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REPORT OF THE AD HOC WORKING GROUP ON MULTISPECIES ASSESSMENT MODEL TESTING

Copenhagen, 3-7 March 1980

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1. Terms of Reference

At the Council Meeting in 1979 in Warsaw the resolution was adopted (C.Res.1979/2:5) that an *ad hoc* Working Group should meet at ICES headquarters in order to:

a) identify the kind of information most urgently required for testing multispecies assessment models,

b) design an international sampling scheme to obtain this information and coordinate the available research effort.

2. Participation

The meeting was held from 3 to 7 March 1980 in Copenhagen and was attended by:

Dr O Bagge	Denmark
Dr K Brander	United Kingdom
M.R Chevalier	France
Dr N Daan, Chairman	Netherlands
Dr S Ehrich	Federal Republic of Germany
Mr H Gislason	Denmark
Dr T Helgason	Iceland
Mr R Jones	United Kingdom
Dr R Langton	U.S.A.
Dr O Pálsson	Iceland
Dr M Sissenwine	U.S.A.
Mr B Sjöstrand	Sweden
Mr O M Smedstad	Norway
Mr P Sparre	Denmark
Dr W Weber	Federal Republic of Germany
Mr T Westgård	Norway
Dr E Ursin	Denmark

The meeting was further attended by Mr A Saville (Chairman, ACFM) and Mr A Sudradjat (Indonesia) as a guest.

Mr K Hoydal (Faroes) and Mr J A Pereiro (Spain) notified their regret that they were unable to attend.

3. Introduction

In the past five years the Danish ecosystem model (Andersen & Ursin, 1977) has been run in different versions for a large number of specific purposes. Although these exercises have resulted in a growing awareness of the limitations of the traditional single species assessments, the important implications have been largely neglected in the advice on fisheries management produced by ICES.

There are two important reasons for this. Firstly, many of the underlying assumptions remain to be tested against empirical information and there are too many unknowns in the data base for the results of these simulations to be accepted quantitatively. Secondly, the model is still not fully understood in all details by many assessment scientists and is too complex to be easily handled during Assessment Working Group meetings. In the past, Assessment Working Groups have chosen to assume that natural mortality is constant throughout the lifespan of a species and over large ranges of exploitation rate. It now seems possible to improve this assumption by means of new models incorporating species interaction.

In 1979 two papers (Pope, 1979; Helgason and Gislason, 1979) which opened new perspectives were presented at the Council Meeting. The essentially similar approach adopted by these authors was to develop algorithms for the solutions of simultaneous VPAs of more than one fish stock, the important feature being that natural mortality is not a fixed input parameter, but is at least partially modulated by inter- and intraspecific predation. Effectively, fishing mortality and natural mortality are simultaneously estimated for each age group and year given a catch array. The additional information required with respect to the traditional single species VPA refers to a suitability index of each prey age group for each predator age group and the rate of total food consumption.

Obviously, in the theoretical field the point has been reached where species interaction could be incorporated in stock assessment. However, in practice there is a clear discrepancy between this progress in the theoretical field and the standstill in practical food investigations, which are required to estimate the suitability indices. This discrepancy has been the motive for establishing the *ad hoc* Working Group.

From the terms of reference it is clear that the Group was intended to address itself to the specific demands which these models make on food investigations and in addition to specify the requirements for international cooperation in this respect. However, the Group took as its first task to review existing species interaction assessment models, to examine whether there are differences in their data requirements and eventually to select the model(s) which should be specifically addressed in setting up programs for stomach content investigations to meet their requirements.

4. Review of Existing Species Interaction Assessment Models

With reference to a recent paper by Ursin (1979) the existing species interaction assessment models were reviewed. For reasons extensively discussed in that paper only those described by Andersen & Ursin (1977), Pope (1979), Helgason & Gislason (1979) and Sparre (1980) were considered to be relevant to the immediate assessment problems within the ICES region.

Essentially these models are very similar in the way prey is distributed among predators. A suitability index G_{ij} of each prey species age group j for each predator age group i is defined which, weighted by the relative abundance of that prey in terms of total prey abundance and the respective suitability indices, determines the actual amount of that prey consumed by the predator group. As shown by Sparre (1980) empirical food composition data can be translated in an estimate of the suitability index by means of an iterative procedure. Such data therefore represent an essential input requirement of these models.

In the models developed by Andersen & Ursin and by Helgason & Gislason this suitability index is formulated as the result of two components. A prey size preference index is derived from a preferred prey size/predator size ratio, whereas the vulnerability index is related to the

the availability of a species as prey for a predator (Appendix II). This more complex formulation has the advantage that the preference index may be estimated from stomach analysis of samples which do not necessarily have to represent a random sample of the population, whereas the vulnerability index can be approximated in connection with the knowledge of the general biology of the species involved.

However, in all these models the suitability index should be tested against or calculated from an estimate of the total food composition of each predator age group in a particular year. In order not to be biased by seasonal or geographical variation in food composition, an empirical estimate of average annual food composition for a population by age groups as a whole makes high demands on the sampling scheme involved.

The almost complete lack of reliable estimates for this food composition in all major fish predators included in any species interaction assessment exercise was identified as the major gulf which has to be bridged in order to apply the models.

The main task of ICES in relation to fisheries is to provide advice on management of fish stocks. This task is to be approached at two levels. A certain strategy is required as the basis of the advice. Formerly the MSY per recruit concept has been extensively used, but obviously this concept has to be improved because of interaction of fish stocks. To define a new strategy, a strategic model is required but almost necessarily such model is going to involve more complex considerations. Essentially, it would require simulation runs over prolonged periods to estimate the effect of different exploitation strategies. Resilience has to be an essential feature of such a model but also it should be based on a fairly realistic formulation of recruitment mechanisms. These are bound to be affected by species interactions in the very early stages of life, which are still largely unidentified.

On the other hand, ICES has the practical involvement of providing annually advice on TACs one or two years ahead. This requires a tactical model which provides accurate assessment of the stock sizes in the present year in addition to estimates of the size of recruiting year classes. Therefore the early life interactions between species are not taken into account in such a model.

For all practical purposes it was decided to concentrate on these species interaction VPA models, which are closely tied up with traditional assessment techniques. Therefore the main emphasis of research should be put on food composition of major predators on fish.

There are differences between the models in the way "other food" than those species and age groups actually incorporated in the VPA is dealt with. In Pope's model the "other food" is assumed to be a constant fraction of the total food requirement. Helgason & Gislason consider "other food" to be a constant quantity, whereas Sparre proposes the total food in the system to be constant. These differences do not affect the essential data requirements from feeding research.

5. Essential Data Requirements

The essential input data for species interaction assessment can be summarised as follows:

A. Average annual estimate of food composition by prey species [defined as those species which are also being assessed as part of the exploited species complex], age groups of each predator age group, which is representative for the population as a whole.

B. Annual rate of food intake for each predator age group, which is representative for the population as a whole.

These should be considered to be the primary objectives of any large-scale stomach analysis program, which are absolutely essential to allow progress in multispecies assessment techniques. However, at the same time the research effort involved should yield information, which can be utilised to test the validity of the major underlying assumptions of these models.

1) Seasonal differences in predation rate can be approximated by constant average annual rates of decrease.

2) Other causes of natural mortality than predation mortality are fixed at a constant rate.

3) Preference is independent of prey abundance.

4) Growth and consumption rates are constant.

Only in case additional information is collected will it be possible to revise the assumptions if necessary and to allow further progress in the theoretical field. The important implication is that this means that the research programme is at least repeated once after the first run, because that would allow to decide if Assumptions 3 and 4 are grossly simplistic ones.

6. Demands on Data Collection

6.1 Stomach sampling

6.1.1 Requirements for surveys

The essential requirements for using any of the species interaction assessment models discussed in Section 4 are estimates of the annual food consumption over the total area of distribution of the stock of each age group of predatory species. This food requirement, in as far as it consists of prey species which are also being assessed, must also be expressed as numbers consumed annually per age group.

Annual food requirements can be estimated in two ways:

1) from information on the amount of food in stomachs and digestion rates,

2) from consideration of energy requirements.

Food "preferences" (in terms of the suitability coefficient G) can also be estimated in two ways:

1) empirically using a set of stomach content observations and population numbers calculated in species interaction cohort analysis (Sparre, 1980),

2) analytically by investigating the choice of food and estimating prey size preferences (coefficient g) and vulnerability to predation (coefficient ρ). The product of these coefficients gives the suitability coefficient G (Appendix II).

With respect to the latter problem the Group is of the opinion that the first approach is to be preferred; for total food consumption both methods should be considered.

It must be pointed out, however, that carrying out surveys to assess food consumption and its composition will make considerable demands on research vessel time and scientific manpower. Within a stock area there are likely to be considerable variations, between sub-divisions of it, in food composition of any species due to geographic variation in species and size composition of suitable prey organisms. Such variations in food composition and food consumption between sub-areas must be converted into an overall mean for the area as a whole by weighting the sub-areas' estimates by appropriate indices of the predator population which they contain. There are, therefore, two basic data requirements: total food consumption and its composition within each sub-area and an index of relative abundance of predator category between sub-areas. Although the first of these could perhaps be, at least partially, obtained by appropriate sampling of commercial catches for stomach contents, the combined requirements are better met by research vessel surveys.

Because there are certainly going to be considerable seasonal variations in food consumption and composition due to seasonal variations in availability of suitable prey and metabolic requirements of the predator, it is also essential that these estimates of food requirements and food composition are obtained several times a year so that a realistic annual estimate can be derived. Obviously the more frequently such surveys can be done the more accurate will the resulting annual estimates be. The Working Group, however, taking into account the demands of mounting such surveys, decided that surveys carried out at quarterly intervals, that is four a year, would probably give a sufficient accuracy to meet the requirements.

Diurnal fluctuations in the catch of numerous species of fish are well documented. Since these may reflect the feeding activity of the fish there could be a resultant bias in the stomach contents data. In order to reduce this possible bias, stomach collections should be made throughout the twenty-four hour day.

It is very difficult to generalise about sampling requirements within a survey when one is considering such diverse assessment areas as were represented by interests within the Working Group as a whole. Ideally it would seem desirable to stratify the total sampling effort by sub-areas of differing ecological conditions for prey organisms. Such sub-areas are, however, difficult to define at our present state of knowledge. An example of what is considered to be a suitable sampling scheme for the North Sea is given in Section 8.1 of this report, based on sub-areas used for grouping demersal fish data for assessment purposes. These sub-areas also appear to be ones of considerable ecological homogeneity in other respects. Similar sub-areas can perhaps be defined in other stock areas where surveys are required to estimate food consumption and composition.

It should be stressed that once adequate sampling has been achieved to give reliable estimates of annual food requirements and composition of the major predatory species, repeated sampling will not be required in each subsequent year. However, in order to test the assumption of a constant suitability index sampling should be repeated at least once though not necessarily immediately. Especially when there is a major change in the abundance of an important element in the matrix, it would seem desirable to repeat such surveys.

6.1.2 Stratification by predator size

The rate of food consumption and the diet change markedly with predator size. It is important, therefore, to stratify stomach collection according to predator size. For this purpose recommended length sampling strata are:

5-7; 7-10; 10-15; 15-20; 20-25; 25-30; 30-40; 40-50;

50-70; 70-100; 100-150 cm.

6.1.3 Regurgitation

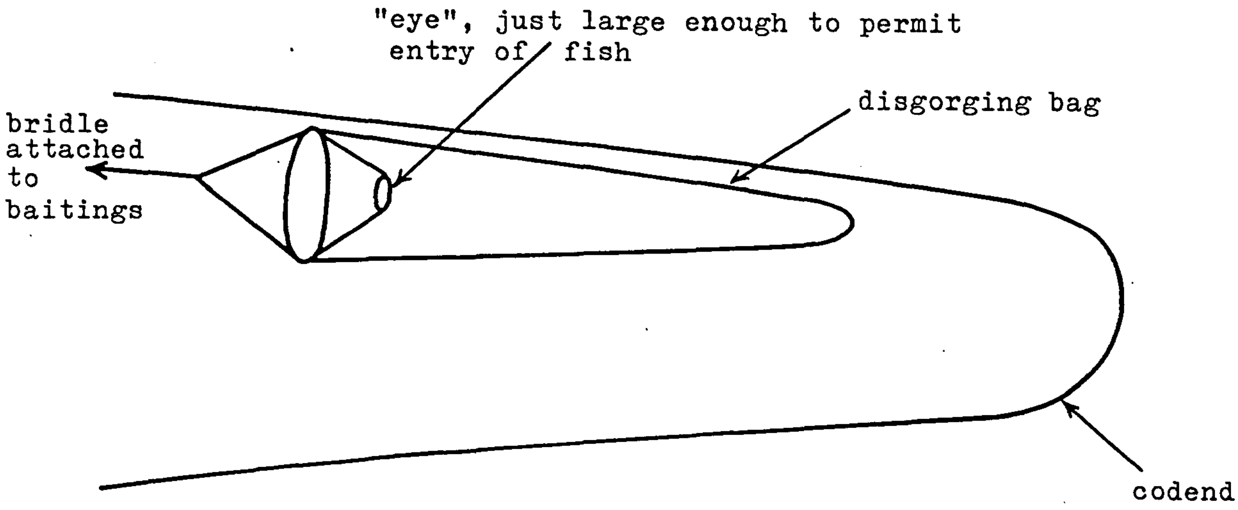
When the fish are captured there may be some loss of stomach contents due to regurgitation of food. In many cases fish can be easily identified as having lost food from their stomach when remains are found in the mouth or when the stomach has been everted into the mouth. In other cases, signs of regurgitation can only be found when gutting the fish. Apart from situations when stomachs are partly everted, criteria for distinguishing stomachs that are empty due to regurgitation from those that have been empty for prolonged periods of time are:

a) a stomach that has been empty for some time tends to be contracted into a small, relatively thick-walled object;

b) a previously full stomach that is empty or partially empty due to regurgitation tends to be larger and relatively thin-walled.

Evidence about regurgitation may also be obtained directly by placing a "disgorging" bag (Figure 1 below) in the codend.

Figure 1 "Disgorging" bag in codend.



A disgorging bag is a small, conical-shaped net that is placed within the codend in order to trap some of the fish that happen to be there. Regurgitation, while the codend is being hauled to the surface, can subsequently be detected by the presence of partly digested food particles in the bag. To be effective, the bag should:

a) be made of a mesh size small enough to contain disgorged food fragments;

b) be fitted with an "eye" (Figure 1) designed to minimise the loss of food fragments without necessarily preventing the entry of fish;

c) be small enough to fit easily into the codend, without unduly interfering with the water flow.

The ability of a disgorging bag to retain food particles can be tested by placing some food particles within the bag at the beginning of a haul, and seeing if they are still there at the end of a haul. Any stomachs from which the contents have been regurgitated, completely or partially, as described under B should be rejected. All type A stomachs should be included in the sample.

6.1.4 Consumption of fish within the codend

Sometimes, stomach contents can be influenced by the ingestion of food within the codend. Any food consumed in this manner will appear extremely fresh. Consequently, if stomachs are opened immediately after capture, freshly ingested food can often be recognised. The presence of prey that obviously have been freshly eaten should be rejected or, if one can be less sure, at least be separately recorded.

6.1.5 Sampling intensity

In regions where species interactions assessment is desirable, stomach sampling should cover the entire area corresponding to the established distribution of the stock for assessment purposes, and all seasons. The number of stomachs sampled of each predator age group at each station should be proportional to the abundance of that predator age group on that station or, if fixed sample sizes are applied, a weighting factor should be used in raising that sample which takes the abundance into account.

To apply a standard method of sampling techniques for intensity stratification seems to be more or less impossible at the present stage of development. To emphasise some of the difficulties in a proper approach in this respect it should be noted that a stratification is wanted, which minimises the variances of the predation mortalities. These again are functions of the suitability matrix (the parameters to be estimated) and the abundance of fish stocks. So the variances and co-variances of the suitability should be transferred to the variances of the predation mortalities, and some weighting by the relative importance must be given to the various predation mortality coefficients, before an evaluation of a sampling programme is possible. The conclusion is that for the time being the sampling intensity has to be based on intuition and practical considerations rather than anything else.

On the basis of experience within the Group, it is recommended that as a minimum requirement 10 stomachs per length group (see para. 6.1.2) per station are collected.

Priority should be given to fish which are known predators on fish for which assessment data are available, including commercially important shellfish species. It should be borne in mind that there may also be other species which are known to prey heavily, on occasion, on fish.

In addition, attention should be drawn to other predators of fish for which reliable catch composition data are lacking and which are not currently handled properly in species interaction assessment. Even so, they might contribute significantly to the total predation mortality on some species of fish.

As a general guideline the following scheme might be helpful:

First priority:	Primary fish consumers incorporated in standard stock assessment (e.g., cod, whiting, saithe, mackerel);
Second priority:	Facultative fish consumers incorporated in standard stock assessment (e.g., haddock, herring);
Third priority:	Other primary fish consumers which are not generally included in routine stock assessment (e.g., dogfish, turbot).

6.2 Stomach analysis

6.2.1 The essential information

The essential information to be collected in stomach analysis comprises the size of the predator, the number and weights of prey species, the sizes of the prey organisms, and the total weight of the stomach contents. This raises the question of level of identification and grouping. Ideally, stomach contents should be identified to species and, where applicable, to life stages and measured and weighed individually. In practice, grouping will be necessary on both counts.

Very often the results of stomach analysis in the past have been presented in terms of "percentage occurrence", such as: "70% of the stomachs contained fish and 80% contained crustaceans". Such information is difficult or impossible to utilise in the type of species interaction models considered by the Group, and the need of adopting a strictly quantitative approach was stressed.

In practice, the practical level of identification will depend, to a large extent, on the state of digestion of the stomach contents, on the knowledge on taxonomic detail of the persons involved and on time available. Fish and commercially important shellfish should be identified to species, whenever possible. Taxonomic units which can be either clearly pelagic or clearly benthic should preferably be identified as such ("pelagic gastropods", "benthic gastropods" instead of just "gastropods").

Numbers and total weight of each taxonomic unit are essential pieces of information. When the same taxonomic unit is represented by obviously different size groups, each should be weighed and counted separately. Stomach contents other than fish and important shellfish could be lumped as one taxonomic unit ("other food") as a time-saving procedure although at the cost of a vast loss of information on food preferences.

Ultimately, it is paramount to the credibility of the result of species interaction assessments that fish consumed are correctly assigned to age groups of prey as well as of predator. Therefore, individual lengths of prey fish and important shellfish should be recorded whenever the state of digestion allow for estimation of size. The length distributions can at a later stage be converted into age groups by means of appropriate age/length keys. An alternative could be to read otoliths of predators as well as of fish in stomachs directly.

As an example of format in which all relevant information can be entered, provided that the survey and haul number refer to a reference file in which other station characteristics are recorded, is given in Appendix I.

Attention was drawn to the existence of a universal coding system for all taxonomic groups from phylum to the species level which is available in the North East Fisheries Center, Woods Hole, USA, and a copy of which is held by the ICES Secretariat. The adoption of such a coding system by different countries involved in feeding research could greatly facilitate the exchange of data bases.

6.2.2 Grouping of samples

Stomachs from each species and cruise can be grouped by size of predator and (small) area unit, and analysed as one. This approach can save considerable time and still provide essentially the same kind of information as described above. The number of truly empty stomachs included in the sample as well as the number excluded because of regurgitation should always be recorded (para. 6.1.3).

Since the samples from each area unit ultimately have to be averaged for each season by means of a weighting factor which takes into account the relative abundance of the size group in that particular area, the average number of fish within that size group per unit of effort should be recorded.

6.3 Additional research

6.3.1 Digestion rate experiments

In order to translate average weights of stomach contents into estimates of food intake, the rate of digestion has to be known. Even though the principles of gut evacuation in fish are reasonably well understood (Fange & Grove, 1979), little of the published information deals with commercially important marine fish. Among the factors which affect digestion rates, size of the organisms, taxonomic group, meal sizes, temperature, and time interval since the previous meal may be mentioned. Therefore, differential rates of digestion of food particles within the food spectrum of a certain predator age group may even affect the actual food composition to the extent that smaller and more easily digestible items may be more important as food than estimated from the average stomach contents.

As a consequence, there is a strong need for extensive digestion experiments which specifically address the problems of differential digestion for different prey types, prey size and meal size and which are directly relevant to the type of food spectrum as observed under natural conditions.

6.3.2 Other experimental studies

The Group also considered two other kinds of experimental work which are directly relevant to feeding studies:

1) experiments on food preference;

2) development of techniques (e.g. antigen-antibody) for identifying partially-digested stomach contents. This might be important for items which are digested quickly or rendered unidentifiable, e.g.larvae.

Although of general interest, these approaches are only indirectly related to the objectives of the special type of research set out earlier.

7. Current Investigations and Needs for Supplementary Research

7.1 North Sea

Although an extensive quantitative study of the average food consumption of North Sea cod over several years is available (Daan, 1973), the information cannot be readily used to solve the problem of estimating the suitability indices, because the amount of sampling did not allow an estimate for any particular year as is required to tie up the specific food composition of the predator with the abundance of fish prey in that year.

Since that time, very little work has been carried out in the area except for English investigations in the summer during the last three years, the results of which are not yet available.

In view of the large changes in fish stocks that have taken place over the last decades, this area is of particular interest in relation to species interaction assessment, even more so because the available catch statistics would allow inclusion of all major fish stocks. For that reason, this area seems to be particularly appropriate for collecting the data on food composition and consumption required to test the models. Section 8 deals specifically with an outline of an internationally coordinated programme to achieve the necessary data.

7.2 Sub-area III

Investigations on feeding of cod are carried out by Denmark in Sub-division 25 by sampling from commercial vessels every month from 1976 onwards. Similar investigations are carried out by Poland and possibly by USSR in Sub-divisions 25, 26 and 28. A coordination of these investigations is needed, if possible supplemented by participation of other countries.

In the Kattegat, an investigation on the feeding of cod and whiting is started in February 1980, based on monthly sampling from research vessels or from commercial vessels.

7.3 Irish Sea

The terms of reference of the Irish Sea and Bristol Channel Working Group call on it to take account of the interactions between species. To date, the Group has given some attention to mixed fishery effects, particularly as a result of small mesh fisheries for Nephrops, industrial processing and shrimps, but biological interactions have not been considered explicitly. The total demersal surplus production models used by the Group are a first attempt to deal with these interactions, but have little potential for development as further information becomes available. Nevertheless, they may serve as a useful function in relation to management, because of the difficulties of assessing the large number of species in the area.

Models incorporating species interactions should be developed for this area for the reasons given in the Introduction, but there are several special considerations which may affect their structure and operation. The first consideration is that, unlike the North Sea, there are several important predator species for which we do not have catch at age data and which cannot be included explicitly in VPA (skates and rays, hake, yellow gurnards). The second consideration is the relative importance of shellfish in the Irish Sea, particularly Nephrops. Among the small number of detailed feeding studies which have been carried out in the Irish Sea is one on Nephrops which gives an estimate of the degree of predation on them by cod. Management measures directed at increasing cod biomass may adversely affect Nephrops.

Information on the feeding of many of the demersal species in the Irish Sea is available from groundfish surveys carried out over the last ten years. This could be used as a basis for planning further sampling directed at feeding interactions.

7.4 The Barents Sea

In the Barents Sea the USSR has a large stomach sampling programme. The investigations on cod started in the 1930s and have continued more or less uninterruptedly. Material on haddock is also available. The samples are partly worked up at sea, using indices of fullness (0 = empty, 4 = full), while some of the material is on a weight basis.

Norway has also started to look into the problem. On cruises in the area a routine examination of cod stomachs is carried out at sea. Vomitting of the fish in the trawl and on deck is, however, a big problem in evaluating total food consumption. Therefore, laboratory experiments have been started on cod feeding on capelin and shrimps, which are aiming at an estimation of total food intake based on energetic reasoning.

At the moment suitability indices have not been established, although the data base available in the USSR could possibly yield the information required. The Norwegian material cannot be used in this respect because the diet of the cod is shifting markedly with the season, which makes quarterly sampling absolutely essential.

7.5 Icelandic waters

Stomach sampling and analysis in the last few years relevant to species interaction assessment model testing are summarised below.

a) In 1976-78

Species	No. of stomachs	No. of surveys	Level of identification of prey	Predator length classes	Prey quantity measuring method
Cod	ca. 9 000	9	4 'life style' groups	10 cm	Displacement vol.
Haddock	ca. 2 500	4	" "	"	" "

b) In 1979 two surveys were made during which samples were collected of the following species: cod, haddock, redfish, catfish, plaice and halibut (by 10 cm length classes) and capelin (by $2\frac{1}{2}$ cm classes). Level of identification is optional. Quantities have been weighed.

In 1980 three surveys are planned, which aim at including the important pelagic fish species.

In the previous years the sampling has been restricted to the northern and the eastern parts of the Icelandic shelf, whereas in 1980 it shall be extended to cover also other areas.

7.6 The Georges Bank region

Large-scale ecologically oriented (multispecies) field research began in 1963 with initiation of stratified random bottom trawl surveys. Bottom trawl surveys are currently conducted during spring, summer and autumn covering the area between Cape Hatteras and Nova Scotia with 250 to 500 trawl hauls made in each survey.

The surveys provide an unbiased time series of indices of abundance describing the finfish community of the region. In addition to bottom trawl surveys, ichthyoplankton surveys are conducted 6 times per year. Macro-benthic surveys (primarily for commercially important bivalves) are conducted routinely. Some special studies of primary productivity have also been conducted.

Data on the stomach contents of fish have been collected during bottom trawl surveys since 1963. The data are, however, divided into three sets representing different sampling strategies. Initially stomachs were analysed at sea and prey classified into generally broad taxonomic groupings or at least as easily recognised prey species. More recently the stomachs have been preserved in formalin at sea and brought back to the laboratory for detail analysis on a wet weight of prey basis. Since 1973 stomach sampling has been conducted as a routine part of the bottom trawl survey cruises. During these cruises individual stomachs have been systematically collected from fish that are both commercially and biologically (large biomass) important, together with some data on other miscellaneous species. To date, the analysis of more than 17 000 stomachs from 17 species of fish has been completed. In total, including all samples from 1963 on, the dietary components of slightly more than 100 species of fish have been identified.

The current sampling plan of collecting information on the major demersal fish components of the region will be completed at the end of 1980 at which time the sampling strategy will be modified.

Part of the information on the food of the fish stocks of the region that has been collected during the bottom trawl surveys has recently been summarised in four papers (Langton & Bowman, 2 manuscripts in press; Edwards and Bowman, 1979; Grosslein et al., 1978).

8. North Sea Stomach Sampling Programme

Many of the recent scientific developments in relation to possible species interaction effects on stock assessment have been referring to the North Sea and the importance of taking these effects into account here have often been stressed. In addition, the availability of extensive catch at age data for most of the commercially important species would allow for a more complete multispecies virtual population analysis than elsewhere. Therefore, this area is particularly suitable for testing this approach, and the more universal data requirements discussed earlier in this report have been made more specific in respect of a preliminary outline of a North Sea stomach sampling programme, which should be carried out in 1981 in order to allow incorporation of the results in ICES stock assessments in 1982.

Because the research effort required is too extensive to be provided by any member country on its own, this programme should be set up as a coordinated survey project under the auspices of ICES.

8.1 Research vessel time

After extensive discussion of the possibilities of using either commercial vessels or research vessels for collection of the stomach samples, it has been concluded that in view of the fact that the ultimate estimate of average annual food composition and food intake has to be representative for the entire North Sea population,research vessel surveys in each season present the only reliable means to meet this requirement.

Apart from the International Young Herring Surveys carried out annually in February, which could be used for the present purpose, many countries have routine trawling surveys in the area during other times of the year. Although these may have other primary objectives, it might be possible to adjust the existing cruise programmes in terms of areas to be covered and timing, and in this way try to minimise the request for extra effort. With reference to the intensity of sampling the area, it was concluded that because of the different objectives, this intensity does not necessarily have to be comparable with the young fish surveys in February. It was agreed that a grouping of four statistical squares as the basic unit area of sampling, adapted to correspond to the established standard areas for reporting demersal assessment data (Figure 2), with a minimum sampling intensity of one sample of 10 fish per size group in each season, could yield the required information at a reasonable level of precision.

Although no actual commitments could be made by the participants, the following scheme shows how the required effort could tentatively be obtained by adjusting existing surveys.

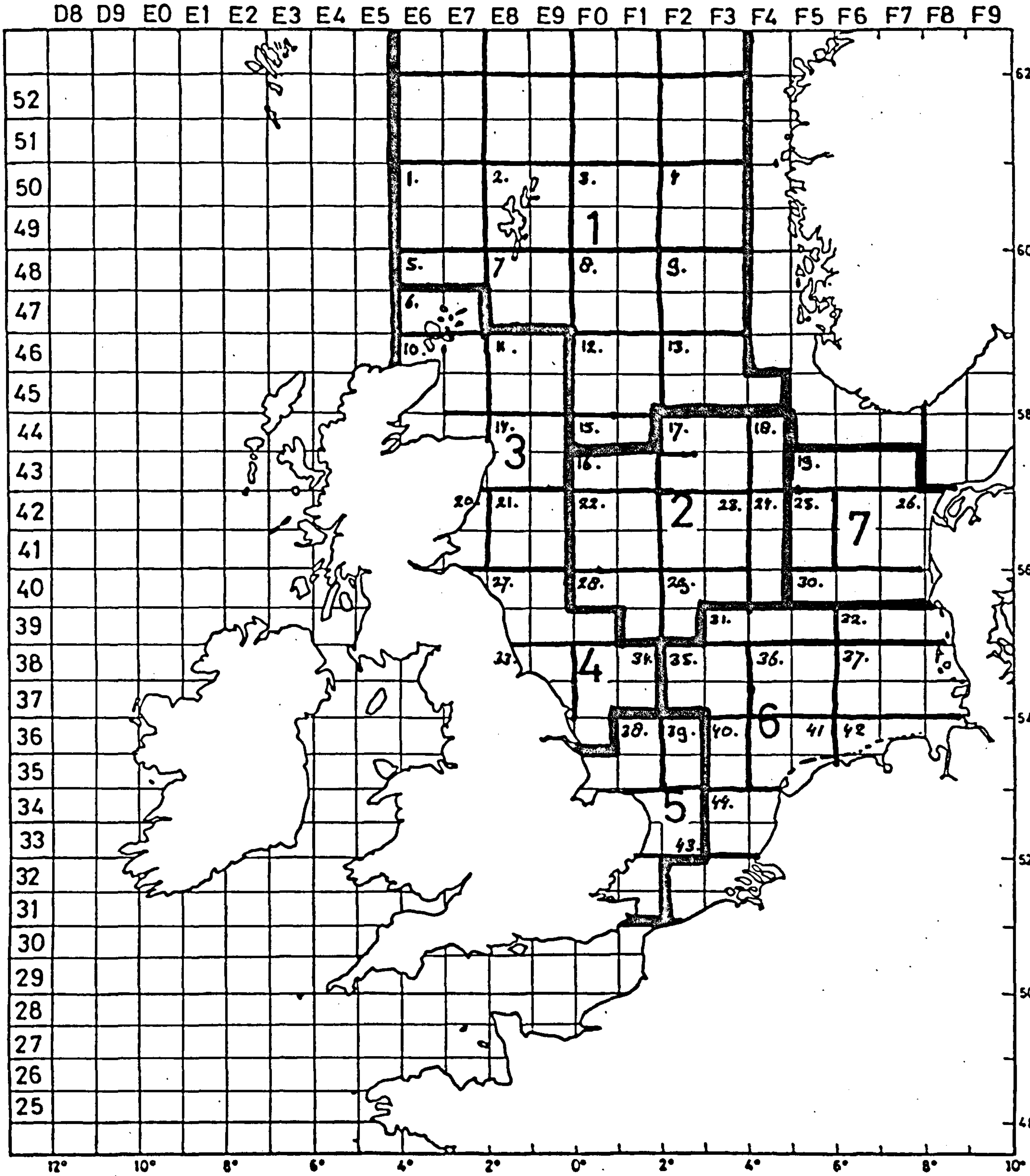
February	IYHS (Denmark, England, France, Federal Republic of Germany, Netherlands, Norway, Scotland)
April-June	Denmark (chartered vessel) Netherlands (special stomach sampling survey)
July-September	England (groundfish survey) Federal Republic of Germany (groundfish survey) Scotland (groundfish survey) Norway (routine survey with various objectives)
October-December	Denmark (chartered vessel) Federal Republic of Germany (groundfish survey) Norway (routine survey with various objectives)

Dr N Daan will be prepared to coordinate activities in these surveys (with the exception of the established IYHS) to ensure that the total area is adequately covered.

8.2 Priorities in predator species

The major fish predators in the North Sea, for which assessment data are available, are represented by cod, whiting, saithe and mackerel, whereas haddock and herring with many other species are known to be occasionally feeding extensively on small fish such as sandeel. The main emphasis of this programme should be put on the first four species.

However, the bottom gears used during the planned surveys are not likely to yield the required number of samples. There seems to be no other possibility than to collect mackerel stomachs on board commercial fishing vessels, which are directed towards mackerel. The Group stressed that national laboratories should investigate the possibilities of starting such sampling schemes.



<u>Figure 2.</u> Proposal for stomach sampling areas of approximately 4 statistical rectangles in correspondence with standard areas as accepted for grouping demersal fish data for assessment purposes (heavy lines).

8.3 Analysis

The number of samples at a sampling intensity of 10 stomachs per length group per standard area would result in approximately 150 samples per survey for cod and whiting involving some 1 500 fish for each species. Saithe would be caught in much smaller numbers and an annual total exceeding 1 000 stomachs would seem unlikely.

The labour involved in actual analysis and processing of data cannot be properly identified, because this will depend on experience, the level of identification and, to a large extent, on whether stomachs are analysed individually or as a group. An estimated 6 000 stomachs per species per year, worked up as grouped samples, should not require more than 2 man-years per species, including processing of data.

8.4 Coordination of sample analysis

There may be advantages in pooling samples by species for analysis by individual laboratories. The participants could not commit their laboratories to such a scheme at the meeting and it will be pursued by post.

Volunteers for taking up responsibility for the analysis of individual species were:

Cod	N Daan
Whiting	J R G Hislop
Saithe	H Gislason
Mackerel	?

In order to arrange close cooperation in the sampling scheme and coordinate optimal exchange of data, it was proposed that Dr Daan acts as a coordinator.

It has also been suggested that ICES headquarters become involved in the computer processing of the basic data. It should be clear that all basic information would be made available to all participating countries.

The ad hoc Working Group notes that reports on the ongoing stomach contents studies of the Georges Bank region may be helpful in further refining the proposed North Sea programme.

8.5 Time schedule

The scheme should be run in 1981 for one year and the analysis should make the essential data available before 1 May 1982 so that in that year species interaction can be taken into account in the management advice given by ICES.

9. Recommendations

1. An intensive stomach sampling scheme for cod, whiting and saithe should be implemented in the North Sea in 1981, and member countries are urged to make available the research effort to meet the requirements as defined in this report, both in terms of research vessel time and analytical labour, so that species interaction can be taken into account in stock assessment in 1982. Special stomach sampling programs for North Sea mackerel by means of commercial vessels should be developed in 1981 at a national level, because these surveys are unlikely to meet the required sampling intensity.

2. Coordination of stomach investigations and implementation of species interaction assessment techniques should be encouraged in other areas where species interaction can be expected to be a major factor in generating mortality. This would apply particularly to the Baltic Sea, the Irish Sea and the Barents Sea.

3. Digestion experiments on renown marine fish predators are stressed as an important tool to improve the estimation of rates of food intake; these experiments should address specifically the problems related to size and species specific rates of digestion within the food spectrum and temperature regimes observed under natural conditions.

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APPENDIX I

EXAMPLE DATA FORMAT FOR STOMACH ANALYSIS

Survey code:
Haul number:
Statistical square:

PREDATOR: Code: Size group:

No. of stomachs sampled:
No. of stomachs empty:
No. caught per hour:

PREY	Code	Size group/ life stage	Total weight	Number	Length measurements

APPENDIX II

Descriptions of:

1) size preference index (g_{ij})
2) vulnerability index (ρ_{ij})
3) suitability index (G_{ij})

These are coefficients used when calculating the quantity of food available to a predator. To a first approximation the food φ_i available to predator i is the sum of all biomasses present: $\varphi_i = \sum_j B_j$. Some, however, are less suitable than others and are weighted accordingly by the coefficients G_{ij} ($0 \leq G_{ij} \leq 1$): $\varphi_i = \sum_j G_{ij} B_j$. These again are the product of two coefficients. One (ρ_{ij}) indicates the vulnerability of one species (or life-stage of a species) to predation by another, irrespective of size. The other coefficient (g_{ij}) indicates the influence of size upon the choice of prey, irrespective of species. Both coefficients range from zero to one. Thus, we have the food available to i as:

$$\varphi_i = \sum_j G_{ij} B_j = \sum_j \rho_{ij} g_{ij} B_j$$