COOPERATIVE RESEARCH REPORT

No. 139

REPORT ON THE FIFTH DIALOGUE MEETING
4 OCTOBER 1985

International Council for the Exploration of the Sea
Palægade 2-4, DK-1261 Copenhagen K
DENMARK

September 1986

https://doi.org/10.17895/ices.pub.5529

ISSN 2707-7144

ISBN 978-87-7482-493-0

TABLE OF CONTENTS

---ooOoo---

DIALOGUE MEETING, 4 OCTOBER 1985

1. INTRODUCTION

The Fifth Dialogue Meeting was held at Church House, London on 4 October 1985 and was chaired by the President of ICES, Professor W.S. Wooster. The General Secretary and Statistician served as Rapporteurs.

The meeting was attended by about 70 scientists, administrators, managers, and fishing industry representatives. A list of participants is given in Annex 1.

The President opened the meeting at 09.30 hrs, welcomed the participants, and presented a brief introductory statement (Annex 2). He indicated that fishery management consists of three levels of activity: 1) establishing harvest levels and structure, 2) allocating the harvest, and 3) enforcing regulations. ICES is concerned only with the first of these levels, but scientists alone cannot set harvest levels. The tasks of the Dialogue Meeting are to: 1) explore the extent to which managers and scientists agree on the kind of scientific advice to be provided; 2) consider how best to improve the quality and timeliness of stock assessments and predictions; and 3) examine ways to improve communications between scientists and managers.

Written presentations and discussion focused on five main topics which are listed in Annex 3. Eight papers were submitted to the meeting, five prepared by ICES scientists and three by representatives from the management and industry sides.

2. PRESENTATIONS

2.1 Mr Ø. Ulltang, Chairman of the Advisory Committee on Fishery Management (ACFM) commented briefly on the report of the May 1985 ACFM meeting. He drew particular attention to the assessment problems created by the increasingly unreliable catch statistics available for some fisheries (e.g., those, such as the North Sea whiting fishery, subject to high rates of discarding) which resulted in uncertainty in the estimation of the fishing mortality (F) rates associated with the total catch.

He reviewed the five categories of stocks for which ACFM provides advice on catch levels (TACs) depending on their state and the level of exploitation (Reports of the ICES Advisory Committee on Fishery Management, 1983, ICES Coop. Res. Rep. 128):

1. Stocks which are rapidly depleted and suffering from recruitment failure. In these cases, ACFM shall not calculate options but shall <u>recommend</u> a single figure.

2. Stocks which are fished at levels largely in excess of the levels indicated by biological reference points. In these cases, ACFM shall give options inside safe biological limits, and shall recommend one of these options, according to the general principles of aiming at more stable levels of stock and catch.

3. Stocks which are fished at levels not very different from the biological reference points. In these cases, ACFM shall give options inside safe biological limits, but shall not recommend any particular one of these. It shall only indicate a preference, which is in line with the general principles mentioned above.

4. Stocks where at present it is not possible to carry out any analytical assessment with an acceptable reliability. In these cases, ACFM shall indicate precautionary TACs to reduce the danger of excessive effort being exerted on these stocks.

5. In cases where fisheries on a stock are not subject to TAC regulation, there may be a danger of catches taken from stocks of the same species in adjacent areas being misreported as having been taken in areas of unregulated fisheries. To reduce the risk of this happening, ACFM, on occasion at the request of management bodies, has advised an implementation of TACs and their levels on this basis. Since, in the majority of cases, the data on these stocks are inadequate for analytical assessment, they too will generally be recommended as precautionary TACs based on historic levels.

Mr Ulltang pointed out that short-cut methods of assessment are useful, but have their limitations, such as not indicating the present fishing mortality rate and not indicating the current position of the fishery on the yield-per-recruit curve. He also drew attention to the recent developments in multispecies assessments which would be dealt with in more detail in another presentation (Section 2.8).

2.2 A statement was presented by the Norwegian Ministry of Fisheries (Annex 4) which included some general comments on ICES advice. It stressed the need for ACFM reports to clearly define the issues and problems for the various stocks. It urged the scientists to state their preferred recommendations and, if possible, in a longer-term perspective. Effort regulation is a necessary component of fishery management, but in view of the excessive capacity of most fishing fleets, catch quotas will continue to be necessary. It emphasized that ICES should not become involved in the economic aspects of formulating management advice as this should be dealt with in a national context. The multispecies approach to fisheries management is important and further work in this area is to be encouraged.

2.3 A discussion paper presented by the Netherlands Ministry of Agriculture and Fisheries (Annex 5) associated the general lack of success of fisheries management in the Northeast Atlantic with 1) the current management objective of aiming to reduce fishing mortality to F_{max} or $F_{0.1}$ and 2) the use of catch regulation by annual TACs to achieve that objective. This management measure leads to undesirable fluctuations in supply for the fishing industry and makes it impossible to develop a long-term management strategy. As an alternative, it proposed a "total target catch" (TTC) as a new management objective which, when reached, should be maintained for 3-5 years. In addition, the paper outlined the advantages of effort regulations, through licensing, as an alternative to, or together with, catch regulation and requested that ICES provide advice on the appropriate effort levels associated with the catch predictions.

2.4 Dr V.C. Anthony (USA) presented a paper which reviewed the attempts within ICNAF to introduce effort regulation in the Northwest Atlantic (Annex 6). This review summarized discussions and events which took place from 1964 to 1973. Discussions in the 1960s led to the adoption of catch quotas as a means of regulating fishing mortality, but by 1973 it had become obvious that single-species catch quotas were not reducing fishing activity. Endeavours were made in 1973 to introduce effort control within ICNAF. It was proposed to use "days on grounds" as the unit of effort for management. The problem, however, was to equate this to fishing mortality. It had become evident after considerable analysis that data were not sufficient to establish a workable international effort limitation scheme.

Dr Anthony identified the following major problems associated with effort regulations:

1) no standard unit of measure,

2) increases in efficiency require constant recalibration,

3) the relationship of fishing effort to fishing mortality varies for many reasons,

4) fishing power of some effort types is not known, and

5) effort information generally is not available.

It was acknowledged that it is probably not possible to resolve all of these problems on a international basis, but that effort can probably be allotted approximately at the national level. It then becomes a national problem to allocate effort amongst the individual fisheries and fleets. This allocation problem cannot be solved by scientists, but is a responsibility of managers.

2.5 Dr Anthony presented another paper (Annex 7) which reviewed the by-catch and biological interaction problems encountered in the Northwest Atlantic in the 1970s and described the unique catch quota system implemented by ICNAF during 1974-1977 to address these problems. By 1973, the catch of all major species in ICNAF Subareas 5 and 6 was regulated by total allowable catches (TACs) and national catch quotas. Because of large by-catches in the directed fisheries, actual catches generally exceeded the TACs. This problem was resolved to a great extent by the imposition of a "second-tier" quota which was set at a level about 20% less than the sum of the individual species TACs using linear programming techniques. The overall effect of this type of regulation was to reduce by-catch and to control catches on a species basis to less than the TACs. The percentage of overall nominal catches taken in directed fisheries (excluding mackerel and "other pelagic" fisheries) increased from 50% in 1972 to 75% in 1976.

2.6 Mr J.R. Lauritsen of the Association of Fish Meal and Fish Oil Manufacturers in Denmark presented a paper (Annex 8) on the future regulation of the North Sea industrial fishery. He considered that the present prohibition on the catching and landing of herring for purposes other than human consumption should be abolished and that the by-catch percentages (of whiting and haddock) in the industrial fisheries for Norway pout and sandeel should be increased. The paper stressed that, in view of the present status of the stocks concerned and the changing dependence of the Danish fishing industry on human consumption and industrial outlets, existing regulations fail to adequately promote the basic objectives of fishery management of regulating catch levels for conservation reasons and of distributing, for social reasons, the available catch among nations to ensure reasonable economic development in areas heavily dependent on fishing.

2.7 Dr W.G. Doubleday (Canada) presented a paper which described the Canadian system of fisheries management in the Northwest Atlantic since 1977 (Annex 9). He indicated that management measures by ICNAF were initially confined to minimum mesh regulations, but these were followed in the early 1970s by catch regulations (TACs and catch quotas), based on F_{max} and $F_{0.1}$ criteria, and control of fishing effort. Following the extension of its fisheries jurisdiction to 200 miles in 1977, Canada continued the use of catch quotas corresponding to the $F_{0.1}$ objective as well as effort control. Canada, as the coastal state, first determines its share of each TAC and then the surplus, if any, is allocated to other countries. The number of vessels licensed from each country corresponds to the days on grounds required to harvest the allocation, based on recent catch rates of the vessel/gear classes involved. Canadian vessels are also subject to catch and effort restrictions. The combination of catch and effort regulations has resulted in a rebuilding of groundfish stocks.

2.8 Mr D.J. Garrod (UK) presented a paper which reviewed the present status and likely future developments in multispecies assessment with respect to ICES scientific advice (Annex 10). He pointed out that complex predatory/prey interactions exist between species such that the abundance of one species can have an effect on the abundance of another. Multispecies assessments are an elaboration of these interactions which focus on immediate management problems. Research to date has shown that natural mortality in many fish stocks varies with age, being much higher at younger ages (0-2 years) than previously assumed in assessments, thus leading to higher estimates of stock size at the younger ages. It has also been shown that, because of the interaction between species, the target level of fishing to optimize the yield from two or more species may not be the same as it is for any of the species taken in isolation, as in the single-species assessments.

Multispecies models are technically feasible and, since they offer the potential benefit of increased long-term yield, must be considered worthwhile. Their use by managers depends on long-term management objectives, which hitherto have not been made clear. Scientists are committed to the multispecies approach, but both scientists and managers must adopt a wider approach involving perhaps area-based assessments and a regional component in management structures and discussions.

2.9 A final paper prepared by the ICES Secretariat (Annex 11) described the processes within ICES of providing advice on the management of fish stocks, including the past and present procedures and methods employed by the assessment working groups and ACFM, and the problems confronting their work. The paper stressed the need for the biological advice to be within the range of acceptable economic decisions and for the biological output to be tailored to the needs of economic analysis, which should be undertaken at the national level.

3. DISCUSSION

The discussions were focussed on the main themes in the order in which they are set out in Annex 3. They are summarized below.

3.1 Mr M. Holden (Commission of European Communities) thanked ICES for holding another Dialogue Meeting and made a number of comments relative to the presentation by the Chairman of ACFM. He said that the catch option tables and the standard plots provided for most stocks in the ACFM reports were very helpful and important, but considered that the projected by-catch of whiting in the most recent assessment of the North Sea industrial fisheries was unrealistically high and stressed the need for a more realistic assessment for that stock.

He also pointed out that $F_{0.1}$ is not a biological, but an economic reference point and, therefore, is not of any particular relevance with respect to the scientific resource management advice.

Concerning the advice for the North Sea roundfish stocks, Mr Holden stressed that since current levels of fishing mortality (F) are far in excess of F_{max}, reductions in F to the F_{max} level as recommended by ACFM would have severe economic and social consequences. Consequently, their implementation would involve tough political decisions and fishermen would need to be consulted about them. In view of this and the fact that stock-recruitment relationships for these stocks are not clearly evident, he questioned whether such a reduction is justified.

Mr Holden felt that ACFM had shirked its responsibility in failing to advise on a specific TAC for the West of Scotland saithe stock. In such situations when data are unreliable, ACFM should still do an assessment and identify the problems with the data. He suggested the more frequent use of the *status quo* method in cases where data are insufficient for an analytical assessment because it uses information other than average catches.

3.2 The Chairman of ACFM responded by agreeing that the by-catch F in the industrial fishery is a problem. Whilst agreeing that the $F_{0.1}$ reference point has no specific biological foundation, he pointed out that it is particularly helpful in the case of flat-topped yield-per-recruit curves. Concerning the advice by ACFM to reduce F towards F_{max} for the North Sea roundfish stocks, he felt that this was the most useful advice that could be provided in the present situation. In the case of the West of Scotland saite stock, he indicated that new data are needed and that a new assessment will be provided in November 1985, but that the stock is not in any danger at the present. He stressed that the *status quo* method requires recruitment data, which are lacking for the West of Scotland saithe stock.

3.3 Mr R. Jones (UK) pointed out that regulating a fishery at F_{max} on the yield-per-recruit curve is not necessarily synonymous with achieving maximum yield. The attainment of F_{max} will not necessarily stabilize a fishery, but it should help by reducing the variability in yield.

3.4 Dr J.-P. Troadac (France) noted that fishing mortality should ideally be at some level below F_{max}, but raised questions concerning the meaning of the yield-per-recruit reference points and how variability is dealt with. He considered that recruitment estimates have to be based on probabilities using past data.

3.5 Dr J.G. Shepherd (UK) commented on the question of stability in catches and indicated that because variability in recruitment leads to variability in stock size and catch per unit effort, a constant level of effort will result in variable catches. It would be economically impractical to reduce effort (and fishing mortality) to a level low enough to stabilize catches over the long term. Therefore, managers and the fishing industry must discuss their objectives and decide if they want stability of catch or stability of effort; they cannot have both.

3.6 Mr T.S. Paulsen (Ministry of Fisheries, Norway) observed that ICES advice has gone from "normative" to "exploratory" and felt that more explanation is necessary in the ACFM reports concerning the different management options for each stock, the "category" in which each stock presently exists (i.e., exploitation level), and the option which scientists think is best. He appreciated the medium-term advice which ACFM has provided in recent years for the North-East Arctic cod and haddock stocks.

3.7 Mr B.B. van der Meer (Netherlands) was concerned, from a management point of view, that the way in which biological advice is presently given results in too many fluctuations in the fisheries and that a more consistent policy is needed.

3.8 The Chairman of ACFM commented that increased stability is achieved by decreasing fishing mortality. He noted that the year-to-year fluctuations for some stocks are becoming more and more severe, which are due, at least in part, to the high levels of F on those stocks.

3.9 Mr M. Haddon (Ministry of Agriculture, Fisheries and Food, UK) considered that the predicted by-catches in the industrial fisheries need to be more realistic. Tables as well as graphs in the ACFM reports which illustate the different forecast options are very useful, but a clearer presentation of the implications and consequences of the different options would be desirable. It would also be helpful if the consequences of alternative levels of catch in the current year relative to the forecast catches and stock sizes could be indicated. A clearer explanation of the basis of precautionary TACs should be provided since these do have important consequences. He also agreed that variability is a problem and that choices between the available management options are politically difficult. He stressed that mixed fisheries present difficult problems for managers and that it is important for these fisheries to be considered by the scientists.

3.10 The Chairman of ACFM responded, concerning precautionary TACs, that scientists, when using them, are in a bad position because they have no information on the size of the stock and are unable to say much more than what has been said in their reports.

3.11 Mr J. Løkkegaard (Ministry of Fisheries, Denmark) indicated that the different reference points (fishing mortality levels) in the options tables in the ACFM report have little meaning for managers or people in the fishing industry. They would be more interested in the effect of, for example, a 10% increase or decrease in fishing mortality (fishing effort).

3.12 In the discussion on topic 2, "Effort regulation as an alternative to, or together with, catch (TACs and quotas) regulation", the Chairman of ACFM, responding to the Dutch paper (Annex 5), indicated that there are some advantages to effort regulation, but that ACFM would get into great difficulty attempting to calculate effort levels by fleet, country, etc. He stressed that effort allocation should be a national responsibility and that ACFM should confine itself to providing advice on the status of the stocks.

3.13 Mr G. Sætersdal (Norway) felt that the total target catch (TTC) proposed in the Dutch statement may be possible but that effort control at the international level would be very difficult because of having to equate the fishing power of different vessels. He agreed that some kind of effort control was necessary, such as a limitation on the number of vessels, but that ICES and ACFM should not become involved in this, or in economic analysis, as it is not within their scope of competence.

3.14 Mr H. Schlapper (Federal Ministry of Food, Agriculture and Forestry, Federal Republic of Germany) also felt that there was no basis for effort control at the international level because of major political issues, but that it would be appropriate at the national level. He agreed that stability was very difficult to achieve and that there should be more discussion among managers and the fishing industry on management issues. He noted that managers tend to ignore recommendations for 5-10% reductions in catch as this type of advice does not imply a serious problem. ACFM should provide estimates of the long-term potential catch for each stock as a guide to managers in making short-term decisions.

3.15 The Chairman stressed the need to maintain a clear view of the role of ICES in the fishery management processes. ICES should restrict its activity to stock evaluation, the results of which can be fed into the follow-up management processes.

3.16 Mr Lauritsen acknowledged that the industry recognizes the need for fishery management, but also is looking for some stability. The main task of ICES is to provide biological advice, not advice on effort which requires social and economic data.

Concerning by-catch and discarding in the Danish industrial fishery, he pointed out that by-catch regulations are an appropriate element of the management measures for that fishery, provided they are based on conservation objectives. However, if the by-catch (e.g., of haddock and whiting) is restricted too much, it can ruin the main fishery for Norway pout. Flexibility in by-catches, reflecting a balance between the fisheries and the stocks, is required. Scientific advice on this matter is requested from ACFM.

Concerning stability, he noted that constant catch levels for a particular stock cannot be achieved in the practical world. Some measure of stability can perhaps be achieved by the industry if it switches from stock to stock.

Mr Lauritsen also indicated that the North Sea herring stock appears to be rebuilt and that the present TAC is greater than what the human consumption market can handle. The situation is fast approaching where the recommended catch levels can have an adverse effect on the market, and discarding represents a waste of the resource.

3.17 The Chairman of ACFM noted the conflict between protecting human consumption fisheries and allowing by-catches in the industrial fishery, but pointed out that a lack of data from the fishery still poses a problem in advising on regulatory measures which could minimize by-catches without causing too much disruption of the industrial fishery.

3.18 Mr van der Meer, whilst agreeing that ICES should not become involved in providing advice on fishing effort regulations, considered it entirely appropriate for it to deal with and provide advice on its technical aspects.

3.19 Mr Garrod stated that managers must decide on their objectives before scientists can provide the appropriate advice. Variability in catch appears to become a management problem only when TACs are reduced. There appears to be a tendency for an upward drift in exploitation when managing fisheries by means of status quo TACs.

3.20 Dr R. Boddeke (Netherlands), commenting on the unsuccessful attempts by ICNAF to implement effort controls (Annex 6), indicated that whilst this method of management undoubtedly has many difficulties and problems, it should not be forgotten that the present method of management by TACs is far from adequate, and felt there is a need for a more balanced look at both catch and effort regulation.

3.21 Mr A.E. Peterson, Jr. (USA) said that fishery management is a question of risk and that the role of scientists in the management process should be to assist in minimizing this risk and to provide the long-term predictive capabilities. He felt that managers must formulate their objectives more explicitly and should maintain continuing dialogue with the scientists in relation to achieving them.

3.22 Mr W.F. Hay (Scottish Fishermen's Federation) reported that virtually all vessels in Scotland are skipper-owned and, therefore, effort regulations would have a harsh impact on the vessel owners' livelihoods. Concerning the industrial fishery, he was critical of the level of by-catch by Danish vessels and urged that scientists recommend the percentage by-catch levels that would not be detrimental to the human consumption fishery. He also noted that many Scottish fishermen dislike closed area regulations and would prefer to have a limited fishery.

3.23 Mr C. Rode Jensen (Ministry of Fisheries, Denmark) pointed out that there is uncertainty in the basis for ICES advice and in the objectives of management. Managers need to establish objectives. Even though effort control is important, it is unlikely that much progress could be made in this regard; but progress can be made in defining objectives. ICES advice should be structured so as to improve fisheries management in general, and regulatory measures other than TACs need to be considered.

3.24 Professor R. Freire (Portugal) reminded the meeting that ICES is an advisory body and should concentrate on studying the total environment of the biological system. It remains a political decision to decide what should be maximized in a fishery.

3.25 Professor B.J. Rothschild (USA) indicated that managers must be more specific in stating their objectives as they are generally very complicated and are often changing. He observed that if scientists are not legally competent and if managers are not technically competent to formulate management objectives, then who is going to do it? He felt that considerably more time and effort must be spent in analyzing this problem, determining the future role of the scientists (e.g.,ICES), and identifying what other steps need to be taken.

3.26 Mr N.D. Atkins (National Federation of Fishermen's Organizations, UK) acknowledged that the Canadian management measures (Annex 9) involving effort control have been successful, especially in relation to third-country fishermen. He considered that since ICES advice is increasingly being translated directly into management regulations, it is most important that the present uncertainties in it be reduced so as to generate greater confidence in it on the part of the managers and the fishing industry. He hoped that ICES advice would continue to remain independent of political and socio-economic factors and asked for a wider distribution of ACFM and assessment working group reports.

3.27 The Chairman pointed out that ACFM currently lacks competence in the field of economics because professional economists are not represented on it. Furthermore, this Dialogue Meeting has no legal competence or authority to implement any of the suggested changes, but rather its aim is to see how well ACFM is doing its defined tasks and to identify ways in which this might be improved. Any fundamental changes in the ICES role in these matters would have to be decided by the Council of ICES. He noted that ACFM is presently not responsible for communicating with the fishing industry, only with the managers. He noted with approval the views expressed from the management side that ACFM should keep its advice free of political, social, and economic considerations.

3.28 Mr Schlapper agreed that ICES should keep its advisory system "clean" and commented that the complexity of the fishery situation in the European parts of the ICES area would not make the Canadian management scheme very useful or applicable there.

3.29 Mr J. Møller Christensen (Denmark) agreed with the comments made by Prof. Rothschild and wondered who is going to do the work (e.g., development of new regulatory schemes, management objectives, effort analyses, etc.). He felt that work would have to be intensified at all levels and that ICES should take a leading role in looking at ways to accomplish this.

3.30 Dr Shepherd pointed out that less attention should be paid to maximization and more to determining the effects of changes, which sometimes may be relatively small.

3.31 Mr F. Doyle (Irish Fishermen's Organisation) emphasized that his fishermen had always been wary of restrictive licensing schemes and that this meeting had been useful in pointing out the advantages and disadvantages of effort control. It is important, he felt, that whatever type of regulations are used, they must be enforced to be effective. It is also useful for ICES to be aware of the views and ideas of the fishing industry.

3.32 In the discussion of the multispecies assessment problem, Mr Sætersdal indicated that the approach to this in the Arctic region is easier than in the more southerly areas because there are fewer species and they live near to the limit of their ecological ranges. He drew attention to changes in the stocks of cod and shrimp in the Barents Sea which might be the consequence of interaction between them and which might provide the basis for constructing a multispecies model.

Additionally, there appears to be some relationship between capelin and cod, and possibly between capelin and herring in this area. The Barents Sea capelin stock has undergone a dramatic decrease in abundance in recent years which has been accompanied by a shift in distribution, a reduced growth rate, and a decrease in larval survival. The rapid increase in cod in 1984-1985 may have led to increased predation on capelin. Also, the large increase in Norwegian spring-spawning herring, due to the very strong 1983 year class, may have influenced the survival of larval or juvenile capelin.

He noted that the use of these predator/prey interactions should increase the capability to predict recruitment in these stocks and that it is hoped the improved knowledge will provide a basis for multispecies interactive management.

3.33 Dr Boddeke posed a question relative to the allocation of "rewards" arising from Figure 3 in the paper on multispecies assessments presented by Mr Garrod (Annex 10) which contained a landings value isopleth for the cod and Nephrops fisheries. The figure was interpreted as implying that a large part of the fleet "weeds out" the less valuable predatory cod, leaving a small part of the fleet to harvest the much more valuable Nephrops.

3.34 In the discussion of topic 5, "Nature and form of interaction between ICES and Fishery Management Bodies", Mr Holden questioned whether fisheries administrators can be considered as managers, but felt instead that the politicians, who respond to the various pressures to which they are subjected, especially from their fishing industries, are the actual managers. This is the case in the EEC where the Commission interprets the scientific advice and drafts legislation but the Council of Ministers makes the final decisions. He indicated that within the EEC, the management objectives have to be set in the light of these pressures and circumstances. Because of this, there is no single long-term management objective within the Community; but a current aim is to endeavour to maintain the fishing mortality at the same level from year to year.

Mr Holden agreed in principle that effort control is desirable, but there is no clear evidence that such measures will be applied at the Community level in the near future; in fact, the present Common Fisheries Policy is based on TACs and technical conservation measures for the next 10 years. He did not think that ACFM should become involved in effort regulation matters.

He noted that the present relationship between the EEC and ACFM is, regrettably, rather distant. The information in the ACFM reports is very useful, but the timeliness of the advice could be improved.

3.35 In this general context, Dr Shepherd drew attention to a UK paper prepared for the current Statutory Meeting (ICES C.M. 1985/G:73) which proposed various procedural and institutional changes to the present fisheries management procedure, including the provision of scientific advice by ICES for the Northeast Atlantic fisheries. He stressed that these proposals were aimed at developing a more cooperative system which, among other things, would ensure closer interaction among managers, scientists, and the industry. One proposed change would result in a more general advisory role for ACFM instead of its current role of reviewing every assessment.

3.36 In commenting on the discussions which had taken place at the meeting, Mr D. de G. Griffith (Ireland) identified three major points which he felt were appropriate for further consideration:

1) ICES should investigate ways in which a wider distribution of ACFM and assessment working group reports could be achieved.

2) The stock assessment and advisory procedures of ICES should not involve economic considerations, but ACFM could perhaps formulate its advice in a way which would be more amenable to economic analysis. A dialogue between scientists and economists would be mutually beneficial and the next Dialogue Meeting should concentrate on this area.

3) The managers' desire for stability in the fisheries (one can aim to stabilize catch or effort but not both) should be considered further at the next Dialogue Meeting at which the question, what is meant by stability and how can it be achieved, should be a major item for discussion.

3.37 In concluding the meeting, the Chairman endorsed these points and indicated that there might be a need for ICES to convene a symposium on the general basis of fishery management. It should be widely based, involving inputs and participation by all of the groups involved in the management process. He thanked all participants for their attendance at what he considered had been a useful series of discussions which he thought had confirmed the importance of dialogue between the parties concerned. The meeting terminated at 16.30 hrs.

ANNEX 1

LIST OF PARTICIPANTS

Dr E.D Anderson
International Council for
the Exploration of the Sea
Palægade 2-4
DK-1261 Copenhagen K
DENMARK

Mr K. Andreassen
Føroya Landsstyri
3900 Torshavn
FAROE ISLANDS

Dr V. Anthony
Northeast Fisheries Center, NMFS/NOAA
Woods Hole, Mass. 02543
USA

Mr N.D. Atkins
National Federation of
Fishermen's Organizations
Exchange Buildings, Fish Dock Road
Grimsby DN31 3NJ
ENGLAND

Dr. O. Bagge
Danmarks Fiskeri- og
Havundersøgelser
Charlottenlund Slot
2920 Charlottenlund
DENMARK

Mr A.D. Baird
Scottish Pelagic Fishermen's
Association
35, Albert Street
Aberdeen
SCOTLAND

Ms E.A. Blackwell
North-East Atlantic Fisheries Commission
Great Westminster House
Horseferry Road
London SW1A 2AE
ENGLAND

Mr J.G. Boavida
Praça Duque da Terceira
1200 Lisbon
PORTUGAL

Dr. R. Boddeke
Netherlands Institute for
Fishery Investigations
Postbus 68
1970 AB IJmuiden
NETHERLANDS

Mr L.P. Brekk
Norwegian Fishermen's Association
P.O. Box 519, 7001 Trondheim
NORWAY

Mr D. Cross
EUROSTAT
B.P. 1907
LUXEMBOURG

Mr. A.H. Dobbie
Fisheries Organization
Society Ltd.
New Fish Quay
Brixham, Devon TQ5 8AW
ENGLAND

Dr W.G. Doubleday
Department of Fisheries & Oceans
Fisheries Research Directorate
200, Kent Street
Ottawa, Ont. K1A OE6
CANADA

Mr. F. Doyle
Irish Fishermen's Organization
Cumberland House
Fenian Street
Dublin 2
IRELAND

Dr R.L. Edwards
Northeast Fisheries Center
NMFS/NOAA
Woods Hole
Mass. 02543
USA

Professor R. Freire
INIP, Avenida Brasilia
1400 Lisbon
PORTUGAL

Mr D.J. Garrod
Fisheries Laboratory
Lowestoft
Suffolk NR33 OHT
ENGLAND

Mr D. de G. Griffith
Fisheries Research Centre
Abbotstown
Dublin 15
IRELAND

Dr J. Guéguen
IFREMER
B.P. 1049 rue de l'Ile d'Yeu
44037 Nantes Cédex
FRANCE

Mr M. Haddon
Ministry of Agriculture,
Fisheries & Food
Great Westminster House
Horseferry Road, London SW1P 2AE
ENGLAND

Dr D.A. Hancock
Western Australian Marine
Research Laboratories
West Coast Highway
Waterman, Box 20
P.O. North Beach, WA 6020
AUSTRALIA

Dr L. Hannerz
National Board of Fisheries
Box 2565
403 17 Gothenburg
SWEDEN

Mr M. Hauge
Ministry of Fisheries
Drammensveien 20C
Oslo 1
NORWAY

Mr W.F. Hay
Scottish Fishermen's Federation
35, Albert Street
Aberdeen
SCOTLAND

Mr B. Heerink
Ministry of Agriculture and Fisheries
Bezuidenhoutseweg 73
's-Gravenhage
NETHERLANDS

Mr M. Holden
Commission of the European
Communities
Directorate General for Fisheries
200, rue de la Loi, 1049 Brussels
BELGIUM

Mr A. Holm
Directorate of Fisheries
P.O. Box 165
5000 Bergen
NORWAY

Dr P. Hovart
Station de Pêche maritime
Ankerstraat 1
8400 Ostende
BELGIUM

Mr K. Hoydal
Director of Fisheries
Tinganes
3800 Torshavn
FAROE ISLANDS

Mr D.M. Hudson
Ministry of Agriculture,
Fisheries and Food
Great Westminster House
Horseferry Road
London SW1P 2AE
ENGLAND

Mr D.E. Hutchinson
Grimsby Fishmeal Co. Ltd.
Pyewipe
Grimsby, Humberside
ENGLAND

Mr J. Jakobsson
Marine Research Institute
Skúlagata 4
Reykjavik
ICELAND

Mr C. Rode Jensen
Ministry of Fisheries
Stormgade 2
1470 Copenhagen K
DENMARK

Mr R. Jones
Marine Laboratory
P.O. Box 101, Victoria Road
Aberdeen AB9 8DB
SCOTLAND

Mr J. Keohane
Department of Fisheries & Forestry
Leeson Lane
Dublin 2
IRELAND

Mr J. Kleniewski
Ministry of Maritime Economy
Department of International Coop.
ul. Hoza 20, Warsaw
POLAND

Mr H. Lassen
Danmarks Fiskeri- og
Havundersøgelser
Charlottenlund Slot
2920 Charlottenlund
DENMARK

Mr J.R. Lauritsen
Association of Fish Meal and
Fish Oil Manufacturers
Vestergade 11
1456 Copenhagen K
DENMARK

Mr J. Løkkegaard
Ministry of Fisheries
Stormgade 2
1470 Copenhagen K
DENMARK

M A. Maucorps
B.P. 1049
rue de l'Ile d'Yeu
44037 Nantes Cédex
FRANCE

Mr B.B. van der Meer
Ministry of Agriculture and Fisheries
Bezuidenhoutseweg 73
's-Gravenhage
NETHERLANDS

Capt. W.J. Muschkeit
Lengstrasse
2850 Bremerhaven
FEDERAL REPUBLIC OF GERMANY

Mr J. Møller Christensen
Danmarks Fiskeri- og Havundersøgelser
Charlottenlund Slot
2920 Charlottenlund
DENMARK

Mr B. Naylor
Department of Agriculture and
Fisheries for Scotland
Chesser House, Gorgie Road
Edinburgh E14 3AW
SCOTLAND

Dr J. Netzel
Sea Fisheries Institute
Aleja Zjednocezenia 1
81-345 Gdynia
POLAND

Mr N.A. Nielsen
Danmarks Fiskeri- og
Havundersøgelser
Charlottenlund Slot
2920 Charlottenlund
DENMARK

Dr I. Olsson
National Board of Fisheries
Box 2565
403 17 Gothenburg
SWEDEN

Dr H. Oostrom
Ministry of Agriculture and
Fisheries
Bezuidenhoutseweg 73
's-Gravenhage
NETHERLANDS

Dr B.B. Parrish
International Council for the
Exploration of the Sea
Palægade 2-4
1261 Copenhagen K
DENMARK

Mr T.S. Paulsen
Ministry of Fisheries
Drammensveien 20C
Oslo 1
NORWAY

Mr A.E. Peterson, Jr.
Northeast Fisheries Center
NMFS/NOAA,
Woods Hole, Mass. 02543
USA

Dr K.H. Postuma
Netherlands Institute for
Fishery Investigations
Postbus 68, 1970 AB IJmuiden
NETHERLANDS

Mr M. Prendergast
Department of Fisheries & Forestry
Leeson Lane
Dublin 2
IRELAND

Dr B.J. Rothschild
University of Maryland
Box 38
Solomons
Maryland 20688
USA

Mr H. Schlapper
Bundesministerium für Ernährung,
Landwirtschaft und Forsten
Postfach 140 270, 5300 Bonn
FEDERAL REPUBLIC OF GERMANY

Professor A. Schumacher
Institut für Seefischerei
Palmaille 9
2000 Hamburg 50
FEDERAL REPUBLIC OF GERMANY

Mr E. Sekkelund
Bygmarken 96
7730 Hanstholm
DENMARK

Dr J.G. Shepherd
Fisheries Laboratory
Lowestoft
Suffolk NR33 OHT
ENGLAND

Mr B. Sjöstrand
Institute of Marine Research
Box 5
453 00 Lysekil
SWEDEN

Mr J. Sprus
Association of
Fisheries Enterprises
Odrwaza 1
Szczecin
POLAND

Dr S.A. Studenetsky
VNIRO Research Institute
Verkhne-Krasnoselskaya 17
Moscow B-14
USSR

Mr J. Søndergaard
Grønlands Hjemmestyre
Danmarks Kontoret
Sjæleboderne 2
1122 Copenhagen K
DENMARK

Mr G. Sætersdal
Institute of Marine Research
P.O. Box 1870
5011 Bergen-Nordnes
NORWAY

Dr J.-P. Troadec
B.P. 1049
rue de l'Ile d'Yeu
44037 Nantes Cédex
FRANCE

Mr Ø. Ulltang
Institute of Marine Research
P.O. Box 1870
5011 Bergen-Nordnes
NORWAY

Dr M. Windsor
North Atlantic Salmon
Conservation Organization
11, Rutland Square
Edinburgh EH1 2AS
SCOTLAND

Professor W.S. Wooster
Institute of Marine Studies HF-05
University of Washington
Seattle, Washington 98195
USA

Mr O.J. Østvedt
Institute of Marine Research
P.O. Box 1870
5011 Bergen-Nordnes
NORWAY

ANNEX 2

INTRODUCTORY REMARKS

Warren S. Wooster
President of ICES

Fishery management consists of 1) establishing harvest levels and structure, 2) allocating the harvest, and 3) enforcing regulations pertaining to 1) and 2). At the national level, scientists may be concerned with any of these elements, but their principal contribution is to the first. In the international fisheries of the ICES area, fishery scientists in their ICES capacity are only concerned with the first.

Harvest levels are set to achieve a variety of objectives, one of which is "conservation"; others include political, economic, or social objectives. Thus, scientists alone cannot establish harvest levels. If, for example, ICES scientists propose TACs to achieve "biological" objectives, the implication is that other objectives are secondary or irrelevant. Thus, it has become accepted that the more appropriate sort of scientific advice from ICES is in the form of predictions of stock response to alternative fishing scenarios, with perhaps an indication of which would be preferable from the point of view of the "health" of the stock.

These thoughts suggest that the Dialogue Meeting has the following tasks: a) to explore the extent to which management and ICES fishery scientists agree on the kind of scientific advice to be provided; b) to consider how best to improve the quality and timeliness of stock assessments and predictions at an acceptable cost; and c) to examine ways to improve communications between the providers and users of ICES scientific fisheries advice.

In considering the proposed discussion topics for the 5th Dialogue Meeting, I have the feeling that the question of effort vs catch regulation is more appropriate for fishery management bodies than for ICES scientists, i.e., that it pertains to the second and third aspects of fishery management rather than the first. The question of the scientific aspects of the multispecies approach, on the other hand, is directly related to the second task of this meeting.

ANNEX 3

DISCUSSION TOPICS FOR 5th DIALOGUE MEETING

1. Brief presentation of, and comments by Managers on, main items in report of ACFM meeting in May 1985.

2. Effort regulation as an alternative to, or together with, catch (TACS and quotas) regulation.

3. Problems encountered with the present TAC advice system, including the problem of mixed fisheries.

4. Scientific aspects of the multispecies approach to resource management and implications for future advice.

5. Nature and form of interaction between ICES and Fishery Management Bodies.

ANNEX 4

STATEMENT BY THE NORWEGIAN MINISTRY OF FISHERIES

1. The ICES dialogue has become a valuable institution. It provides a forum for all parties concerned with fisheries management to get together to discuss the problems in an open-minded way. We seldom have a chance to do that internationally as our meetings are usually in the context of formal negotiations. At such meetings, the atmosphere is often different.

   So let us compliment ICES for taking the initiative to establish a dialogue and for having seen to it that the dialogue meeting has come to stay. A number of different items have been listed on the agenda for this meeting. Many of them are interrelated. The different questions will surely be dealt with in detail and in depth. At this juncture, we should like to make a statement of a more general sort.

2. When the expert puts his case, then it is all important that the message comes across clearly. In our case, that will require the reports of the ACFM to be presented in such a way that decision makers can see the issues at hand. In the past, we felt perhaps that the mode of expert presentation could have been better. Difficult and technical issues remained difficult and technical. That also made it difficult to decide how to act upon the scientific advice.

   Recent reports of the ACFM are much improved, and the scientists have responded well to the plea made at previous dialogue meetings to cater for the needs of the layman.

3. We have seen another improvement as well. We are presented with management options and are being explained how the different alternatives will affect both immediate and long-term development of the different fish stocks. In this, the scientists are providing a crucial service. The basic challenge to management is after all to strike a balance between long-term resource management objectives and immediate industry requirements. The scientific community will no doubt in some cases rightly say that much remains before such a balance is achieved. But decision makers should after all hopefully know more clearly what are the overall consequences of their policies.

4. In the past, we have at times experienced fundamental disagreement over the interpretation of the biological advice submitted by ACFM. Such cases have arisen in connection with fisheries that are in one way or another of a mixed character and/or where we see invariably high by-catches. In what way are the recommended TACS to be applied? Are they all inclusive, or are they meant to deal only with one element of the fishery? The case of herring in the North Sea has provided

discord over interpretation of the advice from ACFM. It is only right that the scientists should know that we have had problems in knowing what they have meant.

5. For certain fish stocks, it remains difficult to know what will be a reasonable long-term management policy. In the case of the demersal joint stocks in the North Sea, recommended catch levels tend to vary considerably from year to year. In addition, there is often a significant gap between the catch levels recommended and the rate of exploitation that the scientists in practice are prepared to accept. That makes it difficult to identify the real biological issues and the weight to attach to the principal scientific recommendations. In this context, we should like to draw attention to one aspect of the multi-option approach which concerns a problem of inadequate weighting. In many cases, we feel that there is a need for stating more clearly which option the scientists are advocating.

   The exercise of careful grading is thus important. If a stock needs stiff protection, then that should be made clear, just as the contrary should apply to stocks that are in an abundant state. Flexibility is thus important to avoid any wrongful impression that the scientists are susceptible to a doctrine of undue biological protectionism.

   In the case of some demersal stocks in the North Sea for example, decision makers will, despite ACFM recommendations, find it difficult to know when to be tough and when to be complacent. Indeed, it is our general feeling that the overall position of the scientists with respect to a better management of these stocks could be more fully stressed, and we should like to see ACFM pronouncing on broad management requirements in a somewhat longer-term prospective.

6. We are glad to see that the question of alternatives to simple TAC arrangements is being put under debate. In this area, we have to do with complementary instruments. The regulation of fishing effort is of course already a widely used instrument. It is applied in national regulations as well as in the context of working out overall fishing plans for foreign vessels operating under allocated quotas. Regulations of fishing effort will provide a basic guarantee against overfishing and will in addition help facilitate control of quota utilization. At the same time, it must be clear that, given the present excess capacity in our fishing fleets, the fishery cannot be effectively regulated unless total quotas are being fixed. At any rate, we envisage the quota instrument to be fundamental also in the future.

7. We have noted that some scientists have made a plea for ICES to take account of economic considerations in the formulation of management advice. We would strongly urge ICES not to do so. The economic implications of a set of management options cannot meaningfully be assessed by ICES, and considerations of economics will have to be dealt with in a national context at the decision-making level.

8. We are often making reference to the ecosystems of the seas. That term also relates to the fundamental interaction between different fish stocks. The regulation of one species cannot be seen in isolation from others. Yet, traditionally we have gone about management within a single-species concept. The reasons are simple. It is the easiest thing to do! It is very difficult to quantify the dividends and costs of a multi-species approach. Valuable research has already been carried out in this area, but we are still in a pioneering phase. Here the scientific community faces an important challenge. We wish to encourage their work in this area.

9. ICES and its Advisory Committee on Fisheries Management are making successful efforts to encourage an ongoing dialogue with the decision-making level. We see an important role also for the representatives of the industry in this dialogue.

ANNEX 5

DISCUSSION PAPER BY THE NETHERLANDS

Introduction

Fisheries management in the North-East Atlantic has, with a few exceptions until now not been very successful. It is our view that this is caused by two main reasons. The first reason is the management objective currently in use (trying to reduce fishing mortality to F_{max} or $F_{0.1}$). As will be explained later, this management objective does prevent the formation of a long-term management policy. The second problem is the main instrument currently in use to reach the management objective (catch regulation by TACs). This system poses a lot of problems and, in our view, effort regulation should be considered as a serious alternative.

Problems with the Management Objective Underlying Present Advice

Present advice of ACFM mainly consists of catch predictions at a number of levels of fishing mortality. In a number of cases, recommendations or preferences are given based entirely on biological considerations, i.e., the reduction of fishing mortality to F_{max} or to $F_{0.1}$.

This management objective and the resulting advice pose the following problems:

1. TACs can differ substantially from year to year while the fishing industry, especially the industry on shore, clearly needs a more regular supply.

2. Even when managers and fishermen would adhere completely to advice given by ACFM, this would not lead to a stable situation nor would it guarantee that collapses of stocks will not occur.

3. The short-term objective chosen makes it impossible to develop a long-term management strategy, a management policy that results in a known stable situation, hopefully with catch levels which will satisfy the needs of the fishing industry.

The Netherlands, therefore, proposes to set a new general management objective:

> for all main species currently assessed, a TTC (Total Target Catch) is set. Once reached, this catch level must be maintainable for a period of three to five years, allowing fluctuations of not more than plus or minus 5%.

The TTC must, of course, be set at a realistic level in a dialogue between scientists, managers, and the fishing industry.

Advice should include predictions of the time needed to reach the TTC and the measures necessary to be taken. Preferably several options should be given in order to facilitate the development and acceptance of a real long-term management policy.

It is evident that, by defining a clear target, many of the problems encountered when trying to convince fishermen of the necessity of catch limitations and technical measures will disappear when the result is known to be a situation that everybody wants. Giving advice based upon the proposed objective should be a challenge for all biologists involved in the work of ACFM.

Effort Regulation as an Alternative to Catch Regulation

The present system of catch regulation (TACs and quota) has a number of clear shortcomings and disadvantages:

1. The TACs and quota only regulate landings, not catches. There is no control at all on discards, which can form a quite substantial part of the total catch.

2. In order to reach an effective regulation of catches, landings must be monitored thoroughly. Until now, this has proven to be very difficult.

3. There is a great incentive for fishermen to circumvent the catch restrictions by several means. One of them is making incorrect landing declarations. This leads to a serious deterioration of catch statistics, which endangers future assessments.

4. In mixed fisheries, closure of the fisheries for one species can lead to a large increase in discards of that particular species. Another possibility is that these by-catches are considered to be unavoidable by prosecution. The consequence of both possibilities is that fishing mortality is not limited to the desired level at all.

Of course, there are also a number of advantages of the TACs and quota system:

1. It is a politically-accepted system with a legal basis.

2. Catch limitations can be based directly on the results of assessments.

3. In theory, each species can be managed individually. (In practice, this is not completely true, e.g., see under 4 above.)

When compared with the system of catch regulation, a system of effort regulation by licensing does score better on a number of the weak points of the TACs and quota system:

1. By limiting effort, all catches including discards are limited. The problem of increased discards as a consequence of closed fisheries on a particular stock does not occur.

2. There is no need to monitor landings, except for statistical and scientific purposes.

3. Control is much simpler and, therefore, probably more effective.

4. There is no incentive for fishermen to fiddle with catch figures, thus no deterioration of catch statistics.

However, a licensing system also has disadvantages:

1. It is no longer possible to manage a single species. It cannot be excluded that a certain stock will be overfished.

2. The system is not really effective for pelagic species which concentrate in small areas and/or in dense shoals.

3. No effort standards are available at this moment. It is, therefore, not possible to make a direct link between the results of assessments and the number of licenses allowed. Due to technical developments, this number will have to be revised from year to year.

4. The system is not (yet) politically accepted.

The first two disadvantages mentioned can, in our view, be overcome by additional measures like closures of certain areas for certain periods for certain types of fisheries. Perhaps for some pelagic species, a TAC will prove to be unavoidable. Lack of effort standards is not the only problem encountered when making the translation from fishing mortality to number of licenses. Apart from technical parameters, catches made also depend to a large extent on things like the skill of the fisherman, the weather, the market situation, etc. The best solution to this problem seems to be to get experience with licensing. The relation between fishing mortality and number of licenses will become clear after some time. Initially, the system could be tried together with a number of TACs for the most threatened species. Since licensing offers clear advantages both to fishermen (more flexibility and no discards of valuable fish) and to managers (simple and better control), political acceptance should only be a matter of time. For scientists, the improvement of landings statistics would have a positive influence on the quality of advice.

The Netherlands would appreciate it very much if ACFM would try to provide advice on "effort allowed" together with the catch predictions presently given. In order to be acceptable within the present political situation, this advice should be in the form of a simple measure of capacity (e.g., engine power, tonnage, number of vessels) specified per area per type of fisheries (e.g., bottom trawling, pelagic trawling, purse seine fisheries, etc.).

ANNEX 6

ATTEMPTS AT EFFORT REGULATION IN THE NORTH ATLANTIC - A REVIEW OF PROBLEMS

V.C. Anthony
Northeast Fisheries Center
Woods Hole

and

D.J. Garrod
Fisheries Laboratory
Lowestoft

Introduction

As fishing fleets become more and more efficient, the management of our marine resources becomes more difficult. More information is needed and corrective actions to reduce overfishing have to be more timely. Single-species catch quotas have been used on both sides of the Atlantic for many years to control fishing mortality with moderate success. As fishing pressure has increased, however, the limitations of single-species catch quotas have become very obvious and the conversations turn to effort control. Many of the views expressed on effort control originated in discussions in the 1960s in NEAFC and ICNAF. Much of the discussion was in ICNAF because that convention offered the possibility of earlier implementation of such measures and the membership of ICNAF was slightly broader than that of NEAFC. The ICNAF events are not familiar to everyone and the objective of this paper is to review the effort discussions in ICNAF in the early 1970s and the events leading up to that point.

Comparison of Methods of Regulation

There are advantages and disadvantages attached to both catch and effort regulations depending on a variety of considerations. The demersal groundfish fisheries of most North Atlantic fisheries are mixed fisheries catching many species. The fishing fleets of many countries have different types of vessels and different types of gear. The economic advantages also differ among countries due to many reasons, such as size and species preference and marketing procedures. Therefore, regardless which method of management is chosen, the advantages and disadvantages will affect each country in different ways. There are, however, some common generic comparisons that can be made between catch and effort regulations. These are summarized in Table 1.

Regulation by catch quotas has the advantage that landings are easy to monitor with most countries doing this routinely. The measurement (usually tonnes) is standard. Most countries routinely monitor their landings for reasons other than catch quota regulation, so no additional costs are required for catch regulation. Catch quotas also can apply directly to a stock. Thus, overfishing from an undue concentration of effort, which might occur under effort regulation, is avoided. Estimates of yield on a species basis are also easier to understand conceptually and may be more acceptable. Catch quotas are easier to allocate nationally because there are historical data bases of catches upon which to base the allocation.

A big disadvantage of this method of regulation is the requirement that abundance and recruitment be calculated correctly every year. The data collection, analysis, and regulation, therefore, must be timely and fairly precise (unless buffers are built into the management system). The biological data needed to provide the required assessment do not exist for many species. Discards are critcal to the estimate of fishing mortality and are often underestimated. Catch quotas do not usually consider the by-catches that occur when several species are managed under single-species quotas and are caught together in a fishery. After the catch quota is taken, fishing effort suddenly has to be diverted to other areas which may intensify problems there.

Regulation by overall catch limits does not result in economic gains unless accompanied by effort regulation. This is because catch quotas encourage competition to take the available quota and result in excess vessels or overcapacity of the fishing fleet. The competition can take place internationally under a total quota system or within a country if national allocations exist.

Effort regulation has great economic advantages over catch regulations. This method of regulation causes no sudden diversion of effort elsewhere. Stock assessments are not required each year and countries and companies have the opportunity to better plan their fisheries each year. If fishing effort is directly proportional to fishing mortality, this method would take care of annual fluctuations in recruitment as the catch would vary with these fluctuations. This assumption may not hold under certain circumstances, however, such as with pelagic species where availability can be a function of abundance or schooling to spawn. This method of regulation minimizes the probability of overfishing on major stocks although the same effort would be applied to all stocks. If the level of effort were set to the MSY of the major stocks, some smaller stocks could be overfished. The by-catch problem could be relieved somewhat through the reduction in total removals. The main disadvantages are in determining a standard measure of fishing effort and making adjustments for changes in fishing efficiency. This measure of effort must also be a direct function of the fishing mortality rate. The total fishing effort applied to a stock of fish depends on the number of vessels employed, their size, power, and the types of gear used, on the number of hours spent fishing, and the particular season and grounds fished. Once such a measure of effort is determined, it has to be recalibrated frequently to account for improvements in fishing technique. The relationship of fishing mortality to fishing effort also changes as fishing changes in space and time. Since catchability changes with time, area, and species from year to year, vessels could concentrate on a different mix of species at different times, allowing changes in fishing mortality. Effort control has been little used in practice to regulate fishing mortality and, therefore, it may be difficult to fully understand or accept. National allocation may be difficult because of the lack of national historical data.

Management of fisheries through the use of closed areas and closed seasons does not generally produce any economic advantages except in special situations (which do not generally occur with demersal fish), such as with pelagic or anadromous species where their schooling or migratory habits alter their vulnerability. Regulation of fishing gear or limitations on the fishing power of vessels could have the reverse effect of decreasing the efficiency and economics of the operation. This is also true of mesh regulations in the short term. Regulation of size limits of fish, realizing that only small proportions of most species survive when returned to the sea, is also essentially inefficient and uneconomic, but might be justified as a necessary support for the enforcement of minimum mesh sizes.

The maximum economic yield is to the left of the maximum sustainable yield on the catch-effort curve. The optimum level of effort, therefore, is different depending on whether one is managing for economic or biological yields.

History of Effort Regulation in the North Atlantic

Serious discussions on the regulations of fishing mortality through restriction on fishing effort began as early as in the 1960s. The ICNAF Commissioners in their third meeting at Hamburg on 4 June 1964 requested:

> "that the Chairman of Research and Statistics and of the Assessment Subcommittee review in general terms the various kinds of action which might be taken by the Commission for the purpose of maintaining the stocks of fish in the ICNAF area at a level at which they can provide maximum sustained yields.--"

The action needed was of two kinds: 1) more research and 2) the control of fishing and catch at the recommended level. This topic was discussed in detail at the Annual Meeting of ICNAF in June 1965 (Templeman and Gulland, 1965). It seemed clear at the time that it was not sufficient to rely only on mesh regulations to control fishing mortality as long as fishing effort continued to increase. For most ICNAF stocks, the amount of fishing was expanding to such a degree that further inceases in fishing would bring no increase in catch and might even reduce the long-term catch. Thus, there was some requirement for the limitation of effort or catch. Problems were similar on both sides of the Atlantic as there was a sustained increase in fishing effort in parts of the Northeast Atlantic following World War II with no increase in total catch but a considerable decrease in catch per unit of effort. The Liaison Committee of NEAFC stated that some regulation of fishing effort or of total catch, thus, would bring beneficial results. While NEAFC was not in a position to recommend specific proposals at that time, it was clear that the problems confronting the managers on both sides of the Atlantic were similar and not independent of one another. If catch limits were introduced in the ICNAF area, significant surplus effort might be directed to the Northeast Atlantic area.

In 1966, the UK presented a memorandum on the subject of regulation of fishing effort (ICNAF, 1966) which provided the first in-depth discussion of the problem. The UK report indicated that the Arctic cod stock was so heavily fished that further increases in fishing effort would actually result in a decrease in the average total catch in the future. The total catch, however, would increase if effort decreased to a level nearly half of the present level. This memorandum discussed in general terms the effect on catches of reducing fishing effort in both situations when size of fish at first capture is small and when size at first capture is relatively large. The various relationships and benefits of regulating mesh sizes along with various levels of effort were also discussed. Management, at this time, relied mainly on mesh regulation for optimizing yield. The concomitant benefits of regulating effort together with fish size were not explored.

The memorandum discussed the economic benefits, as opposed to the biological benefits, of limitations in fishing effort. An economic benefit often occurs when the costs of fishing are reduced. In such cases, the economic benefit occurs at a lower effort level than the effort providing the maximum sustainable yield.

The UK paper examined the various national systems of monitoring catch, effort, and enforcement and the mechanisms by which regulation of fisheries resources could be done within each country. This was reviewed in general terms because of the great difference among countries in their methods of reporting catch statistics, marketing, and mechanisms for enforcement.

The benefits of controlling fishing and mortality on the stocks could be achieved by two main methods, i.e., regulation of the total catch and regulation of the fishing effort directly. Both methods were compared as to data requirements, ease of application, monitoring, and success in a general way.

The total fishing effort applied to a stock depends on the kind, amount, and power of the vessels and gear of each country. At this time in 1966, such detailed knowledge was not available.

The Joint Commissions of NEAFC and ICNAF, therefore, in response to the detailed discussions arising from the UK memorandum and with participation by the Food and Agriculture Organization of the United Nations (FAO) and the Organization for Economic Co-operation and Development (OECD), set up a Working Group on Joint Biological and Economics Assessment of Conservation Actions. Thus, the examination of effort control continued as this Group identified the main benefits and options of effort control as it saw them in 1967 (ICNAF, 1967). These were: 1) the cod and haddock stocks in the North Atlantic were so heavily overfished that a moderate reduction in fishing mortality would not result in a decrease in sustained catch but probably in an increased catch, 2) a reduction in fishing mortality rate on North Atlantic cod stocks would produce a possible savings of 50 to 100 million dollars with the annual catch remaining constant or increasing slightly, 3) a reduction in fishing mortality rate could only be achieved by an allocation of shares of fishing among countries by either catch or effort restrictions, 4) the use of either method seems to be prohibited due to the usual problems, e.g., defining a measure of fishing that was equitable across countries, and for catch control the lack of the considerable amount of data required for calculating current stock sizes, 5) separate regulations of cod-haddock stocks in the North Atlantic were impractical and the combined cod and haddock stocks of the entire ICNAF area and Region 1 of NEAFC should be managed together.

At the ICNAF Annual Meeting in 1967, it was decided that due to the problems of effort calibration as indicated by both the UK memorandum and the Bioeconomics Working Group, catch quotas were the best method of regulating fishing mortality at the moment. To address this issue in particular and other methods of regulation in general, ICNAF set up STACREM (Standing Committee on Regulatory Measures) in 1968 to advise on: 1) the procedure of fixing annual catch quotas, 2) the nature of quotas with respect to species and area, 3) problems of enforcement, 4) principles of distributing quotas among countries, and 5) the administration of catch quotas within countries (ICNAF, 1968a). In 1968, fishing was increasing at its most rapid rate in the Northwest Atlantic area, catches were at their peak, and knowledge of the status of the stocks was still very limited. There were differing opinions among the members of ICNAF on what the objectives of fisheries management should be for this area. One group believed that the objectives should not be just the conservation of the stocks but should address the economic gains that could be realized from effort control. Other members believed that while economic aspects of fishing were important, the emphasis in the short term should be placed on realizing the maximum sustainable yield and on the research needed to determine this level. It was agreed that fishing mortality should be regulated, but this could be done either by direct control of fishing effort or by limitation on catch. It was also agreed that mesh regulations by themselves were not sufficient to control fishing mortality, but that the practical problems involved with directly regulating fishing intensity were difficult to overcome. Further, since the knowledge concerning the fisheries was limited, many on the Committee believed that the emphasis should be placed on determining the health of the various fish stocks, the yield that could be expected from them, and the extent to which the fisheries for such stocks could be conducted independently of other stocks.

Finally, it was stressed that the North Atlantic Convention did not permit ICNAF to recommend measures for the control of fishing effort and while it could propose a global catch limit, it was unable to recommend catch quotas for individual member countries. ICNAF was empowered to provide for conservation of the stocks by allowing for:

1) the establishment of closed seasons,
2) closed areas of spawning,
3) closed areas for protecting young fish,
4) fish size limits,
5) mesh sizes, and
6) overall catch limits.

The Committee thus addressed the aspects of control of fishing mortality by setting up a number of questions that dealt with catch restrictions. One of the questions, however, dealt with the scientific information required to directly regulate fishing intensity. This question received extensive consideration in ICNAF (ICNAF, 1968b) and will be discussed in detail later.

Finally, the USSR indicated that it would only consider catch regulations at the 1968 Annual Meeting. Since the USSR had made the most significant contribution to the increase in fishing which had led to the problem, its view carried overriding weight and ICNAF proceeded to produce a set of proposals for setting up catch regulations. There was general agreement for further research and more discussions on the principles of setting catch (or effort) quotas.

The Report of the 1969 Annual Meeting of ICNAF (ICNAF, 1969) developed the requirements of a catch quota system. A total quota on haddock in Subarea 5 and a closure of spawning areas were imposed in 1970 and an additional total quota on yellowtail flounder was put into effect in Subarea 5 in 1971. It was not until 15 December 1971 that Article VIII of the Northwest Atlantic Treaty Convention was changed to allow for the national allocation of total allowable catches and regulation by effort control. Within one month's time, national allocations of a total catch quota were set for herring for 1972. In 1973, total allowable catches (TACs) and national allocations were applied to 24 species/stocks in the Northwest Atlantic and in 1974-1977 to all major species/ stocks (54-58) supporting an international fishery.

In 1973, however, it became obvious that single-species catch quotas were not reducing fishing activity. The regulation of catches on selected species simply caused fishing to switch to unregulated species. The failure of the catch quota system to control mortality on all species led the USA to call another Special Meeting of STACREM in 1973 to consider a new effort proposal (ICNAF, 1973h). An extensive list of questions was asked by the scientists in addressing this latest initiative on effort control. A special meeting was held in Woods Hole, Massachusetts in March 1973 (ICNAF, 1973a) to answer these questions. This was, perhaps, the most exhaustive review ever conducted of the technicalities of effort calibration and the difficulty of handling mixed fisheries. Considerable analyses remained to be completed and studied, thus another meeting was held in May 1973 in Copenhagen to review the problem again (ICNAF, 1973b). ICNAF discussed the reports of these working groups (ICNAF, 1973c) and concluded that the calibration problems associated with the fishing gear of so many countries were insolvable. With the available scientific knowledge so limited and the need for immediate action so great, ICNAF concluded that the by-catch problem as well as the excess fishing could be handled by a second-tier "all species" quota on top of the single-species quotas.

ICNAF then turned its attention to more creative catch quota systems. Catch quotas, both total and for single species, combined with mesh sizes, minimum sizes of fish landed, and windows (the small areas open for fishing rather than defining areas closed for fishing) remained as the regulatory procedures of ICNAF until its demise in 1976.

Details of Consideration of Effort Control by ICNAF

In 1968, ICNAF realized that fishing effort in the Northwest Atlantic was becoming excessive and must be controlled. The Standing Committee on Regulatory Measures (STACREM) acknowledged (ICNAF, 1968b) that mesh regulation by itself could not do the job. Previous studies indicated that the practical problems with regulation of fishing intensity would make this method difficult to use. The Committee, thus, turned to catch regulations and set up a series of questions to be asked of the Standing Committee on Research and Statistics (STACRES) on expected yields, status of the stocks, and mixed fisheries. Of eight questions asked of STACRES, one dealt with the regulation of fishing effort (ICNAF, 1968b, p. 64). This question was:

> What additional information is required for the regulation of fishing intensity (a) through limitations of effort, and (b) through limitation of catch and what time is required to get it? What continuing study and year-to-year adjustment would be required for (a) and for (b)? Which method, (a) or (b), is preferable as regards effectiveness and work needed for continued study and year adjustment?

Thus, while catch regulation was the chosen method of regulating fishing mortality at the moment, and attention was turned to the development of a research program to learn the status of the stocks, consideration was still being given to effort regulation. It was realized that, to determine a measure of the total effective fishing effort in a fishery and the respective contributions to it from the many main components of the fishery, two major problems needed to be answered. These were:

1) the standardization and combination of effort data from different countries with different methods of fishing, and

2) how to allow for changes in efficiency of a unit of effort.

In 1968, information on these two aspects was not available from some components of the fisheries and it was, therefore, not possible to judge the accuracy with which a total fishing effort quota could be determined for each of the major ICNAF fisheries.

From 1968 to 1973, effort regulation was not considered within ICNAF as single-species catch quotas were developed. By 1973, however, the USA had become dissatisfied because catch quotas were not working. Five problems were obvious:

1) The total yield in 1971 was at or above the maximum sustainable yield (MSY) and the total effort was significantly beyond the MSY point.

2) There were no large finfish resources not under exploitation and the total finfish biomass was declining.

3) The regulation of catches (and hence effort) on selected species simply caused fishing to divert to unregulated species.

4) There was no mechanism to prevent an actual increase in the total amount of fishing in the area if it were directed toward unregulated species.

5) The coincidence of fisheries for regulated and unregulated species in time and area led to severe doubts about the efficiency of enforcement, particularly in respect to the unrecorded by-catch of regulated species in fisheries supposedly directed to unregulated species.

The rapid and obvious failure of the quota regulations to contain foreign fishing effort led the USA to call another special meeting of STACREM to consider a new effort proposal (ICNAF, 1973). The United States believed that there was a demonstrable need for immediate action to control the total fishing intensity within the Northwest Atlantic fishing area, and that the situation was of particular concern and urgency in the southern portion of this region. Therefore, it proposed, for consideration at the January 1973 ICNAF Meeting (ICNAF, 1973e), the following actions for Subareas 5 and 6:

1) That the fishing effort in 1974 be reduced to 25% below that of 1971 to achieve the level which corresponds to the fishing intensity required to provide the total maximum sustainable yield of finfish.

2) That the appropriate units of effort for management be expressed in terms of "days on grounds".

3) That the allocation among countries of the allowable effort be accomplished according to principles developed and applied by ICNAF in setting previous catch quotas. The USA proposed allowable levels of fishing effort for eight countries for 1974 in terms of standardized USA small otter trawler days on grounds.

4) Furthermore, given the urgency of the situation, the USA proposed similar effort reductions in terms of "day on grounds" for the last quarter of 1973.

5) That the catch quotas, mesh regulations, and closed areas then in effect or proposed for 1973 be retained as part of the comprehensive regulatory effect.

The United States also made the point that the problems could not be addressed only in the southern portion of the ICNAF area, although that was the main area of concern to the United States. Reduction in effort in Subarea 5 and Statistical Area 6 would obviously divert effort to more northern areas and even, perhaps, to ICES areas. The USA proposal, therefore, would require effort restrictions in all areas or the requirement that the effort reduced not be diverted elsewhere.

Consideration of the USA proposal by STACREM identified the following problems (ICNAF, 1973d, p. 26):

(a) Effort limitation would not overcome the by-catch problem any better than catch limitation; and while effort limitation could take account of fluctuations in stocks, changes in patterns of fishing could seriously distort its effect on fishing mortality. Moreover, there were not enough data over a period of years to provide an adequate historical basis and it would be unfair to allocate effort quotas between countries by reference to a single year.

(b) If an effort limitation were introduced, it should apply to the whole Convention Area since otherwise diversion of effort would create problems elsewhere.

(c) There were some stocks, e.g., squid, saury, etc., in Subarea 5 and Statistical Area 6, which were not generally fished and were capable of further exploitation in which by-catches of regulated species would be quite insignificant.

(d) With regard to enforcement, the existence of an overall effort limitation would not dispense with the need to enforce the species catch quotas, and the impressions formed by individual fishermen did not enable them to judge how effectively restrictions were being enforced.

(e) An effort limit might prevent some countries from achieving catch quotas.

(f) The proposals on standardization presented many difficulties which required further study.

(g) It was questionable whether effort restrictions could be fixed with any greater confidence than further catch quotas.

The Portuguese Delegation had extensive doubts on the proposed scheme of effort regulation by the USA (ICNAF, 1973e). They stated that in all of the available literature, they could not find one conclusion that fishing effort regulation was more viable or preferable to catch quota regulation. The general view of the January 1973 Standing Committee on Regulatory Measures (STACREM) of ICNAF was that a more detailed study of effort regulation was necessary. STACREM then posed 10 questions to the scientists (ICNAF, 1973g) that should be answered before proceeding.

These questions were:

1. What are the conversion factors needed to obtain "days on ground" from "days fished" for the various member countries? Do countries collect the necessary information to answer this question and, if not, how long will it take to collect the necessary data?

2. Please define exactly the following terms:

   (a) fishing mortality,

   (b) fishing intensity,

   (c) fishing power,

   (d) fishing effort,

   and specify what are the variables that should be discussed for effort control.

3. The Commission is attempting to control the fishing mortality on the resources, and fishing mortality is an abstract quantity which cannot be regulated directly. The Commission may be able to control fishing mortality by regulation of fishing intensity or fishing effort. What is the accuracy with which these quantities can be measured and what is the error involved in using them as a predictor of future fishing mortality?

4. If catch quotas are set for several species which imply different percentage reductions in fishing mortality, what problems does this raise in connection with a fixed reduction in fishing effort, especially for countries only interested in some species?

5. What is the probable increase of fishing mortality in other subareas, if a regulation of fishing effort is introduced in Subarea 5 and Statistical Area 6?

6. If you are controlling your vessels at a level of fishing intensity lower than the one you are allowed, how can that be judged by the criterion of days on ground?

7. If both catch and effort quotas are applied to a given stock, what problems are raised in allocating among countries and within a country to ensure that the two quotas are simultaneously met?

8. What are the opportunities for countries to increase in response to effort control the fishing mortality caused by one unit of fishing effort?

9. Given the present status of stocks and fishing effort in Subarea 5 and Statistical Area 6, assuming that non-member activity does not change, that there are no new entrants, and that the coastal state stabilizes the catches in the territorial waters outside the Convention Area at the 1972 level, what will be the situation of the stocks in those areas in the years 1974 and 1975 if appropriate catch quotas for those years for mackerel and flounders (other than yellowtail) are added to the quotas already established and the by-catch problem is taken care of by revising MSYs of the regulated species in the area at June 1972 and 1973?

10. Could STACRES look into the question of further regulating mesh size and minimum size of fish in Subarea 5?

In addition, the Portuguese Delegation asked four questions of STACRES:

1. Could the fishing power coefficients be taken off continuous curves of tonnage which would take into account horsepower, winch power, fishing aids, and type of fishing (fresh or frozen)?

2. How was the learning factor calculated?

3. How was the increase of total effort from 1971 to 1972 calculated?

4. Could we have data separation on state of stocks, fishing mortality, and fishing effort in waters within and outside the Convention Area, as was done for other subareas?

A special meeting of experts on effort limitation was planned for March 1973 at Woods Hole, Massachusetts to consider the specific questions posed by STACREM (ICNAF, 1973g, p. 41) and the Portuguese Delegation. This meeting provided, perhaps, the most exhaustive review of the technicalities involved with measuring fishing effort, relating it to mortality, and how to regulate it in mixed fisheries.

Days on grounds was used as a measure of effort for several reasons, one of which was ease of enforcement. If a vessel were present on grounds, it was assumed to be fishing. The problem was relating days on grounds with days fished or hours fished. Data were not fully available for this. The delineation of "grounds" was also a problem. Would a vessel be counted simply when passing through the area? It was recommended that each country analyze their data on "days on grounds" and "days fished" and provide estimates of the variances associated with the conversion factors.

Fishing effort quotas are not sensitive to fluctuations in recruitment and abundance as are catch quotas, but they are sensitive to variations in catchability. In dealing with the accuracy of fishing intensity or fishing effort, the Working Group identified problems associated with both variance and bias. Very few data were available for the estimation of variance. It was recommended that catchability coefficients for 1971 be estimated to provide some information on the subject. The bias term is important when trying to control fishing mortality in future years. Factors which affect bias are vessel type, density and species of fish, area and time, water temperature, and learning. The Working Group recommended that each country analyze its own data with regard to the problem of variance and bias in relating effort to mortality.

The question of by-catches was addressed in answering STACREM Question 9 and it was noted that fleets have more flexibility in directing their efforts towards particular species than it appears in the monthly total catches. Management procedures to address the by-catch problem were offered by the Working Group. Recommendations on this subject were made to member countries to provide more refined data on "species not specified", "main species", and "mixed species" and to analyze the more detailed data in national archives (logbooks) to estimate more precisely the by-catch and species interactions.

The estimation of fishing power coefficients was discussed in detail and it was recommended that each country should estimate fishing power coefficients using detailed information in logbooks of individual vessels.

Many other questions were addressed by the Working Group (ICNAF, 1973a) but are not discussed here.

Because of all the analyses recommended by the Working Group, another meeting was convened in May 1973 in Copenhagen to consider further the problem of effort regulation (ICNAF, 1973b). The reports of the March and the May meeting provided some measure of the changes in fishing mortality that could be achieved through effort regulation. It was obvious, however, from the research documents, the report of the March meeting, and discussions at the Annual Meeting in June 1973 that there was not as yet adequate information to permit full evaluation of the proposed effort limitation scheme. The Group of Experts agreed that a major problem was the solution of the by-catch problem and recommended that a Working Group be set up to study that problem.

The USA Delegate at the June 1973 Annual Meeting of ICNAF reiterated that a permanent solution must include effort limitation, but expressed a willingness to explore other possible interim measures in an effort to stop the depletion of the stocks. He pointed out that the current catch quota system had failed because of inherent and practical deficiencies of the system.

The Canadian Delegate supported the USA proposal for effort limitation, but suggested that it might require some modification. It was generally felt by the members of ICNAF that effort limitation was not feasible and that the problem of mixed fisheries must be dealt with in other ways. There was a general concensus that ICNAF should carefully study the management concept of a total catch quota superimposed on individual species quotas.

There the subject of effort regulation lay while ICNAF developed its "second tier" catch quota which began in 1974. This was the main means to control fishing until 1977 when changes in jurisdiction pushed ICNAF out of existence.

Conclusions and Summary of Effort Discussion

A. Conclusions of Templeman-Gulland Report, ICNAF, 1965

1. Small mesh requires tight effort control.

2. When effort is reduced, benefits are usually made in reduction of costs rather than increased yields.

3. ICNAF should seek economic advice.

4. Actions may have to be taken before absolute certainty in understanding conditions is reached.

5. Immediate sacrifice is nearly always required to achieve long-term gain.

6. Losses and gains are unequal for different segments of the fisheries.

7. There must be some direct control of the amount of fishing.

B. Conclusions of United Kingdom Memorandum, ICNAF, 1966

1. High effort requires an increase in mesh size to maintain catch.

2. Significant economic benefits can be achieved from effort control.

3. There is no economic advantage from catch regulation alone.

4. It is difficult to obtain a common unit of measurement with effort control.

5. Mixed species problems are not addressed by either total catch or effort control.

6. Catch control requires timely information on recruitment and abundance.

7. Effort control requires extensive information on fishing effort.

8. Effort control might work without extensive information by trial and error on a national basis.

C. Conclusions of Effort Discussions, ICNAF, 1968

1. Effort regulation requires:

   (a) a standard measure of effective effort and

   (b) a procedure for adjusting changes in efficiency.

2. Information is needed by country, method of fishing, size of vessel and season on:

   (a) measures of effort by area and time,

   (b) catch per unit of effort by area and time, and

   (c) size and age composition of the catches.

3. Information does not exist for portions of the fishery:

   (a) no fishing power factors for long-lines, gillnets, and traps and

   (b) no fishing time for non-trawl fisheries.

4. Information is needed on efficiency changes by fishing power of each group of vessels by season.

5. Information is needed on the variation in "catchability" from year to year in exploited stocks.

D. Conclusions of Committee on Regulatory Measures, ICNAF, January 1973

1. Effort limitation would not overcome the by-catch problem any better than catch limitations.

2. Changes in fishing patterns could distort its effect on F.

3. Insufficient effort data exist to provide an historical basis for effort allocation.

4. Effort would have to apply to the entire convention area.

5. Some stocks are underfished and need an effort increase.

6. Standardization problems require further study.

7. Can effort limits be more precise than catch limits?

E. Conclusions of Meeting of Experts on Effort Limitation, ICNAF, March and May 1973

1. The setting of individual species catch quotas is not satisfactory in achieving MSY in this mixed fishery.

2. Conversion factors are needed to relate "days on grounds" to effective effort such as "days fished" or "hours fished".

3. Variation and bias in the relationship of fishing effort to fishing mortality needs further study.

4. Fishing power coefficients need to be determined very carefully by each country.

5. Due to species preferences by countries, an overall reduction in F could reduce F unevenly across species.

6. Effort regulation does not solve the problems of by-catches which is the major problem.

<u>Overall Summary Problems with Effort Regulations</u>

A. There is no standard unit of measure.

B. Increases in efficiency require constant recalibration.

C. The relationship of fishing effort to fishing mortality varies for many reasons.

D. Fishing power of some effort types is not known.

E. Effort information generally is not available.

Literature Cited

ICNAF. 1966. Note by the United Kingdom Commissioners on the regulation of fishing effort. ICNAF Comm. Doc. 66/17 (also presented as Doc. NF 4/51 to 4th meeting of NEAFC.

ICNAF. 1967. Report of the Working Group on Joint Biological and Economic Assessment of Conservation Actions. Annu. Proc. int. Comm. Northw. Atlant. Fish. 17:48-84.

ICNAF. 1968a. ICNAF Annual Meeting 1968. Annu. Proc. int. Comm. Northw. Atlant. Fish.

ICNAF. 1968b. ICNAF Redbook, Report of Standing Committee on Research and Statistics, Appendix 1, Annex V, p. 64-68.

ICNAF. 1969. ICNAF Annual Meeting. Proceedings No. 11, Appendix 1.

ICNAF. 1973a. ICNAF Annual Meeting. Proceedings No. 5, Appendix I, p. 75-102. (Also ICNAF Summ. Doc. 73/5.)

ICNAF. 1973b. ICNAF Annual Meeting. Proceedings No. 5, Appendix II, p. 116-118. (Also ICNAF Summ. Doc. 73/37.)

ICNAF. 1973c. ICNAF Annual Meeting. Proceedings No. 4, p. 73-74.

ICNAF. 1973d. ICNAF Annual Meeting. Proceedings No. 4, p. 25-26.

ICNAF. 1973e. ICNAF Annual Meeting. Proceedings No. 4, Appendix I, p. 27-35.

ICNAF. 1973f. ICNAF Annual Meeting. Proceedings No. 4, Appendix III, p. 41.

ICNAF. 1973g. ICNAF Annual Meeting. Proceedings No. 4, Appendix III, p. 41.

ICNAF. 1973h. Memorandum by the US Commissioners on the regulation of fishing effort (as presented to the Special Commission Meeting, January 1973). ICNAF Comm. Doc. 73/3.

Templeman, W., and Gulland, J. 1965. Review of possible conservation actions for the ICNAF area. Annu. Proc. int. Comm. Northw. Atlant. Fish., Part 4, 15:47-56.

Table 1 Advantages and disadvantages of catch and effort restrictions.

Catch restrictions		Effort regulations	
Advantages	Disadvantages	Advantages	Disadvantages
Catch data easy to measure	Encourages over capacity	Cost effective	Effort units hard to measure
Standard units of measurement (weight)	Catch quota varies every year and must be calculated in advance	Minimizes probability of overfishing	Very difficult to calculate standard units
Catch monitoring system in place			Effort data generally not available
Catch restriction applies directly to a stock	When catch quota reached, sudden diversion of effort	No sudden diversion of effort elsewhere	Difficult to account for changes in fishing efficiency
Accuracy is independent of variation in catchability coefcients	Sensitive to fluctuations in recruitment and abundance	Accuracy not sensitive to fluctuations in recruitment or abundance	Accuracy sensitive to variations in catchability
Readily understood, hence more acceptable	Difficult to hold at desired level; leads to overfishing		Relation to effort to fishing mortality changes by area and stock
	By-catches often a problem		

ANNEX 7

MANAGING MULTISPECIES FISHERIES WITH CATCH QUOTA REGULATIONS - THE ICNAF EXPERIENCE

V.C. Anthony and S.A. Murawski
Northeast Fisheries Center
Woods Hole

Introduction

The mixed-species fisheries problem comes in many forms. How many fish of each species should be caught to achieve some preselected economic objective, given biological and technical interactions among the species? When and with what gear (mesh size) should all, or part, of them be harvested to maximize aggregate yields? A common problem caused by incidental catches (by-catches) is when the fish comprising the by-catches are smaller than those in the stocks constituting the directed fishery. This situation is most likely to exist when the mesh sizes of the fishery of which the stock is a by-catch is smaller than that of the stock's directed fishery. In such a situation, the sustainable yield of the by-catch will be less than that anticipated under the hypothesis that the size composition of the fish taken as by-catch is the same as that taken in the directed fishery.

Assessing catches of a species taken only in directed fisheries underestimates the fishing mortality of that species (particularly at younger ages). Managing only directed fisheries ignores the mortality on the incidental species that are caught which could be substantial. In some cases, regulation of the by-catches may be so rigid that it results in underharvest of the directed species. A directed fishery for megrim, monk, rays, etc. in the Celtic Sea, for example, results in a by-catch of plaice, which is regulated under a catch quota. Although plaice are far less valuable than some of the other species, the catch quota for plaice may limit the more valuable directed fishery for the megrim and monk.

In the Northwest Atlantic, the mackerel fishery is expanding gradually as the stock rapidly rebuilds. The current optimum yield for this stock is 225,000 tonnes, which carries with it a by-catch of river herring of about 2% of the mackerel catch. The river herring stocks are in very poor condition and the catches have steadily declined from 1970 to only 4,000 t in 1984. Even a few tonnes of river herring may be important to the rebuilding of the stocks. Thus, by-catch limitations for river herring may limit the valuable harvest of the large mackerel stock. In these two examples, the management questions are: should catch quotas be placed on Celtic Sea plaice that could reduce the harvest of megrim and monk; and should the management of river herring in the USA be so restrictive so as to prevent the harvest of the large mackerel resource? These are just a few of the questions that appear when trying to regulate mixed-species fisheries.

The problem of regulation of mixed-species fisheries is thus the problem of understanding and estimating the incidental catches from all directed fisheries and regulating all species and fisheries for particular economic benefits. These benefits vary from country to country and require careful management decisions beyond the purview of assessment scientists.

This paper examines by-catch problems encountered in the Northwest Atlantic in the early 1970s. In 1973, the catch of all major species in ICNAF (International Commission for the Northwest Atlantic Fisheries) Subarea 5 and Statistical Area 6 (Figure 1) was regulated by total allowable catches and national quotas. The estimated by-catch of the major directed fisheries was large. Under these circumstances, attempting to catch the entire quota of a given species by means of directed fishing caused the total catch to exceed the allowable aggregate catch. This document reviews regulatory mechanisms implemented by ICNAF to address the by-catch problem.

Development of Single-Species Catch Quota Management in ICNAF

ICNAF was established in 1949-1950 to "investigate, protect, and conserve the fisheries of the Northwest Atlantic in order to make possible the maintenance of a maximum sustained catch from those fisheries". Prior to the early 1960s, fishing in the ICNAF convention area was primarily by Canada and the USA, as well as a few European nations. In the early 1960s, exploratory and production fishing by large distant-water fleets increased effort and landings dramatically. This was particularly evident in the southern portion of the ICNAF area off the USA coast (Subarea 5 and Statistical Area 6, Figure 1). The number of countries fishing in the ICNAF area and the diversity of directed fisheries also increased in the 1960s and early 1970s. Primary management regulations used by ICNAF prior to 1970 included mesh-size restrictions, areal and seasonal closures to protect spawning concentrations, and maximum by-catch percentages for small-mesh fisheries (i.e., redfish fisheries). ICNAF recognized during the 1960s that fishing effort was excessive to the point that yield was being lost. Attempts to discuss the regulation of effort in 1965, 1966, and 1967 failed to initiate actions to directly limit fishing mortality. Finally, the USSR stated in 1968 that they would control their fishing in 1969 but only with a catch quota. The report of the 1969 Annual Meeting of ICNAF (ICNAF, 1969) developed the requirements of a catch quota system. Catch quota regulations in ICNAF were instituted beginning in 1970 with the adoption of a total allowable catch (TAC) or global quota for haddock in Subarea 5. A global quota was also imposed on yellowtail flounder in Subarea 5 in 1971. There were no national allocations of these quotas until 1972. The ICNAF Convention did not permit national allocations until December 1971 when the Convention was modified. During 1972, the catch quota management program of ICNAF was expanded to allow national allocations of global quotas and they were first instituted for herring stocks in Subareas 4 and 5 and Statistical Area 6. The program of national allocations was further expanded in 1973 to include about 24 stocks in the Northwest Atlantic. The quota system was fully implemented by 1974, covering all species subject to exploitation either by directed fishing or by-catch. Quotas for stocks in ICNAF Subarea 5 and Statistical Area 6 were reduced progressively in each year from 1974-1977, reflecting the general decline in the fishery resources of the area. Fisheries jurisdictions of the coastal states were extended in 1977 and ICNAF passed out of existence.

The By-Catch Problem

The problems of by-catches in the greatly mixed fisheries of ICNAF Subarea 5 and Statistical Area 6 were recognized from the very beginning. ICNAF modified its regulatory measures several times in an attempt to account for by-catches of species under quota restrictions. The initial haddock quota regulations (Subarea 5 and Division 4X) stated that the directed fishery should cease whenever the accumulated catch (directed catch plus by-catch) reported to ICNAF biweekly reached 80% of the quota, anticipating in advance that the catch after closure (a by-catch by definition) would be 20% of the quota. When yellowtail flounder was added to the list of species under quota, the closure procedures were changed. The Assessments Subcommittee of ICNAF first estimated the expected monthly by-catch after closure of directed fisheries. The decision to cease directed fishing was then made when the accumulated total catch reported to ICNAF on a biweekly basis plus the expected by-catch during the remainder of the year equalled the quota. With the introduction of national quota allocations in 1972, the procedure again changed, requiring each country to control its directed fishery so that the sum of its directed catch and the estimated by-catches would not exceed its quota allocation. In spite of the initiation of the above procedures to include by-catches in the ICNAF quota management structure, abundance indices for major fish stocks of interest in Subarea 5 and Statistical Area 6 continued to decline (Figure 2). The magnitude of the by-catch problem is shown by Table 1 for Subarea 5 and Statistical Area 6. By-catch ratios for 1971 were applied to the catch quotas for 1973 in Table 1. A considerable portion of the catch of various species would be taken as by-catch in directed fisheries in 1973 if the 1971 by-catch ratios continued. Overall, about one-third of the total catch in ICNAF Subareas 5 and 6 during 1973 would be taken as by-catch. If mackerel and other pelagics were not included as directed catch, the proportion of overall by-catch taken in directed fisheries would have been 40%. The average by-catch ratio (ratio of by-catch to directed catch) was 0.56 and 0.51 during 1972 and 1973, respectively. Thus, for every 1,000 t taken by directed fishing, another 560 or 510 t of by-catch of other species were landed. The relatively high by-catch rates are illustrated for two directed fisheries pursued by Japan during 1973-1976 (Figure 3). By-catch in their squid fisheries was about 34% during 1973. In the directed fishery for "other pelagics" (primarily butterfish), the by-catch percentage was about 45% in 1973.

By-catch ratios of the USSR fisheries in 1973 also illustrate the problems with by-catch in controlling fishing mortality (Table 2). In the directed fishery for red hake, 41 t of silver hake was taken for every 100 t of red hake that was caught. In the directed fishery for silver hake, 24 t of red hake was caught for every 100 t of silver hake that were caught. Silver hake, in particular, are taken as by-catch in significant numbers in the directed fisheries for red hake, other groundfish, herring, and mackerel.

At the second Meeting of Experts on Effort Limitation in Copenhagen in May 1973 (ICNAF, 1973a), the following conclusions were reached:

(a) the finfish biomass in Subarea 5 and Statistical Area 6 was being fished in 1971 at a point beyond the fishing mortality corresponding to its maximum sustained yield;

(b) the difficulties of management in fisheries in this area were related to the mixture of species and the consequent by-catch problem;

(c) the Assessments Subcommittee concluded that this problem could be alleviated by controlling the fishing mortality either by means of total catch quota or a total effort limitation and that the relative merits of the two aproaches to regulation were difficult to decide on scientific grounds; and

(d) the total finfish catch quota must be less than the sum of the individual species quotas.

The high degree of intermixture of fishery resources in ICNAF Subarea 5 and Statistical Area 6 and the large percentage of fishing mortality generated as by-catch led ICNAF scientists to attempt quantitative evaluations of the impacts of various schemes to regulate the mixed-species fisheries of the region. This problem had been reviewed by the ICNAF Assessments Subcommittee (ICNAF, 1973b) and proposed methods of solution have included linear programming techniques (Brown et al., 1973; Anthony and Brennan, 1974). The results of such techniques specify directed fishery catch levels which will produce the maximum total catch over all stocks and countries, given ICNAF allowable catch restrictions. Brown et al. considered maximizing the 1973 total catch, given 1971 by-catch ratios and 1973 quota restrictions; and Anthony and Brennan dealt with maximizing the 1974 total catch, given 1972 fishing patterns and 1974 total allowable catches.

A simple illustration of a by-catch problem evaluated with these techniques is given in Figure 4. In this example, two species (cod and haddock) are caught by two different directed fisheries. Single-species TACs are cod = 20,000 t and haddock = 10,000 t. For the given proportions of each species in the two fisheries, the goal is to determine the level of maximum fishing in both fisheries combined, subject to the two single-species TACs. In this example, the line drawn between points dBC on Figure 4 is the constraint that total combined catches of cod cannot exceed 20,000 t. The line given by points ABe indicates the limit of a 10,000 t haddock catch. The intersection of the two lines defines all potential solutions to the problem (shaded area). At point B, both species TACs are exactly met and total fishing is maximized. Total catch at point B from Fishery 1 is 21,430 t; 8,570 t is taken in Fishery 2 (total from both fisheries is 30,000 t).

The previous example is, however, a relatively simple example of the quantitative evaluation of the consequences for mixed-species management. In the ICNAF situation, there were 13 nations conducting about 10 directed fisheries for about 20 regulated species. An example of the solution of the ICNAF linear programming problem is given in Table 3 (Anthony and Brennan, 1974). The linear constraints were that the catches were maximized to the 1975 TACs but could not exceed any species quota. By-catch ratios for 1972 were used for the 1975 simulation. The analysis was done on a country basis and then added over country in Table 3. About 90% of the total allowable catch constraint was achievable under this scenario. About 37% of the yield should be reserved for by-catch. For some species (haddock, red hake), the by-catch was so great in other directed fisheries that no directed fisheries for these two species is allowed. Of course, these results depend on the by-catch ratios used in the analysis. These ratios are a function of the relative abundance of each combination of species caught, their mixture in space and time, and the fishing strategy of the national fleets.

Problems of Biological Interaction

The analyses of aggregate MSYs in ICNAF provided the impetus for further study of the multispecies problem. The USA scientists in 1973 were very interested in the problem of biological interactions and the long-term effects on the total productivity from single-species catch quota management of many species. The feeding habits of fish of the Georges Bank region (ICNAF Division 5Z) indicated the potential for biological interactions. The diets of several species were similar (i.e., potential for competition) and several others feed primarily on fish (i.e., potential for predator-prey interactions). Brown et al. (1976) treated biological interactions implicitly by applying a surplus production model (e.g., Schaefer, 1954) to the aggregate catch of all species of finfish and squid, except menhaden (which are captured close to shore in the southern part of the region) and large pelagic species (e.g., swordfish, tuna). Fishing effort of different gear types and nations was calibrated and combined to provide a standardized index of days fished. A multiplicative learning function was also applied as a correction to fishing effort in newly-developing fisheries.

Brown et al. (1976) demonstrated a sixfold increase in standardized fishing effort and a 55% decline in abundance during the period 1961-1972. They used Gulland's (1961) method to fit a surplus production model to aggregate catch and standardized effort data. The resulting estimate of maximum sustainable yield (MSY) of the region (Subarea 5 and Statistical Area 6) was 900,000 t, 33% less than the sum of MSYs of individual species or species groups (1,352,000 t). Brown et al. (1976) inferred that the difference reflected the biological interactions among species.

Development of the Second-Tier System

As a result of by-catch problems, species interactions, and declining biomass, ICNAF established a 'second-tier' quota in 1974 which limited the aggregate catch to less than the sum of the individual species quotas. This was a catch level of all finfish and squids except menhaden, billfishes, tunas, and large sharks and designed to be 15-20% less than the sum of the individual TACs. The objectives of this TAC as stated by ICNAF (1974 ICNAF Redbook, pp. 5-6) were:

1) to compensate for by-catch mortality which is difficult to quantify and control by more direct means,

2) to take some account of species interactions which are not satisfactorily taken into account in single-species assessments, and

3) to allow recovery of the total biomass from the reduced level in recent years to a level giving the maximal or some optimal yield in a fairly short period of time.

The first-tier TACs (which were the sum of the individual species TACs) and the second-tier TACs for 1974 to 1977 (proposed) are given in Table 4. Total catches (all species and countries) from 1973-1977 were:

Year	Catch ('000 t)
1973	1,159
1974	942
1975	845
1976	663
1977	455

There are several indications that the second-tier quota system was effective in: 1) reducing the level of overall by-catch in the fisheries, and 2) helping to control landings on a species basis to less than the TACs. Overall, the total proportion of landings taken in directed fishing increased from 1974-1976. Excluding mackerel and "other pelagic" fisheries, the percentage of overall landings taken in directed fisheries increased from 50% in 1972 to 75% in 1976. The overall by-catch ratio decreased from 0.56 in 1972 to 0.43 in 1976. For squid and pelagic directed fisheries of Japan, reduction in by-catch was dramatic (Figure 3). By-catch in the squid fisheries was reduced from 34% in 1973 to an average of 12% in 1974-1976. By-catch in the pelagics fishery declined from 45% in 1973 to 25-30% in 1974-1975 and less than 10% in 1976.

Quota and landings data for the USSR indicate the effects of the second-tier quota system in reducing the total catch to less than the sum of individual species quotas. During the period 1974-1977, USSR landings were generally less than the sum of single-species allocations, but slightly higher than their second-tier quotas. Total USSR landings in Subareas 5 and 6 were 206,000 t in 1976, 21% less than the sum of single-species allocations, but 16% greater than their second-tier quota. (Table 4).

Adoption of the second-tier system in part resulted in some countries redirecting their fisheries to reduce by-catch, thereby taking the more desirable species in directed fisheries. By reducing by-catch of species with small allocations, these countries were able to catch a higher proportion of their second-tier quotas than if fishing patterns used in previous years were employed. In this regard, ICNAF offered incentives for countries to minimize by-catch by changing operational fishing procedures, rather than the disincentives of percentage by-catch regulations or fixed quotas for minor species.

Summary

ICNAF did not "solve" their by-catch problems with the institution of national or second-tier quotas systems. There are indications, however, that by-catches in Subareas 5 and 6 were reduced during 1974-1977, a period when resources were declining dramatically. The problem was obviously more clearly defined at the end of the ICNAF era, and additional measures for regulating mixed-species fisheries were being contemplated (e.g., effort control). Quantitative evaluations of by-catch by ICNAF scientists provided a foundation for assessing the impacts of mixed-species harvests on landings and fishing mortality rates on the major components of the multispecies ecosystem.

The extent to which mixed-species fisheries can alter operational fishing procedures to reduce by-catch will determine the ability of management to fully meet single-species catch goals. By-catch percentage goals do not necessarily offer economic incentives for fishermen to reduce by-catch, since the regulations simply limit total fishing to some harvest level that fleets may or may not be able to meet. By-catch over the specified limit will probably be wastefully discarded, even if discarding is prohibited. The second-tier allocations to fishing nations, such as in ICNAF, offered each country an economic incentive to reduce by-catch and increase directed fishing to maximize economic gain from the fisheries. It should be recognized that fishermen can exhibit tremendous technological innovation if there is an economic incentive to do so (one need only consider the various methods fishermen have used to get around various regulations which have been attempted or implemented in the past).

Mixed-species quota approaches are obviously not the only regulatory measures that can be used to maximize production from multispecies resources. Recent research by ICES and other scientists has addressed the implications of common net mesh sizes and mixed-species fishing effort levels on total catches from particular areas. Maximization of overall mixed-species yields can involve trade-offs of yields from some stocks for yields of others (some species would be "underfished" and others "overfished" to maximize multispecies yields). Regulation by a combination of fishing effort limitations, catch quotas, and gear restrictions may be appropriate for particular multispecies fisheries situations. However, none of these regulations will be effective unless there are positive short-term incentives for fishermen to obey them. It is the continuing challenge of managers and scientists to design and evaluate regulatory schemes that take into account the "real world" responses of those being regulated.

Literature Cited

Anthony, V.C., and J.A. Brennan. 1974. An example of the by-catch problem on directed fisheries for 1975. ICNAF Summ. Doc. 74/47 (Rev.).

Brown, B.E., J.A. Brennan, E.G. Heyerdahl, and R.C. Hennemuth. 1973. Effect of by-catch on the management of mixed species fisheries in Subarea 5 and Statistical Area 6. ICNAF Redbook 1973, Part III.

Brown, B.E., J.A. Brennan, E.G. Heyerdahl, M.D. Grosslein, and R.C. Hennemuth. 1976. The effect of fishing on the marine finfish biomass in the Northwest Atlantic from the eastern edge of the Gulf of Maine to Cape Hatteras. ICNAF Res. Bull., 12:49-68.

Brown, B.E., J.A. Brennan, and J.E. Palmer. 1979. Linear programming simulations of the effects of by-catch on the management of mixed species fisheries off the northeastern coast of the United States. Fish. Bull., U.S. 76:851-860.

Gulland, J.A. 1961. Fishing and the stocks of fish at Iceland. Fish. Invest. Minist. Agric. Fish Food (G.B.), Ser. II, 23 (4), 52 pp.

ICNAF. 1969. ICNAF Annual Meeting. Proceedings No. 11, Appendix 1.

ICNAF. 1973a. ICNAF Annual Meeting. Proceedings No. 5, Appendix II, p. 116-119.

ICNAF. 1973b. ICNAF Redbook, Report of Standing Committee on Research and Statistics, Appendix 1, p.8-301.

Schaefer, M.B. 1954. Some aspects of the dynamics of populations important to the management of commercial marine fisheries. Bull. int. Am. Trop. Tuna Comm. 1 (2): 26-56.

Table 1 1973 quotas ('000 t) for Subarea 5 and Statistical Area 6 with associated by-catch if "quotas" are all caught in the directed fisheries. (Based on 1971 by-catch ratios).

Species sought		Species caught (finfish only)									
		Cod	Haddock	Redfish	Silver hake	Flounders	Other groundfish	Herring	Other pelagics	Other finfish	Total
Cod	Catch	45.0	8.2	0.8	0.1	2.7	5.9	<0.1	<0.1	0.2	63.1
Haddock	Catch	8.1	6.0	0.8	<.1	2.5	3.9	-	<0.1	-	21.5
Redfish	Catch	2.2	0.8	30.0	0.5	1.1	2.6	0.1	-	<0.1	37.4
Silver hake	Catch	4.6	2.0	2.0	170.0	11.6	35.5	33.2	33.2	26.4	318.4
Flounders	Catch	12.0	4.5	3.1	2.6	51.0	9.0	0.5	0.7	0.6	84.0
Other groundfish	Catch	4.6	1.4	0.4	18.4	9.0	80.0	9.4	8.3	10.7	142.4
Herring	Catch	0.5	0.2	0.7	5.8	0.7	3.3	175.0	19.2	8.9	214.4
Other pelagics	Catch	0.5	-	4.2	16.4	5.6	15.0	49.8	470.0	55.0	616.6
Other finfish	Catch	0.3	0.2	-	31.7	5.0	39.7	8.8	17.5	90.0	193.0
Total	Catch	77.8	23.3	42.0	245.5	89.2	194.9	276.8	548.9	191.8	1,690.8
Quota (1973)		45.0	6.0	30.0	170.0	51.0	80.0	175.0	470.0	90.0	1,117.0
Catch/quota		1.73	3.88	1.40	1.44	1.75	2.44	1.58	1.17	2.13	
Percent catch from by-catches		42	74	29	31	43	59	37	14	53	34

Table 2 Ratios of by-catch to main species sought within fisheries for the USSR in 1973 (from Brown *et al.*, 1979).

Main species sought	Species caught										
	Atlantic cod	Haddock	Redfish	Silver hake	Red hake	Flounder	Other groundfish	Atlantic herring	Atlantic mackerel	Other pelagic	Other fish
Silver hake	0.005	0.001	0.034	1.000	0.236	0.008	0.062	0.069	0.303	0.006	0.188
Red hake	0.020	-	0.019	0.410	1.000	0.025	0.117	0.118	0.237	0.002	0.107
Other groundfish	0.494	-	-	0.571	0.101	0.107	1.000	0.164	0.148	0.036	0.031
Atlantic herring	0.011	-	-	0.187	0.140	0.060	0.100	1.000	0.227	0.001	0.110
Atlantic mackerel	0.010	0.005	0.017	0.147	0.094	0.011	0.051	0.301	1.000	0.003	0.082
Other pelagic	-	-	-	0.092	0.299	-	-	-	0.055	1.000	0.061
Other fish	0.068	0.003	0.010	0.147	0.245	0.112	0.675	0.099	0.250	0.020	1.000

Table 3 Linear programming simulation of 1975 catches maximizing total catch ('000 t).

Species caught	Total allowable catch constraint	Directed catch	Total catch
Cod	45.0	22.5	35.0
Haddock	6.0	-	6.0
Redfish	25.0	23.0	25.0
Silver hake	175.0	114.0	130.0
Red hake	65.0	-	50.0
Pollock	27.0	23.5	27.0
Yellowtail	21.0	6.0	21.0
Other flounder	25.0	20.0	25.0
Other groundfish	55.5	-	26.5
Herring	175.0	92.0	175.0
Mackerel & other pelagics	292.0	246.0	292.0
Other fish	62.5	-	62.5
Total	974.5	547.0	875.0

With added constraint of preserving portion to the USA directed fishery, the totals were 974, 543, and 855, respectively.

Table 4 Country allocations (first-tier quotas) and second-tier quotas for ICNAF Subareas 5 and 6 assigned to various fishing nations, 1974-1977. First-tier quota allocations are the sum for all species allocated to each country. Data are in '000 t.

Country	1974 First tier	1974 Second tier	1975 First tier	1975 Second tier	1976 First tier	1976 Second tier	1977 First tier	1977 Second tier
Bulgaria	28.5	29.1	24.8	24.7	21.8	14.4	8.3	6.8
Canada	56.2	25.0	52.0	26.0	45.8	18.0	42.0	23.0
FRG	29.0	27.0	28.2	24.9	13.0	14.9	6.5	6.3
GDR	99.4	97.6	94.5	82.9	64.7	48.8	20.2	16.9
Italy	4.7	4.7	4.7	4.1	4.3	6.8	4.2	5.0
Japan	31.3	24.3	24.3	21.3	16.8	18.0	21.6	25.0
Poland	152.3	152.2	145.7	129.3	106.5	76.5	37.3	32.1
Romania	4.9	4.3	4.6	3.9	4.3	3.9	1.4	1.2
Spain	21.3	17.2	21.3	14.8	21.9	16.0	14.4	18.5
USSR	376.2	342.5	366.6	301.8	259.9	177.3	174.4	141.3
USA	259.8	195.0	266.4	211.6	237.7	230.0	267.8	228.0
Others[1]	57.4	97.6	59.3	5.0	54.5	25.6	21.7	16.1
Total	1,121.0	923.9	1,082.0	850.0	851.0	650.0	621.0	520.0
% Difference	-18		-22		-24		-16	

[1]Includes France and Cuba, as well as quotas for countries without specific allocations.

Figure 1 ICNAF Statistical Areas in the North Atlantic.

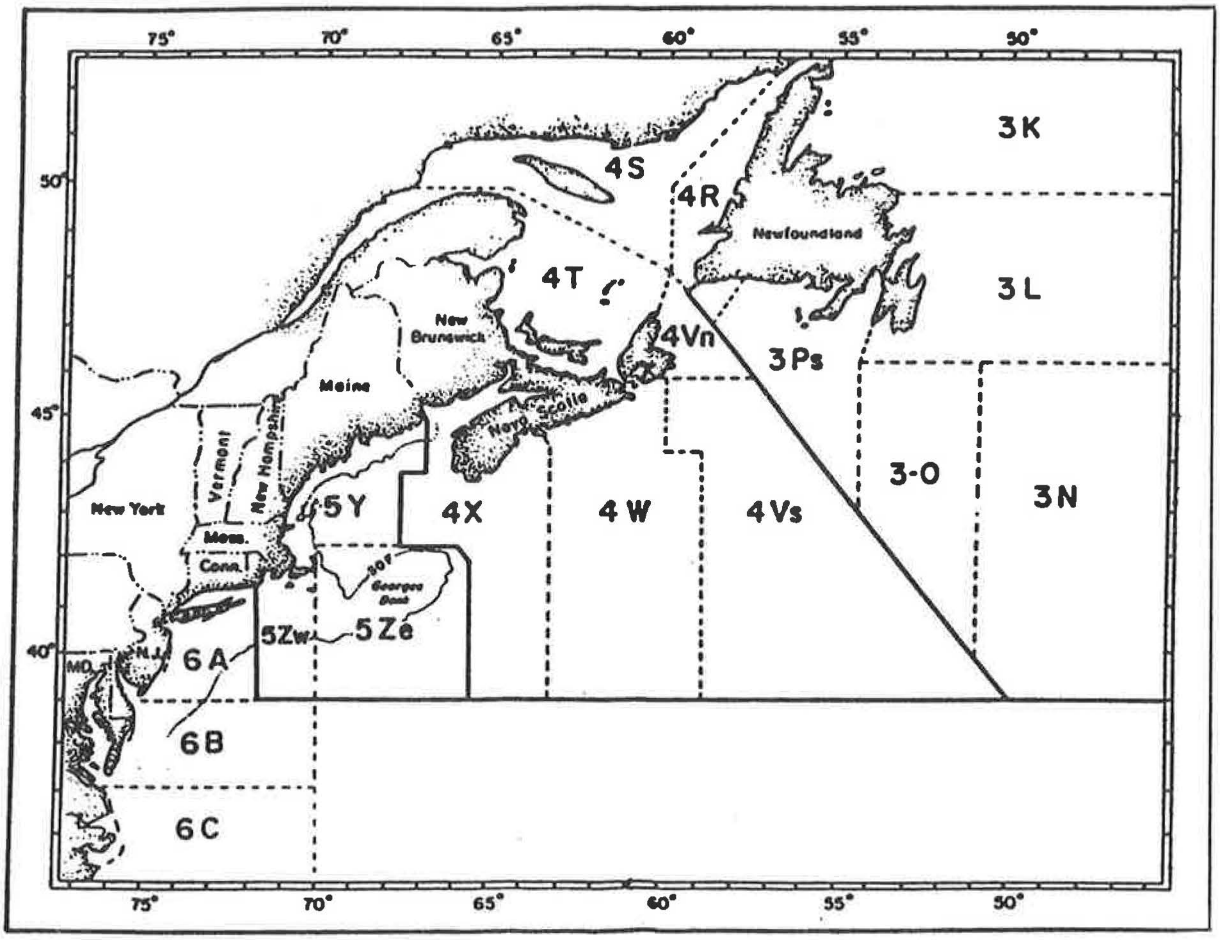


Figure 2 Relative abundance of principal groundfish and flounders in ICNAF Subarea 5 and Statistical Area 6 from USA research vessel information.

Figure 3 Total by-catch as a proportion of main species catch for two directed fisheries conducted by Japan in ICNAF Subareas 5 and 6, 1973-1976. Data are for the directed fisheries for squids (two species), and pelagic fishes other than mackerel and herring (primarily butterfish).

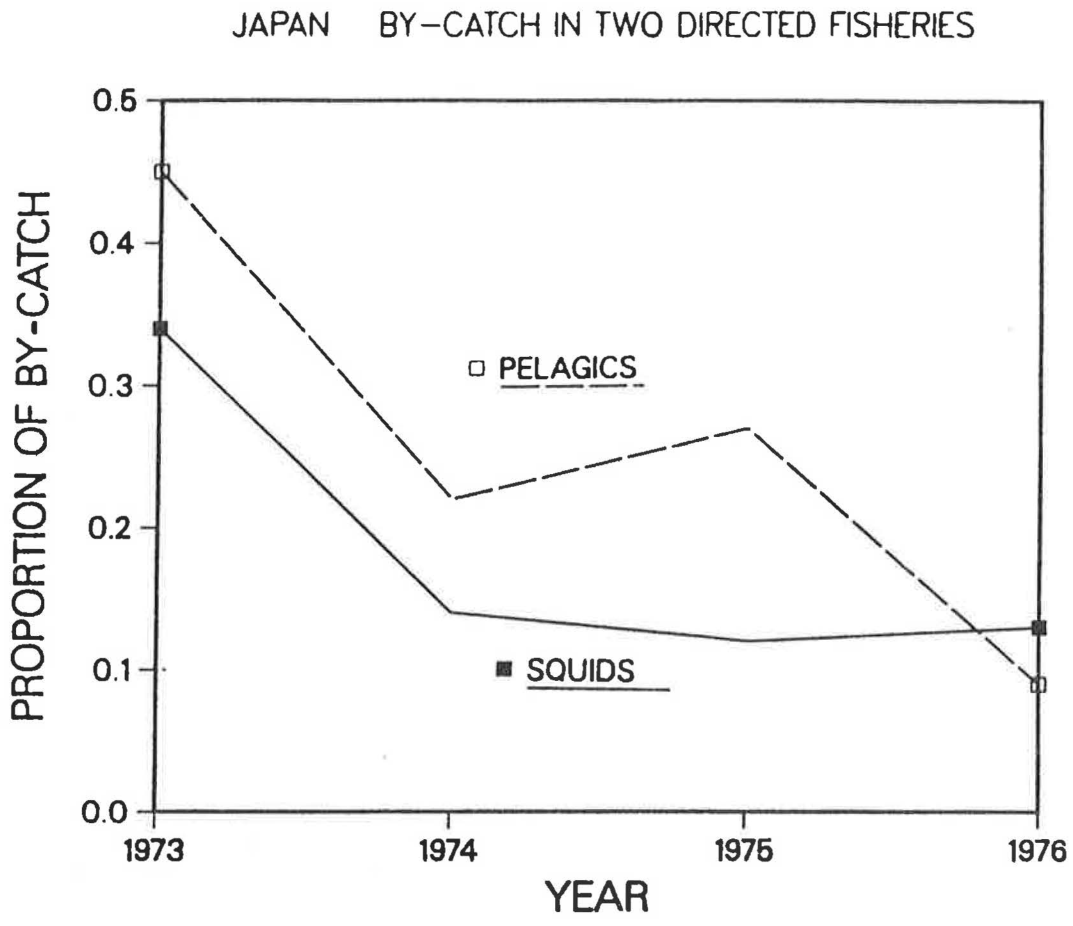
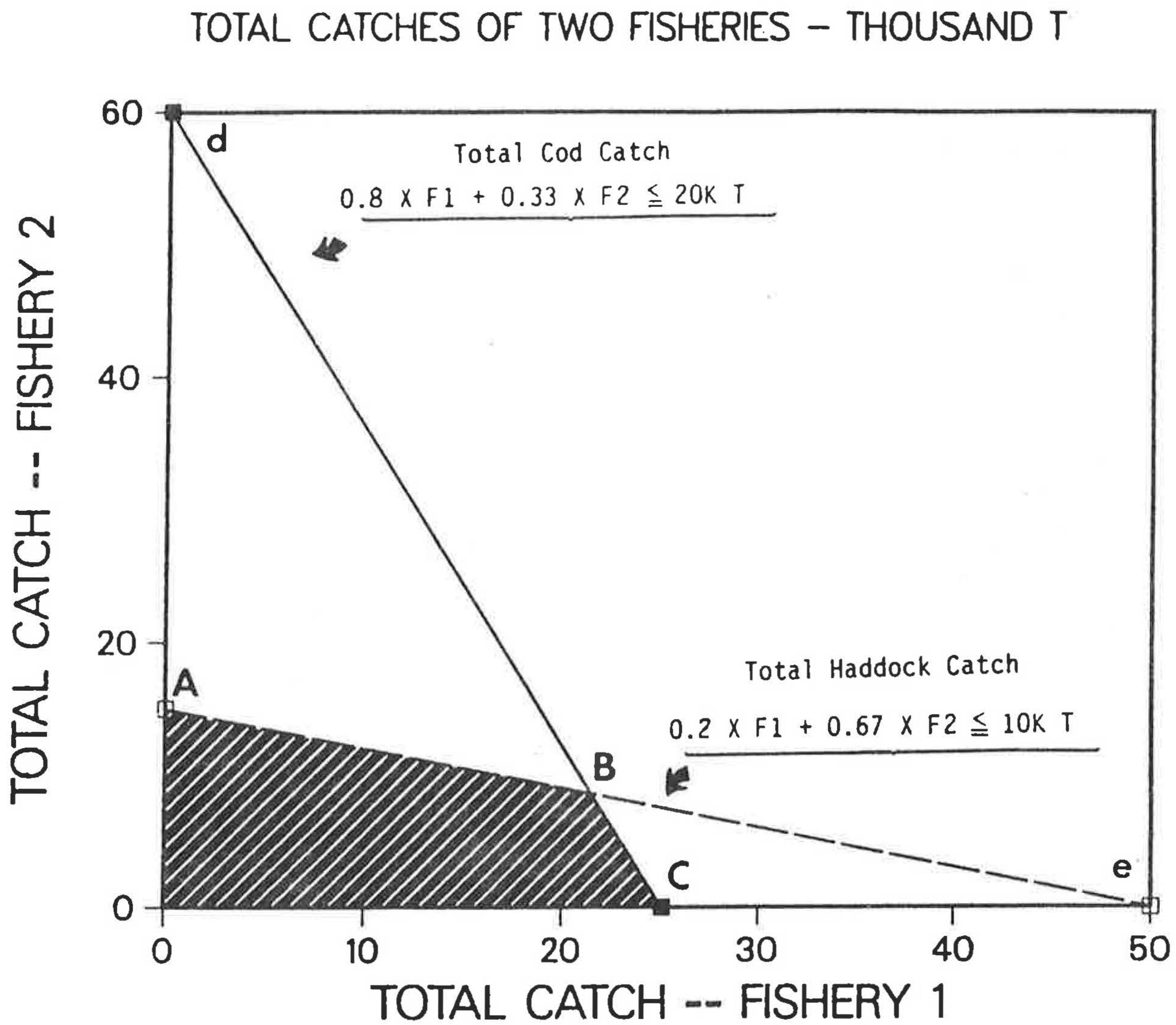


Figure 4 Graphical solution to the simple by-catch problem for two hypothetical fisheries (Fisheries 1 and 2) exploitating different proportions of two species (cod and haddock). Fishery 1 (F1) takes 80% cod and 20% haddock, Fishery 2 (F2) takes 33% cod and 67% haddock. Total species quotas are cod = 20,000 t, haddock = 10,000 t. Shaded area represents all possible solutions where the catch of cod is less than or equal to 20,000 t, and the catch of haddock is less than or equal to 10,000 t.



ANNEX 8

THE FUTURE REGULATION OF INDUSTRIAL FISHERY

Jens Rosendal Lauritsen
Association of Fish Meal and Fish Oil Manufacturers in Denmark

Introduction

A British Minister once said that next to the sexual urge, the railway services was the most difficult factor to regulate in a society.

Fisheries in the EEC, and in particular the industrial fishery, seem at times to cause biologists and officials, both in the EEC and at national levels, just as great problems as the railway services seemed to cause the Minister mentioned above. If you moreover consider that fishing is one of the few types of hunting that has survived in the industrial communities and continues to be the basis of the daily existence of many people, problems in connection with regulation are certain to arise.

If we choose as our starting point the technological development within European fisheries over the past two decades and compare this with the fish resources available within the respective economic zones established during the same period, it must gradually have become clear to everybody that:

1) it is necessary to regulate catching activities for reasons of conservation, and

2) it is necessary, for social reasons, to distribute the available quantities among the nations to ensure a reasonable economic development in areas heavily dependent on fishing.

Various factors will be explained below, particularly within the industrial fishery, to which the above objectives still apply, but where existing regulations may hardly be said to promote the objective.

In my view, the aspects in question also illustrate some shortcomings in the decision-making process which have developed within this field during recent years.

By-catches

Regulation in the shape of limited by-catches of one species when fishing for another species is a sensible form of regulation, with a view both to conservation and to distribution, if based on a reasonably certain knowledge of the size of the stock of the individual species at the moment fishing takes place and if due regard is being paid to the future overall optimum utilization of the species which form a part of the economic fishery.

Let us look at an example. In the ACFM Report FC 4/3 (Part I) from the meeting in May 1985, the potential catch of whiting and haddock in the North Sea in 1986 is assessed.

As far as whiting is concerned, the biologists estimated that the quantity representing by-catches in the industrial fishery amounted to 19,000 t out of total landings of 93,000 t, whereas the quantity discarded at sea amounted to 39,000 t. These 39,000 t were not included in the quantity forming part of the landing surveys.

As far as haddock is concerned, the biologists estimated the corresponding figures to be 170,000 t, 10,000 t, and 72,000 t, respectively, according to the same method of computation.

When it is further considered that a large part of the whiting and almost all of the haddock caught as by-catches in the industrial fishery are sorted out, degutted, and landed as fish for human consumption, as opposed to the discarded fish, it seems, both from the point of view of conservation and utilization of resources in relation to the stocks of whiting and haddock, to be more relevant to give regulation of discarded quantities a higher priority than by-catches within the Norway pout fishery, or at least to look at both aspects when employing regulatory measures. So far, however, administrators have focused in particular on the regulation of by-catches and only to a limited extent considered the possibilities with a view to the development of the stocks by involving the discarding problem.

This is in spite of the fact that biologists have pointed this out for years.

The consequences of the order of priority chosen have, in my view, limited the possibilities of catching Norway pout, which, I believe, is not considered to be an endangered species, without increasing the catching possibilities in directed fishing for haddock and whiting. This has had various unfortunate economic and social consequences for the fishing industry and the processing industry on land which is based on this utilization of resources. In the light of this correlation, it seems surprising, therefore, that the administrators had great difficulty as late as last week in making an adjustment of by-catches in the Norway pout fisheries not least when considering the fact that the figures stated by the biologists to a large extent cover the period in 1984 when the so-called 18/8 percentage rule applied.

If we compare 1984 with 1983 with a view to the quantity of haddock and whiting taken as by-catches, no increase worth mentioning seems to have taken place.

All of the important factors, thus, seem to point fairly unambiguously towards the fact that such change of regulation can be made without damaging other species of fish and without changing the distribution of catching possibilities among the North Sea countries as laid down in the EEC fishery compromise in 1983.

The above adjustment of by-catch rules could possibly be combined with an adjustment of the Norway pout "box" in the case of areas requiring special protection. It would also be of great interest to obtain a biological evaluation of the effect of the present "box" on the haddock and whiting stocks.

Herring

Another complex problem which has caused increasing difficulties in a large number of fisheries in the North Sea and adjoining waters is the development of the herring stock. The difficulties are particularly noticeable as regards the sprat, Norway pout, and sandeel fisheries.

The development of the herring stock related to existing catch and landing regulations has also led to difficulties concerning prices and sales.

The low by-catch rules (5%) within the haddock and sandeel fisheries and the prohibition against the catching and landing of herring for purposes other than human consumption has totally distorted the development within these fisheries and resulted in great economic problems both within the fishing industry and the fish meal industry.

The strict rules governing by-catches have thus changed the utilization of capacity within the industry in a negative direction and led to increased catching activity within the non-industrial fisheries.

The fundamental question is of course whether maintenance of these regulations is necessary for reasons of conservation, because you cannot ignore the experience gained when the herring stock at the end of the 1960s and the early 1970s was overfished and collapsed.

Therefore, everybody agrees today that a similar development must be avoided.

On the other hand, it is necessary to consider the expedient size of the herring stock to be maintained in the North Sea, with regard also being had to the negative consequences of a big stock of this species in relation to other fisheries.

In my opinion, three overall considerations must be taken into account when determining the level of the herring stock and thus the possibilities of catching:

1) First, the stock and the composition as to particular ages must be adequate for regeneration so as to prevent a collapse such as the one which occurred in the 1970s.

2) Second, catching regulations within the herring fishery must not unnecessarily limit the possibilities of carrying on other types of fisheries.

3) And third, catching regulations must not prevent efficient economic utilization of the herring.

If we look at the situation today, the objective of point 1 has been achieved.

As regards point 2, the size of the herring stock and its extension have caused an increasing number of fishermen to get into conflict with existing by-catch rules, as far as herring is concerned, which has resulted in a shift in catching activities particularly from whiting, Norway pout, and sandeel to non-industrial fisheries. This restriction is obviously unnecessary, at any rate as far as Norway pout and sandeel are concerned, since these species are not endangered. A change in the herring by-catch will to some extent lead to increased catching of herring, but this does not in any way mean that the stock will be endangered, if it can be ensured that the by-catch rules reflect the proportion between herring and the other species. If you want to maintain the types of fisheries mentioned, it is, therefore, decisive to change the by-catch rules in step with the development of the herring stock.

In evaluating the third point, it is necessary to look closer on the forms of sale and the catching situation.

All herring caught in the North-East Atlantic area are chiefly sold on the European market.

A Danish study from 1984 (report of 22 May 1984 on by-catch problems within the industrial fishery by the Danish Ministry of Fisheries) showed that the human consumption market was already saturated with herring at the catch level existing in 1984. This was confirmed particularly by a drastic reduction in prices and increasing withdrawal of herring under the EEC market system.

This development has been intensified in 1985.

In Denmark alone, 10.5% of all herring landings had been withdrawn as of 31 August this year under the EEC market system and the prices are on an average 15% below those of last year.

This has had the result that today herring fishing in Denmark is only profitable if carried out by means of large seining vessels, since the costs of trawling cannot be covered by the present herring prices. Moreover, the quantity of discarded herring has increased drastically since the fishermen endeavour to limit landings to the best quality herring. This is an inexpedient utilization of resources, according to the circumstances.

In 1986, we know that catching of herring will increase further.

If the present regulations are maintained, there is no doubt, therefore, that it is very likely that:

1) the herring market will collapse,

2) the EEC market subsidy system for herring will be utilized optimally, and

3) there will be the biggest waste of fish in the form of discarding ever effected.

Which changes are required to avoid this development?

First and foremost, the prohibition against catching and landing of herring for purposes other than human consumption must be abolished.

Next, the by-catch percentages in the Norway pout and sandeel fisheries must be increased.

To ensure the present level of the stock, the catching of herring spawn must continue to be limited. The prohibition areas already introduced at the Jutland west coast seem to have had a beneficial effect and should, in principle, be maintained, but the geographical area should perhaps be adjusted.

Herring should be caught with 32-mm meshes in the gear.

During the period of change, it may be expedient to make access to the herring fishery dependent on special permission for the individual vessel in particularly sensitive areas.

I hope that both the biologists and the administrators will include the above proposals in their considerations when the regulation of the fishery is to be determined in 1986.

ANNEX 9

A VIEW OF CANADIAN FISHERIES MANAGEMENT IN THE NORTHWEST ATLANTIC SINCE 1977

R. Wells
Northwest Atlantic Fisheries Centre
St. John's

Introduction

Extension of jurisdiction in 1977 to the 200-mile limit brought increased fisheries management responsibilities to Canadian authorities. Within the economic zone, Canada is obligated to manage on a rational basis a large number of marine stocks occurring over a very large geographical area. As a reference point, Canada has adopted the $F_{0.1}$ fishing mortality level or its equivalent. Exploitation of marine species is controlled through catch regulation of the Canadian fleet and by both catch and effort restrictions in the case of the fleets of other countries.

Allocations and Licensing

Scientific advice is made available from the Northwest Atlantic Fisheries Organization (NAFO) or the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC). The advice is base upon biological and statistical data provided by national laboratories. Additional information is available from the Scientific Observer Programme and from catch and effort data reported to Canada as a condition for fishing inside the economic zone. Overall total allowable catches (TACs) for the various stocks are determined either by the Canadian authorities or by the Fisheries Commission of NAFO, usually consistent with the reference fishing mortality.

After the TAC for a stock has been set, the coastal state determines its needs and the resource surplus to this need is allocated to other countries. In certain cases, allocations are made in fisheries in which there is no surplus, but the TAC is nevertheless maintained by means of a reduced allocation to the coastal state. For a number of stocks, the Fisheries Commission of NAFO determines the TACs and allocations.

When allocations to the other countries have been set, catch rates are determined from recent past performance for the various vessel and gear classes involved. Confirmation of trends in commercial catch rates is often available from research vessel survey results. These catch rates are used to determine the fishing days and thus the operating days on the fishing ground necessary to take the allocation. Upon receipt of an application from the designated foreign fisheries representative in Canada, licenses are issued to individual vessels for a specific species/stock area and period of time. The total licensed days for all vessels fishing a national allocation cannot exceed the number of days on ground determined by applying the daily catch rate to the total allocation and then adjusting by a factor to account for steaming and other normal non-fishing time.

A fishery may be closed either when the allocation is taken or when the total number of days has been used without the allocation having been taken. In practice, and within the catch and effort level restrictions, requested amendments to licenses are routinely considered. In extenuating circumstances, such as the disruption to fishing caused by unusually severe weather or ice conditions, additional fishing days may be granted to allow a country the opportunity to take its complete allocation.

Canada's authority to license fisheries by other countries does not extend beyond the 200-mile zone. For stocks which are overlapping the zone, Canadian authorities monitor the catches both inside and outside through inspection of catches, logbook examinations, reported catches, and catches estimated from known fishing effort and catch rates. Although licenses for such stocks are required only for fishing inside the zone, when the stock allocation is about to be reached, the portion of the stock area within the Canadian zone is closed to fishing as of the appropriate date. The relevant catch information is forwarded to NAFO by the coastal state so that NAFO can advise the flag state that the quota has been reached. The flag state then takes appropriate action for its own fleet fishing outside the zone.

Regulatory Control - Inside the Zone

Vessels from other countries fishing within the zone are required to comply with Canadian fisheries legislation including compliance with the requirements of the fishing licenses. Regulations include provisions for control over such things as mesh size, quotas, incidental catches, and closed areas and seasons; and for inspection of foreign vessels found within Canadian waters, seizures, forfeitures, and penalties. Also included are provisions to issue licenses and impose license fees.

In order to monitor compliance with applicable acts and regulations, patrol vessels with surveillance officers on board make frequent checks within the fishing areas including detailed examinations to determine if the operation is being carried out in line with fisheries legislation. For minor offenses such as use of undersized mesh or for unauthorized fishing, a vessel may be escorted to port, the catch seized, and charges laid.

In addition to patrol vessels and surveillance officers, patrol aircraft regularly monitor the number and nationality of vessels encountered, their position, and fishing activity. Violations detected and areas of concern identified by such aircraft are fully documented and may lead to on-the-spot inspection by officers from a patrol vessel.

Vessels fishing inside the zone are required to submit weekly catch reports showing the catch of the directed species and of other species taken as by-catch for each day of the weekly period. Vessel movements into or out of the zone as well as port visits are also reported. Records outside the zone of inspected catches and catches recorded in ships' logs are available through the NAFO Joint Enforcement Scheme. Not all vessels fishing outside the zone are inspected. Such information is entered into the Foreign Licensing and Surveillance Hierarchial Information System (FLASH). Information from patrol vessels and aircraft is also entered into the system. Rapid access to data for quota monitoring and to confirm compliance to licensing requirements and fishery regulations is supplied by FLASH.

Regulatory Control - Outside the Zone

For fishing areas outside the zone, namely the "nose" and "tail" of the Grand Bank and the Flemish Cap, vessels are not subject to any licensing provisions nor are they required to report vessel location or catches to Canadian authorities, but they are required to report catches to NAFO. Outside the zone, Canadian fishery officers are designated as NAFO Inspectors under the Joint Enforcement Scheme and their authority is restricted to inspections of vessels from member nations of NAFO. If a violation is detected, the Master is cited for the violation and the details are forwarded to the Master's flag state (through NAFO) for further action. In 1984, Canada adopted a NAFO Sanction Policy providing for the cancellation or non-issuance of licenses to fish inside the zone on the basis of infringements of NAFO regulations by member nations fishing outside the zone.

Vessels from non-member nations operating in NAFO waters are not obligated to permit vessel inspections, but a number of "courtesy" boardings have, nevertheless, been made.

Management Success

The intent of the management system is to allow the full utilization of allocations by Canada and other countries without significant overruns. The system appears to be working in that, in general, neither TACs nor allocations are being exceeded (Tables 1 and 2). Where allocations have not been taken, practical logistical considerations, market conditions, and uneconomical catch rates have apparently been more important than restrictions imposed by the coastal state. While the rate of rebuilding of stocks since the depressed state of the mid-1970s has not been as rapid as earlier projected, there has in fact been significant improvement as reflected in catch rates and average size of fish landed.

Table 1 Catches and allocations (t) by country during the period 1977-1984 for cod in Divisions 2J,3KL. Catch figures were taken from NAFO Summary Documents 85/9 and 85/25. Allocations since 1980 to the EEC member states were determined by the EEC from its overall allocation. Certain of the apparent overruns of allocations may be explained by the cooperative arrangements made by Canada with certain countries to fish from the Canadian allocation.

Country	1977		1978		1979		1980		1981		1982		1983		1984	
	Alloc.	Catch	Alloc.	Catch	Alloc.	Catch	Alloc.	Catch	Alloc.	Catch	Alloc.	Catch	Alloc.	Catch	Alloc.	Catch
Bulgaria	600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canada	70,000	79,561	97,000	102,377	145,000	130,779	155,000	147,558	190,000	147,071	221,300	207,506	243,500	214,452	246,000	201,173
Cuba	1,810	18	700	28	1,400	1,031	700	12	-	-	-	-	-	-	-	-
EEC																
France	5,630	5,385	2,190	2,511	1,390	1,311	880	696	-	-	1,300	1,102	1,545	-	1,545	-
Deu	8,030	14,661	3,120	3,103	1,980	1,894	4,320	4,469	-	-	6,000	5,477	7,125	1,793	7,125	7,505
Italy	600	33	200	-	-	-	-	-	-	-	-	-	-	-	-	-
UK	1,330	1,641	520	462	330	458	300	449	-	-	700	851	830	-	830	765
Denmark (F)	1,690	1,196	660	782	700	768	700	1,823	700	1,812	700	692	1,000	984	-	-
DDR	4,970	4,300	1,950	1,990	1,500	10,012	700	509	-	23	-	12	-	29	-	77
Norway	1,610	194	630	410	700	1,094	700	963	700	799	1,000	1,070	800	2,107	-	-[1]
Poland	7,430	7,429	2,890	2,874	3,000	4,256	700	733	-	196	-	11	-	792	-	112
Portugal	21,100	18,695	8,210	8,027	8,000	8,283	7,000	10,127	5,000	9,685	5,700	8,690	6,500	6,962	6,700	6,273
Romania	700	24	250	3	-	-	-	-	-	-	-	-	-	-	-	-
Spain	18,760	20,725	9,330	8,609	5,000	5,996	7,000	7,014	5,000	8,636	-	1,451	-	5,062	-	8,159
USSR	18,880	18,850	7,350	7,349	1,000	1,009	700	297	-	114	-	452	-	159	-	488
Others	-	8	-	34	-	-	-	1,132	-	2,412	-	2,460	-	-	-	470
Total		172,720		138,559		166,891		175,782		170,748		229,774		232,340		225,022

[1] A catch of 1,140 t was reported for Subarea 3 as a whole.

Table 2 Catches (t) of cod from Divisions 2J,3KL taken by certain countries as part of co-operative arrangements with Canada.

Country	1977	1978	1979	1980	1981	1982	1983	1984
Norway	-	290	392	219	-	-	1,336	-[1]
Germany, Fed.Rep.	5,338	-	-	-	-	-	-	-
Japan	-	34	-	1,132	2,412	2,459	-	430
Portugal	-	-	668	3,083	4,676	3,018	370	-
German Dem.Rep.	-	22	8,470	-	-	-	-	-
Poland	-	-	1,282	-	-	-	-	-

[1] A catch of 1,140 t was reported for Subarea 3 as a whole.

ANNEX 10

FUTURE DEVELOPMENTS IN ICES SCIENTIFIC ADVICE: MULTISPECIES ASSESSMENTS

D.J. Garrod
Fisheries Laboratory
Lowestoft

ICES advice is based on single-species assessments, but frequently refers to possible effects of multispecies interactions. These can occur at the operational level (e.g., the mixed-fishery problem,), but in the assessment context, the interactions always refer to situations where the stock of one species can affect or be affected by the stock of another species. This can occur by competition or by predator-prey interaction at any stage of the life history. The direct effect of predation on stock size is thought to be the more important mechanism and one which it is at present possible to measure. Scientists are, therefore, attempting to measure, interpret, and then model predation within and between fish stocks. These are not the infinitely more complex total ecosystem models; they focus on well-established relationships which may have management implications concerning, in particular, the long-term balance between species/stocks most appropriate to management objectives.

Three questions arise: are the models technically feasible, will they provide worthwhile benefits, and will they be used?

The international programme in the North Sea has established a matrix of predation interactions (Figure 1). These can be measured and estimate the tonnage of one stock eaten by another during a year and, added across all species, can be expressed as natural mortality. This is then used in conventional procedures to estimate stock sizes and predicted yields, etc. The main differences from single-species models are the use of predator stock size to "tune" the natural mortality and the computational complexity of running assessments on several species together. The models are complicated but technically feasible.

Work to date has two important results:

1) It has shown how natural mortality can vary with age (Figure 2). Estimation of even an approximate rate of natural mortality in 0-, 1-, and 2-year-old fish is new; previous assessments stopped at 2- or 3-year-olds. The levels are generally higher for these younger age groups than previously supposed and hence stock numbers are also higher. The increased mortality on the youngest age groups means it may be better to catch more before something else eats them; so our perception of the balance between fisheries on young and older fish may change.

2) The fact of interaction between two species means that the target level of fishing to optimize the yield from two or more species may not be the same as it is for any of the species taken in isolation as in the single-species assessments (Figure 3). Scientists' perception of an appropriate balance between species is also changing.

Multispecies models are expected to provide a basis for objective and more confident scientific advice on the balance between different sectors of a fishery, both between species and between age group sectors of a single-species fishery. The potential benefit in long-term yield could be tens of thousands of tonnes and, since the additional equivalent scientific cost is only in the order of thousands of tonnes, one can presume the cost of research and development could be recouped and the effort is worthwhile.

Whether the models will be used by managers is another matter, depending on long-term fishery management objectives. In recent years, the preoccupation with allocation problems appears to have diverted attention from the long-term management objectives of improving overall yield and industry performance. At least the objectives have not been made explicit to ACFM, with the result that the directed thrust of advice and its clarity and usefulness is being degraded to merely information and generalities.

Because it will improve our present assessments, scientists are committed to following through the multispecies approach. They expect it to make a major contribution in the coming years providing in particular a more informed basis for advice on the very difficult problems of achieving a more appropriate balance between different sectors of fisheries exploiting the same stocks. But in that context, both they and the managers will need to take a broader view. We can foresee area-based assessments aimed at fisheries as the unit of management rather than individual species and that in turn implies a regional component in management structures and discussions.

References

Anon. 1984. Report of the ad hoc Multispecies Assessment Working Group. ICES CM 1984/Assess:20, 99 pp.

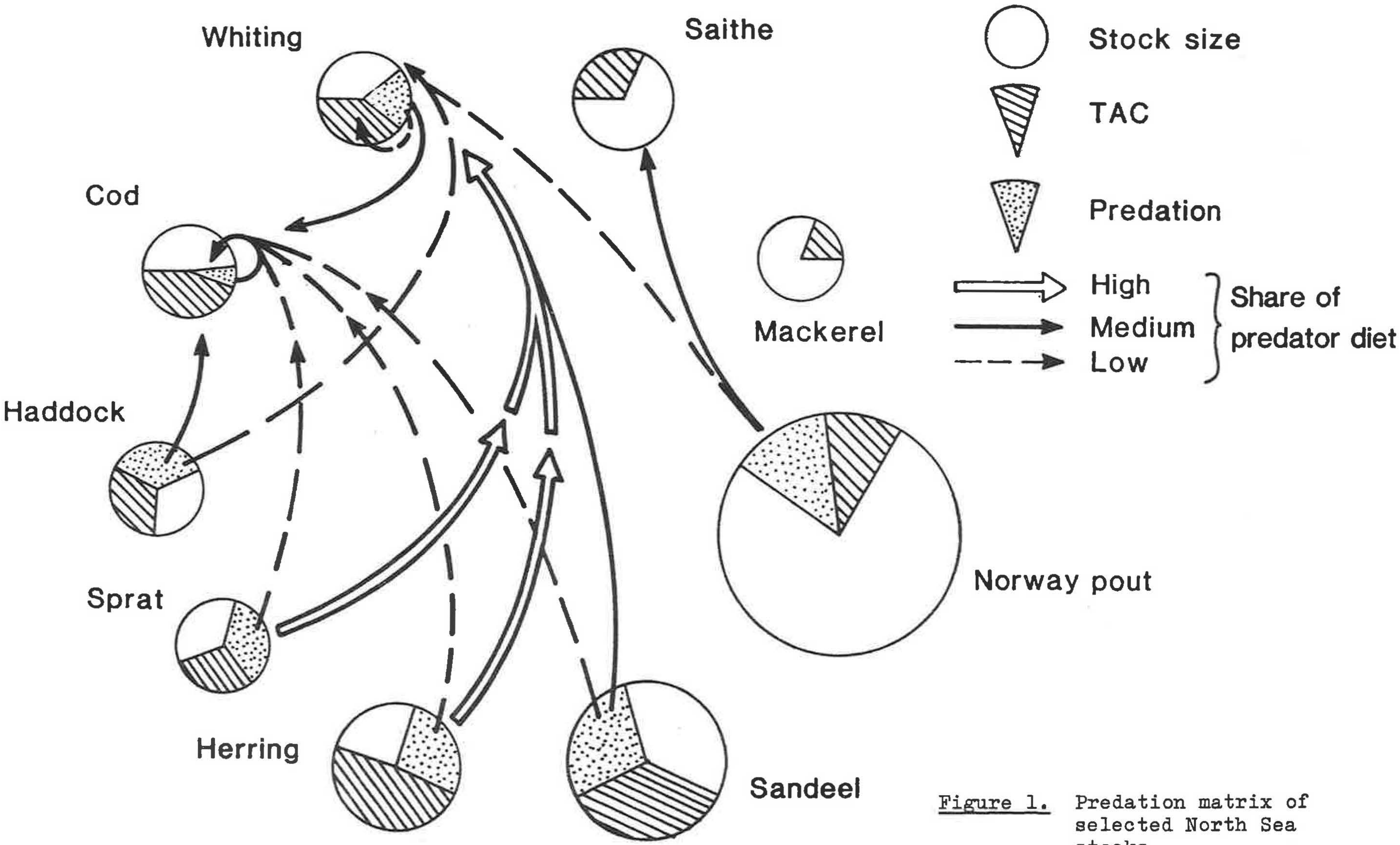
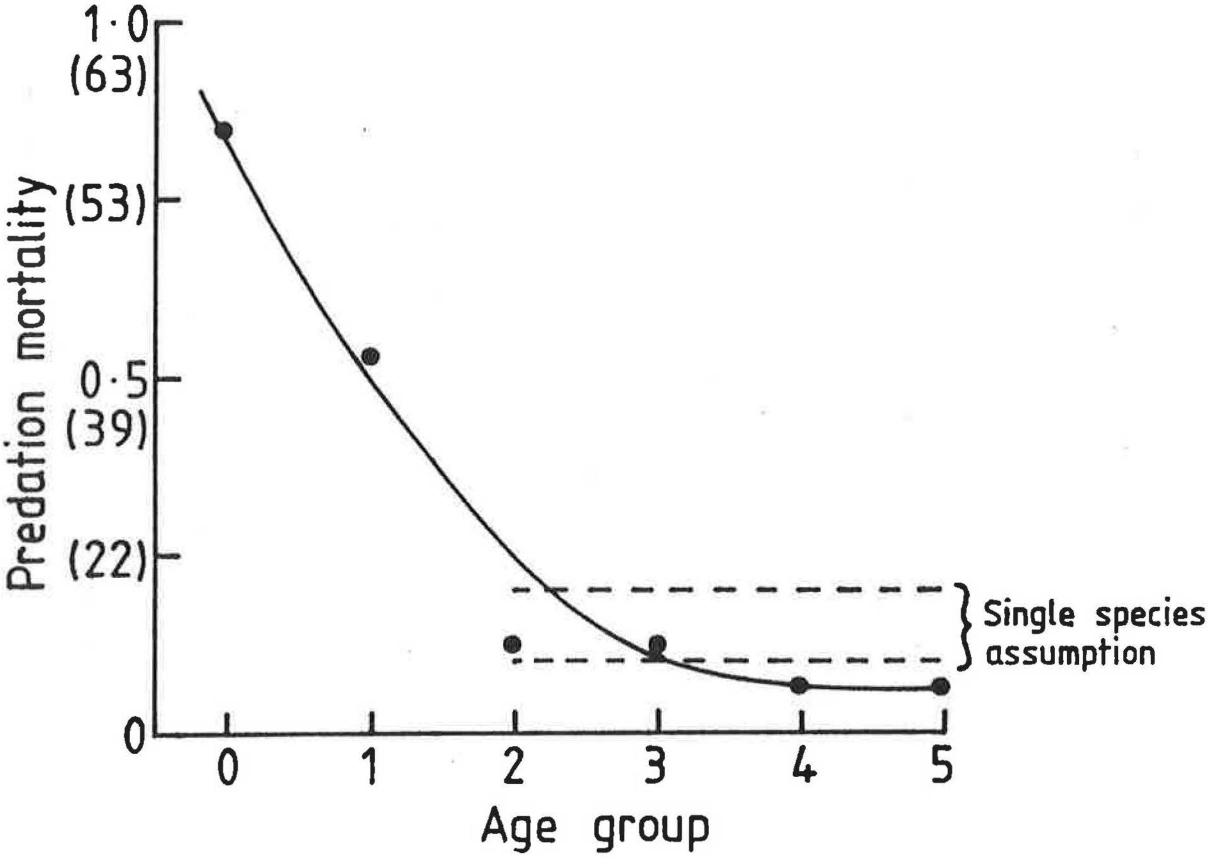


Figure 1. Predation matrix of selected North Sea stocks.



<u>Figure 2.</u> Preliminary estimates of predation mortality in the younger age groups (illustrative and averaged for cod, whiting, haddock, herring) (Anon., 1984, Table 6.4.1).

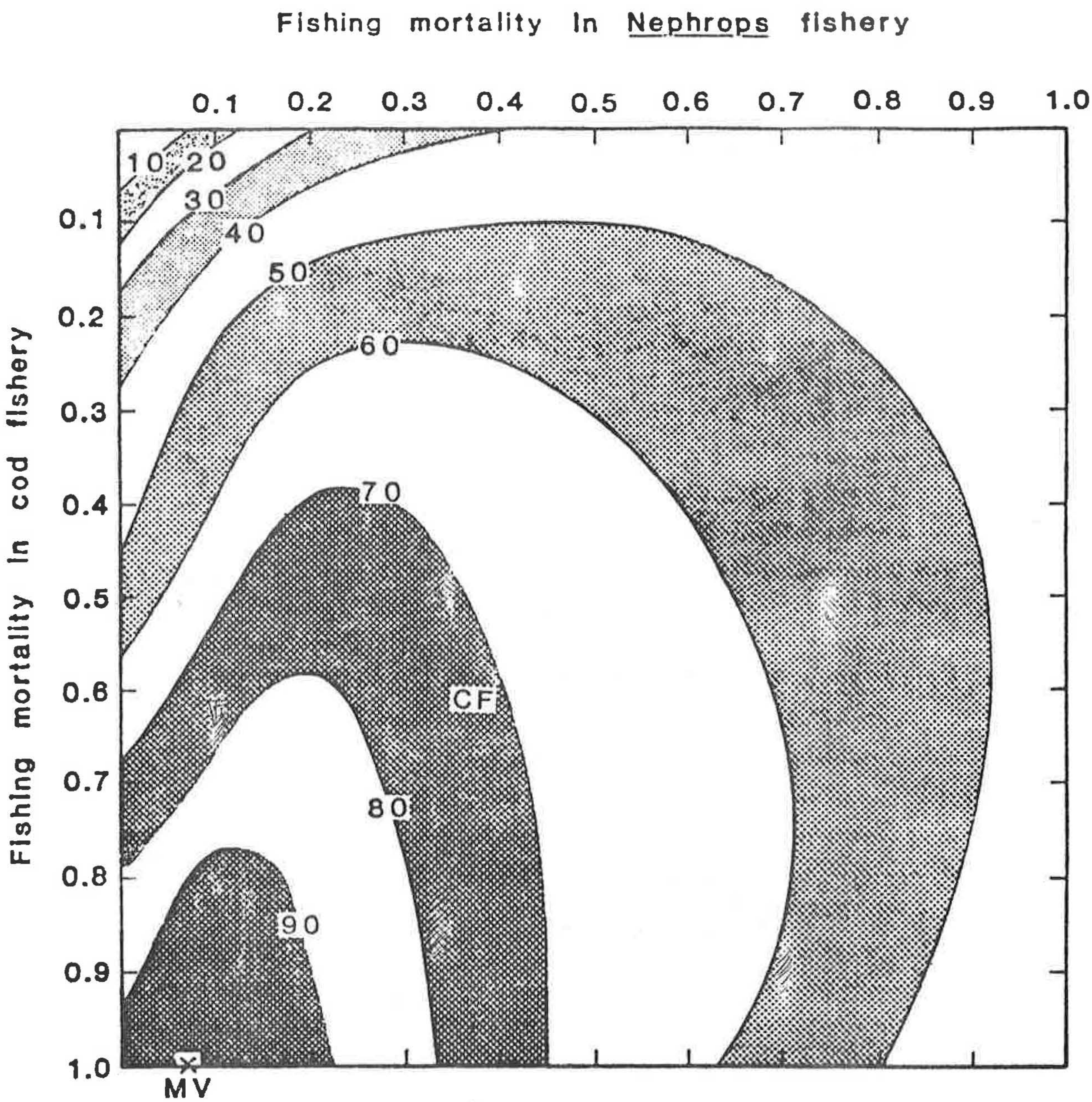


Fig. 3 Contour plot of total value of cod plus *Nephrops*. Key; maximum value (MV) = £12.4 million. CF = current fishing mortality in both fisheries. Contour lines are 10% intervals of maximum value.

ANNEX 11

ICES PROCEDURES IN PROVIDING ADVICE ON MANAGEMENT OF FISH STOCKS

ICES Secretariat

Introduction

The advice of ICES is submitted to the Member States as well as to the North-East Atlantic Fisheries Commission (NEAFC), the International Baltic Sea Fishery Commission (IBSFC), and the North Atlantic Salmon Conservation Organization (NASCO), which have no scientific bodies of their own. The ICES area includes the EEZs of the following countries, starting from north: Iceland, Faroe Islands, Norway, USSR, EEC (with 7 Member States of ICES), Sweden, Finland, Poland, German Democratic Republic, Portugal, and Spain.

The Production of Advice by Working Group and ACFM

Changes in international fisheries and the Law of the Sea have introduced changes in the formal advisory process within ICES in recent years, but the basic philosophy has remained unchanged. First, the basic description of the fisheries and the stocks exploited has been given by a working group which, ideally, has included scientists directly involved in the assessment work at the national level. Secondly, this description has been scrutinized by another group, the Liaison Committee until 1978 and the Advisory Committee on Fishery Management (ACFM) since 1978, and converted to management advice.

The advantage of this system has been that the full utilization of specific local expertise has been guaranteed, while at the same time the later scrutiny of the working group reports has secured a certain uniformity in quality and approach in all areas. The risk of contaminating the basic description with political considerations has also been reduced.

Until 1974, the product from ICES was essentially a description of the state of the stocks, giving, if possible, an estimate of the fishing mortality level (F) and, if any specific regulatory measures were discussed, mainly gear or area regulations.

Since 1974, catch regulations have to a greater and greater extent been introduced and, at the time ACFM was formed, the ICES product was, for almost every fish stock assessed, a single recommended TAC value for every year. The basis of the recommendation was purely biological (Anon., 1977).

In 1980, ICES took steps to intensify the dialogue with managing bodies and, as a result, the product since then has changed and is now an array of options "inside safe biological limits" which gives the managers the option of taking into account factors other than those strictly dependent on the biology of the stocks, providing that none of the options given would endanger recruitment.

The Working Groups and their Methods

It should be noted that the changes in fisheries in the 1970s following the introduction of the EEZs had a very marked effect on the assessments or on the possibilities for producing accurate assessments. This was realized by the Liaison Committee already in 1972 (Anon., 1972): "With the rapid changes in the fisheries and with the introduction of catch regulation, the comparability of the present abundance indices will become less and less precise. They are based on long established national patterns of fishing. Closed seasons, closed areas or quotas will disrupt these patterns, making it essential to obtain estimates of stock independent of catch and effort data .....".

Where a working group in the early 1970s would have had a rather good measure of fishing intensity from long effort series, or a measure of abundance from long catch-per-unit-effort series, both describing fisheries which had been stable for many years, the working groups of the late 1970s found many of these important data series disrupted by the large-scale changes in fleet composition. Further, the introduction of catch quota regulations demanded that ways be found to make very accurate predictions of catches in the years to which the catch quotas were to apply. This is a much more difficult task than indicating the general stock situation (e.g., the position of the present F on the yield-per-recruit curve).

The typical working group procedure to cope with this has been as follows:

> The group establishes a data base encompassing several years. This is updated with data for the last year in preliminary form, and the data for the year preceding it are brought into final form.
>
> The data include yield by country, catch in numbers by age and country, and possibly catch-per-unit-effort and fishery-independent data (surveys, etc.). Table 1 shows the data available to some of the working groups meeting in 1985 and indicates considerable variability among stocks.
>
> The data on catch at age by country are aggregated to a combined estimate of total catch by age and year, and a VPA[1] is run, with the results differing somewhat from those of the previous year because of the added year of data.

[1] Virtual population analysis which, based on catches, gives an historical estimate of stock numbers, biomasses, and level of exploitation.

Trial VPA runs are made and, if available, are calibrated to effort or survey data. Anecdotal information might also be used at this stage. At some point, the group agrees on one of the trial runs as the final version.

The fishing mortality level for the last year and the exploitation pattern (possibly smoothed) are taken from the VPA, and from this and the catch, the stock as of 1 January in the following year (of the assessment) is calculated.

To predict the stock biomass and catch for the following year, catches in the year of the assessment must be assumed and recruitment must either be estimated or assumed. Projections of catch and stock biomass for the following years are then calculated.

Schematically, the procedures can be described as follows (for the assessment year 1985):

1984	1985	1986
Fishing mortality estimated, total level and exploitation pattern	Stock as of 1 January calculated, catches assumed	Stock and yield projected
Last year with data	Year of assessment	Year of advice

Problems Experienced by the Working Groups

Table 1 shows which data are available for assessments of different stocks in the ICES area.

For those stocks where an analytical assessment has not been possible, only a precautionary TAC can be indicated from catch figures over several years using various "short-cut" methods.

In a number of cases where an analytical assessment has been undertaken, the working group has only the catch-at-age data to go on, which means that there is no basis for estimating the fishing mortality rate in the last year for use in the VPA, and hence the VPA cannot furnish a reliable starting point for a projection. This makes the calculation of a TAC, with any degree of certainty, impossible. Experience has, however, shown that in some cases detailed knowledge of the fishery and anecdotal information of any kind can be very helpful, making it possible to pick an appropriate VPA to furnish the starting point for a projection.

Some groups will, in addition to their catch-at-age data, have detailed data on fishing effort. The calibration of VPAs by fishing effort data has been dealt with in recent ICES papers and especially the North Sea Roundfish Working Group. There is no simple solution to this problem in a mixed-fishery situation such as that in the North Sea, and experience has shown that the consistency of the effort series used through the years is especially critical.

However, the major difficulties in making sufficiently accurate projections have occurred in two general situations, both hinging on the problem of predicting recruitment: when dealing with very short-lived species and with fisheries where the fishing intensity is very high. In both cases, the fishery will be dependent on the strength of incoming year classes, and without methods to estimate this accurately, it is impossible to predict yields corresponding to a given level of fishing mortality with any certainty. The establishment of central data bases of survey data at ICES headquarters, as in the case of the Young Fish Surveys in the North Sea, may improve the situation.

For pelagic species, where catch-per-unit-effort data are generally not reliable for measuring changes in stock biomass, survey data are used extensively. In the Barents Sea and the waters around Iceland, the echo-integration surveys on herring and capelin have reached a high level of accuracy. Surveys of egg production, from which absolute estimates of spawning stock number or biomass can be obtained, have also proved to be useful in calibrating VPAs (e.g., North Sea and Western mackerel, Anon., 1985a).

In addition, some major steps have been taken in the use of echo-integration for demersal species in the Barents Sea (Anon., 1985b). These have given estimates of absolute stock size for calibration of the VPAs, in contrast to the indices which are output from most demersal surveys and which demand a reasonable time series before the data can be of use.

Although, in general, requests addressed to ICES from management bodies only ask for advice one year ahead, some working groups have tried to work out medium-term predictions. This would correspond to an attempt to define a medium- or long-term level of fishing. The question of estimating recruitment in future years then becomes a major one. It has not been possible to establish any clear stock/recruitment relationships which can be used, so an average figure is generally calculated from the historic evidence of the VPA.

The ACFM Filter

The working group reports are scrutinized by ACFM. This can result in major re-assessments if, for example, new data have become available since the working group's assessments were made, or if ACFM does not accept the findings of the working group, or if it has reservations about the working group's methods or assumptions. In most cases, however, ACFM does accept the assessments and translates them into actual advice. The form of the advice has changed in recent years. In the early days of ACFM, a single TAC figure would be recommended. The ACFM advice is now more comprehensive. Figure 1 is an example of a standard set of graphs prepared for each stock including a summary of the history of the fishery and the stock, the yield curve with the present exploitation pattern, and a graph showing the consequences of different fishing intensities in the short term. In the body of the ACFM report, options within safe biological limits are given and eventual additional conservation measures are indicated.

It should be noted that this two-tier system is quite time-consuming. In 1985, for example, the first round of working group meetings started in late February and ended in mid-April, with one to three groups meeting concurrently at ICES headquarters. The reports from these meetings had to be ready for the ACFM meeting in mid-May. One additional working group meeting took place in June, and the last groups met in September/October, reporting to the November 1985 ACFM meeting. So altogether, the advice for 1986 was an almost continuous process from February to November, and the management bodies will not receive the final information for some stocks from ACFM before late November. There can also be a large gap between the actual time of the assessment made at a working group meeting and the time when the management advice is finally passed to the managers through ACFM.

Discussion of the Present Procedures Inside ICES

In the continuous discussion of the basis of the advice given by ICES, three major reservations in principle have emerged, leaving aside all the cases where disagreement over an assessment is due to uncertain data which permit multiple interpretations. Of these three reservations, two basically challenge the science, and the third deals with the role of advice given by ICES in what has been termed "the fisheries continuum" of biology, fishery, and socio-economics.

Basic Scientific Problems in the Present Assessments

The advice given at present is based on the premise that the scientists are able to predict or at least project the consequences of changes in the pattern and levels of fishing on individual fish stocks. A general criticism of this approach has been that the assessments do not take into account biological interaction between fish stocks (multispecies assessments) or technical interaction (multispecies fisheries).

The obvious example of the former is that fishing at a very low fishing mortality level on all stocks in a certain region would change the predation pattern, so the projected benefits for individual stocks would not be achieved. The results of a large-scale experiment on stomach analysis in the North Sea will, it is hoped, throw light on the subject for this area. Multispecies assessments have been attempted in the Baltic and the North Sea, but the calculations do not yet allow any firm conclusions to be made (Anon., 1982) and cannot, therefore, form the basis for projections. This whole approach and the state-of-the-art is a specific item on the agenda of this meeting.

The obvious examples of the latter are from NEAFC Regions 2 and 3, where single-species fisheries are very rare, if they exist at all, and the total mortality on any one stock is caused by the combined effect of directed catches and by-catches of a number of fleets. This has an especially strong impact on the interpretation of the projections. For some stocks, assessments are presently made by the type of fishery, thus predicting, for example, for North Sea whiting, the yield taken in human consumption fisheries and in the small-meshed industrial fisheries (Anon., 1985c). There is a growing interest in proceeding further in this direction and attempting to make assessments on a "fleet basis", but so far the results in actual management advice remain to be seen.

The Process from the Biological Description to Viable Management Advice

Since 1974, the TAC has been the magic word in fish stock management in the Northeast Atlantic. One of the serious problems with this form of management is that of choosing the reference point to which the TACs should be tied. Quoting from the 1978 report of ACFM (Anon., 1979): "ACFM has, throughout this report, attempted to base its advice on gradually reducing the exploitation rate and improving the exploitation pattern in a phased programme, so as not to cause too great disruptions in current fishing activities". Therefore, if the assessment showed a fishing mortality level of, say, 1.0 and the yield curve had an optimum at 0.2, ideally ACFM would, for the first year, calculate a TAC corresponding to a reduction in fishing mortality to 0.9, for the next year to 0.8, etc. until the appropriate level on the yield curve had been reached.

However, in practice the situation has never been quite as simple as that. The following problems have been encountered over the years:

(a) No management action to reduce the fishing mortality has been agreed, so for the next year, the starting baseline is unchanged or has even increased.

(b) A revision of an assessment gives a new estimate for the level of fishing mortality and a new exploitation pattern, so the baseline and the desired optimum change.

(c) Although the ACFM report clearly states the assumptions underlying the advice, these tend to disappear in the later events and only the single TAC figure remains. This figure, depending on the case, may mean anything from an exact optimum on the yield curve to a fishing mortality level several times higher.

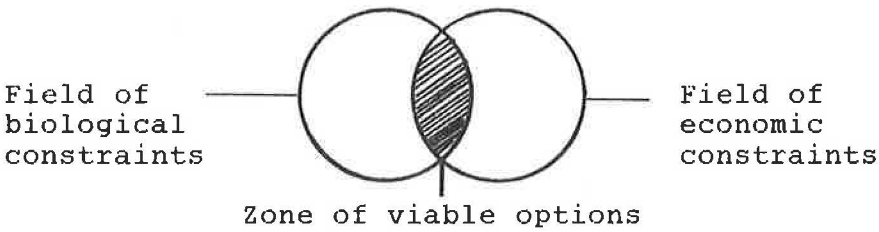
(d) The single-figure advice does not give due consideration to other parts of the fisheries continuum and, in effect, gives the scientists the role of managers and leaves to the management bodies only the choice of accepting or rejecting the advice.

As one of the results of the Dialogue Meetings convened by ICES, this whole approach has been changed, so that ACFM has gone from "normative to exploratory advice" (Hoydal, 1982).

This has obviously solved one of the problems and, according to the management bodies, has increased considerably the usefulness of the advice given (Anon., 1983a). However, the question of how to get the biological constraints into the right place in the total management system still remains.

As pointed out by several workers, including Gulland (1979), the scope of management is essentially economic and certainly not biological. It is, generally speaking, a planning problem, as are so many others in modern society, and the decisions to be made which can guide the system towards a desired stage demand knowledge of, among other things, the biology of fish stocks, the related industries, and the influence of the benefits from the fisheries on other parts of society.

These problems were indicated by a former chairman of ACFM in a recent paper (Griffith, 1982) as follows: "Biological advice can really only establish one set of constraints within which management ought to be applied. Even with the increased flexibility now built into ACFM advice in order to provide managers with a wider range of options, it would appear that a course of action recommended on biological grounds alone has little chance of being accepted (and probably no chance of being implemented or enforced) unless it lies within that part of the biological 'field' which overlaps with the economic 'field'".



Based on the same kind of considerations, ACFM, in its July 1982 report (Anon., 1983b), asked for a dialogue with economists on how to tailor the biological output to the needs of economic analysis. At the 1983 Statutory Meeting, this dialogue was initiated by inviting several fisheries economists to submit papers.

Although this is a process which has just started within ICES, there has been a great deal of activity in this field at the national level, due to the fact that, even though the fisheries may be multi-national, the socio-economic aspects must be evaluated on a national basis. From some of these attempts (e.g., Kristiansen, 1982), it is clear that one of the paramount demands is for better descriptions of "unit-fisheries" and "unit-fleets", and a gross estimate of what might be taken by a fishery from a stock "within safe biological limits" is not all the information required by managers in trying to achieve some economic optimization for the fishery. Thus, the increasing interest from the assessment point of view in investigating technical interactions coincides very nicely with what is probably needed to "tailor" the biological output to the needs of economic analysis".

References

Anon. 1972. Report of the Liaison Committee of ICES to the North-East Atlantic Fisheries Commission 1972. ICES Coop. Res. Rep., No. 31.

Anon. 1977. Report of the *ad hoc* meeting on the provision of advice on the biological basis for fisheries management. ICES Coop. Res. Rep., No. 62.

Anon. 1979. Reports of the ICES Advisory Committee on Fishery Management, 1978. ICES Coop. Res. Rep., No. 85.

Anon. 1982. Report of the *ad hoc* Working Group on Multispecies Assessment in the Baltic, Copenhagen, 25-28 May 1982. ICES C.M.1982/Assess:15, 26 pp (mimeo.).

Anon. 1983a. Report of the Fourth Dialogue Meeting, 8 October 1982. ICES Coop. Res. Rep., No. 122.

Anon. 1983b. Reports of the ICES Advisory Committee on Fishery Management, 1982. ICES Coop. Res. Rep., No. 119.

Anon. 1985a. Report of the Mackerel Working Group, Copenhagen, 18-27 February 1985. ICES C.M.1985/Assess:7, 98 pp (mimeo.).

Anon. 1985b. Report of the Arctic Fisheries Working Group, Copenhagen, 26 September - 3 October 1984. ICES C.M.1985/Assess:2, 52 pp (mimeo.).

Anon. 1985c. Report of the North Sea Roundfish Working Group, Copenhagen, 12-21 March 1985. ICES C.M.1985/Assess:9, 159 pp (mimeo.).

Griffith, D. de G. 1982. Review of scientific advice on fisheries management, 1982. ICES C.M.1982/Assess:22, 6 pp (mimeo.).

Gulland, J.A. 1979. Long-term potential effects from management of the fish resources of the North Atlantic. ICES C.M.1979/G:58, 18 pp (mimeo.).

Hoydal, K. 1982. From normative to exploratory advice on fishery management and the general framework of advice. ICES C.M. 1982/Assess:21, 18 pp (mimeo.).

Kristiansen, A. 1982. En bioøkonomisk simuleringsmodell av linefisket ved Færøyene. (In Norwegian.). (A bio-economical model of the long-line fishery in the waters around the Faroes.) Tromsø.

Table 1 Data available to selected Fish Stock Assessment Working Groups meeting in 1985.

Region / Stock	Yield Data		Catch at Age		Discard Data		Fish.-Indep. Stock Est.		Fish.-Indep. Recruit. Est.		Effort Data		Comments
	Land-ings	Unrep. catches	Avail-able	Used	Avail-able	Used	Avail-able	Used	Avail-able	Used	Avail-able	Used	
NE Arctic													
Saithe	x		x	x									Data on migration not used
Greenland Halibut	x		x	x							x	x	
Golden Redfish	x		x	x					x				Catches split by species on an area basis
Beaked Redfish	x		x	x					x		x	x	
E Greenland													
Prawn	x										x		Catch/effort data only covering part of the year
Cod	x	x	x	x			x	x	x				Migration data on age needed to improve assessment
E Greenland, Iceland, Faroes													
Greenland Halibut	x		x	x							x	x	
Golden Redfish	x		x	x					x				
Beaked Redfish	x		x	x					x				
Iceland													
Saithe	x		x	x							x		Limited cpue time series by Icelandic trawlers

..../contd.

Table 1 .../contd.

Region / Stock	Yield Data: Land-ings	Yield Data: Unrep. catches	Catch at Age: Avail-able	Catch at Age: Used	Discard Data: Avail-able	Discard Data: Used	Fish.-Indep. Stock Est.: Avail-able	Fish.-Indep. Stock Est.: Used	Fish.-Indep. Recruit. Est.: Avail-able	Fish.-Indep. Recruit. Est.: Used	Effort Data: Avail-able	Effort Data: Used	Comments
Faroes													
Cod, Plateau	x		x	x					x		x	x	Effort series short because of large-scale changes in fisheries
Haddock	x		x	x					x		x	x	
Saithe	x		x	x							x	x	
Skagerrak Kattegat													
Herring	x	x	x	x	x	x	x	x	x	x			Separation of autumn and spring spawn.comp.& interchange with adjacent areas cause problems in this assessment.TAC for 1986 to be determined at Nov.'85 ACFM meeting.
Sprat	x		x				x		x	x			Catch at age data only avail. for half of catch.No TAC for 1986
Cod	x		x	x					x	x			Precautionary TAC
Haddock	x												Precautionary TAC
Whiting	x								x				Precautionary TAC
Plaice	x		x						x	x			No basis for analytical assess-ments.Precautionary TAC.
North Sea													
Herring	x	x	x	x			x	x	x	x			Fishery-indep.stock est. from larval survey & acoustic survey used.
Sprat	x	x	x	x			x	x	x	x			

..../contd.

Table 1 ...../contd.

Region / Stock	Yield Data: Landings	Yield Data: Unrep. catches	Catch at Age: Available	Catch at Age: Used	Discard Data: Available	Discard Data: Used	Fish.-Indep. Stock Est.: Available	Fish.-Indep. Stock Est.: Used	Fish.-Indep. Recruit. Est.: Available	Fish.-Indep. Recruit. Est.: Used	Effort Data: Available	Effort Data: Used	Comments
North Sea (contd.)													
Mackerel	x	x	x	x			x	x	x		x	x	Problems in stock delineation between the two components. This applies also to Western stock. Effort data only for West. Stock.
Cod	x		x	x	x				x	x	x	x	
Haddock	x		x	x	x	x			x	x	x	x	
Whiting	x		x	x	x	x			x	x	x	x	
Saithe	x	x	x	x							x	x	Effort data for one country, 1979-84 consist. with VPA. Data on migration not used.
West of Scotland													
Cod	x		x	x	x						x		
Haddock	x		x	x							x		
Whiting	x		x	x							x		
Saithe	x		x								x		Precautionary TAC, due to problems with data base.
Herring	x	x	x	x			x	x	x	x	x		
Clyde Herring	x		x	x	x	x					x	x	Interchange with adjacent areas but treated as separate management unit.
Sub-area VII (excl. Div. VIIa)													
Cod	x												No assessment
Haddock	x												
Whiting	x												

..../contd.

Table 1 ...../contd.

Region / Stock	Yield Data: Landings	Yield Data: Unrep. catches	Catch at Age: Available	Catch at Age: Used	Discard Data: Available	Discard Data: Used	Fish.-Indep. Stock Est.: Available	Fish.-Indep. Stock Est.: Used	Fish.-Indep. Recruit.Est.: Available	Fish.-Indep. Recruit.Est.: Used	Effort Data: Available	Effort Data: Used	Comments
Irish Sea													
Herring	x	x	x	x			x				x	x	
Cod	x		x	x							x	x	
Whiting	x		x	x	x				x		x	x	
Plaice	x		x	x					x	x	x	x	
Sole	x		x	x							x	x	
West of Ireland													
Herring (Div.VIIb,c)	x	x	x	x			x	x			x		
Celtic Sea													
Plaice	x		x	x							x	x	Low percentage of catches covered by age samples
Sole	x		x	x							x	x	
Cod	x		x	x							x	x	
Herring	x	x	x	x			x	x					Includes Div.VIIj herring.
Northern Hake	x	x			x				x		x	x	Length cohort analysis used.
Southern Hake	x	x	x	x	x		x		x		x		
Northern Blue Whiting	x		x	x		x	x	x			x	x	
Southern Blue Whiting	x		x										

...../contd.

Table 1 ..../contd.

Region / Stock	Yield Data		Catch at Age		Discard Data		Fish.-Indep. Stock Est.		Fish.-Indep. Recruit.Est.		Effort Data		Comments
	Land-ings	Unrep. catches	Avail-able	Used	Avail-able	Used	Avail-able	Used	Avail-able	Used	Avail-able	Used	
Baltic													
Herring													By-catch and discard data very incomplete
22-24	x	x	x	x					x	x			Migration data necessary
25,26,27	x		x	x			x	x					
28,29S	x		x	x			x	x					
Gulf of Riga	x		x	x					x	x			
29N,30,31	x		x	x					x	x	x	x	
32	x		x	x							x	x	
Sprat													
22,24,25	x		x	x			x	x					
26,28	x		x	x			x	x	x	x			
27,29-32	x		x	x			x	x	x	x	x		
Cod													
22 & 24	x	x	x	x	x				x	x	x	x	Discard data available only for Sub-div.22
25-32	x	x	x	x	x				x		x		
Salmon	x							x	x	x			

FISH STOCK SUMMARY

STOCK: Western Mackerel

5-3-1985

Figure 1.