Faroes. Methods of adjusting this overall control to provide some degree of differential regulation between stocks are suggested.

Biological and economic effects on Georges Bank haddock of conservation actions

A. Biological aspects - by R. Hennemuth, Bureau of Commercial Fisheries, Woods Hole, Mass.

Introduction

The Georges Bank haddock stock was one of the first to be regulated by ICNAF, and has been extensively studied and reported on by the ICNAF working group on mesh assessment and other scientists.

The earliest comprehensive records of haddock fishing on Georges Bank begin about 1917, when fishing was still relatively light. The fishery expanded rapidly during the late 1920's, with annual landings increasing from about 50 x 10^3 metric tons in 1926 to 115 in 1929. In spite of increasing effort, landings dropped rapidly to about 55 x 10^3 tons in 1932. From 1932 to 1963, the fishery stabilized with average annual landings of 45 x 10^3 tons. Landings increased to 65 x 10^3 tons in 1964 and to a record high of 154 x 10^3 tons in 1965. The recent increases are the result of new fleets entering the fishery; the 1965 increase stimulated by the recruitment of a particularly large year-class to the fishery.

Available Data

Samples of length-frequencies of landings, scales for assessing ages and statistics of landings and effort expended by a homogeneous class of otter trawlers have been obtained since 1932. Data on length and age compositions prior to 1932 are not available. Landings and effort statistics prior to 1932 were obtained from records of fishing companies. By a series of adjustments based on comparisons of relative catch rates of the different types of fishing gear and vessels, the units of effort from 1917 to 1931 were made as comparable as possible to the post 1932 series. Total annual effort was estimated by dividing the total landings by the average landings per day fished of the standard fleet.

Estimation of Mortalities

An average total annual mortality rate,

$$Z = 0.7,$$

was estimated from relative abundance at age of year-classes in the landings for the 1932-62 period. The estimates varied between 0.4 and 0.9 and were to some extent seasonal and age-dependent. Although the estimated annual days fished over the same period has varied from 5 to 9 x 10^3 days, most years were in the 6 - 8 x 10^3 days range, and it has not been possible to establish any relationship between Z and effort with these data.

No direct estimates of the relative magnitudes of fishing and natural mortality rates have been obtained. The consensus of those who have studied this population is that natural mortality,

$$M = 0.2, \text{ whence}$$

$$F = 0.5,$$

$$F/Z = 0.7,$$

$$F/M = 2.5,$$

on the average for the period covered.

The uncertainty of these numbers require that a reasonable range of values of these parameters be considered. We have chosen as follows:

Z : 0.5 to 0.9

F : 0.4 to 0.6

M : 0.1 to 0.3

F/Z : 0.5 to 0.9

F/M : 1.5 to 4.5

Application of the limit values in the yield model employed below does have a substantive effect, although quantitatively the percentage changes in yield are small, and the degree of the action recommended would change, but not the action itself. The estimates below are based on the central values.

Yield-Effort Relationship

The estimated annual landings and landings-per-day fished, assumed proportional to abundance, were plotted against the terminal year of a three year running average of days fished. The average landings per day fished has decreased from about 15 tons at a level of 2-3,000 days fished in the early 1920's to about 5 tons at a level of 10-11,000 days in 1963-64; roughly a 1/3 decrease. The periods 1927-1933 and 1963-1965 include large annual increases in effort. Hence, the observations of abundance beyond the 10,000 day level included in these years, which are of critical importance, do not represent the long run, equilibrium values, and cannot be used directly in assessing effects of regulation.

The equilibrium curve of yield-per-recruit and the expected reduction of abundance, both per unit of fishing mortality, was calculated from the Beverton-Holt model. Assuming that days fished is proportional to fishing mortality, an estimate of the constant of proportionality was obtained from the average of F and days fished over the period 1932-62. Using these values, a line of equilibrium conditions was obtained by choosing a value of initial abundance (at zero level effort) which produced a curve most closely fitting the observed points. The curve fits the data adequately up to about 10,000 days fished; it would not be wise to extrapolate much beyond this level.

The curve is quite flat from about 5,000 days annual effort onward. A maximum yield of 45×10^3 tons occurs at about 7,000 standard days. For an average level (of three years running) of 10,000 days, which is the 1963-64 level, the equilibrium landing is about 42×10^3 tons, a very small decrease from the maximum. The equilibrium landings per day for these two levels of fishing are 6.4 and 4.2 tons, respectively, a 34% decrease.

Table 1 below summarizes the trends since 1960.

Table 1.

	1960	1961	1962	1963	1964	1965
Annual Landings (MT x 10^{-3}):						
Actual	41	47	54	55	64	150
Equilibrium	44	44	45	42	40	---
Annual days fished:						
Actual	7,700	7,200	8,600	12,400	12,100	26,700
3 year average	8,300	8,100	7,700	9,400	11,000	17,100
%*	119	116	110	134	157	244
Landings per day (MT):						
Actual	5.4	6.5	6.3	4.4	5.3	5.6
Equilibrium	5.4	5.5	5.8	4.5	3.6	---
%*	85	86	91	71	56	---

* Percent of maximum equilibrium yield level

The state of the fishery in 1965 was far off the equilibrium curve. The recruitment in 1965 of a strong year-class and the increased effort has resulted in higher landings and landings per day than the long run expectation. It is estimated that in the long run a 30% decrease in effort from the 63-64 level (it is highly unlikely that the 1965 level will be sustained) would increase landings by about 7% and landings per day by about 52%. These expectations are used in the economic assessment.

Interim effects

A reduction of 30% in effort would cause an immediate and proportional drop in landings, and only gradually would the benefits accrue. The calculated interim catches for each year following the decrease assuming an equilibrium state at year of decrease are as follows:

Year after decrease	% of 63-64 landings
1st	75
2nd	86
3rd	93
4th	98
5th	100
6th	102
7th	105

Thus, in about 5 years the equilibrium landings would be back to the magnitude when the decrease took place, and the full benefit would accrue in about 7 years. The actual landings would of course vary because of varying year-class strengths, and would also be affected by the degree to which the fishery departed from the equilibrium state before the change in effort was accomplished. These factors could produce a marked departure from the expected yields in the haddock on Georges Bank, where year-classes do vary considerably in relative strength, and where effort has changed considerably in the last three years.

B. Economic aspects - by L. Van Meir, Bureau of Commercial Fisheries, Washington, D.C.

As indicated in the foregoing discussion of the biological model of the Georges Bank haddock population, fishing effort can fluctuate from 4,000 to 10,000 standard days without causing large long-run changes in total landings. However variation in fishing effort has a significant effect on the catch per day of effort, and hence on returns to labour and capital employment in the fishery. But the manner in which fishing effort is curtailed to the 7,000 days of effort estimated to produce the maximum sustainable yield of 45,000 metric tons is of greater consequence to earnings of the fishing firms than is the change in catch per day of effort.

Fishing effort, costs, and earnings for the Canadian and Russian vessels fishing haddock on Georges Bank were not available. Therefore, measurement of the economic results of changes in fishing effort was based on results of the Boston offshore-trawler fleet.

The average offshore-trawler fishing Georges Bank out of Boston spends 270 days at sea each year to achieve 180 standard days of fishing effort. Therefore, 56 such vessels would be required to apply slightly over 10,000 days of fishing effort annually on Georges Bank. If the fishing effort of the fleet of 56 vessels were limited to 7,000 days annually, each vessel would be limited to 125 days of fishing effort requiring approximately 188 days at sea. However, 7,000 days of fishing effort could be applied to the resource by a fleet of 39 vessels, each spending a full 270 days at sea. (An even smaller fleet would be required if the fleet were comprised of vessels like the more efficient vessels in the Boston fleet.)

Average cost and earnings per vessel for 1965

Cost and earnings for the average Boston offshore-trawler are based on data taken directly from the settlement sheets for 23 vessels. Supplemental information was obtained for insurance, repair and maintenance costs incurred by the vessel operators. Although these vessels fish for haddock on Georges Bank, approximately 31% of their landings in 1965 consisted of other species of fish caught incidentally while fishing for haddock.

Fishing Effort, Cost and Earnings per Average Boston Trawler - 1965

Days at sea	270
Days of fishing effort	180
Total landings (M.T.)	1,057
Gross receipts	$253,279
Out-of-pocket costs	$ 51,476
Net for vessel and crew	$201,803
Crew earnings	$115,267
Vessel owner's share	$ 86,536
Insurance, maintenance and repairs	$ 43,440
Balance for interest, depreciation and management	$ 43,096
Interest @ 5% and depreciation 20 years	$ 51,000
Return to management	- $7,904

The average vessel in the fleet in 1965 did not earn a sufficient gross to cover depreciation and interest on the investment, let alone a return to management. Furthermore, the average annual wage per fisherman of $6,619 is not an attractive annual wage considering the rigors, hazards, and long hours involved, and earnings in alternative occupations.

Average cost and earnings per vessel at 7,000 days fishing effort (56 vessels)

As indicated above, fishing effort could be reduced to 7,000 days annually by limiting the amount of fishing per vessel in the fleet. The catch of haddock per vessel would be somewhat greater but incidental catch likely would decline due to fewer days at sea per vessel per year. A slight increase in average ex-vessel price of haddock was introduced in the 7th year after regulation of fishing on the basis that haddock landings would include a higher proportion of the higher valued large haddock and for each year for incidental catch due to reduced landings of incidental catch. The estimated results per vessel in the fleet for the 1st, 5th, and 7th year of adjustment would be as follows:

Fishing Effort, Cost and Earnings per Average Boston Trawler, 7,000 days Fishing Effort (56 vessels).

	Years after decrease		
Item	1st year	5th year	7th year
Days at sea	188	188	188
Days of fishing effort	125	125	125
Total landings	775	975	1,025
Gross receipts	184,875	239,175	262,392
Out-of-pocket costs	35,025	36,890	37,354
Net for vessel and crew	149,850	202,285	225,038
Crew earnings	86,787	120,113	134,675
Vessel owner's share	63,063	83,172	90,363
Insurance, maintenance and repairs	40,000	40,000	40,000
Balance for interest, depreciation and management	23,063	42,172	50,363
Interest and depreciation	51,000	51,000	51,000
Return to management	$-27,937	-8,828	-363

The immediate impact on the fleet of reducing fishing effort without reducing the size of the fleet would be a significant decrease in annual earnings for both vessel owner and crew. The average earnings per deckhand would drop to $4,944 per year and the vessel operator would have about $20,000 less income annually to apply against depreciation and interest charges.

Returns to crewmen and vessel operator would not be reinstated to the 1965 level until about the 5th year of reduced fishing effort. By the 7th year, the overall position of both crewmen and vessel operator would be somewhat improved over the 1965 position. But even after the haddock stock had been completely rebuilt, returns to the vessel operator would not include anything for management. Thus, the prospects of this proposal cannot be viewed as being very acceptable to either the fishermen or the vessel operators.

The above analysis does not include an allowance for utilization of the vessel and crew in other fisheries. The vessel could spend an additional 80 days or so fishing for other species. However, if these vessels applied this fishing effort to haddock on Browns Bank or some other haddock fishery, the management problem would simply be transposed to the other fisheries. Furthermore, net gains from fishing these other fisheries would be much less because of the greater distance. No data are available to indicate what the Boston offshore-trawler would be able to do in fishing for whiting, hake or some other species. However, considering the much lower price which these species command, it is doubtful if this could be profitable fishing for these vessels. Their best alternative might be to merely lay up when their quota of fishing for Georges Bank haddock was completed.

Average Cost and Earnings per Vessel at 7,000 Days Fishing Effort (39 vessels)

An alternative to reducing the fishing effort per vessel as a means of rebuilding the Georges Bank haddock population would be to reduce the number of vessels in the fleet. This means of reducing the amount of fishing effort in the fishery produces dramatic results in terms of return to economic inputs in the fishery. In order to demonstrate the immediate impact of a reduction in size of fleet as well as to illustrate the result of rebuilding the population, costs and earnings are calculated for the 1st year of adjustment, the 5th year, and at the 7th year when the stock would be completely rebuilt to yield the maximum sustainable yield.

Fishing Effort, Cost and Earnings per Average Vessel, 7,000 Days Fishing Effort (39 vessels)

	Years after decrease		
Item	1st year	5th year	7th year
Days at sea	270	270	270
Days fishing effort	180	180	180
Total catch (M.T.)	1,156	1,546	1,617
Gross sales	$301,948	$337,938	$361,208
Out-of-pocket costs	53,191	54,803	55,540
Net for crew and vessel	$248,757	$283,135	$305,668
Crew share	$145,318	$167,212	$181,561
Vessel share	$103,439	$115,923	$124,107
Fixed costs	43,440	43,440	43,440
Balance for interest, depreciation and management	59,999	72,483	80,667
Interest and depreciation	51,000	51,000	51,000
Return to management	8,999	21,483	29,667

Thus, a reduction in the number of vessels in the fishery brings an immediate and substantial improvement in earnings to fisherman and vessel owner. The average annual earnings per deckhand would increase to $8,395, and the vessel owner would be able to realize a positive return for his management in the first year of change. As the stock is rebuilt and catch per day of fishing effort increases, the return to labour and management becomes even more favourable. When the stock is fully rebuilt, the average earning per deckhand would be over $10,000 annually and management would realize a net return of almost $30,000 annually.

This is a conservative estimate of the economic advantages that could be gained from management. These data are based on the average achievement by the fleet. If the below-average vessels were eliminated, the average performance for the remaining fleet would be higher than reflected in the data used in this assessment. For example, a fleet of approximately 35 vessels could put 7,000 days of fishing effort on Georges Bank if the vessels performed in the manner that the above-average vessels now perform.

Biological and economic effects on West Greenland cod of conservation actions

A. Biological aspects - by J. Gulland, FAO, Rome

Introduction

The state of the stocks of cod at West Greenland has been considered in some detail by a special ICNAF working group. Though this group was specifically concerned with the effects of protection of small fish (by closed areas or large meshes), the results of the working group can be used to assure the effects of changes in fishing effort. No new analysis of the basic data has therefore been attempted.

As pointed out by the working group, there are at least two stocks of cod in the West Greenland area, and substantial numbers of all the larger fish, at least of the southern stock, move from West Greenland to East Greenland and Iceland. Ideally the analysis should therefore deal with cod stock separately, and include a study of the effects on the Iceland and East Greenland fisheries. Fishing in all these areas is heavy, so for simplicity the West Greenland fishery has been considered as a self-contained unit, but in interpreting the results it should be remembered that some of the increased numbers of older fish resulting from a reduction in effort would be caught at Iceland rather than at Greenland. This will make little difference to the total North Atlantic cod catch.

Trends in effort

The character of the fishery at W. Greenland has been changing so much that there is no one series of effort data which can be used to provide a consistent index over a period of years of the effort in the biologist's sense, i.e. a quantity proportional to the fishing mortality coefficient. The working group report used two measures, based on the total catch, and the catch per unit effort of certain types of vessel at certain seasons. The report of the ICNAF Assessment Subcommittee at the 1966 and earlier meetings used a less precise measure derived from the catch per day's fishing or days on the grounds of all trawlers and the total catch of all species, i.e. the number of days fishing or on the grounds that the average trawler would have to do to catch an amount equal to the total catch by all gears. These are tabulated below:

Table 1. Estimates of fishing effort (mortality) at West Greenland.

Measures of effort used	1959	1960	1961	1962	1963	1964	1965
a) from Horsted 1965	.99	.95	1.38	1.42	1.43		
b) from working group report	1.10	1.18	1.36	1.25	1.43		
c) Trawler days fished				18.100	18.900	20.300	
d) Trawler days on grounds	18.200	16.200	22.100	23.400	24.100		
e) mean of a) and b)	1.05	1.07	1.37	1.33	1.43		
Best measure, as % of 1960	98	100	128	124	134	145[1]	160[2]

Notes: [1] estimated from the increase from 1963 to 1964 in days fished
[2] estimates assuming a 10% drop in catch per unit effort in 1965

Mortality coefficients

The working group report gives estimates of the mortality coefficients in 1960; these were:

$$F = 0.30 \text{ to } 0.50$$
$$\text{and } M = 0.15 \text{ to } 0.20$$

If the fishing effort (in the biologist's sense) has increased 60% since 1960, then the range of values in 1965 are:

F = 0.48 to 0.80
M = 0.15 to 0.20
Z = 0.63 to 1.00

i.e. F/Z is about 0.75 to 0.80, F/M is about 3 to 4.

If the catch/effort curves for W. Greenland cod can be determined from the simple Beverton and Holt/Bertalanffy model, and taking L_c = 50 cm (see Fig. 5 of the working group's report, which gives the length compositions of catches and landings), and the parameters of the Bertalanffy growth curve as

L_∞ = 90
K = 0.25

then the yield/effort curve can be determined from the FAO yield tables, using suitable values of M/K, c and F/M. For a set of probable values (M/K = 75, c = .56 F/M = 3.5), the effort is greater than that giving the maximum yield, which would be obtained with an effort 35% below the 1965 effort. This maximum catch would be about 2% greater than that obtained with the 1965 level of effort. Using different values of the parameters, the conclusions reached are quantitatively slightly different, but there is qualitative agreement within the probable range of values that the 1965 level of effort is not substantially below the level giving the maximum sustained yield, and may be well above it. Thus an appreciable reduction in effort could be made without appreciably reducing the sustained catch and is more likely to increase the sustained catch bearing in mind the fact that the actual values are most likely to lie in the lower and right hand side of Table 2. Specifically a 30% reduction in effort (fishing mortality)was considered, and the resulting change in long-term catch for different possible values of c (size at first capture, as a percentage of the maximum size) and F/M, are tabulated below:

Table 2. Change (%) in long term catch as a result of 30% reduction in fishing effort (mortality).

	F/M			
c	2.0	3.0	4.0	5.0
.64	-6.0	-2.0	-0.2	+1.1
.60	-4.7	-0.6	+1.0	+2.5
.56	-3.4	+0.4	+2.8	+5.3
.60	-1.3	+3.1	+5.4	+8.5

From these figures it is reasonable to assume that the long-term catch at a level of effort 30% below that of 1965 will be the same as that with the effort maintained at the 1965 level; possibly it might be very slightly higher. This figure of a 30% reduction in effort, with no change in total catch, has been used in assessing the economic effects.

Interim effects

The calculations in the previous section refer to the long term steady state, and would not be reached immediately following a 30% reduction of effort from the 1965 level. Calculations have been made of the interim catches in each year following a 30% reduction in effort from a steady state situation with the effort equal to that in 1965; for a probable set of parameters, the catches, expressed as percentages of the initial catches are as follows:

Year 1..................76%
" 2..................86%
" 3..................93%
" 5..................100%
" 10..................104%

i.e. the reduction in catch is less than the 30% reduction in effort even in the first year (assuming the fishing is spread evenly through the year), and after 5 years the catch is close to the long term value.

As Table 1 shows, the effort on West Greenland cod is far from being steady, and has been rapidly increasing; therefore the above calculations of the change from a steady state do not apply directly. However, it is likely that they do give a fair measure of the difference in catch to be expected from two possible courses of action - maintaining the effort at the 1965 level, or reducing the effort to 70% of the 1965 level. Because of the lower pre-1965 efforts the catches at the 70% effort would, during the interim period, be nearer the long-term value than is suggested in the table, i.e. would be larger. Equally the catches with the 1965 effort would also be different from the long term value, i.e. would also be larger. The difference between the catches from the two regimes of effort may therefore still be close to those given in the table, i.e. the table gives a useful measure of the difference in catch from the two regimes even when initially the stock is not in a steady state.

Also it must be remembered that the actual catch in any year will depend on the strength of the year-classes present, and at West Greenland the year-classes are highly variable. However again, the table gives a fair measure of the difference in catch, in any year, resulting from the two possible regimes.

B. Economic aspects - by W. Krone, OECD, Paris

Introduction

The following analysis is based on the assumption that only the cod fisheries off West Greenland are regulated, i.e. the effort reduced by 30% of the 1965 level. While in the biological investigation an isolated approach can be taken without any harm, the economic evaluation of possible effects is rendered highly theoretical. Total benefits or losses - short and long term - can only be properly measured if repercussions on other stocks, total supplies and markets are taken into consideration. These will entirely depend upon how the eliminated fleet capacity is utilized.

Aggregate costs

Latest information on costs for different types of vessels of various nationalities operating off West Greenland is available for 1964. On the basis of certain assumptions, the annual costs of the relevant vessels can be broken up and a proportional share be allocated to the operations off West Greenland. Estimates have been made where no data are available.

The results of the calculations are summarized in Table 1, which gives the aggregate total costs for 1964 operations off West Greenland amounting to about U.S. $50 to $55 million.

Table 1. Estimated aggregate costs in million U.S. $ (1964 and 1965) - (increase of effort in 1965: 10%).

	1964	1965
1. Operating and crew expenditures	42.0	46.2
2. Interest on capital invested	5.2	5.7
3. Sub-total 1 + 2	47.2	51.9
4. Depreciation (5% on capital invested)	5.2	5.7
5. Total costs (1st alternative)	52.4	57.6
Sub-total 1 + 2	47.2	51.9
6. Depreciation (8% on capital invested)	8.7	9.6
7. Total costs (2nd alternative)	55.9	61.5

Taking the increase of the biological fishing effort as a basis (increase of 10% from 145 in 1964 to 160 in 1965), total aggregate costs for 1965 operations off West Greenland have, approximately, been U.S. $55 to $60 million. In this it is assumed that types of operations have not drastically changed from 1964 to 1965 and that costs per day fishing have not increased in this time. When assuming an average cost increase of 5% the aggregate cost figure is raised to U.S. $58 to $63 million. It seems therefore reasonable to use for the further calculation a figure of U.S. $60 million; this is approximately made up of U.S. $46 million exploitation costs and $14 million interest and depreciation.

Cost savings of a reduction in effort

As a most simple case it can be estimated that the annual cost reduction is proportional to the contraction of fishing effort (in the biological sense). A 30% reduction of fishing effort from the 1965 level would thus result in a 30% decline of costs, i.e. roughly $18 million. But there are a number of important assumptions underlying this calculation, assumptions which are more or less unrealistic. These are:

(a) the redundant fleet capacity can be absorbed in other fishing, either inside or outside the North Atlantic, without any economic disadvantage;

(b) the relative composition of the fleet as regards types of operations remains unchanged from year to year;

(c) the total number of days fishing is proportional to changes in mortality rate.

Moreover, total benefits can only be evaluated if the effects on market returns are taken into account. Even when assuming that, generally, cost/price ratios remain unchanged, the reduction in effort has an impact on supplies and market prices.

Excess capacity

There are various possibilities as regards the utilization of the redundant capacity:

(a) cod fishing elsewhere in the North Atlantic;

(b) fishing for other species in the North Atlantic;

(c) fishing in areas outside the North Atlantic;

(d) stopping fishing for part of the capacity (part of the year) and laying up the vessels;

(e) scrapping of excess capacity.

A precise forecast of the course likely to be adopted would imply evaluation of a number of factors, which would lead too far for this limited case study. These include not only national and international consideration (e.g. composition of national fleets, structure of national market, relative abundance on alternative grounds,market prospects for alternatively fished species, etc.), but also individual operator's assessments of future trends, which again would be influenced by decisions competing fleet operators will take. These implications can only be properly evaluated by a much more detailed examination than is possible here.

Nevertheless, working on the premise that other cod stocks in the North Atlantic are not regulated, a switch of effort to these grounds seems inevitable. Present catching prospects would then suggest that this would have rather detrimental effects on these stocks, at least in the long run. Any benefit from reducing the effort at West Greenland would thus most likely be partly or totally dissipated. In fact, it becomes obvious that restricting regulations to single grounds is not feasible. It is therefore more logical to assess the problem of excess capacity in a wider context.

The foregoing remarks refer mainly to the mobile part of the fishing fleet off West Greenland. The alternatives for other vessels are much more limited. For example, the Greenlandic small boats have practically only the choice between laying up (or scrapping) and - to a little extent - switching to shrimp fisheries. Social reasons and problems of general economic development would therefore warrant that these operations are excluded from the regulation of effort.

Effects on various types of operations

A reduction of fishing effort at West Greenland might affect different operations in various ways, depending on the composition of national fleets and on how the owners decide to operate these fleets under a regulated fishery. It is, however, unrealistic to assume that, total effort being reduced by 30%, the remaining fleet will have, proportionally, a similar (or even the same) composition. It has therefore to be assessed, how the costs saving of $18 million will be changed if one type of operation is more affected than the others.

Table 2. Aggregate costs according to types of operations

	Annual costs			Days fishing		Days at sea	
	1964		1965(a)	1964	1965 (a)	1964	1965 (a)
	$ mill.	%	$ mill.				
Trawler:	38.0	68	40.8	13071	14350	22334	24600
- wetfish	7.7	(20)	8.3	2147	2350	5617	6200
- freezer (b)	8.8	(23)	9.5	2779	3050	4843	5350
- salter	12.6	(33)	13.5	5701	6250	7382	8100
- not specified	8.9	(23)	9.5	2444	2700	4492	4950
Longliners and dories	13.5	24	14.5	12222	..	16600	..
Small boats	4.4	8	4.7	40000	..	41000	..
Total	55.9	100	60.0	..	..	..	..

(a) Estimated on the basis of a 10% increase in fishing effort from 1964 to 1965; the number of days fishing (and days at sea) for 1965 is only theoretical, because the same composition of the fleet as in 1964 is again assumed. In reality the effort of freezer trawlers and more efficient vessels has increased, so that the actual number of days fishing was lower.

(b) Including part-freezer

Table 2 gives an approximate breakdown of total costs according to types of operations, together with a summary of days fishing and days at sea spent by the different groups.

Total costs are shared thus:

Trawlers	68%
Longliners and dories	24%
Small boats	8%

If all types would be equally affected the same shares would apply to the cost savings of $18 million:

Trawlers	$12.3 million
Liners, etc.	$4.3 "
Small boats	$1.4 "
Total	$18.0 million

But these shares (and the total) change considerably if various alternative assumptions are made regarding the composition of the fleet after reduction of total effort by 30%:

(i) Assuming that the reduced number of days fishing of the trawling section (14,350 minus 30% = 10,000) is exclusively used by wetfish trawlers, total costs of this section would amount to $35 million and savings thus be (reduction for liners and small boats being 30%):

Trawlers (wetfish)	\$5.4 million
Liners	\$4.3 "
Small boats	\$1.4 "
Total	\$11.7 million or about 20% of the 1965 level of total costs.

High costs per day fishing, because of the long steaming time (up to about two-thirds of total trip duration) is the explanation for this drop in benefit.

(ii) If it is assumed that the remaining fishing days are exclusively used by freezer (or part-freezer) trawlers, the following cost savings can be calculated:

Trawlers (freezer and part-freezer)	\$9.6 million
Liners	\$4.3 "
Small boats	\$1.4 "
Total	\$15.3 million or about 25% of the 1965 level of total costs.

This saving would, however, be considerably increased if only the most efficient full-freezer vessels would continue to operate in the area.

(iii) If, in another extreme case, all remaining trawling days would be taken up by salter trawlers, the following results would be obtained:

Trawlers (salters)	\$19.2 million
Liners	\$4.3 "
Small boats	\$1.4 "
Total	\$24.7 million or more than 40% of the 1965 level of total costs.

The examples quoted above indicate that the cost savings would be quite different depending on which types of boats are more or less affected by the conservation measure ranging from about \$12 million to \$26 million per annum, or 20 to 40% of the costs incurred in 1965.

The examples are theoretical extremes and only give the ranges of possible developments. A more likely approach would be to assume that small boats are exempted from the regulation because of social reasons and that longlining would drop less than 30% (say 15%), because better size composition of the catches from the improved stock could give them comparatively better gains. If this were the case and the same reduction in total effort (mortality) is to be achieved, effort of the trawling section would have to be lessened by more than 30%. Part of the additional diminution would have to be guaranteed by those countries operating a mixed fleet of trawlers and liners in the area. This raises then the question of how to relate a liner's fishing day to a trawler's fishing day, which in terms of yield are not the same. These remarks already involve the third assumption made about the direct relationship between effort (in days fishing or a similar yardstick) and mortality.

<u>Effort/mortality relationship</u>

The assumption that the mortality of the stock is proportional to changes in the number of days fishing underlies the biological forecasts: it should be pointed out here that while this may be a viable premise if applied to a gradually developing, unregulated fishery, it might no longer be realistic, when effort regulations are introduced. The effects of various types of gear and vessel on fish mortality are rather different and as sudden and drastic changes in the fleet composition may result from the enforcement of conservation action, a direct proportionality could no longer be assumed. If, for example, with the reduction of total effort at West Greenland the share of longlining and trawling for wetfish (smaller boats compared with freezer trawlers) is increasing considerably, a reduction of mortality of 30% (effort in the biological sense) would probably require a diminution in the number of days fishing of less than 30% or, in other words, a reduction in the number of days fishing by 30% would lead to an undesirably low level of exploitation. This is mainly a biological problem, but as the biological "optimum mortality" would have to be translated into another yardstick in a conservation program, it will have to be borne in mind that the actual fishing intensity will depend upon the individual operator's decision as regards the various types of vessels.

Influence on markets

It has been assumed that cost/price ratios remain unchanged during the conservation period, that is to say that costs of operating fishing vessels and prices returned for the produce move in the same proportion. Though it is, of course, obvious that neither costs nor fish prices will remain stable during a period of 5 years (or change at the same rate), the assumption is permissible if only the particular influence attributable to the conservation action has to be assessed. Its direct influence on operation and building costs of fishing vessels should be negligible. As regards price developments, distinction has to be made between the short-term effects in the intermediary period and the long-term effects after recovery of the stock.

It has been calculated that in the year following the reduction of effort by 30%, cod catches off West Greenland will diminish by 24%. In terms of total cod supplies from the North Atlantic this would mean - everything else remaining unchanged - a contraction of about 3 to 4%. But here again, it will depend upon how the redundant capacity is employed, whether this percentage will not actually be lower, e.g. if cod stocks in other areas are fished or other species liable to replace cod on certain markets, e.g. Cape hake or redfish. To evaluate the short-term effect on cod supplies of the regulatory action, an assessment of the employment of the eliminated capacity is therefore essential.

Nevertheless, a certain, though small, reduction in cod supplies can be taken for granted because it is logical to assume that alternative areas are comparatively less advantageous. The extent to which market prices are affected by the decline in cod catches depends on the average price elasticity of demand. The demand for mass consumption species, such as cod, shows a fairly general pattern with a rather elastic range until the saturation point is reached (this is mainly because these fish can be easily substituted by other products) and a very inelastic part, if supplies increase beyond that level. At the present supply and price level, demand is probably near to unit elasticity and a small reduction in supplies would then cause an equivalent price increase so that total revenues remain unchanged. For the West Greenland case it would mean that, though return for West Greenland cod will decrease (something less than 24%), this will be made good by higher prices for cod from other areas.

It has, however, to be stressed that this holds true only for a small decline in supplies. If this is greater, total supplies will most likely come into the range of elastic demand, thus causing a decline in gross returns. In this context, it has to be borne in mind that different national markets would be differently affected by the reduction in supplies according to the share they have in Greenland cod fishing. For example, in 1964 about 70% of German trawled cod originated from Western Greenland. A reduction of 24% would, in a case like this, mean a considerable reduction in total cod supplies (almost 20%). If these cannot be compensated to a large degree by cod from other areas, a diminution of total gross returns from cod is rather certain.

Considering the effects on markets it also has to be taken into account that different products might be differently affected. For example, price elasticities for frozen fish should be greater than for wetfish because of various factors (even easier substitution, wider distribution possibilities, and better keepability of the product and greater concentration on the buying side). Reduction in supplies would thus be made good only to a small degree by price advances. On the other hand, demand for saltfish and stockfish is rather inelastic and a decrease in production would probably induce relatively big increases in world-market prices. This has been manifested in the past years when prices for salted cod have shown distinct upward trends because supplies fell short of demand. It has, however, to be borne in mind that prices for saltfish are already nearing the price level for frozen fish.

In continuation of the conservation program catches will very soon approach the original level and market effects thus become smaller. The rebuilding of the stocks results in improved size composition of the catches and, as larger-size species generally achieve higher market prices a favourable effect on returns can be expected. Moreover, the larger sizes will particularly benefit certain operations, such as salting and longlining. This might suggest that the regulated cod stocks off West Greenland could become a most important reservoir for these types of operations.

Also to be taken into consideration is the gearing of mass-processing plants, such as those in the shore-based freezing industry, to handle the most common size of fish being landed. Any sudden changes in size composition might therefore tend to upset the equilibrium of the market but the effect would not be pronounced if the change was spread over five years.

Conclusions

The foregoing discussion presents evidence that a reduction of fishing effort would bring about considerable economic benefits. For example, even with the least favourable assumptions with regard to type of operations and market prices the long-term net gain would certainly by far exceed the total financial aid granted to this section of the fleets by the various governments. In fact, it would probably be two to three times greater.

Moreover, it is realistic to conclude that such a scheme would - in the long run - be associated with considerable profits for the participating industry. The level of profits would most likely be higher than could be achieved in any other industry and the problem would thus be to build up an enforceable system of controlled effort whereby access to the increasingly profitable ground could be restricted.

This is particularly relevant as it is almost certain that efficient regulation of the North Atlantic fishery as a whole would result in redundant fishing capacity. The possibilities of disposing of this capacity and its evaluation in economic terms is therefore a prerequisite for a complete assessment of the costs or benefits of a conservation program.

APPENDIX III

Biological and economics effects on north-eastern Arctic fisheries of conservation actions.

A. Biological aspects - B.B. Parrish
Dept. Agriculture & Fisheries, Aberdeen, Scotland

Introduction

Detailed assessments of the state of the fish stocks in the north-eastern Arctic and of the effects of fishery regulations have been made in recent years by the ICES Arctic Fisheries Working Group. The main activities of this group were directed to the assessment of the effects of increases in mesh size in the trawl fisheries, but consideration was also given by it to the effects of a reduction in fishing mortality rate (= effective fishing intensity). The Working Group's assessments were made on data for the post-war period up to 1963. This report is based on the assessments made by the Working Group with, where possible, adjustments for more recent changes in the fisheries.

The Arctic fisheries are centred principally on cod and haddock, which together make up 75-80% of the total groundfish landings from the north-eastern Arctic (ICES Statistical Areas I, IIa and IIb). The detailed assessments dealt with in this report are, therefore, confined to these two species. However, some general consideration is given to other species exploited in this area, with special regard to the utilization of surplus fishing effort.

Cod

The Arctic cod fishery is carried out in the Barents Sea, in the Bear Island-Spitzbergen area and off the Norwegian coast (Lofoten). The Barents Sea and Bear Island-Spitzbergen fisheries are conducted principally by trawl on the immature and prespawning adult concentrations of cod, while the Norwegian coast fishery is a mixed gear one, centred principally in the spring, on mature, spawning cod.

Total landings of cod from these three areas combined increased rapidly after the war to a level of between 700 and 800 thousand tons by 1947 and, apart from 1955 and 1956, when they jumped to over a million tons, they fluctuated around this level up to 1963. Since then the landings have decreased substantially to between 400 and 500 thousand tons. The relatively stable total yield picture up to 1963 was maintained by a large increase in the landings of the younger age-groups of cod from the Barents Sea, due to a marked growth in the USSR fishery there; at the same time, the landings of large, mature cod from Norwegian coast fishery declined during this period, their proportion of the total landings decreasing from around 40% in 1946-47 to around 15% in 1962-63. Catch-per-unit-effort data show that this was associated with a marked decline in stock abundance in this area and a decrease in its average age. The decrease in total landings since 1963 has been due partly to a decrease in fishing effort especially in the Barents Sea as a result of the diversion by the USSR of part of its fishing fleet, exploiting this stock to other, more productive fishing areas, and partly to low recruitment to the exploited stock due to poor year-classes. Detailed information is not currently available on the actual magnitudes of these two contributory factors since 1963. Therefore, in this analysis the assessment of the biological effects of a decrease in fishing effort are considered for the period prior to the reduction in fishing after 1963.

While in the period 1947-1963 the total landings of cod have fluctuated about a fairly steady level, estimates of total fishing effort on the stock show a major increase throughout this period. This is shown by the estimates in Table I, obtained by the Arctic Fisheries Working Group for the years 1947-1952 and 1959-1963.

Table I

Estimates of Total Fishing Effort on Arctic Cod: 1947-1952 and 1959-1963

	1947	1948	1949	1950	1951	1952	1959	1960	1961	1962	1963
Estimated Total Fishing Effort in English trawler units (ton-hours x 10^{-8})*	2.6	3.0	2.9	4.7	6.0	6.9	7.8	8.2	9.4	9.7	9.3

[*These estimates refer to the total ton-hours fishing by the English trawl fleet required to take the total catch of all fleets combined in the whole area. They represent the sum of the estimates of English trawl effort (in ton hours) x $\frac{\text{total catch by all fleets}}{\text{catch by English trawlers}}$ for each of the main fishing areas -Barents Sea, Bear Island-Spitzbergen and Norwegian coast. They provide the best available indices of the quantity which is proportional to fishing mortality rate].

Long-term effects of reduction in fishing mortality rate

Data on estimated total mortality rates of Arctic cod in relation to the data for catch, catch-per-unit- fishing effort and estimated fishing effort, during the post-war period indicate clearly that in the period of high fishing effort in 1959-63 fishing was the major cause of mortality, probably accounting for about two-thirds of the deaths amongst the younger age-groups and perhaps more amongst the older ones. Although, as pointed out by the Arctic Fisheries Working Group, the nature of the Arctic cod fishery is such that the fishing mortality rate is probably not constant for all age-groups in the exploited phase, the following estimates of the mortality parameters represent reasonable average values for the exploited phase as a whole:-

$Z = 0.6-0.8$
$F = 0.4-0.6$

$F/Z = 0.7-0.8$

$F/M = 2.0-3.0$

Equilibrium yield per-recruit calculations in which the values of these parameters are assumed constant over the whole of the exploited phase indicate that for the present age of first capture, corresponding to a manila codend mesh size of 120mm the fishing mortality rate and total fishing effort generating it was higher than that giving rise to the maximum sustained catch-per-recruit. They show that no loss and probably an increase of up to 10% in equilibrium catch-per-recruit would accrue for a reduction in the fishing mortality rate (and hence of effective fishing effort), on all age-groups of cod in the exploited stock, by up to 30-40% from the 1961-1963 level.

This assessment is based on the assumptions that the mortality rates under present conditions are the same for all exploited age-groups and that the reduction in fishing mortality rate also takes place proportionately on them. Neither of them are likely to be strictly valid. In particular, a reduction in fishing mortality rate on all age-groups would lead to an increase in the abundance of the larger, more valuable cod, so that unless restraints were imposed on the fishing fleets, there would be a tendency for the fishing effort to shift from the smaller to the larger fish areas. Such a situation would result in higher long-term gains than those predicted above from a proportionate decrease on all age-groups.

The estimates of long-term effects, given above, are on a "per-recruit" basis; they represent the average annual yield relative to what it would be in the absence of any change in fishing mortality rate (and natural mortality and growth rate). They can only be converted into absolute catch quantities if the future average annual level of recruitment is known or does not change significantly from the average level in past years. Future levels of recruitment cannot be predicted, but on the assumption that the average level does not change significantly from that of the past 10 years, the reduction in fishing mortality rate on all age-groups by 30-40% from the level of the early 1960's would be expected to increase the average annual cod catch by up to 60-80,000 tons.

Interim effects

With a decrease in fishing mortality rate, the recovery of the stock to its new, higher equilibrium level will be at the expense of a short term decrease in total catch throughout the recovery period. For the Arctic cod, the total recovery period to the new equilibrium catch level would take 6-8 years, and to the previous catch level 4-5 years. The year-by-year changes in catch, assuming that recruitment remained constant throughout the recovery period would be as follows:-

12 months following reduction in fishing mortality rate	Catch as percentage of original catch
1	74-76
2	85-88
3	92-95
4	97-100
5	100-105
6	105-110
7	
8	

In practice, of course, owing to year-class fluctuations, the absolute changes in catch would not necessarily follow this course, but would be subject to wide variations from year to year. If the introduction of the reduction occurred at a time when a strong year-class was recruiting the fishery the decrease in catch during this period might be negligible; indeed, it might even be higher than the average for the preceding period.

The above assessments relate to the changes in catch following a reduction in fishing mortality rate (= effective fishing effort) from the high level in the years 1961-1963. As mentioned earlier, since 1963 there has been a decrease in total fishing effort (and hence fishing mortality rate) in the cod fishery. This has taken place mainly in the younger, immature cod area in the Barents Sea. Although the actual magnitude of this decrease has not yet been ascertained (a further meeting of the Arctic Fisheries Working Group, to assess this and other recent changes in the cod fishery and stock will take place in April 1967), it is clear that, if sustained, it will result in at least some of the recovery predicted above. The preliminary data available for the years 1964-1966 suggest, in fact, that the reduction has been of sufficient magnitude to move the effective fishing effort (fishing mortality rate) close to the level yielding the maximum catch-per-recruit for the present age of recruitment to the fishery (corresponding with an "effective" manila trawl mesh size of 120 mm).

Haddock

The post-war history of the haddock fishery in the north-east Arctic resembles closely that of the cod. Landings increased rapidly after the end of the war to a level of 120-140 thousand tons in the late 1940's, and except in 1955 and 1956, when they increased to over 200 thousand tons, they fluctuated around this level thereafter.

The main fishery for haddock in the Arctic is tne Barents Sea where they are exploited by the same trawl fleets as exploit cod in this region. Therefore, as with cod, they were subject to the same large increase in fishing intensity in the period up to 1963, which was accompanied by a marked reduction in catch-per-unit fishing effort and a reduction in the average age of the exploited stock. Again, as with cod, the available data indicate that at the high level of fishing effort during the early 1960's, the fishing mortality component was the largest of the mortality components, accounting for about three-quarters of the total deaths of haddock each year. Average mortality parameters for the haddock at this level of fishing are estimated to be as follows:-

$$Z = 1.1\text{-}1.2$$

$$F = 0.8\text{-}0.9$$

$$\frac{F}{Z} = 0.7\text{-}0.8$$

$$\frac{F}{M} = 2.7\text{-}3.0$$

Estimates of the equilibrium yield per-recruit, using these parameters, indicate that, as with cod, in the early 1960's the fishing mortality rate had reached a level higher than that necessary to obtain the maximum sustained catch. They show that a decrease of 30-50% in this mortality rate should lead to no decrease in sustained catch and probably an increase of up to 10%.

Again, as for the cod, this assessment relates to the catch relative to what it would be with no change in fishing mortality rate; if average recruitment and other population parameters remained the same as during the past, the reduction should result in an average annual increase of up to about 15,000 tons of haddock. The interim changes, for a decrease in fishing mortality rate of 30% would be approximately the same as for cod, the recovery period to the previous catch level being 4-5 years and to the new equilibrium level 6-7 years.

Other resources

The principal demersal resources other than cod and haddock, fished in the north-eastern Arctic are saithe and redfish. While the distribution of saithe overlaps that of cod and haddock in the area at least for part of the year that of redfish is largely distinct from it so that it could be exploited independently of cod and haddock in this region. Also, in the spring, concentrations of saithe occur off the Norwegian west coast largely independently of these species.

The stocks of both of these species have been subject to intensive fishing in this area for a number of years, and for the redfish in particular there has been a substantial decrease in catch-per-unit-effort during the past 10 years. In this case, therefore, it is unlikely that with increased fishing this resource would sustain large increases in yield beyond the level of recent years. It seems likely on the other hand that the present exploitation of saithe is below the level giving the maximum sustained yield and therefore that catches could be increased somewhat above the present level, with a moderate increase in fishing.

In addition to these major resources the main alternatives for any large diversion of fishing effort in the north-eastern Arctic would seem to be potential demersal and pelagic industrial fish species (e.g. blue whiting, silver smelt, capelin and perhaps also herring) which are potentially capable of providing substantially greater yields tnan at present.

The estimates of long-term effects, given above, are on a "per-recruit" basis; they represent the average annual yield relative to what it would be in the absence of any change in fishing mortality rate (and natural mortality and growth rate). They can only be converted into absolute catch quantities if the future average annual level of recruitment is known or does not change significantly from the average level in past years. Future levels of recruitment cannot be predicted, but on the assumption that the average level does not change significantly from that of the past 10 years, the reduction in fishing mortality rate on all age-groups by 30-40% from the level of the early 1960's would be expected to increase the average annual cod catch by up to 60-80,000 tons.

Interim effects

With a decrease in fishing mortality rate, the recovery of the stock to its new, higher equilibrium level will be at the expense of a short term decrease in total catch throughout the recovery period. For the Arctic cod, the total recovery period to the new equilibrium catch level would take 6-8 years, and to the previous catch level 4-5 years. The year-by-year changes in catch, assuming that recruitment remained constant throughout the recovery period would be as follows:-

12 months following reduction in fishing mortality rate	Catch as percentage of original catch
1	74-76
2	85-88
3	92-95
4	97-100
5	100-105
6	105-110
7	
8	

In practice, of course, owing to year-class fluctuations, the absolute changes in catch would not necessarily follow this course, but would be subject to wide variations from year to year. If the introduction of the reduction occurred at a time when a strong year-class was recruiting the fishery the decrease in catch during this period might be negligible; indeed, it might even be higher than the average for the preceding period.

The above assessments relate to the changes in catch following a reduction in fishing mortality rate (= effective fishing effort) from the high level in the years 1961-1963. As mentioned earlier, since 1963 there has been a decrease in total fishing effort (and hence fishing mortality rate) in the cod fishery. This has taken place mainly in the younger, immature cod area in the Barents Sea. Although the actual magnitude of this decrease has not yet been ascertained (a further meeting of the Arctic Fisheries Working Group, to assess this and other recent changes in the cod fishery and stock will take place in April 1967), it is clear that, if sustained, it will result in at least some of the recovery predicted above. The preliminary data available for the years 1964-1966 suggest, in fact, that the reduction has been of sufficient magnitude to move the effective fishing effort (fishing mortality rate) close to the level yielding the maximum catch-per-recruit for the present age of recruitment to the fishery (corresponding with an "effective" manila trawl mesh size of 120 mm).

Haddock

The post-war history of the haddock fishery in the north-east Arctic resembles closely that of the cod. Landings increased rapidly after the end of the war to a level of 120-140 thousand tons in the late 1940's, and except in 1955 and 1956, when they increased to over 200 thousand tons, they fluctuated around this level thereafter.

The main fishery for haddock in the Arctic is the Barents Sea where they are exploited by the same trawl fleets as exploit cod in this region. Therefore, as with cod, they were subject to the same large increase in fishing intensity in the period up to 1963, which was accompanied by a marked reduction in catch-per-unit fishing effort and a reduction in the average age of the exploited stock. Again, as with cod, the available data indicate that at the high level of fishing effort during the early 1960's, the fishing mortality component was the largest of the mortality components, accounting for about three-quarters of the total deaths of haddock each year. Average mortality parameters for the haddock at this level of fishing are estimated to be as follows:-

$$Z = 1.1\text{-}1.2$$
$$F = 0.8\text{-}0.9$$
$$\frac{F}{Z} = 0.7\text{-}0.8$$
$$\frac{F}{M} = 2.7\text{-}3.0$$

Estimates of the equilibrium yield per-recruit, using these parameters, indicate that, as with cod, in the early 1960's the fishing mortality rate had reached a level higher than that necessary to obtain the maximum sustained catch. They show that a decrease of 30-50% in this mortality rate should lead to no decrease in sustained catch and probably an increase of up to 10%.

Again, as for the cod, this assessment relates to the catch relative to what it would be with no change in fishing mortality rate; if average recruitment and other population parameters remained the same as during the past, the reduction should result in an average annual increase of up to about 15,000 tons of haddock. The interim changes, for a decrease in fishing mortality rate of 30% would be approximately the same as for cod, the recovery period to the previous catch level being 4-5 years and to the new equilibrium level 6-7 years.

Other resources

The principal demersal resources other than cod and haddock, fished in the north-eastern Arctic are saithe and redfish. While the distribution of saithe overlaps that of cod and haddock in the area at least for part of the year that of redfish is largely distinct from it so that it could be exploited independently of cod and haddock in this region. Also, in the spring, concentrations of saithe occur off the Norwegian west coast largely independently of these species.

The stocks of both of these species have been subject to intensive fishing in this area for a number of years, and for the redfish in particular there has been a substantial decrease in catch-per-unit-effort during the past 10 years. In this case, therefore, it is unlikely that with increased fishing this resource would sustain large increases in yield beyond the level of recent years. It seems likely on the other hand that the present exploitation of saithe is below the level giving the maximum sustained yield and therefore that catches could be increased somewhat above the present level, with a moderate increase in fishing.

In addition to these major resources the main alternatives for any large diversion of fishing effort in the north-eastern Arctic would seem to be potential demersal and pelagic industrial fish species (e.g. blue whiting, silver smelt, capelin and perhaps also herring) which are potentially capable of providing substantially greater yields than at present.

B. <u>Economic aspects</u> - A. Laing
British Trawlers Federation Ltd., Hull, England.

Careful consideration was given to the economic effects of a limitation of fishing effort (input) in the North-eastern Arctic fisheries. It was concluded that it would not be helpful to make any detailed economic assessment of these effects at the international level. This region is exploited principally by the fleets of three countries that have widely differing cost structures, fishing patterns, marketing methods, product valuations and, to some extent, fishing techniques also. But there is little quantitative information in respect of any of them that could be used to make a meaningful international economic assessment. Moreover, there is insufficient material available on which to make a rational assessment of the manner in which these fleets would, on any given reduction of effort, redeploy their remaining fishing effort - spatially and temporally - within this region.

On one set of assumptions it is possible to show that one fleet would be a significant loser, another a significant gainer and the third a probable gainer. Other sets of assumptions result in two significant losers and a wide range of alternative sets of assumptions would produce gains for all but in differing absolute and relative amounts. There seems to be no basis for preferring one set of assumptions to another. To have presented an assessment on the basis of any one or even on a few sets would have served to highlight the artificiality of the exercise and, hence, to cast doubts upon the worthwhileness of effort limitation generally.

Moreover, it seemed that at best any attempt at an economic assessment in this region would add little or nothing to that which the biologists have already stated in clearly understandable terms. At bottom, any such economic assessment would say merely that we are offered the opportunity of landing, after some period of re-adjustment, the same or somewhat greater weight of fish at a proportionate saving in the economic resources devoted to its production more or less equal to the initial reduction in fishing effort. The distribution of this saving in each country among producers, processors, distributors, consumers and the state would be a matter of national economic policy.

An economic assessment of effort limitation in this region which would go beyond what is largely a restatement of the biologist's proposition about the nature of the long-term yield/effort curve would, in this case at least, need to be done in national terms on the basis of a concrete and complete proposal concerning the limitation and the administrative arrangements made in respect of it.

In conclusion, therefore, we think it right to say, first, we have no doubt that the North East Arctic Cod Fisheries do offer the possibility of substantial economic gains to be obtained from effort limitation in that region; but, secondly, so far as the international commission is concerned, we doubt whether - at this stage and with the information currently available - the economists have anything helpful to add to the biological assessment.

Projections of the Fishing Fleets operating in the North Atlantic in 1970

(prepared by the OECD, Fisheries Division, with the assistance of Mr Guéroult [France] on the basis of information supplied by the relevant countries or gathered from various publications.)

Introduction

Forecasting any future developments can never be exact and this certainly applies, but even more so, in fisheries in which rapidly changing and unpredictable conditions present particular difficulties. Past experience shows that the rhythm of new investments is never regular and that the decision whether a vessel is obsolete and should be scrapped depends on many factors. An exercise on fishing fleet projections, even for a relatively short period of four to five years, can therefore not be expected to give precise and definite results. It can only indicate the tendencies most likely to occur and give the possible range of increase or decrease in fishing power.

Even more difficult, is to forecast which part of the fishing fleet existing in 1970 is likely to exploit a definite area, like the North Atlantic. A considerable and rapidly expanding section of the fleet in and outside the North Atlantic is mobile enough to fish practically any area in the oceans. The proportion operating in the North Atlantic might therefore fluctuate considerably from year to year depending on the relative fish abundance in various areas. The forecasts given in the following sections have therefore to be interpreted cautiously.

Canada

In 1965 the otter-trawl fleet of the Atlantic coast of Canada numbered 110 vessels over 100 feet in overall length (200 gross tons and over). (1) Average size of these vessels is slightly over 300 gross tons, thus the total represents about 35,000 gross tons. This fleet's landings made up about 35 to 40% of total groundfish landings, but its contribution to cod landings was only about 20%, these being dominated by the small or "inshore" boats.

Prior to 1965 net additions to the fleet of these larger vessels were on average ten units each year and forecasts for the immediate future resulted in an even greater rate for the years up to 1975. These have, however, to be evaluated carefully, because during the preceding five years or so a mood of extreme optimism had spread throughout the fishing industry of the Atlantic coast, due to the persistence of a strong market, appearance of capital from private sources outside the industry and the mounting volume of financial and other forms of assistance in the region. In the meantime a brake on further rapid expansion of the fleet appeared in the form of a shortage of skilled manpower. At the same time, the price for the major product derived from groundfish species, i.e. frozen blocks of fillets, began to weaken. Moreover, the catch per vessel-ton-year (as a measure of yield per unit of input) has tended to decline: by 15 to 20% since 1950.

Under these circumstances it would be more realistic to assume that the present rate of expansion for the Atlantic large trawler fleet might be maintained for some time, at least for the period 1966 to 1970. A net increase of 10 vessels per year would approximately amount to an increase of about 15,000 gross tons.

Development of the fleet of medium-sized craft and inshore boats, which accounts for the major part of the cod catches, cannot be assessed. Prior to 1965 there was a substantial increase in the number of medium-sized fishing craft (50 to 100 feet in length approximately) i.e. small draggers, longliners and seiners, but these have, at least to a considerable extent, replaced larger numbers of small boats.

---
(1) In addition there were about 55 to 60 vessels between 75 and 100 feet (100 to 200 gross tons).

Faroe Islands

The Faroese fishing fleet in 1965 consisted of about 170 units above 20 gross tons, accounting for a total of about 35,000 gross tons. Most important were 59 steel longliners, representing 17,000 gross tons, with an average age of 4 years. The rebuilding of this fleet must be considered as terminated. 11 trawlers with about 9,000 tons are second in importance, but since 1957 there has been considerable decline in this section.

The Faroese fishery is at present in a transitional stage, the future way to go being difficult to anticipate. Salted cod operations face serious economic difficulties so that some conversion to purseseiners for herring fishing has already taken place. Traditionally, Faroese fishing is mainly a distant water operation and it is at present being considered whether its position can only be maintained by going into freezing at sea (or combined freezing/salting). One freezer trawler (part-freezer) was purchased from Germany in 1966 but whether more will follow until 1970 cannot be anticipated. It is therefore assumed that the Faroese fishing capacity (for groundfish) will remain stagnant or decrease slightly.

France

First, it must be decided which part of the French fishing fleet is to be included in this study. Obviously, the salters and the new freezers operated or ordered by the owners formerly specializing in salted cod must be taken in since they exploit far distant grounds (Newfoundland, Labrador, West Greenland). But among wetfish vessels, although a number of them are fishing exclusively in the North Sea or in the Atlantic south of the British Isles, others spread their operations over the North Sea, Norwegian Sea, and grounds as far west as the Faroe Islands or Iceland

For the purpose of the present study, consideration will only be given to those vessels which can be called far distant, i.e. which are likely to fish grounds further than the North Sea.

(a) Wetfish, or former wetfish, fleet

This heading covers the wetfish fleet (or former wetfish fleets), of 40, or more likely 50 meter vessels. The decision to build such vessels is not at present easy. The financial help to be expected from the authorities is limited and the economic conditions are not too favourable. Competition from other European countries has increased partly as a result of the Common Market and market prices have not developed as favourably in France as they have in other European countries. Possibilities of development exist in the consumption of deep-frozen fish but French owners are entering this venture rather late and are faced with powerful foreign competitors.

It would perhaps be a reasonable forecast to schedule about 20 new vessels between 40 to 50 metres, all stern trawlers and ready to be fitted with freezing equipment on board without structural modifications. It should be added that part of these vessels would be exploiting only the North Sea, being therefore outside the scope of the North Atlantic as defined for the present exercise. It is therefore between 6 to 10 vessels, nearer 50 meters than 40 meters, which might be added to the fleet exploiting North Atlantic grounds.

Any forecast on the degree of scrapping is much more difficult than on the rate of new construction. It can, nevertheless, be assumed that the older vessels will be kept in use as long as they are profitable. Therefore, if no radical changes happen in the course of the following years, either with regard to the catch rates of the different grounds of the North Atlantic or with regard to the market for fish and fish products, scrapping will only touch the older vessels and these scrappings would be more or less compensated by new entries of vessels in the range of 40 meters.

(b) Salters and cod fleet

The last new salter was launched about 5 years ago and it seems certain that present conditions will not allow any new vessels of this type to be built. The owners have, therefore, switched to part or full freezers, but this has created problems: the investments are enormous and difficult for individual firms which explains why some of the new vessels have been built on a cooperative basis.

The new vessels at present in operation (2) or under construction and due to begin exploitation in 1967 (4), make a total of six vessels, all of which are stern trawlers, full or part freezers of a gross tonnage of between 1,500 and 2,000 G.R.T. Although other projects have been studied, it is not certain whether they would be confirmed. The financial means would be difficult to collect and the developments in the market for frozen fish during the last one or two years have been rather unfavourable. Taking into account unforeseeable developments, it is nevertheless possible that some of the projects for three new part-freezer trawlers could be realized.

With regard to scrapping, it would seem that most of the present salters which are more or less completely written off are still in good condition and would be kept in operation.

Overall, this conservative forecast would, therefore, lead to the following increases (from 1965 until the end of 1970) all being full or part freezer:

around 50 meters	... ...	1,000 G.R.T. ...	6 to 10
around 70 meters	... ...	1,500/2,000 ...	4 to 7

(these figures include all vessels put in service from the end of 1966 onwards)

<u>Germany</u> (Federal Republic)

At the end of 1965 the German distant-water fleet consisted of 155 units representing a total gross tonnage of about 130,000. About half of this capacity (62,000 gross tons and 98 vessels) were wetfish trawlers, 14 of them being also fitted with fishmeal plants. Of the 57 freezer trawlers (68,000 gross tons) 7 units (15,000 gross tons) were full freezer trawlers, freezing all their catch, 11 (15,000 gross tons) potential full freezer trawlers, part of their hold capacity being convertible for wet or frozen fish and 39 units (38,000 gross tons) part freezers, with varying processing and storage capacity.

The development of the German distant-water fishing fleet in recent years has been characterized by the emphasis on freezing at sea. Of the 60 units (approximately) which entered the fleet after 1960, only 8 were traditional wetfish trawlers; and, at present, a considerable share of the wetfish supplies in Germany is landed by part-freezer trawlers. The main factor for this development was the increased need to exploit more distant waters because the extension of fishing limits and biological changes in formerly exploited grounds had resulted in declining catches. Factors on the market side were very largely responsible for the emphasis on building <u>part</u>-freezer trawlers. Until 1964 the gap between first-hand prices for frozen fish and the higher prices for wetfish had widened; in 1965, however, this gap was nearly closed but in 1966 prices for wetfish rose considerably, while the international market for frozen fish showed a weakening tendency.

These factors are relevant when attempting to forecast future developments in the German fleet and the present uncertain conditions of both production and marketing make this very difficult. One will have to assume that certain conditions will not change drastically, e.g. catching prospects and market outlets; only then can broad tendencies be indicated.

Under present conditions the wetfish fleet is likely to be reduced. Considering the age distribution of this fleet, one can expect that in 1968-1969 between 25 to 30 vessels (15,000 to 20,000 gross tons) will be scrapped and that this will be only partly compensated by new additions to this section of the fleet.

The fleet of part and full freezer trawlers is fairly new and no scrapping can be envisaged in this fleet before 1970. As some units of the wetfish fleet will be replaced by freezer trawlers there will be probably an expansion of this fleet with possible emphasis on full freezer trawlers.

	1965 fleet (a)		1970 projection (a)	
	No	'000 gross tons	No	'000 gross tons
Wetfish trawlers	98	62	74	54
Freezer trawlers:				
part-freezer (b)	50	53	59	69
full-freezer	7	15	17	35
Total	155	130	150	158

(a) beginning of the year
(b) including "potential full freezer"

Taking into account the consideration made above, it is likely that the total number of distant water trawlers will slightly decrease, but that there will be a certain net increase of the total gross tonnage in the range of 25,000 and 30,000 tons. As the wetfish fleet will show a contraction of about 8,000 to 10,000 gross tons, the expansion of the freezer fleet would amount to 35 to 40,000 tons, of which 20,000 tons would be full freezer vessels (cf. Table).

It has, however, to be emphasized that both scrapping and replacement will depend on the development of marketing conditions and that a further deterioration of catching prospects in the North Atlantic will accelerate the scrapping program and impede new investments.

But even if the estimated increase in total gross tonnage should eventually be realized, it cannot be assumed that all will be added to the catching power on the North Atlantic groundfish stocks. Already in the past year some trips of freezer trawlers have been made to the South Atlantic (South Africa) and some effort was diverted to herring stocks in the North Sea and off Iceland. If present catching conditions for groundfish do not improve an expansion of freezer operations in the South Atlantic is likely and it could even occur that most of the gross tonnage of full freezer trawlers is switched to these grounds. Also, considering the stable herring market in Germany (processing industry) some expansion of herring fishing cannot be excluded. The increase of total catching capacity exerted on North Atlantic cod and related species might thus only be in the magnitude of 10,000 to 15,000 gross tons, mainly consisting of part-freezer trawlers.

Greenland

Greenland's fishing fleet consists mostly of small boats for use in inshore waters; at the beginning of 1965 only 5 vessels were above 50 feet. In the course of 1965 two 80 footers (130 gross tons) and two 95 footers (200 gross tons) were commissioned and it is the expressed aim of the Danish authorities and the Royal Greenland Trade Department to develop cod fishing on the offshore banks. Plans exist for the construction of a 500 ton stern trawler. It should therefore be envisaged that the fishing capacity of the Greenlandic industry continues to increase.

Iceland

The number of deep sea trawlers has shown a declining tendency for a number of years. In 1965, 38 units representing about 27,000 gross tons were in operation as against 48 units (33,000 gross tons) in 1960. During 1966 another six trawlers were withdrawn from the fleet, total gross tonnage contracting to 23,000 gross tons.

Future developments are difficult to forecast. The present trawling fleet seems to be operating at a loss, but on the other hand, this sector is important as supplier of the processing plants ashore (particularly deep-freezing). Operating subsidies have therefore been introduced to maintain present fleet strength.

Furthermore, consideration is being given to the question of which type (size, etc.) of new trawler would be suitable for operations from Icelandic ports. It can, however, be assumed that new units would basically only replace old trawlers taken out of commission.

Another section of the Icelandic fleets has expanded considerably in recent years: the number of vessels of 100 GRT and over increased from 86 (14,000 gross tons) in 1960 to 181 (40,000 gross tons) in 1966. Smaller decked vessels less than 100 GRT slightly declined in number (650 in 1960 to 575 in 1966) and gross tonnage (23,000 gross tons and 19,000 gross tons respectively). In the former group, emphasis has been on building purse-seiners for herring fishing.

Norway

At the end of 1965 the Norwegian fishing fleet included the following vessels over 80 feet, partly or totally used for groundfish fishing:

18 stern trawlers (including 2 freezer trawlers)
45 side trawlers (over 200 gross tons)
about 50 longliners (some combined with purse-seining)
about 70 combined purse-seiners/side trawlers (100 to 200 gross tons)

In addition were the boats, all under 80 feet, engaged in Lofoten spawning cod and the Finnmark young cod fishery. In 1964, 5,400 vessels participated in the fishery off Lofoten and 1,800 vessels off Finnmark.

Investment in the groundfish industry has been limited in recent years. Most of the capital available from the State Fishery Bank and private sources went into more profitable purse-seiners for herring fishing, the number of which has augmented considerably. In 1965 the loan scheme provided by the State Fishery Bank was extended for liners and trawlers. This might encourage new capital injections to this sector in the period 1966-1970, but its eventual impact cannot be anticipated at this stage. No forecast for an increase or decrease of the Norwegian groundfish fleet is therefore made.

Poland

Poland's catches until now have been mainly derived from "middle waters." Of the 1965 catch (about 300,000 tons) roughly two-thirds came from the North Sea and Baltic Sea, the remaining third being, approximately, divided equally between the North Atlantic (56,000 tons) and the South Atlantic.

Original Polish plans aimed at an increase in total catch to 450,000 tons in 1970 (increase of 50% over 1965) and to 900,000 tons by 1980. The plans assumed that catches from the Baltic and the North Sea are stabilized around 200,000 tons, and an addition of about 100,000 tons of herring was expected by 1980 from grounds in the North Atlantic. The rest of the 1980 plan was to be made up of 400,000 tons of groundfish from the North Atlantic (of which about 250,000 tons would be cod) and about 200,000 tons from the South Atlantic (100,000 tons of which would be for reduction to meal). In the meantime, this plan has been revised and the 1970 total has been raised to 500,000 tons and the 1980 total to 1 million tons.

Implications of these plans would be that North Atlantic groundfish catches (particularly cod, haddock and redfish) are to increase to between 150,000 and 200,000 tons by 1970.

In trying to realize this program, Poland will expand its fishing fleet considerably, particularly as regards vessels capable of undertaking self-dependent trips to distant grounds. The number of factory trawlers (around 2,500 to 3,000 gross tons) is to increase from 15 in 1965 to 30 in 1970 (60 in 1980); the number of freezer trawlers (1,200 to 1,300 gross tons) from 6 to 20 (62 in 1980) and the number of "motor-trawlers with freezing plants" (around 800 gross tons) from 28 to 49 (128 in 1980). Up to 1970 this represents an addition of approximately 75,000 gross tons to the fishing fleet, against which only a restricted number of vessels not concerned with North Atlantic groundfish (drifter-trawlers and small cutters) are expected to be scrapped. (In the plans for the decade 1970-1980 another 200,000 gross tons will be added to the fleet).

According to production plans the larger part of the 75,000 gross tons net addition will have to operate on the North Atlantic groundfish stocks, and a conservative estimate would be that the total gross tonnage operating there under the Polish flag will increase by about 50,000 gross tons (40,000 to 60,000 gross tons).

Portugal

New vessels to be built for Portuguese owners might represent a tonnage smaller than the old vessels to be taken out of operation. The higher efficiency of the new vessels will, however, have the result that total fishing effort in 1970 should be about equivalent to the present one.

Spain

The Spanish fishing fleet has developed in recent years more than any other Western European fleet, but this development mainly concerns vessels with deep-freezing equipment on board which were built for exploiting South Atlantic grounds. The consequence is, for the present exercise, that it is not difficult to assess which part of the increased capacity, which already exists, must be allocated to North Atlantic grounds; it is small indeed, but the Spanish fishing enterprises show an overall dynamic attitude which might also lead in future years to an increased capacity for the North Atlantic grounds.

The Spanish authorities play an important role in the growth of the fishing fleet and publish, attached to the official statistics, figures for new constructions up to 1970. These figures do not unfortunately separate the vessels fishing for hake in the South Atlantic from the vessels exploiting the cod stocks of the Northwest Atlantic. It can, nevertheless, be assumed that these two fleets will not easily be intermingled. The market for fresh hake is an important traditional market in Spain and it took a number of years to create a market for frozen hake, a product which is still sold at prices significantly lower than the same species as wetfish. The market for salted cod is also an important traditional market and there has not yet been any real attempt to establish a market for frozen cod. No radical market changes should occur before the end of 1970, but it is likely that the Spanish fisheries, pushed by the example of other North Atlantic fleets and by their own experience in the South Atlantic, would in the years to come launch some frozen cod fishing in the North Atlantic. In any case, the length of time spent at sea by salters or freezers is only limited by the hold capacity of the vessel and by the necessity of refuelling; if the number of vessels remains unchanged, the pressure on stocks will not be considerably increased. It should, nevertheless, be noted that the new vessels which will be introduced into the North Atlantic grounds will benefit from the latest technical improvements, the result being a noticeable increase in fishing capacity.

The attached table gives a summary of the present Spanish projections. It should be noted that they are specified in tonnage without indication of the number of vessels. As it can be seen, the expansion should influence mainly the upper tonnage groups (over 500 G.R.T. and between 500 and 250 G.R.T.); the lower groups should be kept at a similar or lower total, but significantly modernized. It obviously means that the fishing capacity, susceptible to be used on distant grounds including the North Atlantic, will be increased. It cannot, nevertheless, be said to what extent this increased capacity will be used in the North Atlantic waters.

United Kingdom

Present structure of trawler fleet

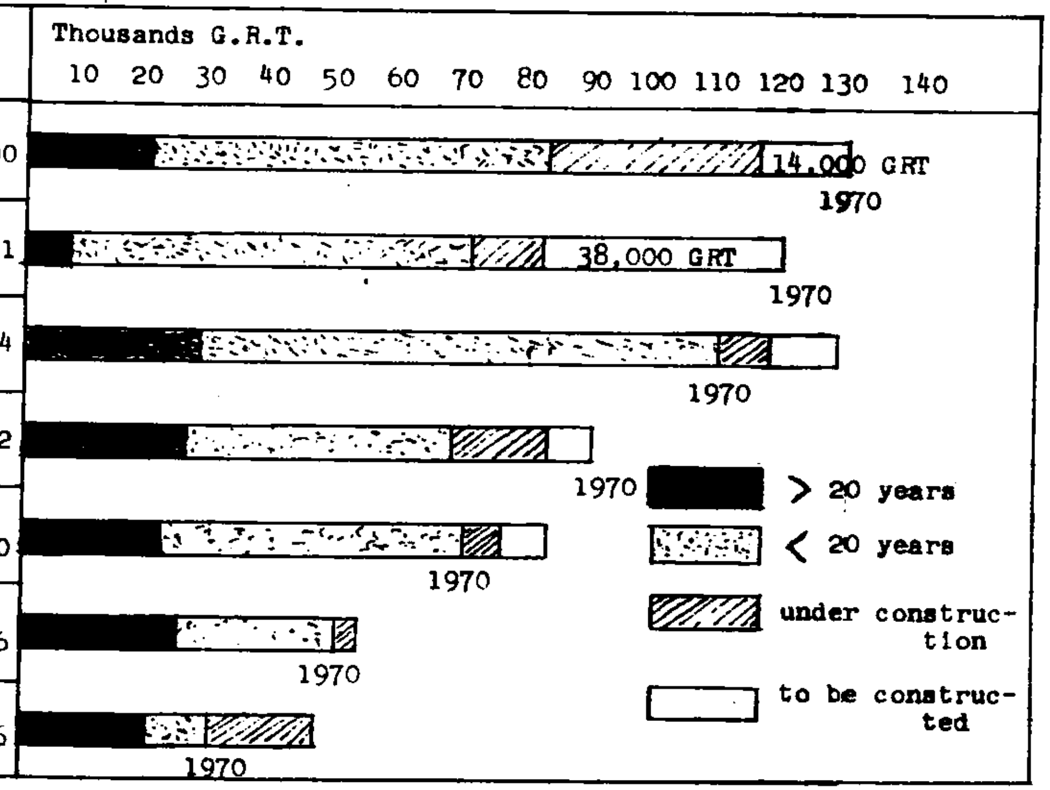
The following table shows the age structure of the trawler fleet at 31st December 1965:

Year of construction	Near 80 to 109.9 ft	Middle 110 to 139.9 ft.	Distant 140 ft. & Up	TOTAL
Pre-1921	4	3	-	7
1921-1930	20	1	-	21
1931-1940	10	-	17	27
1941-1945	8	1	8	17
1946-1950	17	7	65	89
1951-1955	25	12	32	69
1956-1960	85	111	46	242
1961-1965	60	57	28	145
TOTALS	229	192	196	617

COMPOSITION AND STRUCTURE OF THE SPANISH FISHING FLEET

IN DECEMBER 1966

Group	Class	Vessels built before 1950	Vessels built since 1950	under construction	Crew
I	>500 GRT	16	59	33	3,000
II	>250 to 500 GRT	23	188	31	4,071
III	>150 to 250 GRT	156	467	55	9,484
IV	>100 to 150 GRT	210	355	121	8,742
V	>50 to 100 GRT	310	766	86	17,150
VI	>20 to 50 GRT	761	647	84	17,186
VII	upto 20 GRT	3,632	5,442	-	39,806



Projected structure

In attempting to project this structure to 1972, reference has been made to the changes between 1962 and 1965 as, at the same time, representing a recent period in which conditions are likely to be most similar to those operating in the next few years and more practically, because it was the earliest year in which the length groupings coincided with current ones.

Comparison of the two years showed that the distant water fleet was replaced more chronologically than either of the other two and the near-water fleet least so This is thought to be due to the greater need for operating reliability in vessels fishing further afield and because smaller vessels are associated with smaller firms some of whom are perhaps prepared to accept a lower level of efficiency rather than bear the cost of replacement.

Thus, comparatively few pre-1946 near-water vessels were scrapped during the 3 years compared with three-quarters of the middle-water and two-thirds of the distant-water vessels built before that date. It has been assumed that by 1972 the near-water fleet will lose all pre-1921 vessels; 50% in the 1921-30 class and 20% to 1955. The replacement rate is assumed at the scrapping rate of 1:1 1/2 although the effective rate could be greater than this if second hand vessels are bought from abroad or less than this insofar as vessels are scrapped without replacement

For the middle and distant water projections, losses have been assumed at 100% pre-1940; 75% in 1941-45; 40% in 1946-1950; 25% in 1951-1955 and, for the distant water fleet only, 5% in 1955-60. Thereafter it is assumed that net losses will be nil. As with the near-water fleet, replacement rates have been assumed at existing scrapping rates or 1:1 1/2 for conventional trawlers and 1:2 for freezers although it is possible that the industry will succeed in replacing at a higher rate than this.

Application of these assumptions gives the following projected structure at December 1972.

Year of construction	Near Water 80-109.9 ft.	Middle Water 110-139.9 ft	Distant Water 140 ft & Over	Total
1921-1930	10	-	-	10
1931-1940	8	-	-	8
1941-1945	6	-	2	8
1946-1950	14	4	39	57
1951-1955	20	9	24	53
1956-1960	85	111	44	240
1961-1965	60	57	28	145
1965-1972	23	15	37	75
Totals	226	196	174	596

Similarly detailed projections have not been made for other parts of the fleet but the inshore fleet (vessels generally less than 80 ft.) may increase its capacity by between a quarter and a third. As a result, the number of distant water vessels is forecast to decrease from 196 to 174. Against about 60 withdrawals from the fleet are 37 additions. Assuming that the replacements have a somewhat higher average tonnage than the older vessels, total gross tonnage might not change significantly. It should be added that the 13 freezer trawlers which entered the fleet in 1966 represented about 20,000 gross tons.

The number of middle-water trawlers shows a slight increase and taking into account a likely increase in average size, should increase their overall capacity.

United States

Conservative estimates about new investments in the New England trawler and dragger fleet up to 1970 have been given as follows:

2 stern trawler factory ships (292 ft) (one of which is scheduled to operate in the North Atlantic)
2 stern trawlers (135 ft.)
25 trawlers or scallopers (90 to 110 ft), but mainly scallopers

Considering the age composition of the New England trawling fleet (in 1961 about 40% were more than 40 years old) it can be assumed that apart from the factory ships, these investments will be exclusively for replacing vessels to be taken out of operation, and it is even likely that scrapping will outnumber replacements in tonnage, total fishing effort potential might, however, remain similar due to improved efficiency. The two factory vessels, the first to enter the United States fleet, represent a gross tonnage of about 4,000 to 5,000 gross tons.

USSR

Soviet official figures for shipping at 1 January 1965 give 2,370 vessels of over 100 gross tons in the Soviet fishing and whaling fleet, totalling about 1.8 million gross tons. According to another source, the following Soviet vessels have been estimated for the end of 1965:

800 medium and small trawlers (under 800 gross tons)
250 large factory trawlers (800 to 3,000 gross tons)
and 50 mother ships
in addition there were about 150 large refrigerated transport vessels.

The Five-Year-Plan 1966-70 provides for an increase in the USSR fishing fleet of 1,500 units, of which about 250 will be of the freezer-factory trawler type (2,500 to 3,000 gross tons). A mother ship of more than 40,000 gross tons is at present under construction at Leningrad, and others (number unknown) will enter the fleet by 1970.

This 1966-1970 plan also envisages an expansion in total annual fish production from about 5 million metric tons in 1965 to 7 million metric tons in 1970, an increase of 40%. The growth in catching power required to achieve this aim is in the order of 500,000 to 600,000 gross tons (this would exclude transport vessels and non-catching mother ships).

It is realized that the expansion in production can only be achieved if additional, at present unfished, areas in the oceans are exploited and thus emphasis will be on the South Atlantic, South Pacific and Indian Ocean. The catch from the Pacific and Indian Ocean is to augment from about 2 million tons in 1965 to 3.2 million tons in 1970. Assuming that catches from freshwater, the Caspian, Black and Baltic Seas will stabilize around 1 million tons, the increase to be expected from the Atlantic will be about 800,000 metric tons (from 2 million to 2.8 million tons). Thus the effort of the combined USSR fleet in the whole Atlantic Ocean can be expected to increase at least by 40%, or around 200,000 gross tons. A large part of this additional effort will most probably be directed toward the South Atlantic and another part to pelagic species (herring) or species other than cod and haddock (e.g. silver hake) in the North Atlantic. What proportion of this completely mobile effort will exploit groundfish stocks will depend on relative catch rates, but even if only a small percentage of the total (say 20%) will be directed to these stocks, it would mean a considerable increase in gross tonnage (40,000 gross tons).

Other Countries

The foregoing sections do not include a number of countries known to have or to be developing a fleet capable of fishing in the Atlantic, e.g. Italy, Greece, Netherlands and Belgium. Italian and Greek operations are mainly confined to the middle Atlantic; for Belgium, no particular development has been envisaged; the Netherlands have recently launched the first freezer trawler (1,200 gross tons). Moreover, some other countries have to be mentioned here, which have recently started fishing operations: Israel and Romania, who operate a number of freezer trawlers in the Central and North Atlantic. Bulgaria has at present a fleet of 4 large freezer stern trawlers (about 3,000 gross tons) operating in the South Atlantic, and this fleet is to increase to 20 by 1970. Cuba has purchased a number of trawlers which are scheduled to produce salted cod etc. from North Atlantic grounds.

Summary and Conclusions

The assessments made for single countries in the foregoing sections will have made it clear that the margins of possibilities render it difficult to arrive at a meaningful overall forecast for the North Atlantic groundfish fishing fleet in 1970. By simply adding together the extremes for the various countries, one would arrive at a total net addition of between 100,000 and 200,000 gross tons or about 10 to 20% of the present North Atlantic trawling fleet. But this needs more specification to guard against misinterpretation.

The most important part of this overall estimate (60,000 to 140,000 gross tons) originates from the planned expansion of the fishing fleets of Poland and USSR. It should be recalled, however, that a considerable part of the scheduled growth in these countries has been excluded from the forecast as being built for other than North Atlantic whitefish fisheries but that most of these units will also be capable of operating in the North Atlantic. Indeed, they are likely to do so, particularly if favourable years occur and/or if other grounds outside the North Atlantic show signs of over-exploitation.

Changes foreseen in OECD member countries' fleets are relatively small and in fact, for most of them, no increase of gross tonnage is in prospect (e.g. Faroe Islands, Iceland, Norway, Portugal, United Kingdom and USA. Moreover, it should be borne in mind that forecasts for these countries are largely based on present conditions as regards catch rates, markets, availability of capital including subsidies, manpower availability, etc. Any change of these data, mostly beyond the operators' influence, might completely change their decision as to both scrapping and new investments. Recent history provides ample evidence in a number of countries of the mood changing quickly from extreme optimism to pessimism or conversely. These additional circumstances render the forecasts for the OECD member countries particularly uncertain.

There is nevertheless an important aspect which is common to all these countries: all desire to maintain their present fishing capacity and, if financial means allow it, to improve efficiency by replacing old vessels by more modern ones. For a number of years the profitability of the different fleets has often been marginal or bad, which is an incentive toward improving efficiency. In this regard, it should be recalled that the trend toward more freezing at sea and better fishing techniques (electronics, progress in fishing gear), implies an increase in effort even if total number of vessels or total gross tonnage remain stable.

As new units, as well as replacements, will be more efficient than the average existing vessel the estimated net increase of gross tonnage does not provide sufficient indication of the expansion of fishing power to be expected. Freezer trawlers, in particular, represent a noticeable increase of fishing effort in terms of days or hours fishing, as the productive time spent fishing is about 70 to 80% of total trip duration as against 35 to 50% for conventional wetfish vessels.

APPENDIX V

Control of Fishing on Several Stocks

by J. Gulland
FAO, Rome.

Ideally each stock of fish should be separately managed, with its own appropriate control of size at first capture (mesh size) and fishing mortality (catch quota, effort limitation, etc.). This is impracticable, and probably the most easily enforceable control for the North Atlantic would be a global catch quota, allocated by countries, for each species. This however does not guarantee an appropriate level of fishing for any stock; for example in 1960 the N.E. Arctic cod stock was overfished, though for the North Atlantic cod as a whole further expansion of effort was possible i.e.if a global quota had been set in 1960, as the sum of the desirable quotas of each stock, it would not have been reached, and the N.E. Arctic would have been still over-fished.

To illustrate the problem the fishing effort (mortality) on the three major cod stocks of eastern part of the North Atlantic (Arcto- Norwegian, Iceland and West Greenland) in each year since 1953 has been calculated as a percentage of the optimum effort for each stock. These optima were estimated, from the various working group reports as being: i) half the 1963 effort, ii) the 1954 effort, and iii) 70% of the 1965 effort respectively. In addition, the catches (quotas) that would have been taken each year if, in that year the effort had been brought to the optimum level, have been calculated, and the total of these quotas compared with the actual total catch from the three areas. The total catch, expressed as a percentage of the total quota gives a measure of the reduction of effort which would be achieved by applying a global quota.

The table shows that while appreciable reduction of effort on the Arctic stocks would have been desirable as early as 1953, in that year, and also in 1954, the total catch did not reach the global quota, so that a global quota would have caused no reduction in fishing. Later, say 1960, a global quota would reduce the total amount of fishing, - by 44% of the optimum level - but this is substantially less than the reduction needed in the Arctic, while the Greenland effort in fact could still be increased.

Table I

Fishing efforts (mortalities) in various areas of the N. Atlantic as percentages of the optimum level of effort

Year	Effort, % of optimum Arctic	Iceland	Greenland	Total Catch (Thousand tons)	Quota	Catch as % of quota
1953	124	88	41	1467	1758	84
1954	129	100	58	1669	1697	98
1955	168	96	57	1953	1713	114
1956	200	87	61	2145	1753	122
1957	170	103	60	1513	1353	112
1958	176	118	77	1598	1284	124
1959	168	125	87	1431	1073	133
1960	178	152	89	1339	929	144
1961	202	151	116	1502	934	161
1962	209	148	112	1738	1095	159
1963	200	156	120	1571	974	161
1964		187	129			

[Note, that these quotas are the quotas that would be necessary if in that particular year, the effort was reduced to the optimum level. They therefore correspond to the reduced interim catches taken in the transitional period while the stocks are rebuilding to the optimum level. The quotas that could have been taken if the effort had been kept at the optimum level since 1955 would of course be much greater.]

Some further protection of particularly heavily fished stocks, such as those in the Arctic, is therefore desirable. It is suggested that a closed season could provide such protection, provided that it is operated as a supplement to the global quota.

Since this possible over-fishing of one stock is assumed to be taking place within a global quota which is set correctly, some other stock, included in the total, must be correspondingly under-exploited. The season would then be chosen to take place at a time when substantial fishing occurred on the over-fished stock, but also fishing was also feasible on the under-fished stock. The closed season on the over-fished stock would then encourage fishing on the other. The duration of the closed season would be chosen to give the correct quantitative reduction; e.g. if fishing were spread evenly through the year a reduction of 8% would be achieved by a close season of about one month. Thus for example in 1953 the Arctic grounds mught have been closed for a period during which, other things being equal, about 20% of the catch would have been taken - say for the months of July and August. This would not change the total fishing much, as some effort would be diverted from the Arctic to Iceland and Greenland - perhaps bringing the Iceland effort close to the optimum, and the Greenland effort up to 60% of the optimum. As another example, if limitation had been brought in 1960, to reduce the fishery in the Arctic very greatly, and increase the fishery at Greenland, then it might be necessary to close the Arctic grounds for 3 months, the Iceland grounds for one month, and leave the Greenland grounds always open.

By itself a closed season does not allow the economic advantages of reduced effort to be achieved. Without other restrictions the individual country, or commercial enterprise will tend to increase its fishing during the open season so as to maximise its share of the catch, and there will be the well known scramble for the biggest share, leading to a shorter and shorter season and increased costs of applying a given fishing mortality. Under the present scheme, assuming the global quota has been allocated to countries this will not apply. If a country fishes harder say in the Arctic during the open season and thus gets a bigger share of the Arctic catch, then it will have less of its quota available to be taken at Iceland and Greenland, and will gain no overall advantages.

Any advantage in having more of the presumably more readily caught Arctic cod will be balanced by difficulty of keeping the fishing fleet fully occupied throughout the year. Thus any country which can fish in any area will have no need to compete in a scramble for the biggest share in an area where a closed season may apply.

A country which cannot switch its effort from area to area would however be at a disadvantage. For instance, if the concentration of the USSR fishing on the haddock on George's Bank which occurred in 1965 were continued, then it might be necessary to close the area for 6 months to keep the effort at the optimum level, to the obvious disadvantage of the local U.S. fleet, which has little alternative, at least for cod and haddock, and therefore could not take advantage of less USSR fishing on other grounds, e.g. Labrador. This difficulty might be overcome if a country had its share of the total quota assigned to a particular area or stock; in return for an undertaking not to fish on other stock the country's vessels would not be bound by the closed season. For instance, the U.S. might decide to take its quota only in Subarea 5, and its share might be say 80% of the total. This could be taken at any time, and a closed season set, if necessary, for the mobile fleets such that their catch make up the other 20%. This seems to give a reasonable balance; any advantage that the non-mobile fleet has in its local area being set against the advantage for the mobile fleets in the other areas. This concept could be extended so that closed seasons only applied to mobile vessels (perhaps vessels above a given size, perhaps 400 gross tons), but that smaller vessels would only be licensed to fish in one area; such an arrangement might cover the difficulties of some countries, e.g. Norway, with both large and small vessels.

This scheme seems to provide enough flexibility to achieve considerably better management of the separate stocks than would be achieved by global catch quotas alone. The problems of enforcement also seem not too large; at least there is no need, for enforcement purposes, to establish the source of a particular catch of fish, as there would be if separate catch quotas are established for each ground.