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REPORT OF THE COMMITTEE ON RESEARCH AND STATISTICS ON AN INTERIM SESSION HELD IN BIARRITZ FRANCE MARCH 1 - 10, 1956

L. A. Walford, Chairman

Background

None of the various species of fishes with which this Commission is concerned are confined to the western side of the Atlantic. All of them are trans-oceanic. Those of greatest interest to the Commission are characterized as bottom dwellers of the banks, yet none of them live wholly on the bottom. Certain ones rise to upper levels diurnally; all are pelagic in early life, in some instances for several months. During that time they drift in the ocean currents far from the places where they were spawned.

Thus it seems unlikely that the populations of fishes on any bank are quite independent of those on other banks. Studies that have been made in a few localities indicate that the spawning grounds, the dispersal of young, and the distribution and migrations of adults do follow definite average patterns At the same time there are evidently fairly consistent differences in physical characteristics of the fishes composing the populations of different banks. If these differences are inherited there must be some mechanisms by which the young return to their points of origin in order to replenish their parent stocks; otherwise, judging from the direction of the currents in which the eggs and larvae drift, few stocks replenish themselves; many of them, if not most, must depend on the spawning of neighboring or even far distant stocks. Understanding of these mechanisms of replenishment, and of the identity and degree of independence of stocks is essential to scientific direction of North Atlantic fisheries in order to attain maximum utilization.

To reach this understanding requires studying each species of interest as a whole, throughout its range. So far, research on cod, haddock and redfish in the North Atlantic has been very uneven, being intensely pursued in certain localities and neglected in others. Even in the most studied areas, some essential lines of research have been neglected. If the Commission is to achieve its purposes, the research programs in the Convention area must be strengthened. This cannot be accomplished by simply agreeing to "co-operate" and "exchange information" about the work which the several member countries happen to be currently engaged in; it can be accomplished only by substantially enlarging programs--increasing their size and their scope. This enlargement should be according to a plan of truly international collaboration, designed by this Commission and recommended to its members.

It is true that this Commission is bound to focus its attention on the problems of its Convention area. Nevertheless, it is very much to its interest to see that its research programs and those carried on by European countries east of the Convention area should fit together, so as to produce most economically and adequately all of the information which both sides need.

At the Fifth Annual Meeting, held at Ottawa in June, 1955, this Commission endorsed the recommendation of its Committee on Research and Statistics, that an interim technical meeting should be held in a European country, to which scientists of both sides of the Atlantic would be brought together to (1) specify the absolutely essential information needed for predicting the effects of various fishing intensities on stocks of various sizes and various biological properties; (2) to assemble American and European fishery scientists engaged in North Atlantic problems in order to compare, by working together with actual materials, their practices in field and laboratory techniques, to learn where important differences exist, and to determine how these differences can best be resolved; (3) to discover gaps in research programs now being carried on in the North Atlantic; and (4) to suggest how these gaps might best be filled.

The Commission accepted the invitation of the French delegation to hold the meeting in Biarritz, France. In preparation therefor, the Committee on Research and Statistics drew up nine subjects for discussion; these were modified in subsequent correspondence between the Chairman, Executive Secretary and members. On each of these subjects the Chairman appointed a Convenor to lead the discussion of the whole Committee, or, as necessary, to organize a working party of specialists to meet separately to consider assigned problems, study demonstration materials together, compare techniques of measurement and interpretations of material, develop conclusions and prepare a report thereon to the whole Committee. The convenors were further asked to recommend for publication documents especially prepared for this meeting.

Subjects
(numbered according to the order in which they were first proposed).

I. The problem of sampling oceanic stocks which are partly demersal, partly pelagic (e.g. redfish and cod) and whose distribution differs with size and age, and which are fished by diverse techniques and by diverse countries. Develop a plan of sampling the fishery stocks of the Convention area, and of collating and analyzing the samples.
Clyde Taylor, Convenor (vice John Hart).

II. A special study of the characteristics of the catches of the salt cod fleet.
Robert Martin, Convenor.

III. Devise means of reducing the time required to obtain data necessary for making assessments of stocks, especially those required as the basis for a program of conservation.
Sydney Holt, Convenor (vice Raymond Beverton).

IV. To make the best use of the scientific talent, arrange that men with special skills are most effectively used for the needs of the whole Commission. This may require allocating tasks and materials.
L. A. Walford (Discussion Leader on this topic in meeting with whole Committee).

V. Assess the effects of the haddock mesh regulation in Subarea 5.
Herbert W. Graham (Discussion Leader on this topic in meeting of whole Committee).

VI. Comparison of European and North American techniques of measuring nets, of reading ages of fish and of studying growth.
Basil Parrish, Convenor.

VII. Differentiation of fish stocks.
Cyril Lucas, Convenor.

VIII. Prepare plans for the review of cod biology to be held in the 1956 Annual Meeting.
Gunnar Rollefsen, Convenor.

IX. A review of knowledge about the Atlantic halibut.
Gunnar Rollefsen (Discussion Leader on this topic in meeting of whole Committee).

The reports of these working parties follow the general discussion below.

General Discussion

Throughout these discussions at Biarritz the Committee and its working parties emphasized the fundamental purpose of the Commission, i.e., to determine how to scientifically increase the production of fish and to maintain it at its highest sustained yield. At the heart of the questions which the Committee considered was the problem of how the information needed to achieve this purpose could be obtained most quickly and cheaply. To this end each working party looked particularly for short cuts in the various technical processes that go into determining maximum sustainable yields. The working parties have suggested a number of ways to save labor and improve the efficiency and accuracy of operations, but they found no quick, easy, cheap method of determining the maximum sustained yields. There is no substitute for collecting enough of the right kind of data for every species of fish of interest. To try to make do with any less is false economy.

The Committee emphatically affirmed the principle that the foundation of all biological fishery studies must be a full, accurate reporting of statistics on the catches (not just the landings) of all species, specifying not only the quantities caught, and the place and mode of capture, but also the composition of the catches by length, weight, age, sex, and when possible, by racial stock. The Commission should publish such detailed statistics. Besides the information which commercial fishing vessels must furnish, the desired detailed reporting necessitates representative sampling of the catch throughout the Convention area. This sampling cannot be haphazard, but must be designed to take into account the existence of different stocks of fish, the selectivity of different kinds of gear, the variations in the habits of different sizes and ages of fish, and variations in the distribution of fishing effort. In general the sampling as carried on now is far below the

minimum needs of the Commission. If only one thing were to be done now for the scientific research programs by the 10 member nations of this Commission, that one things should be to improve the sampling of their commercial fisheries so as to provide accurate data on sizes and ages of fish composing the catches of their fleets and the stocks of fish in the sea. This is especially needed in Sub-areas I and III where sampling programs are particularly deficient. These areas are of greatest importance in the production of cod. Recent changes in fishing gear have so increased the rate of catching young cod as to threaten the supply of the relatively large-sized fish which are required by the salt cod industry. It is therefore essential that those countries engaged in the salt cod industry should substantially increase the number of biologists and assistants sampling the catches of their fleets at sea as well as the landings ashore so as to maintain a constant watch for changes that do occur.

In order to combine the biological statistics from the samples which the countries collect, it is essential that all measurements of fish should be comparable. The working parties found that methods do differ widely, and therefore are not comparable in many instances. It was agreed that a sub-committee should be appointed at the 1956 annual meeting to study the problem of standardizing measurements, and to draw up a conversion table of lengths obtained by different methods. To provide the materials for carrying out this assignment, it was decided that each country should submit to the Executive Secretary a report on its method of measuring fish length, along with a description of the devices used. The Committee asked that the Executive Secretary collate this material and prepare a working report for the use of the Sub-Committee on measurements at the June meeting.

There was much discussion on the question of whether fish could be measured by some mechanical means. It was the consensus of the group that this is more a matter of cost than of feasibility. The Executive Secretary was asked to request F. A.O. to make a suitable inquiry into the engineering problems and probable cost of producing such a device.

There is more to combining samples than merely measuring the fish by a standard procedure and totalling the results. The individual samples must be appropriately weighted, in one way to reflect accurately the populations of fishes in the sea, and in another way to reflect the total commercial catch. To design a system of sampling and combining samples requires special study. Putting a system into effective practice once it is developed will require coordination of all sampling carried on by the member countries.

It was brought out in the discussion that a manual on techniques of sampling and on designing sampling systems, written in non-mathematical language for the use of biologists and their assistants is urgently needed. Dr. Kesteven reported that the F.A.O. has commissioned Dr. Gulland to prepare such a manual for general use, which can be enlarged, as necessary, to meet the requirements of this Commission. Members of the Committee pledged their cooperation in this project, and agreed to supply statistical

data and examples of problems such as Mr. Gulland may request to help him develop a comprehensive manual. The Committee commends F.A.O. for fostering this project, and urges that the manual be published as promptly as possible when the manuscript is completed.

The Committee calls attention to one particular obvious limitation in the commercial catch statistics: they give no information on the abundance of year broods before entrance into the fishery, hence cannot be used for predicting fluctuations. For this it is necessary to sample the pre-commercial sizes by research vessels. If this is to be done, however, special provision must be made for it, which is not now available. Where research vessels are operating in the Convention area, special time should be allotted for the purpose; but such arrangements alone will not suffice to cover the whole area, for research vessel facilities are far from adequate to fulfill the Commission's purposes. One of the most important statistics needed for following changes in abundance of fishery populations and their relation to fishing pressure, is the age composition. The working parties have made a number of recommendations for research designed to improve the consistency and to test the accuracy of age determination of scales and otoliths. These include research to test ways of minimizing the labor required for age determination, and to devise substitute methods where scales and otoliths are not usable.

Adequate sampling is basic; so also is adequate knowledge of what it is we are sampling. Each of these is necessary to the other. Improvement in one leads to improvement of the other. The importance of this fact was forcibly brought out in this conference, for the Committee was continually faced with the problem of defining stocks; and in several instances it transpired from the discussions that differences of opinion and differences in the interpretation of data resulted from the fact that the members were talking about different varieties of the same species of fish. These evidently differ in all sorts of ways, such as growth rate, maximum size attained (therefore age and size composition of the population) habits, fecundity, etc. It is generally accepted that the various species in the North Atlantic are not homogeneous entities, but are composed of an unknown number of units which are variously called stocks, communities, cohorts, races, sub-populations, etc. It is not possible with present knowledge to define these units precisely or to know what mechanisms keep them apart, or whether they are permanent, self-sustaining and genetically peculiar, or whether they are wholly the creatures of the environment. All studies and conservation actions relating to North Atlantic Sea fishes depend on definition of these units of population. This requires close cooperation among the member countries in making comparable measurements and counts of body parts of specimens collected in the samples; furthermore, it requires making special provision in the budgets of research programs, not only for the collection of the necessary data, but for its analysis, a phase of research which is often neglected in the planning. It is unlikely that stocks can be diagnosed by any single feature; consequently, it will probably prove necessary to work several in combinations, including proportions of body parts, counts of repeated structures, blood types, and chemical composition of body tissues.

In examining the research programs which the member nations conduct in the Convention area, the Committee finds that they are particularly deficient with respect to redfish and halibut. Redfish is one of the species of greatest interest to the Commission,

and likely to increase in importance commercially. Because of certain apparent peculiarities in the life history of the redfish, the effect of overfishing may appear suddenly and disastrously. This species is one of the most difficult to study, resisting most of the classical techniques of fishery research. Important though it is, difficult though it is to study, probable though the serious ultimate depletion seems in the light of accepted information, none of the member countries puts enough effort into research on this species to provide even the barest information necessary for prescribing conservation measures. The Committee therefore urges the Commission to give particular attention to the program of redfish research recommended in Section IV below.

Halibut is not of much commercial importance to all the member nations. Yet it occurs throughout the Convention area. It seems peculiarly vulnerable to undue fishing pressure, and, judging from experience in the Pacific Ocean, is remarkably responsive to a proper regulation of fishing rate. There are serious obstacles that would make restoration of Atlantic halibut stocks difficult. If these difficulties could be overcome, this species might yield substantially higher quantities of sea food. Very little effort goes into research on halibut at present. This Committee therefore asks that the Commission consider the desirability of recommending to the member nations increasing provision for research.

The Committee recommends that special emphasis continue to be placed on cod research, as indicated elsewhere in this discussion. It recommends further that the United States continue its careful study of the effects of the mesh regulation on the populations of haddock in Sub-area V.

In addition to these recommended research programs about particular species, which involve acquiring certain classically prescribed information, such as rate of growth, for example, certain lines of study must be pursued which apply to all fishes which share the same environmental system. Such, for example, is oceanographic research, to delineate the currents, follow their fluctuating courses, and determine how they and the various properties of the water affect the dispersal and survival of eggs, larvae and adults. Trans-Atlantic oceanographic research for the specific purpose of increasing our understanding of fishery matters has been largely neglected in the past. To collect information necessary for study on this subject requires the full use of every possible facility, including research vessels, commercial fishing vessels, trans-oceanic passenger and freight liners, weather ships, Texas towers, drifting buoys, etc. Sorting and identifying the plankton, and analyzing the data collected from all these sources, for fishery purposes however, requires adequate shore staff, for which hardly more than token provision is now made.

Much attention was given in several of the working parties, to the effects which various factors of the environment have on the growth, physical characteristics, behav and survival of larvae and young fish. Some parts of this great and important comp of problems can best be studied by carefully designed study at sea. Others of it ca attacked only by laboratory experiments, which require special facilities providi absolutely controlled conditions. Here is another field of research for which p is not made in any of the programs in the Convention area.

The selectivity of fishing gear has been given a good deal of study which should be continued. The working party on techniques (VI) pointed out a number of problems relating to selectivity of nets, to the techniques of measuring meshes of nets, and to the properties of materials composing nets. Every encouragement should be given to people engaged in net studies in the various countries, to coordinate the planning and execution of their work, to exchange information, and to discuss their results.

The collection of data on sizes and ages of fish, and on the intensity of fishing effort, is not an end in itself. This information must all be analyzed and resynthesized statistically in order to determine the effects which various levels of exploitation have on the numbers, lengths, weights and ages of fish composing a given stock, and on the relative abundance of the various species composing a given environment. The balance among all of these elements of fishery populations is constantly changing in response to changing conditions of environment and in response also to changing habits of fishermen and techniques of fishing. All of this necessitates providing special staffs to process and study current data in accordance with established techniques. In addition, however, there are many unsolved problems in population dynamics, as pointed out by Working Party III, for which special developmental research is needed. The lines of research suggested by this group should lead to improving the accuracy of present methods, and to sharpening our knowledge of the precise kinds of data needed. Such research should demonstrate how the judicious use of mathematical models which need yet to be developed and tested, can provide satisfactory working estimates of relations between various levels of fishing intensity and characteristics of catches. For this kind of research, at least one team of statisticians should be set up in the Convention area to devote their full time to the task. There is no single piece of research which could offer so much for so little cost.

A most critical lack of research facilities is manpower. All delegates reported a difficulty in recruiting young men to fill fishery posts. Students in colleges where courses in aquatic biology are offered, are choosing chemistry, engineering and medicine in preference. The Committee urges the Commission to make a special inquiry into the causes of this condition and means of correcting it.

The following sections give a fuller reporting on the discussions, conclusions and recommendations of the several working parties at the Biarritz meetings.

I

THE PROBLEM OF SAMPLING OCEANIC STOCK WHICH ARE PARTLY DEMERSAL, PARTLY PELAGIC AND WHOSE DISTRIBUTION DIFFERS WITH SIZE AND AGE, AND WHICH ARE FISHED BY DIVERS TECHNIQUES AND DIVERS COUNTRIES *

Among the stocks of fish in the ICNAF area which present peculiar sampling problems, either because of their biological characteristics or because of the diversity and distributions of fishing, are the redfish and the cod. Two questions were posed to the working party: (1) what information is required, and (2) how can this information be obtained on an international basis? The working party was asked to keep in mind that two major objectives of sampling are to provide information adequate to demonstrate changes in abundance and the effectiveness of the recruitment of year classes.

The working party recognized early in its discussion that an intelligent sampling program depends in large measure on the type of population model necessary to apply to the individual peculiarities of a stock. For this reason, Working Party I combined with Working Party III to consider jointly: (1) the requirements of a population model for interpreting the dynamics of populations partly demersal, partly pelagic, fished in various parts of their range by different types of gear; (2) the kind of sampling program best suited to provide efficiently the information required for applying such a model.

The Symposium on sampling presented at the 1954 meeting of the International Council for the Exploration of the Sea (Problems and methods of sampling fish populations. Rap. et Proc.-Verb., 141, Pt. 1, 1956) was circulated to members of the working party and a review of the Symposium, prepared by Beverton and Parrish, was given by Mr. Parrish. The group commended the fundamental principles presented in the papers of this Symposium and these principles were considered as a background in the further discussions.

A paper of major interest to the working party "Sampling of semi-oceanic fish", was presented by Mr. Gulland. In order to make use of data from commercial vessels, Mr. Gulland pointed out that it is necessary to know (a) the total catch by all methods of fishing from each area and depth, (b) the total effort which, if in mixed units, would need to be expressed in homogenoeous units, (c) the composition of the catch with respect to size and age, from which growth and mortality estimates could be made; and that insofar as the catch might not be representative of the true population sampled, it would be necessary to know (d) to what extent the effective fishing intensity varied with size and age and this would require having samples of size and age from all sections of the fleet.

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* Dr. John Hart, Director of the Atlantic Biological Station, St. Andrews, New Brunswick had been appointed chairman of this working party and although he was unable to attend the Biarritz meetings, the success of the discussions was owing in large measure, to his planning and efforts.

Dr. Templeman presented data on the distribution of redfish on the Grand Banks and on the Gulf of the St. Lawrence. The points brought out by Dr. Templeman's talks which were especially pertinent to the problem of sampling were as follows: Apart from spacial variations, there are variations in the catches from different depths, fish being taken at all depths between 50 and 500 fathoms. There is a gradual decrease in catches below 300 fathoms. The sex ratio varies with season, and in March and April females do not appear abundant at any depth. Spawning occurs in May and June, and sometimes as late as July. The size distribution varies with depth and it is not known for certain whether or not the fish mix to any degree between depths. The presence of certain parasites at certain depths and their absence at other depths suggests little, if any, vertical mixing.

Diurnal variations in catches of redfish show generally a midday maximum, so that any organized sampling program would have to take this into account. Another sampling problem arises from the fact that the fishermen generally work within a restricted range of depth; therefore the population outside this range is not adequately sampled.

Mr. Fleming presented information on the size distribution of cod on the east coast of Newfoundland from 1950 to 1953 and drew attention to the relation between sizes caught and the method of capture. There was a general tendency for the size distribution to increase with increasing depth of water.

Dr. Rollefsen gave an account of the arctic cod in the Barentz Sea. Fairly lengthy migrations are made to the Lofoten Islands where a large fishery exists on spawning fish. Statistics are available from 1860 on the numbers and weights caught.

Mr. Taylor presented data on diurnal variations in catches of several species in the Gulf of Maine and on Georges Bank. The data were obtained during round-the-clock trawling operations, using a 1 1/2-inch (stretch) mesh liner. Two types of diurnal variations were recognized in the data. The first, typified by the redfish and haddock, shows a midday maximum and a midnight minimum. The second type (some skates and flatfishes) shows a midday minimum and a midnight maximum. The silver hake and some other species show no significant diurnal trends.

Recommendations

1. In sampling oceanic stock being fished by several types of gear, the working party considered the following statistics essential:

(A) Total catch by species, subarea, and type of gear. Subarea of capture should, at the minimum, separate areas containing independent stocks. (These minimum statistical requirements are now generally met in the ICNAF area, with the possible exception that information on independence of stocks may be in question for some species).

(B) Effort data for each type of gear, expressed in standard units. This is especially important where each gear selects differently from the population as in the Lofoton cod fishery. The working party pointed out that in some situations, one type of gear fishing the species representatively might provide adequate data and that the reporting of the effort of this type of gear alone would allow some diversion of sampling

time to other problems. (Since efficiency varies from vessel to vessel using the same type of gear, it is desirable to set up standards for the various vessel categories to which the performance of individual vessels may be compared. Thus total effort by all types of vessels may be expressed in terms of standard units. For example, 100 days fishing by an otter trawler of 150 gross tons is not likely to be equivalent to 100 days fishing by an otter trawler of 200 gross tons. At the present time, no country is reporting effort data to ICNAF in standard units.)

2. The working party emphasized the importance of continued studies examining the amount of sampling necessary for determining age and size composition. Such studies frequently save many man-hours by improving the efficiency of the sampling procedure.

3. Where growth and recruitment are well known, the group recommended the use of age-length keys so that less time need be placed on age determination, permitting the collection of more length data. It was suggested such age-length keys be shared by countries fishing the same areas. Where growth rates are known to vary considerably, the working party cautioned that individual cases must be carefully studied before applying such keys.

4. The group recommended the collection of weight as well as length information to reveal the operation of density-dependent factors. Recognizing the manpower problem involved, the group recommended investigation of the possibility of bulk weighing plus individual measuring. The possibility of using dry otolith weight instead of fish weight was suggested as a better indicator of fish condition than body weight.

5. The working party recommended that research vessel time devoted to sampling the pre-exploited ages of fish be increased wherever possible. The importance of measuring abundance as early in life as possible, especially prior to commercial exploitation, was stressed, since such measurements are not only useful for predictive purposes but also may provide invaluable information on the influence of natural factors on brood strength and the magnitude of natural mortality.

6. With regard to the problem of sampling problems in the redfish fishery, the working party considered present hypotheses concerning the biology and distribution of this species to be inadequate for the purpose of interpreting the observed facts in terms of an intelligent sampling program. The working party considered that:

(A) All methods of investigating redfish, however unlikely, should be explored.

(B) Collection of data on catch and effort by area and depth should be continued, together with other concomitant observations now in progress.

(C) Special surveys should be made at all depths redfish inhabit.

(D) A high priority should be given to the development of tagging methods as the technique most likely to reveal the requirements of a sampling program.

II

CHARACTERISTICS OF THE CATCHES OF THE SALT-COD FLEET

In the ICNAF area cod is by far the most important species; cod landings amount to two-thirds of the total groundfish landings. Three-quarters of these cod are salted. It is accordingly of great importance that the Commission give close attention to the salt-cod fishery.

The discussion of the salt-cod working party are reported under the following headings: Participants, Fishing Equipment, Statistics of Landings, Abundance, Sizes, Conversion Factors, Biological Observations, and Proposed Research Program. A list of papers and charts presented to the working party is attached as an Appendix.

Participants

Canada	:	W. R. Martin, Chairman; A. M. Fleming, Rapporteur.
Denmark	:	P. M. Hansen
France	:	J. Ancellin; G. Kurc
Portugal	:	M. Ruivo
Spain	:	D. O. Rodriguez; A. Rojo.

Fishing Equipment

Cod for salting are caught in the Convention area by many widely different methods: pound nets, traps, jigs, baited handlines, baited longlines, otter trawls and pair trawls. To handle these different types of gear many different types of fishing boats are employed: small rowing and motor boats for fisheries near the shore, and larger longliners, dory schooners and otter trawlers for fisheries off shore.

Inshore fisheries.

Greenland's shore fishery in Subarea 1 is carried on with jigs, baited handlines, longlines and pound nets. Rowing boats 12-26 feet in length and motor-boats 26-30 feet in length are used. The fishing season extends from July to October in the northern part of Greenland (1A) and from April to October in the southern part (1E, 1F).

Canada has the largest inshore cod fishery in the Convention Area. This fishery is conducted in Subareas 2, 3 and 4.

In Subarea 2, with traps, jigs and handlines, using motor-boats 25-35 feet in length, fishing is from June to September (2H, 2J).

In Subarea 3, the season extends from May to November in the east Newfoundland area (3K 3L) using traps early, and handlines and longlines throughout the fishing season. In southwestern Newfoundland (3P) fishing with lines continues throughout the year. Motor-boats 20-55 feet in length are used in these fisheries, with those 35-55 feet in length being equipped with power haulers for longlining.

In Subarea 4 the fishery is by trap, handline and longline. In the Gulf of St. Lawrence area the trap fishery is centered mainly in 4R and 4S, with line fishing predominating more to the west. The season in the Gulf extends from June until October. Outside the Gulf the fishery from Nova Scotia is mainly with handlines and longlines and the season extends throughout the year. Motor-boats used are from 25-60 feet in length, with those from 35-60 feet being used for longlining with power haulers.

In recent years, both in Greenland and Canada, there has been an increase in the number of motor-boats used in the fishery. In Canada the use of power haulers has in creased the efficiency of the longline fishing.

Offshore fisheries.

In the offshore fisheries for cod for salting, landings are made by otter-trawlers, dory schooners, longliners, and pair trawlers, in decreasing order and importance.

Otter-trawlers. The largest fleets of otter-trawlers are operated by France, Portugal, and Spain, the ships ranging in size from about 900 to 1,400 gross tons. These trawlers usually arrive in Subareas 3 and 4 each year in February and fish in Subareas 4, 3, 2 and 1 as the season advances. Most of these ships make two or three trips during the February to December fishing season. A small fleet of large-sized otter-trawlers from Italy also fished in these Subareas during the past few years. Fleets of otter-trawlers from Iceland, Denmark (Faroes Is.) and Norway (ships mainly around 500 - 700 gross tons) fish each year in Subarea 1 from April to November.

Dory schooners. Portugal has the most important dory schooner fleet; a small number fish entirely in Subarea 3 and the others fish in Subareas 1 and 3. These dory schooners make only one trip each year; their season is from June to September in Subarea 1, and from April to October in Subarea 3.

Canada has a small, but decreasing, dory schooner salt-cod fleet which fishes from March to October primarily in Subarea 3. These ships generally make three salt-fishing trips each year.

In Subarea 1, Denmark (Faroes Is.) carries on a small fishery by schooners.

Longliners. The only offshore longline fishery for cod is in Subarea 1. A Norwegian fleet of longliners ranging between 100 and 500 gross tons fishes from April to September. Denmark (Faroes Is.) operates a small fleet of longliners in Subarea 1 during the same season

Pair trawlers. Spain is the only country operating pair trawlers in the Convention area. These fish in Subarea 3 mainly during the summer months but their season extends from about March until October.

Table I - Selectivity of gear used in the salt-cod fishery

Country	Otter trawling cod-end mesh size #(mm)	Line Fishing Size of hooks (Mustad)
Canada		11 (a) 14-17 (b)
France	120-125 (about)	
Portugal	110-115	14-15 (b)
Spain	90-127 (1) 89-101 (2) 110-131 (3)	

\# As measured with ICNAF or Scottish gauge.

(1) Measurement of first cover for one section of fleet using double cod-ends.
(2) Measurement of second cover for a second section of fleet using triple cod-ends.
(3) Pair trawler cod-end (no cover).

(a) Handline.
(b) Longline.

In the offshore fishery, in a move toward more efficient fishing, practically all otter-trawlers are now fitted with depth-recorders; many have Loran and Radar for more accurate navigation; many have radio-telephones for communication, and many are now being fitted with sonar equipment to aid in detecting the presence of fish schools. Many of the dory-schooners are now fitted with similar equipment. In the longlining fleets more ships are now using power haulers than in previous years.

Statistics of Landings

The following countries, listed in decreasing order of importance of landings, participate in the salt-cod fishery in the Convention area: Canada, Portugal, France, Spain, Denmark, Iceland and Italy. The order of importance of subareas producing salt-cod is 3, 1, 2 and 4.

Recent trends in the salt-cod fishery may be summarized as follows:

1. The Canadian salt-cod fishery has been declining. Schooners have been reduced to very small numbers. The bank fishery for salt-cod has been replaced by an otter-trawl fishery for fresh groundfish.

2. The Portuguese salt-fishery has been increasing. Schooner landings, which exceeded those of otter trawlers until 1949, have now levelled off while otter-trawler landings have continued to increase.

3. The French salt-fishery has fluctuated greatly. It virtually disappeared during both world wars and during the depression in the "thirties". Franch dory schooners have been completely replaced by large otter-trawlers which catch more cod for salting than any other otter-trawl fleet.

4. The Spanish salt-fishery has grown steadily from 1927 except for a ten-year wartime decrease beginning in 1936. Recent developments have included (a) large catches of haddock for salting; (b) an increasing fleet of large otter trawlers; and (c) a salt-cod fishery in Subarea 3 by pair-trawlers.

5. The Danish salt-fishery has increased sharply during recent years. The shore fishery from Greenland has increased, and the Faroese schooner and trawler fishery developed quickly following the last war.

6. The Norwegian salt-fishery gained prominence after 1948. The development of a pelagic line-fishery for large cod is the major factor responsible for the increased landings. A few otter-trawlers have also contributed to the Norwegian catch.

7. The Icelandic fishery became important in Subarea 1 in 1951.

8. An Italian fishery by a few large otter-trawlers has contributed to salt-cod landings since 1950.

Table II - Landings of salt-cod for 1953

In thousands of metric tons (round fresh)

	Canada	Denmark	France	Iceland	Italy	Norway	Portugal	Spain	Total
Otter trawlers (1)									
- very large	-	-	114	-	14	-	97	59	284
- large	-	14	-	14	-	4	-	-	32
Pair trawlers	-	-	-	-	-	-	-	23	23
Dory schooners (2)									
- very large	-	-	-	-	-	-	67	-	67
- large	16	2	-	-	-	-	-	-	18
Longliners	-	8	-	-	-	27	-	-	35
Inshore boats	155	26	4	-	-	-	-	-	185
Total	171	50	118	14	14	31	164	82	644

(1) For details of otter trawler sizes refer to section on fishing equipment.
(2) Very large dory schooners - 250 to 1,200 gross tons.
Large dory schooners - 100 to 250 gross tons.

Recent changes in the salt-cod fishery may be summarized as follows:

1. There has been a post-war increase in the landings from the Convention Area. This is largely due to increased fishing in Subareas 1 and 2. In Subareas 3 and 4 the total cod production has been maintained at a high level.

2. There has been a sharp increase in the landings by otter trawlers; about half the salt-cod landings were taken by otter trawls in 1953. Line-fishing from dory schooners has become relatively less important.

Abundance

Abundance indices are available for some salt-cod fisheries in Subareas 1 to 4. In Subarea 1 favorable climatic conditions have resulted in the production of a series of very rich year-classes of cod. In Subarea 2 cod abundance has not changed appreciably during the past 25 years. In Subarea 3 catch per unit of effort has increased with increased efficiency of fishing methods, but abundance indices have not changed significantly during recent years. In some years favorable hydrographic conditions concentrate cod along the Newfoundland coast and in those years landings increased. In Subarea 4 cod indices of abundance have decreased since the last war as a result of a decline in the numbers of large cod.

There is good evidence that the large salt-cod fishery can be increased substantially from the present level of production. Post-war developments of otter-trawl and pair-trawl fisheries, recent introduction of pelagic longlining in Subarea 1 and deep water longlining in Subarea 3, both for large cod, and finally the known, but little-fished, cod stocks of Subarea 2 all support the conclusion that the cod fisheries in Subareas 1, 2 and 3 can be increased.

Sizes

Table III - Recent observations on sizes of cod taken by different gears

	Gear	Length range (cm)	Mode (cm)	Subarea
Canada	Trap	35 - 95	53)	
	Handline	35 -105	63)	3L
	Longlines	40 -120	65 - 68)	
	Dory schooners	50 -140	65	3, 4
Portugal	Dory schooners	55 -100	67	1D
	Otter trawlers	40 - 90	70	1C
		32 - 70	52	2J
Spain	Otter trawlers	38 - 83	60	3L
		32 - 71	52	3N
		44 - 83	63	30
		41 - 74	50	4V

The decreasing relative importance of linefishing and the increasing importance of otter-trawling have resulted in a reduction in the sizes of cod taken from the Convention area. Since large cod are of special interest to the salt-fish industry, because of greater market demand and higher value, it is important to study the relation between landings of small and of large cod. If the proportion of large cod in landings could be increased, it is possible that fishing effort and total production of cod could be increased. Increased long-term total production is the aim of the Commission.

Conversion Factors

New studies of conversion factors for landed weights of salt-cod provided data which conform with the conversion factors tentatively accepted by the Commission in June, 1955. Preliminary data were presented on conversion factors for landed lengths of salt-cod to lengths of round fish.

Biological Observations

Some of the highlights in biological observations presented in papers and charts to the salt-cod working party are listed below:

1. Dr. Hansen (Denmark) presented a figure showing the decreasing growth rate in recent year-classes as compared with that found in Greenland in the "twenties". An earlier age of maturity has also been observed. Good year-classes continue to appear frequently at Greenland and catches have accordingly continued at a high level. Some recent signs of a return to a period of low landings have been observed.

2. Dr. Rodriguez (Spain) reported on recent studies of cod taken by Spanish otter-trawlers from the southern Grand Bank. The 1949 year-class has predominated in the catches and the modal sizes taken have increased from 43 to 60 cm. during the period 1953 to 1955.

3. Mr. Rojo (Spain) reported on discards of cod at sea by Spanish trawlers, showing wastage by numbers to be 0.5 to 37 percent. He also presented data on catch per unit of effort for cod and haddock, showing that Spanish trawlers concentrate either on cod or haddock.

4. Dr. Ancellin (France) presented an interesting chart describing the seasons fished by French otter trawlers in the various ICNAF subdivisions.

5. Dr. Ruivo (Portugal) presented valuable information on conversion factors, sex ratios and age composition.

6. Growth rate studies by Canada, Denmark, Portugal, and Spain were considered and good agreement was observed for areas where two countries sampled the same stock. Great variation in growth rate was observed throughout the Convention Area. The fastest growth rates have been found on the southern Grand Bank and at Greenland; the slowest growth was observed on Labrador, and along the east coast of Newfoundland.

Proposed Research Program

1. Statistics

(a) The Commission has made outstanding progress with the collection and publication of statistics of landings. It is believed that these statistics are approaching adequate detail and accuracy for Commission purposes, and that increased energy in this field is not required.

(b) Studies of available log-book records of past fishing are needed in order to allocate landings of cod by subarea of capture and by fishing effort.

(c) Studies of conversion factors for weights landed to round weights have reached the point of diminishing returns. All material should now be reviewed. It is proposed that research in this field should now be directed to studies of conversion factors for lengths as landed to total lengths as caught.

2. Sampling

(a) Progress has been made with the study of sizes of fish caught and landed, but it is proposed that work in this field should be increased. Consideration might be given to the publication of size compositions along with statistics in ICNAF publications. The basic data should include detailed information on fishing ground, depth, and selectivity of gear fished (mesh or hook size). These data should be grouped for publication. In order to advise the Secretariat on such grouping of data, the proposed cod symposium in June, 1956 might give consideration to division of stocks, and to horizontal and vertical movements of cod in relation to sex and size.

(b) Sampling can be improved by shore sampling of landings taken from restricted areas. Landings by pair trawlers and by dory schooners might be studied in this way. Such sampling would require length conversion data (see 1(c) above).

(c) Sampling at sea must be continued in order to sample trips which move from one area to another, and in order to assess differences between sizes caught and sizes landed. Observers should move from vessel to vessel for sampling.

3. Gear selection

(a) Studies of mesh selectivity should be extended to nets with double cod-ends.

(b) Mesh selection data for otter trawls should be studied in relation to the selectivity of other gears such as pair trawls, hand lines, long lines, pound nets and traps.

4. Population dynamics

(a) Studies of recruitment, growth, and mortalities must be pursued in order to determine optimum size for first capture and optimum fishing intensity for each stock.

(b) It is of special interest for salt-cod to study the possibility of increasing total production by providing for increased catches of large cod.

5. Prediction

(a) A number of basic biological studies must be continued in order to predict changes in the commercial fishery e.g. (I) studies of abundance of pre-recruits from egg, larval and small-fish surveys; (II) studies of the factors controlling year-class strength; (III) studies of changes in growth rate, maturity, and conditions factors; (IV) studies of distribution in relation to such factors as depth and temperature; (V) studies of efficiency of different baits in relation to analysis of indices of abundance.

List of papers and charts presented

Ancellin, J. - La Campagne de Pêche morutière des Chalutiers Français dans l'Atlantique N.W. en 1954.

- Campagne de Pêche à la Morue dans l'Atlantique Nord-Ouest en 1954 (1 chart)

Fleming, A. M. - Characteristics of Canadian (Newfoundland) salt-cod fleet.

- Landings, sizes, and growth of cod caught by Canadian (Newfoundland) salt-cod fleet (8 charts)

Hansen, P - Special study of the characteristics of the catches of the Greenland salt-fish fleet.

- Changes in growth rates of year classes in Greenland waters (1 figure).

Martin, W. R. - Characteristics of the fishing and landings by the Canadian dory-schooner salt-fishing fleet (12 charts).

Rodriguez, D.O.- Report on the cruise carried out by the Spanish vessel Cierzo in the waters off Newfoundland, June - July, 1955.

- Short history of the Spanish cod-fishery.

- Conversion factors (Subarea 3, Cierzo, June - July, 1955)

Rojo, A. - Total capture of cod and haddock; catch per unit of effort; and haddock sizes taken by 10 Spanish trawlers, 1955 (Graphic presentation).

Ruivo, M. - Conversion factors for cod. Portuguese investigations in Subareas 1 and 3 in 1955.

B

W. R. Martin, Chairman

III

DEVISE MEANS OF REDUCING THE TIME REQUIRED TO OBTAIN THE DATA NECESSARY FOR MAKING ASSESSMENTS OF STOCKS, ESPECIALLY THOSE REQUIRED AS THE BASIS FOR A PROGRAMME OF CONSERVATION

1. Introduction

The Working Party received eleven written contributions giving either general comments or analysis of particular aspects of our problem. These papers are listed in Appendix II. They were not presented formally during our sessions, but were circulated in advance of the meetings and studied with reference to particular aspects of the subject as these were being discussed.

Participants

Mr. S. J Holt, (Convenor)
Mr. John Gulland, (Rapporteur)
Dr. A.I.C. Jensen
Mr. R. Jones
Mr. E.D. Le Cren
Mr. C. Taylor

In addition:

Dr. W. R. Martin and
Dr. W. Templeman presented illustrative material.

The following also took part in discussions when they were free to attend the meetings:

Mr. L. K. Boerema, The Hague
Dr. Arni Fridriksson, ICES, Copenhagen
Dr. G. L. Kesteven, FAO, Rome
Dr. C. Lucas, Aberdeen
Mr. F. D. McCracken, St. Andrews, N.B.
Mr. G. Saetersdal, Bergen.

It was indeed most unfortunate that Mr. R. J. H. Beverton, whose preparatory work was eventually such an important factor in the development of our discussions, was unable to be present at the meeting. We were, however, fortunate in having, by correspondence, the benefit of the thought that he had given to the problem set to the Working Party, and his assistance in preparing the final draft of this report. It should be mentioned, finally, that before the meeting Mr. Beverton had corresponded with Dr. W. F. Thompson who, though he did not send a formal contribution, raised several important points in his letters, the substance of which has, I think, been incorporated in this report.

All meetings were held jointly with Working Party 1 and it was decided that the discussions on population dynamics should precede those on sampling problems. Although there was a reciprocal relation between the two subjects, it was felt that the greater need was to define first the population properties for the estimation of which adequate sampling procedures need to be devised.

The group considered first the types of assessment that are needed, then how these may be made in a wide variety of possible situations with respect to type of fishery and type of data available. It then discussed how the desired information might be obtained, or used, more efficiently, and time saved also by:

(a) defining situations in which it is safe to make recommendations for action (e.g. beneficial increase in mesh size, reduction of fishing intensity, etc.) when only certain limited data are available;

(b) improving the choice of priorities in research;

(c) supplementing - or substituting other kinds of information for - the usual time series (e. g. annual statistics of catch and fishing effort), the rate of accumulation of which cannot be hastened.

2. Types of assessment

(a) Rough appreciation of the present state, or condition, of a fishery, the principal question being whether the fishing is having any significant and measurable effect on the size or composition of the stock, and if so, whether the catch being taken is in general a large or small proportion of the potential steady catch.

(b) More detailed diagnosis of the present state of a fishery, and predictions of the probable long-term effects on the characteristics of the catch of various sustained changes in the amount or selectivity of fishing.

(c) Assessment of changes from year to year in observed characteristics of catch and population to supplement a diagnostic assessment of type (b) above, and to detect any unexpected changes that may occur. A particular need is to establish as soon as possible whether or not a given regulative measure is have the predicted result.

3. Characteristics of the fishery to be evaluated

The group concluded that the method of assessment used in evaluating the effect of changes in either or both the amount or kind of fishing must be capable of giving information about the following characteristics:

(a) the total weight of the catch;
(b) the catch per unit fishing effort;
(c) the composition of the catch, especially by species and size of fish;
(d) the partition of the catch between different parts of the whole fishery (different kinds of vessels or gear, or between fleets of different nations,

4. General examination of the history of a fishery

In the past much study has been devoted to methods of determining the state of a fishery from long series of data on annual catch and fishing effort. There has been some success in this, but the group did not consider that total catch, and perhaps not even catch per unit effort, could provide a very sensitive measure of changes in fish stocks. The group recommends that greater attention should be given to methods of using other characteristics of the catches (e. g. species composition, sex ratio, average size or range of size of fish) to indicate changes in the stocks, and hence point to possible effects of fishing. The need for long time-series might also be reduced by comparing, over relatively short time periods, changes in stocks of the same species in different areas, or in stocks of different species in the same area. However, the group considered that such methods could do little more than give a guide to future research, and could not lead to firm conclusions about the expected quantitative results of changes in either fishing or natural conditions.

It is well known that observation of the consequences of large changes in fishing effort, such as have occurred during and after the two world wars, can give good indications of the general effect of fishing on the stock and hence of the possibility of improving catches by adjustment of fishing effort or selectivity of the gear. It was suggested that advantage might also be taken of such changes as rapid alterations in the type of fishing gear used.

5. Diagnosis of the state of a fishery and stock

The group considered that for this purpose the most powerful analytical method is the development of mathematical models of fish populations, into which may be fed information relating to real populations and their structure, and predictions made of the magnitude of changes in characteristics of the catch with changes in the amount and selectivity of the fishing. Some models are, however, less efficient than others. In particular it was felt that those models in which only the gross magnitude of stock, and of catch and effort, were related by a simple theory of population growth, were of limited application. The results obtained from them were unlikely to be sufficiently reliable or detailed to give a reasonably sound basis for practical recommendations concerning a particular fishery. A satisfactory model should at least take into account separate measures of the fishing and natural mortality rates, the growth pattern of individual fish throughout their fishable life-span and the number and age of fish recruited and the age at which they first become exposed to fishing. Methods for determining these quantities depend to a great extent upon the analysis of the age and size composition and other features of the catch. It is important that these methods should always be developed and applied in parallel with the models in which the observed values of the mortality, growth and recruitment are to be used.

The group then considered each of the above quantities in turn, paying attention to the methods of measuring and observing changes in them; the required accuracy of measurement; and the extent to which bias in estimation, through ignorance of such factors as the degree to which catch samples are representative of the whole population, may lead to wrong diagnosis.

6. Natural mortality: the analysis of the total mortality into its components

There are several methods of estimating natural mortality rates and they are summarized in "Problems and Methods of Sampling Fish Populations", ICES, Rapp. Proc.-Verb. 140(1), 1956. The basis of most methods is the estimation of total mortality and the subtraction from this of a measure of the fishing mortality. An example is the procedure of plotting yearly estimates of total mortality (usually obtained from age composition data) against some appropriate index of fishing intensity. This may give a regression line from which the total mortality when there is no fishing (i.e. the natural mortality) can be calculated. Confidence limits for the natural mortality can also be calculated, and such limits may be of great usefulness for certain limiting cases outlined in a later section of this report. In practice, when such procedures are used, there is a very great scatter of points, and the error of estimation is large. This might be reduced by taking longer time series but this increases the likelihood that the period covered would include changes in the relation between fishing effort and the mortality caused (resulting from unnoticed changes in either the power of the fishing units or their spacial distribution with respect to the stock), or in the natural mortality itself. The scatter may also be reduced by improved sampling methods for age composition and more accurate estimation of effort, but there remains the possibility of year to year variation in the natural mortality. If an index of this variation could be found, it could be used to reduce the scatter, and thus shorten the time series required for reliable estimation of the average natural mortality. To do this an investigation of the causes of natural mortality and their relative importance is essential, and this would enable some rough index of the intensity of the main factors, e. g. predators or disease, to be obtained. In practice, each factor that was suspected of having an influence on natural mortality would be examined; if by taking it into account the sum of squares of deviations from the regression line of total mortality on fishing effort could be significantly reduced, then this would strengthen the conviction that that factor was indeed influential. The group therefore agreed that measurement of the causative agents of natural mortality would promise to improve greatly our knowledge of the dynamics of fish populations, and might reduce the time required to reach practical conclusions as to their exploitation, and therefore recommends that the Commission should encourage research on this question.

The group noted that natural mortality can be estimated also from regressions of total mortality on fishing intensity when the latter varies not only with time but also with place or with age of fish, and these methods would be useful in reducing the time required for adequate measurements.

The group agreed that in principle as many different methods of estimation as possible should be used, drawing on the widest variety of kinds of data. Cross-checking the results obtained by different methods (including tagging where this is possible) gives a means of minimizing the time needed to come to a firm conclusion. Natural mortality is the most difficult to measure of the vital rates in a population and it may often be the most critical in assessing the effects of changes in the fishing. To enable a variety of methods to be used, the group recommends that the collection of the necessary data should be as complete as possible over all sections of the fishery; such data should include weight caught (including fish rejected at sea), fishing effort, and the species, sex, size and age composition of the catches. Various types of changes in these characteristics of

the catch can in certain different circumstances give information about the natural mortality. Development of methods for this purpose should be pursued, and attention paid to the comparison of natural mortality rates and their variation with age and between different stocks, either of the same or different species.

7. Growth

When the age of individual fish can be determined, then growth is easily measured to the accuracy required in the diagnosis of the state of a stock. The most important aspect of growth variation is its dependence upon the abundance of the stock. Regression methods are again useful in estimating the magnitude of the density dependent effect. As with natural mortality, regressions corresponding to variations in space as well as in time might be useful, but need to be tried with care. Similarly, the variance about the regression line might be reduced by allowing for measured differences in environmental factors such as food abundance, even if only a rough index of them can be obtained. Surveys of available food would in any case be essential in any attempt to study the density dependence of growth rate by regional comparisons. In addition, sensitive measures of the recent rate of growth of a fish should be sought to supplement information on food availability. The variation in the weight-length relation (condition) may be useful, and it is suggested also that such measures may be found by detailed examination of anisometric growth - relative growth of otoliths (which may differ in fish of the same length and weight but different ages), and eggs and gonads were mentioned as examples that might repay closer study.

Attention was drawn to the possible use of pond experiments in the study of growth variation. Even though the rates of growth observed under such conditions do not necessarily correspond to those attained naturally, an estimate of the possible range of variation might be obtained and this would be useful in certain circumstances. The group therefore recommends that consideration be given to the possibility of increasing knowledge of growth by direct study of the natural food populations and experimental study of growth variations in fishes, and their causes. Development of techniques for valid comparison of growth of different species or stocks, by distinguishing variations due to feeding from inherent variations, is desirable.

When age itself cannot be determined, measures of growth increment and relative age (see below) are still useful. The former may sometimes be obtained by tagging and it has been suggested that an idea of the latter may be obtained from the appearance of the fish. Instances were given of changes in the relative sizes of certain external structures or features of the fish indicating relative age, and it is recommended that further studies of this matter should be made. However, the group felt that collateral evidence of growth rate would usually be required and that great care would have to be taken to ensure that the feature used as an index of relative age did not vary greatly with such factors as temperature and food supply, and also that observed differences in appearance were not of toxanomic significance.

8. Recruitment

To obtain directly an absolute value for the number of fish annually recruited to a stock presents very great difficulties, but if data on growth, the fishing and natural mortalities and the total catch are available, the number of recruits can readily be computed. Much can be done also with a simple proportional index of recruitment, obtained, for example, as the catch per unit effort of fish at the recruitment age or size. It is very important to know whether recruitment is significantly dependent upon the size of the mature population from which the recruits are derived, and if so, the general form of the relationship. It may be necessary to know whether there is at some high level of stock density an inverse relation, that is, the number of recruits decreasing with increasing stock size, but usually, in cases where regulation is in force or contemplated, the stock size maintained might be expected to be less than that giving maximum recruitment. Then an assumption of independence, when in fact there may be some unknown degree of direct dependence, may be an acceptable procedure because it will lead to an under-estimate of the expected effects of changes in either amount or selectivity of the fishing. (The group felt that to under-estimate the effect was less undesirable than over-estimating it because then there would be no danger of encouraging regulation in a situation when it would not in fact be beneficial)

In attempting to identify the relation by plotting indices of recruitment against indices of egg-production, or size of mature stock, over a period of years, the observed points are again liable to have a wide scatter, making it necessary to deal with time series as long as the statistics will allow. If, however, there had been a long-term trend in the conditions for larval survival, the result might be an associated change in both recruitment and egg production and when observed values of these were plotted against each other they may show a relation which would be mistakenly interpreted as one of cause and effect. It is therefore particularly important to find means of reducing scatter and thus allow effective analysis of data referring to shorter periods of time. In considering methods of reducing the scatter the group considered that a less variable index of recruitment may be obtained by suitable use of data obtained throughout the whole fishable life-span of a group of recruits. The scatter might also be reduced by studying the form of the survival curve during the pre-recruit phase, especially in identifying stages at which large density-independent mortalities occur. This is essentially a sampling problem.

It was agreed that a useful technique is to follow through the early life of a particular group of fish, such as those hatched together and subject to particular environmental factors, and thus possibly having identifiable meristic characters. At the same time there is a complementary need for study of long-term trends in environmental factors thought to affect larval survival.

The particular importance of having an adequate index of recruitment when regulation of gear selectivity is considered, or changes in gear evaluated, was emphasized. Ideally this index should be obtained at an age before the fish are exposed to any of the gears considered.

9. Interdependence of growth and mortality rates

It is possible that growth and survival rates (both on the average and with respect to variations between individuals in a brood) may sometimes be inversely related. Although it is not thought that this phenomenon will cause appreciable errors in use of simple models that do not take the effect specifically into account, the effects being compensatory, nevertheless some further attention should be paid to this and other similar relations between what are usually considered to be independent factors. Another example would be the possible relation in some cases of high recruitment to fast growth in the pre-recruit phase, so that there is a rapid growth through a size range in which the young are particularly vulnerable to some cause of mortality.

10. Use of limited data

The group paid much attention to the value of analytical models when information on critical factors such as natural mortality is lacking or poor. It was generally agreed that there were several situations in which a proper understanding of the properties of simple models, with constant parameters of growth, mortality and recruitment, can permit useful conclusions to be drawn about the expected direction of changes in size or composition of the catch following changes in the amount of selectivity of the fishing even when data on the necessary parameters are somewhat inadequate. There is need for further examination of these possibilities but some special cases are mentioned below. It cannot be too strongly emphasized, however, that the shortcut methods suggested are for use in special cases and in making particular kinds of decisions with regard to a fishery, and their application can be no more than a temporary measure pending a comprehensive and detailed study of the stock and fishery in question.

10.1 If only the growth rate and total mortality are known then it is possible to calculate a value of the natural mortality, such that if the true value is above it, then an increase in fishing intensity or selectivity (mesh size) will give an increased steady catch. When the relative growth rate is high and the upper limit of size is being rapidly approached, there may be cases when this calculated value of natural mortality is close to zero and well below the value of natural mortality usually found in similar stocks. There may also be some collateral evidence that the minimum possible value of the natural mortality is above this calculated value.

Conversely there is another value of natural mortality such that provided the true value is less than that value then there will be an increase in steady catch following a reduction in effort or mesh size. Evidence that the true natural mortality is below this second calculated value may come from the lowest values of the total mortality coefficient observed over a period of time for a fishery in which the effort has fluctuated widely (allowance being made for extreme values occurring due to sampling errors). Information on total mortality in virgin stocks, or soon after exploitation began, may delimit the natural mortality even better. In such conditions the growth rate may be abnormal, but will probably indicate a lower limit to the changes expected in growth rate when the stock is fished.

It was pointed out incidentally that data obtained before or soon after a commercial fishery develops are exceptionally useful and that special steps should be taken wherever possible to ensure that such data are obtained in the greatest detail.

The group recommends that calculations should be made and diagrams prepared of these upper and lower values of natural mortality for a wide range of total mortality, growth rate and age at recruitment, as an aid to diagnosis of the condition of the stocks.

10.2 If the average weight of fish in the catch, the weight at which fish enter the exploited phase, and the ratio of fishing mortality to total mortality are known, it can be determined whether the steady catch will increase or decrease following a change in the selectivity of the gear. Even if the fishing mortality or total mortality are not separately measurable, their ratio might be estimated by simple marking experiments, and determined even by those experiments in which the exact number and size of fish released is unknown (as might occur with tagging by detachable hooks). Such experiments will tend to under-estimate the ratio, but this direction of error is such that it is still possible to identify situations in which it would be advantageous to increase the size at first capture.

As in 10.1 above there may be other evidence on the possible limits of fishing and natural mortality such that a firm conclusion may be reached as to whether an increase or decrease in age at first capture is desirable. The group recommends that the ratio of the weight to the exploited phase to the average weight in the catch should be explicitly calculated. When the selectivity is optimal for the actual fishing effort being made, this ratio is equal to the ratio of fishing mortality to total mortality. The aforesaid calculation should be compared with the observed ratio of the fishing to the total mortality, for any fishery for which mesh or other corresponding regulation might be contemplated.

10.3 When considering the direction of change as in 10.1 and 10.2 above, the change in density of stock will be small near to the observed situation, so that as a good approximation the possibility of density-dependent changes in the vital rates may be neglected. However, calculations could be made of the limits of the rate of density-dependent change which, if exceeded, would invalidate conclusions based upon the behaviour of simple models with constant parameters.

In all the above cases, similar arguments can be applied to the direction of change in catch per unit effort and certain indices of the composition of the catch, such as average length or weight of fish.

10.4 The length composition of the catch has sometimes been used instead of age composition, when the latter is not available, to give indices of mortality. The procedure is simple if, during most of the fishable phase of the life span, the growth in length of the fish can be considered as approximately linear (for example, as determined from marking experiments, moulting of crustacea, etc.), since a linear relative age scale can be established. There is, however, a need to develop corresponding methods for using length (or weight) compositions in cases where a more realistic, non-linear, representation of growth (i.e. a steady increase in length with age, towards an upper asymptote) is necessary or desirable, and it is recommended that this problem should be investigated.

10.5 Special problems arise when there is a bias in the determination of age of fish, as for example may occur when there is uncertainty in the interpretation of the nucleus, or of intermediate rings in a scale or otolith. However, if both mortality and growth rates are determined from the same data of "age" composition, assessments may sometimes be attempted before the true method of age determination has been established. Thus consistent differences of one or more years (i.e. reading a fish of age x as x + k) still give correct values for mortality, and since the error in the location of the growth curve on the age-axis is exactly compensated by the error in the estimation of age at first capture, the resulting catch curves are identical. Thus conclusions concerning the state of the stock are unaffected by such an error in age-determination. The same is true for errors of a constant multiple or fraction (i.e. reading a fish of age x as kx). This will be precisely equivalent to expressing mortalities, growth and age at first liability to capture in terms of the same unit of time, equal to 1/k years. The resulting calculations concerning the state of the stock are unaffected by such errors provided that such calculations were concerned only with steady-state conditions; predictions could not be made, for example, of year to year changes following a change in fishing intensity or mesh size, during the period before a new equilibrium was established, because the results of the calculations would depend critically on the number of age groups represented in the accumulated stock. It was emphasized that real evaluation errors would be introduced if other kinds of data are used for measuring either the mortality or growth rates. For example, data from marking experiments would refer to the true time scale. Since one important general conclusion of our meeting was the need to use and compare results of several methods for determining population parameters, it is clear that the necessity to refer readings to a true absolute age scale could not be long postponed. Nevertheless our discussions served to bring out the point that errors in thinking about dynamics of populations (for example, attempts to judge the condition of a stock and its possible response to fishing from consideration of growth or mortality rates separately) may at times have greater significance than bias in the techniques of obtaining data. In view of the insufficiency of our knowledge of the basic processes determining ring formation in hard structures, which limits our certainty in age-reading (especially with respect to variation of bias in reading with age itself), the group recommends that investigations should be made of the extent to which various kinds of undetected bias (especially contraction of the time-scale at high age) may be expected to lead to important errors in evaluating stocks. The results of such studies would perhaps help also in planning investigations of the bases of age-determination methods of the kind discussed by Working Party No. 6.

10.6 Frequently fishing is carried out on only part of what is believed to be the geographical or depth range of a unit stock, but it is not known what fraction the part is of the whole, nor what is the rate of interchange of fish between fished and unfished areas. Preliminary calculations show that at least in some circumstances important errors are not introduced by treating the fished part of the stock, as reflected in the composition of the catch, as if it were independent of the unfished part. Discussions of this problem showed that there is some useful work to be done in analysing the errors of evaluation which might arise if calculations are based upon simple models of independent populations with constant vital rates when it is known that the real situation departs, but to an unknown extent, from the simple assumptions. It is suspected that the simple models give

answers valid for practical purposes when there is a considerable degree of departure, provided that the parameters are computed from the data in the analogous way to that in which they are applied to the model to give assessments. Clearly any errors would increase as fishing intensity or selectivity departs markedly from the initial observed values, and sometimes even the direction of change of catch characteristics may not be correctly predicted. However, it has already been shown that the simple models can sometimes be applied to complex situations of spacial variation of fish concentration and fishing to give valid predictions, provided the distribution pattern of the fishing in relation to that of the stock does not greatly change. The group recommends that further studies of this general problem of the extent to which simple models can give useful working answers in complex situations should be made. Other such situations are the fishing of the same stock by gears having different selectivities, the simultaneous capture by the same gear of species having similar mortalities or growth characteristics, and fisheries based upon migrant stocks, whose presence in the fished area may be only transient.

At the same time it is of the greatest importance to continue to develop methods of analysing patterns of movement (especially offshore movements and general movements between deep and shallow water) and detecting or predicting the existence of stocks outside the fished area. No one method is sufficient and the group recommends that attention should be paid to methods of interpreting marking experiments carried out for this purpose, variations in morphometric and meristic characteristics (for which frequency distributions of measures or counts are of equal, if not greater, importance than the mean values), and data of catch, effort and composition of catches by as small areas as possible.

10.7 It was confirmed that there are as yet no special methods for assessing the effects of variation in the accessibility of the stock other than the most detailed and persistent study of as much of the stock and as many of the possibly significant environmental factors as can be dealt with. However, even when such basic data are available, there remains a need for satisfactory analytical techniques. It was suggested that a useful start had been made in studying how fluctuations in availability can be analysed in terms of deviations from an expected regression of apparent mortality on fishing effort.

11. Identity of stocks

Insufficient attention has been paid to the criteria by which it is decided that an observed population may be considered as effectively a homogeneous unit stock. Something has been said earlier of cases in which, even though the limits of the stock are unknown, some evaluation can be made, but the full implications of such procedure are not well understood. It is suggested that differences in reaction to fishing, particularly in fishing mortality, of two stocks whose degree of interdependence is unknown, might be useful as a means of differentiation, and that errors in such methods might be of little importance in evaluation. It seems likely that when there is doubt as to the allowable procedure, the correct catch curve will lie between that based on an assumption of homogeneity and the sum of those based on complete independence. This problem is part of the larger question of determining the practical significance of any observed inter-relations between different stocks, and the group recommends that further studies of this matter should be made.

12. Detection and prediction of year to year changes in stocks and their reaction to fishing

The group agreed that this aspect of our work is in urgent need of systematic development. The basic data for this purpose are catches and their location, their species, age, size and perhaps other composition, and standard measures of fishing effort and its distribution by area. Methods are available for making year by year estimates of growth and total mortality. These should be further employed and refined, but the group recommends also that close study should be made of the expected dependence of various characteristics of annual catches on possible kinds of changes in fishing or particular environmental factors. The more sensitive of them might then be used for testing whether or not regulative measures are having the expected effects, and for detecting unexpected changes in the stocks.

With regard to information on fishing operations, the most important points to watch for are changes in fishing power of the fishing units which would bias fishing intensity statistics, changes in selectivity with changes in gear, and changes in the distribution of the fishing in space or time which might change the effective fishing intensity or the effective selectivity of the gear. Unfortunately the group did not have time to discuss these points in detail, and no other specific recommendation can be made.

In connection with regulations it is perhaps a commonplace that research programmes have to be planned integrally with them in order to check as quickly as possible any important factors that may not have been understood or measured adequately before regulative action was taken.

The group agreed that the simple population models at present used do not use data as efficiently as may be possible; in processing data to obtain average values of various parameters, and to eliminate effects of sampling and similar errors, much potentially useful information regarding the variability of the stock and the fishery may be unused. Steps should be taken to correct this situation by continuing the development of models that make full use of all estimates of population parameters and which can also incorporate a wide variety of data relating to environmental factors. The group emphasized that in this work continued reference must be made to the available data referring to particular stocks of fish, and to the particular factors which have, in each case, been shown to be significant in modifying the characteristics of the stock, and hence of the catch. It was at the same time pointed out that improvement of the methods of analysing data would sharpen the already urgent need for more rapid processing and dissemination of detailed commercial statistics and basic sample data such as length compositions.

13. The time required to make assessments

A view was put forward that by a carefully planned and sufficiently comprehensive qualitative and quantitative analysis of the stock during two consecutive years, and including also tagging experiments, both the mortality between the individual age-groups, and their growth, can be obtained. If such investigations are possible then calculations of the change in catch per recruit, resulting from a change in fishing intensity or selectivity, can be made. However, it was thought generally that although this may be so in ideal circumstances, the conditions necessary for success are rarely fulfilled in practice. C 2

14. Notation and terminology

The group discussed at some length the question of notation in studies of the dynamics of fish populations. It was agreed that it is most desirable to establish standard symbols for the elementary quantities that are most frequently manipulated in the mathematical models that are being increasingly used for the evaluation of fisheries. The chief considerations when examining possible systems of notation are:

(a) the possibility of expressing the relevant formulae in a simple and compact form which is easy to write, type and print;

(b) the advantage of similarity of different measures being reflected in similarity of their symbols;

(c) the desirability of arranging that relations between different measures are not unnecessarily obscured, for example by using an extra symbol for a simple function of other symbols;

(d) the extent of conflict with the established notation of mathematics and statistics, and perhaps other sciences;

(e) the extent of departure from present usage.

Bearing these in mind, the group listed the quantities for which it was considered standard symbols were required at present; there are certain important differences in the definitions both of these and also of the quantities for which special notation is not yet required, and the names used for them by various workers. Knowing that FAO Fisheries Division is working on a dictionary of terms used in fisheries biology, the group recommends that FAO be asked to circulate proposed definitions of the fundamental terms used in studies of population dynamics to research workers on this subject in member countries of ICNAF, to receive comments and suggestions and make available a reference list of these definitions.

It was thought desirable that in any acceptable notation distinction should be made between true population values and sample estimates or measures of the causative factors (e.g. between fishing mortality and fishing effort). This can most conveniently be done by using lower case letters for the latter, or, when this is for other reasons undesirable, to indicate sample estimates by a circumflex accent or an underline.

A list of terms and symbols is appended. These symbols are almost all in common use, and the group recommends that the Committee should consider proposing the adoption of these symbols by workers in the ICNAF region, and especially in submitting documents to the Commission for discussion at meetings or for publication.

The detailed considerations which guided the group's recommendation for indiv' symbols, as they arose in discussion, were as follows:

14.1 Mortalities

The choice for this group of symbols lay essentially between two distinct sets, used characteristically by Ricker, and by Beverton and Holt. Both sets of symbols have been used extensively in the literature and are in general use among substantial groups of research workers. Some clash with existing usage is therefore inevitable. Considering the symbols for the instantaneous rates, the group believed that the symbols p and q conflicted with the established statistical usage as probabilities (in particular q is in general equal to 1 - p and also added confusion can arise because mortality coefficients have a probabilistic interpretation), and therefore recommend the use of F and M, following Beverton and Holt.

14.2 Numbers and weight of fish in catch and stock

The group considered that the symbols recommended for these quantities were the most suitable, and these did not depart significantly from any well established usage.

14.3 Fishing effort and fishing intensity

The group strongly recommended that distinct symbols should be used for a crude measure of fishing effort, e.g. the number of boats operating, which has rather greater economic than biological significance, and the best measure of the effective fishing (that is, effective in generating a fishing mortality rate in the fish population) calculable from the available data, the effective overall fishing intensity. The latter would include the standardization of fishing effort, and corrections for its geographical distribution relative to the fish. The symbol f has been widely used for both these quantities, but more generally - at least implicitly - for the latter. Because also of the close connection with the instantaneous fishing mortality coefficient, for which the group recommended F, and of which the fishing intensity may be considered an index, the group recommended f for fishing intensity and a similar symbol, g, for any crude measure of fishing effort.

14.4 Ratio fishing intensity/fishing mortality

The group considered that by its nature a lower case letter was essential for this quantity. However, there were serious objections to all lower-case letters used in the literature consulted, and the group therefore recommended the use of q as approximating to a present use of Q. It was felt that in any likely context there would be little confusion with the use of q as a probability.

14.5 Age and recruitment

The group considered that while a clear distinction should be made between age at recruitment to the exploitable phase, and age at which a fish is first liable to capture by the gear in use, such distinction could be well made by the use of suffices. The group recommended the use of t_r and t_c respectively.

14.6 Suffices

With the development of more detailed population analysis, increased use has been made of suffices to denote the values of parameters referring to a particular age of fish during a calendar year or at a particular time. The group felt that while not as essential as the standardization of the other symbols given in the appendix, a consistency in the use of symbols is greatly desirable. A suggested notation is given.

14.7 Other symbols

The group considered the possibility of recommending other standard symbols, particularly in regard to marking experiments and growth studies. They felt, however, that for these applications it is not yet clear which are the exact quantities for which standard symbols are needed. It is recommended, however, that workers in these fields should pay more attention to the use of a consistent notation. They also considered that the essential preliminary to a standard notation is a precise definition of each concept for which a symbol would be required, and that advantage would come in thus eliminating the present necessity to define terms anew in each contribution to fish population dynamics.

15. Some general conclusions

The group did not feel that any definite statements could be made as to the absolute time required to make assessments in particular cases with any given accuracy. However during our discussions certain general principles emerged. These are detailed below, with the recommendation that the Committee consider whether they might help to guide the planning of investigations of stocks in the ICNAF area.

15.1 The trend of research is increasing emphasis on the detailed analysis of the structure of exploited fish populations, in order to understand the rates of the separate processes of reproduction, growth and mortality, with a view to deducing expected general changes in the populations with changed conditions. The eventual aim is, however, once these processes are understood, to return as far as possible to simple but well founded methods of stock evaluation, and devise sensitive measures of stock changes.

15.2 It is highly desirable that as many methods as possible be used to estimate each vital rate, to provide checks on the value obtained and to bring to light unsuspected sources of error or bias in any one method. It is important that the relative accuracies of the different methods be determined under varying conditions and, if possible, confidence limits established. There is also an urgent need for means of assigning some measure of precision to predictions of changes in catch characteristics expected to result from changes in fishing. To do this effectively will require direct observation of the important natural factors that may disturb the predictions, and a procedure for allowing for as many of these factors as possible in the calculations. It would be an essential part of such a procedure that year by year estimates would be made of the rates of growth and mortality, and an index of recruitment. In addition, more efficient methods are required for determining which of the factors external to the stock, considered a priori as relevant, do in fact have significant effects.

15.3 The group considered the general question of reducing the variance in sample data from which vital rates are to be estimated. There should be a dual approach to this problem - by the improvement of sampling methods, and by seeking very much more knowledge of the inherent variation among the fish and the actual causative and controlling factors in recruitment, growth and mortality. The biological studies should preferably be made with the definite aim in mind that the results will be incorporated in equations describing the dynamics of the population. Concerning the reduction of time to make assessments, it was concluded that time could be saved proportionately with the extent to which a wide variety of different kinds of data could in this way be brought to bear on each problem.

15.4 The group was impressed by the importance of taking into account some estimate, no matter how rough, of all the vital rates, in assessing the condition of a fishery. Arguments that have been based, for example, on observations simply of a slow or fast growth rate, are especially misleading, and we have seen that, paradoxically, strongly biased estimates of growth and mortality can in certain situations (where the bias is of the same kind in both estimates) be more useful than an accurate estimate of either one of these rates alone.

15.5 The group considered that insufficient attention has been given to the distinction between true vital rates in the population and the estimates of those rates from samples, and examination of the theoretical relation between the true and estimated values. It is most important that the procedures in computing parameters from data be complementary to the calculation of predicted catch characteristics from the parameter values. If this practice is followed rigorously it will often be possible to make approximate evaluations when complete information is unobtainable.

15.6 It seems that the basic principles of those methods for estimating vital rates that depend on analysis of changes in catch characteristics or other quantities with time (for example, the plotting of annual values of total mortality against the corresponding values of fishing intensity to estimate the fishing and natural mortality rates separately), can be applied equally to differences with sex and age of fish or with location, and perhaps also with species. This offers important opportunities for saving time in evaluation and for increasing confidence in conclusions. Development of these comparative methods is most desirable.

15.7 Much of the emphasis during the discussions was on the determination not of particular quantities such as the 'maximum sustainable yield', nor even of absolute values of catch at different levels of fishing or with gears of different selectivities, but of direction of change in steady catches, their composition, and the catches per unit effort, with changes in the fishing intensity and selectivity. The group were then concerned with the topography, near the point of observation, of diagrams in which the important catch characteristics are plotted simultaneously against measures of the two independent variables of fishing mortality and age or size at first liability to capture by the gear. Some results of examining this topography have been mentioned, but there is much more to be done along these lines, including the analysis of situations where one or other kind of information is lacking, by considering the limiting possible values of the unknown parameters. This approach to stock assessment presents also new problems in graphic presentation of the results.

15.8 The group paid some attention to the importance of measurements of fishing effort. There has been in recent years much refinement of measures of effort and intensity for biological purposes, with the aim of getting values that are proportional to the fishing mortality caused in the stock, but these are not necessarily more useful for economic evaluation than the earlier crude measures. Although accurate fishing intensity statistics will always be essential, values of fishing intensity to relate to mortality, when a stock is being fished by a number of different types of vessel and gear, can be obtained from effort statistics of some homogeneous part of the whole fleet that covers a fairly large proportion of the fished area. These statistics can be used to convert the catches of the whole fleet to give values of total effective efforts. It is desirable to explore further the possibilities of using such a method, as a way of overcoming some of the difficulties of converting effort statistics for different parts of the fleet (especially those using gears having differing selectivities) to standard units. If, eventually, 'sample' methods of the kind described can be used to minimize the work involved in producing routine statistics of standard fishing intensity, then more attention could be paid to securing the very desirable wide sample coverage for species, sex, size and age composition of the catches, and also to obtaining the wide range of data on the different phases of the fishing operations necessary to develop the measures of real total fishing effort (including, for example, manpower, time of travel to and from fishing grounds, turnround at port, loss of fishing time at sea through various causes, etc.) necessary for a full understanding of a fishing industry.

15.9 The group recognized the especial importance to this subject of good definition of concepts, terminology and notation.

16. Summary of specific recommendations

The group recommends:

16.1 that greater attention should be given to methods of using characteristics of the catches such as species composition, sex ratio, average size and range of size of fish, to indicate changes in the stocks and hence point to possible effects of fishing (section 4);

16.2 encouragement of research on the causes of natural mortality in fish stocks, and their relative importance (section 6);

16.3 collection and prompt tabulation and dissemination of statistical data on fishing effort, total catches (including fish rejected at sea), and their species, sex, size and age compositions, over all sections of a fishery and broken down by as small areas and time intervals as practicable (sections 6, 10.6 and 15.8);

16.4 consideration of the possibility of increasing knowledge of growth by direct study of the natural food populations and by experimental study of growth variations in fishes and their causes; development of techniques for comparison of growth in different stocks, or of different species (section 7);

16.5 further study of the significance of the external appearance of fishes in indicating their relative ages (section 7);

16.6 further study of the problem of relating egg production to subsequent recruitment, and of the environmental influences on larval mortality (section 8);

16.7 that further attention should be paid to the possible interdependence of the rates of mortality and growth in fish stocks (section 9);

16.8 further examination of the possibilities of drawing useful conclusions about the expected direction of changes in the size or composition of the catch, following changes in the amount or selectivity of fishing, even when the available data are inadequate for full analytical treatment (section 10);

16.8.1 that as an aid to diagnosis of the condition of stocks calculations should be made, and diagrams prepared, of upper and lower values of natural mortality such that if the true natural mortality, though unknown, is between these values then certain conclusions can be drawn as to the probable effects of changes in the amount or selectivity of fishing. These calculations should cover a wide range of values of total mortality, growth rate and age at recruitment (section 10.1);

16.8.2 calculation of the ratio of the weight at entry to the exploited phase to the average weight of fish in the catch, and comparison of this ratio with the observed ratio of the fishing to the total mortality for any fishery for which mesh or similar regulation might be contemplated (section 10.2);

16.8.3 investigation of the problem of using length and weight compositions of catches more extensively as a substitute for age composition in assessment of fish stocks (section 10.4);

16.8.4 investigation of the extent to which undetected bias in age determination may be expected to lead to important errors in assessing stocks (section 10.5);

16.8.5 further study of the general problem of the extent to which simple population models can be used to represent complex situations without important errors being made in predicting the effects of changes in the amount or selectivity of fishing on the catch and its various characteristics (section 10.6);

16.8.6 that attention should be paid to methods of interpreting variations in morphological and meristic characters, data on effort, catch and catch composition, and marking experiments, for the purpose of analysing patterns of movement in fish stocks and of detecting or predicting the existence of stocks outside the fished area (section 10.6)

16.9 further study of the practical significance, in evaluating stocks, of a greater or lesser degree of interdependence between them, and development of methods for determining the degree of interdependence (section 11);

16.10 close study of the expected dependence of various characteristics of the annual catches on possible kinds of transient or sustained changes in fishing or particular environmental factors, with the object that the more sensitive of these characteristics might be used for testing whether or not regulative measures are having the expected effects, and for detecting unexpected changes in the stocks (section 12);

16.11 continuing the development of population models than can make full use of all estimates of population parameters and which can also incorporate a wide variety of data relating to environmental factors (section 12);

16.12 that FAO be asked to circulate proposed definitions of the fundamental terms used in studies of population dynamics to research workers in member countries of ICNAF, to receive comments and suggestions on these and to make available a reference list of these definitions (section 14);

16.13 that the Committee should consider proposing the adoption of the appended notation as a standard for workers in the ICNAF region and especially in documents submitted to the Commission for discussion at meetings or for publication (section 14);

16.14 that the Committee consider whether certain general principles which emerged during the discussions of the Working Party might help to guide the planning of investigations of stocks in the ICNAF area. The suggestions related to:
the importance of detailed analysis of the structure of exploited fish populations (sections 15.1, 15.4 and 15.5);
the use of several methods to estimate mortality and growth rates and the developement of means for assigning measures of precision to predictions of changes in catch characteristics expected to result from changes in fishing (section 15.2);
the improvement of sampling methods and complementary biological studies of the causative and controlling factors in recruitment, growth and mortality (section 15.3);
the development of methods of using the differences between fish or stocks of different kinds or ages or in different places, as well as changes in stocks with time, to estimate the vital rates (section 15.6);
emphasis on the estimation of the direction in which, and by how much, the catch will change with a given kind of change in the fishing, rather than the estimation of particular theoretical quantities such as the 'maximum sustainable yield' (section 15.7);
the importance of catch statistics and of measurements of fishing effort (section 15.8);
definition of concepts, terminology and notation (section 15.9).

Recommended Notations

Instantaneous total mortality coefficient	Z
Instantaneous fishing mortality coefficient	F
Instantaneous natural mortality coefficient	M
Annual fraction surviving (survival rate)	S
Observed annual fraction surviving	s
Total number of fish in the exploitable phase of the stock	N
Total weight of fish in the exploitable phase	P
Number of fish in the catch	C
Weight of fish in the catch	Y
Number of recruits entering the exploitable phase	R
Fishing effort	g
Effective overall fishing intensity	f
The ratio between the best index of effective overall fishing intensity, and the resulting instantaneous fishing mortality coefficient	q
Length	l, L
Weight	w, W
Age at entry to the exploitable phase	t_r
Age at entry to the exploited phase (i.e. first liability to capture)	t_c
Length at entry to the exploited phase	l_c
Suffix denoting the value of a parameter:	
at a particular time	t
relating to a particular age of fish	n
during a particular year	x

Parameters of equations describing growth of fish: use preferably the symbols adopted by the author of the particular equation, if these do not conflict with the above symbols. E.g. L_∞ W_∞ and K in von Bertalanffy's equation.

Written Contributions Presented to Working Party III

No. 1	Graham, Michael	Fish population assessment by inspection
2	Gulland, J. A.	Notations in fish population studies
3	Widrig, T. M.	(Untitled, general examination of problem)
4	Lundbeck, J. and D. Sahrhage	Some suggestions on fish population development especially in the North Sea
5	Watt, K. E F.	A model for use in predicting the productivity of a commercial fishery, and determining how to maximize the productivity.
6	Martin, W. R.	Population dynamics in relation to management of the sub-area 4 cod fishery
7	Le Cren, E. D.	Some notes on methods of speeding up fish population assessments
8	Beverton, R.J.H. and J. A. Gulland	Mortality estimation in partially fished stocks
9	Holt, S. J.	(Untitled, general examination of problem)
10	Jensen, Aa.I.C.	Considerations on the subject of rational fishing, with special regard to conditions in Denmark
11	Saetersdal, G.	The rate of exploitation of the Arctic cod, and the problems of studying the effects on the stock.

V

THE EFFECTS OF THE HADDOCK MESH REGULATION IN SUBAREA V
(Discussion of whole Committee led by Herbert W. Graham)

The history and present status of the regulation was reviewed by H. W. Graham. The Committee re-examined the need for regulation, the scientific basis upon which the decision was made to increase the age of first capture of Georges Bank haddock, the basis for selecting 4-1/2-inch mesh, and the research program set up to assess the effect of the regulation.

From the report submitted the Committee noted that the 4-1/2-inch mesh is releasing small sizes of haddock precisely as had been predicted. The discard of unmarketable size has been reduced to practically nothing. The Committee also noted that the large mesh nets are more efficient in the capture of larger sizes of haddock so that, unless the fleet is fishing on large concentrations of scrod haddock, there is a distinct benefit derived from the use of the larger net.

It was observed that the real test of the value of delaying captures of the small fish lies in comparing year class yields before and after regulation, and that, doing this requires continued use of some vessels with the old small mesh gear. The 1952 year class is the first large brood to be used in the assessment of the conservation value of the regulation. A preliminary measure on relating yield of this year class may be ready for the June meeting of this Committee.

The Committee congratulated the United States for its success in maintaining the research program endorsed by the Commission in 1951 realizing that considerable difficulties must be met in continuing a program which involves special cooperation of the fishing fleet.

The Committee re-affirmed its original recommendation that a program designed to assess the effect of the regulation be rigidly adhered to. Toward this end it urges that every effort be made to continue the group of licensed vessels so that a satisfactory abundance index of two-year-old fish can be maintained, an index which is essential to the assessment of the effects of the regulation on the population of haddock.

VI

Chairman: Mr. B. B. Parrish, U.K.
Reporter: Mr. J. R. Clark, U.S.A.

Representation:

The attendance at the various sessions of the Working Party varied widely during the course of the meeting. Some of the sessions were attended by a large part of the whole Committee while others (e.g. the net study meetings) were attended by a small number of participants. Two meetings were held jointly with other working parties, one with working party 7 to discuss speciation in redfish, and one with working party 1 to discuss methods used in growth studies.

Topics covered by the Working Party:

The following topics were covered in the eight sessions held by the working party:

A. Biological problems:

1) Methods of measuring and recording lengths of fish.
2) Methods of age determination of cod, haddock and Sebastes.
3) "Racial" investigations of Sebastes (jointly with working party 7).
4) Methods used in growth studies, with special reference to the use of skeletal structures (jointly with working party 1).

B. Net and mesh problems:

1) Methods of mesh measurement.
2) Shrinkage of net material.
3) Mesh selection experiments.

General considerations:

The working party centered its attention chiefly on:-

1. Examining the features of the present methods used by different workers in the I.C.N.A.F. area.
2. Comparing the results obtained by these different methods, assessing their accuracies and relative merits, and highlighting the chief problems and difficulties associated with each.
3. Determining possible lines of investigation for resolving the most important problems and difficulties.
4. Seeking agreement on standardisation of methods wherever practicable.

Throughout the proceedings, emphasis was placed on the importance of "economic" considerations in the choice and application of methods, and of possible ways in which greater mechanisation of routine methods might be effected.

Time did not permit a complete treatment of all aspects of the wide range of methods discussed by the Working Party: Discussions on some topics had to be restricted within rather narrow limits, and some interesting and important facets of the main topics had to be overlooked. In particular, growth and mesh selection problems were dealt with only briefly.

Proceedings:

Throughout its deliberations, the Working Party centered attention on the exchange of data, views and ideas by informal discussion. In accordance with a request made in advance of the meeting, a number of written contributions on various topics dealt with by the Working Party were available to members, and most of which had been circulated in advance of the meetings. These were not formally read by the authors during the proceedings but their contents, together with other material presented during the course of the proceedings, provided the subject matter on which discussion and debate were centered. A list of the written contributions for the various topics dealt with by the Working Party are given at the end of this report.

The following report gives a brief summary of the main items discussed by the Working Party, and the conclusions and recommendations arrived at for each major topic.

1. Methods of measuring and recording lengths of fish.

Consideration was given to the following main aspects of this subject:-

1) The choice of length dimension.
2) The methods used by different workers in making and recording measurements.
3) Standardisation and mechanisation of measuring and recording methods.

Each of the workers on the main I.C.N.A.F. species - cod, haddock, halibut and Sebastes, first described the length dimension used by them in routine length measuring and then outlined the method adopted for taking these measurements. This revealed that present practices differ both as to the precise length dimension measured and the method used in measuring and in recording the data. Some workers measure fork or "median fin" length, while others measure total length either with the caudal fin in its natural position or with the lobes drawn together in the midline. No workers reported using "standard length". Whilst most workers adopt the simple measuring board in making measurements, some use an "offset" scale and others not, and some read the lengths always to the nearest whole length interval, while others read to the length interval below.

The discussion indicated clearly that there are important differences between the length measuring procedures adopted by different workers on the same species, and between different species, and it was recognised that for some species, the differences might be large enough to invalidate the pooling of length frequency data. Perhaps most important of all, it was evident that workers were not aware of the various length dimensions and recording practices adopted, or of the magnitude of the differences between their recorded results.

It was agreed that comparability of length frequency data for each species studied throughout its range of distribution was very desirable and that steps should be taken to ensure that they should be made so. However, it was also recognized that complete standardisation of the whole measuring procedure might prove difficult to put into effect. For example, a worker might be reluctant to break with the traditional length dimension and method of measuring and recording in his country. Earlier attempts in the I.C.E.S area at complete standardisation of length measuring methods had failed largely for this reason. Thus, while the

need for standardisation of measuring procedure was fully endorsed in principle, it was felt that, until some definite decision could be reached on its practicability, steps should be taken to achieve comparability of length frequency data in other ways. It was agreed that this could be accomplished without complete standardisation by the use of conversion factors, relating one length dimension with another. It was also felt that there was an urgent need for all workers to know precisely the dimensions and measuring methods used by all other workers on each species of fish. It was agreed that details of the methods used should accompany all reports and publications involving length frequency data.

The problem of the choice of length dimension was considered in some detail. It was generally agreed that the choice must be governed primarily by scientific considerations, but that practical considerations such as "ease and speed of handling" must be taken into account. Such considerations, for example, will usually tip the balance of choice in favour of "total" rather than "standard" length if there are no other grounds governing the choice. It was generally agreed that the universal use of some measure of "total" length for the main species was due mainly to practical considerations. Discussion revealed that little was known about the differences in scientific result which might be derived from different length dimensions. In particular, insufficient evidence was available for making decisions regarding the relative merits of "standard" and "total" lengths, on scientific grounds. It was generally agreed that the answer might differ according to the nature of the investigation. The "efficiency" of the relationship between length and weight was suggested as a criterion against which to judge the merits of these measurements. In view of the large practical advantages of using "total" length rather than "standard" length all workers present felt that at present there were no firm grounds for changing the present general routine practices of measuring "total" length, but it was felt that investigations should be instituted to arrive at more comprehensive data on which a decision could ultimately be made. It was recognized that the decision might not be the same for all species or for all types of investigation.

Length measurements are taken in very large numbers by all fishery workers throughout the world, and as investigations develop there is a growing need for larger and larger masses of length data. The total cost of this routine operation is therefore very formidable and measures for increasing the overall efficiency of the operations, both as regards the speed and cost, must be given serious consideration. The possible introduction of mechanical measuring and recording devices was considered in some detail. A possible form which an apparatus for measuring and recording length and weight might take was outlined by Dr. Kesteven. It was clearly evident that mechanisation of this sort was feasible, and that, providing the apparatus could be constructed at a reasonable cost and would be able to withstand the rough handling which is inevitable under field conditions, it would be of substantial help in current fisheries investigations. The Working Party felt that funds should be made available for a full-scale investigation of this type of project to be made by qualified technicians. Dr. Kesteven pointed out that F.A.O. might be able to help in initiating such a project.

Conclusions:

It was unanimously agreed by the members of the Working Party that all length data for a species, compiled by different workers in different countries, should be comparable and readily exchangeable between workers. In principle, this is

best accomplished by the adoption of a standardised system of length measurement in which the dimension to be measured, the method of measurement and the system of grouping and recording the data are defined in clear terms. However, it was recognized that this may not be easy to adopt in practice, and would necessarily take time to achieve. As an immediate measure, therefore, it was agreed that all workers should record in reports and publications details of their measuring methods at the present time. Meanwhile, attempts should be made to assess the practicability of standardisation of length measurement by I.C.N.A.F. workers, to determine for each species which length dimension is the best to use for general routine investigations, and to arrive at conversion factors relating one length dimension to another.

Recommendations:

The following recommendations were drawn up for passing on to the Research and Statistics Committee:-

(1) Standardisation of length dimension and method of measurement is desirable in principle.

(2) Workers should define length dimensions and the grouping system in precise terms in publications.

(3) The relations between different length dimensions should be investigated for all species and factors should be made available for converting one dimension to another.

(4) Detailed investigations should be conducted to determine for each species which dimension is most appropriate in scientific work.

(5) Attempts should be made to introduce mechanisation in length and weight measurements of fish, and facilities and funds should be provided for a detailed study of this problem by skilled technicians.

2. Methods of Age Determination

The Working Party considered the methods used, the major difficulties and problems involved and the general accuracy in age determination of the three species cod, haddock and Sebastes. In addition to the presentation of data and the exchange of views and ideas in the meetings of the Working Party, considerable time was spent by the chief workers in practical demonstrations of the methods and material and in comparisons of their criteria of age interpretation. The following remarks summarise the most important points revealed by these deliberations.

COD

Discussion centered chiefly on the methods used in age interpretation of cod from otoliths. No workers present used the scale for age determination of any but the youngest age categories. It was discovered that all I.C.N.A.F. cod workers used the same general method of otolith examination, i.e. the low-power examination of the broken or cut surface of the otolith in reflected light.

Mr. Rollefsen demonstrated in detail the essential features of this method, and emphasised the importance of the distribution of the light for easy and accurate recording. He showed that some shading of the surface of the otolith was desirable, and he demonstrated how, with the appropriate lighting arrangement, the zones could be interpreted. He urged all otolith workers to experiment with the lighting arrangement when commencing reading. Mr. Rollefsen also emphasised the importance of a rigorous training schedule for otolith reading technicians, and he reported that in Norway all technicians recruited for this work were subjected to a thorough eye and general medical examination.

The method of distinguishing the spawning zones of cod otoliths was demonstrated by Mr. Rollefsen, who also indicated how a study of the distribution and nature of the zones in the otolith gave important information on ecological differences between groups of cod in neighbouring areas.

No major difficulties in age determination by the method were mentioned by the workers present, and it was generally felt that it provided a sufficiently accurate method for all purposes.

While the otolith gives an accurate measure of the age of cod, difficulties sometimes arise in obtaining samples of otoliths, particularly from market sources, where cod are often landed in a headed state. For this reason, English workers had studied the uses of cod fin-rays for age determination. Data were presented by Mr. J. A. Gulland of a comparison between age readings determined from dorsal fin-rays and from otoliths. These results showed that fin-rays can be used with reasonable efficiency for fish less than 6-7 years, but that for older fish the fin-ray assessments gave progressively lower age readings than the otoliths. It was agreed that the fin-ray could not be regarded as an efficient substitute for the otolith in cod age analysis, but it might be of use in age readings of young cod in situations where otoliths are unobtainable.

The importance of "Petersen's method" of determining age composition of large samples of cod length data was stressed, particularly in situations where large samples of otoliths could not be obtained or where facilities for reading large samples were not available.

Recommendations:

The following recommendations were drawn up for passing to the Research and Statistics Committee:

(1) The Working Party recommends that the otolith age reading technique developed and perfected in Scandinavia, should be adopted by cod workers, and that each worker should examine possible improvement in the method by modifications of the lighting system.

(2) Attempts should be made by all cod workers to incorporate in the otolith analysis the discrimination of spawning zones, as developed by Mr. Rollefsen.

HADDOCK

Two skeletal structures are in general use in age reading of haddock; the scale and otolith. Discussion in the Working Party was centered on the differences in results obtained from these two structures, and on the relative efficiencies of each.

Dr. Templeman presented haddock length frequency data from sub-area 3 and their age compositions obtained from scales, and showed that the scale readings fitted well with the dissection of the length frequency data, and revealed the presence of a dominant year class passing through the fishery. It was abundantly clear that the scale reading method provided an efficient means for obtaining the overall age composition of the catch. Dr. Templeman reported some difficulties in age reading from scales, particularly amongst older haddock, and because of frequent occurrences of check rings, but provided the reader was familiar with the material, efficient interpretation was possible. Dr. Templeman stressed the importance of a thorough knowledge of the biology of the species in the area under investigation, and he observed how, from a detailed examination of the scale structure "check" rings can be distinguished from true winter rings.

Data on differences in age reading of haddock from sub-areas 3, 4 and 5 obtained from scales and otoliths were presented by North American workers (Kohler, Templeman, Clark and Jensen), and of haddock from the Barents Sea by Parrish. These data indicated general agreement, but with some random variation between the two methods for fish less than 6-7 years of age, but illustrated a progressively greater and more systematic discrepancy for the older ages, for which the otolith gave the higher readings. The European material in particular indicated wide divergence of result for haddock older than 8 years. Mr. Parrish also demonstrated the same discrepancy in age reading of North Sea herring from scales and otoliths, and also showed a greater consistency between otolith readings taken by different workers than between scale readings.

Mr. Saetersdal showed that otolith age readings of young Norwegian haddock agreed better with the age composition as determined by Petersen's method than did scale readings. This he attributed to a total lack of zone formation in the scales of some haddock, whereas in the otolith these zones were always formed. He mentioned also the greater ease in counting the outer zones in the otoliths of mature haddocks. Thus, otoliths are now always used in the Norwegian haddock age investigations, the method employed being the same as that used for cod. However, scales are still taken for use in growth investigations. Mr. Saetersdal demonstrated how, as with cod, spawning zones can be recognized in the haddock otolith.

General discussions revealed that haddock workers are divided on the issue of choice of skeletal structure for age determination. It was generally acknowledged that the otoliths gave more accurate and consistent readings over the whole age range, but that in some areas, particularly where the stock is composed principally of young fish, the scale provides satisfactory results and is preferred because of the greater ease in obtaining the material and greater speed in handling. It was agreed that in some investigations a compromise, involving the use of scales for young fish and otoliths for older fish, might be appropriate.

The data presented in the meeting showed that haddock workers should not become complacent about their methods of age determination, particularly the scales workers, and it was suggested that they should undertake rigorous checks of their results against other methods. Staining techniques were suggested as a possible aid in increasing the efficiency of reading age from scales.

Recommendations:

The following recommendation was passed on to the main Committee:-

All haddock workers should undertake to examine their methods of age reading critically, including comparisons between scales and otoliths. Wherever possible checks of the readings obtained with their current methods should be made with other data.

SEBASTES (REDFISH)

The current controversy concerning the interpretation of age of Sebastes was one of the main topics considered by Working Party 6. This problem was discussed during three sessions and a fourth meeting was held jointly with Working Party 7 to discuss the allied "speciation" problem. Much time was also spent by the interested workers in studying otoliths and other material brought to the meeting.

Current views are divided as to the rate of growth of the main body of redfish, Sebastes marinus in the North Atlantic; Dr. Kotthaus claims a relatively fast rate of growth for Sebastes marinus in the North Atlantic while Mr. Kelly and other workers claim a very much slower rate of growth. The Working Party examined the basic features of the methods used by these workers and the data presented on this important subject. It set out to determine whether the differences in growth rate claimed by these workers could be attributed to real biological differences in the stocks of Sebastes on which their respective investigations have been based or whether they can be attributed, at least partially, to differences in age interpretations by the two workers.

The methods of investigation and the results obtained by Dr. Kotthaus were first examined. Dr. Kotthaus presented a written contribution outlining the main arguments underlining his general thesis. These are essentially as follows.

1. The otoliths of Sebastes when viewed, in a whole state, under low magnification contain a large number of distinguishable narrow zones interspersed between distinct wider zones. These thin zones do not represent true winter zones and must be discounted when reading the age of the fish.

2. A consequence of reading the narrow zones is an unreasonably slow rate of growth, an unreasonably high age of first maturity (reaching an age of 17 years in some instances) and a wide range of ages reaching first maturity each year.

3. In general, the length frequencies of the commercial catches from the north-east Atlantic fishing grounds do not comform with the hypothesis of extremely slow growth in Sebastes.

For these reasons, Dr. Kotthaus had adopted the method of counting only the wider zones on the otoliths which, providing the whole otolith was viewed under low magnification, could be readily distinguished from the narrow zones.

Mr. Kelly then presented the alternative viewpoint. Photographs of Sebastes otoliths taken from fish in the Northwest Atlantic were presented, all of which showed clearly defined "winter" zones and between which no sound reason for discounting some and counting others could be found. These readings

indicated a very slow rate of growth in Sebastes. The method used by Mr. Kelly in viewing the otoliths is the same as used by Dr. Kotthaus, except in the large specimens when he examines the broken surface as in the cod investigations. Photographs of specimens of small Sebastes from the Gulf of Maine were also presented and were used to illustrate the small increase in size of Sebastes throughout the year.

Data, relevant to the subject, were also presented by other members of the Working Party. Dr. Lucas presented a series of length frequency data taken by Scottish research vessels off the southwest coast of Iceland and around the Faroes over a number of years. These data revealed great consistency between the length frequencies from month to month and from year to year, and the Icelandic data showed two main modes, at 20-22 cm and 35-40 cm respectively. No interpretation of these data was put forward but the view was expressed that the two modes might belong to the two species, S. viviparus and S. marinus respectively.

Dr. Templeman presented length frequency data of a group of small Sebastes, caught in Hermitage Bay off the south coast of Newfoundland over a period of years. Very small changes in length frequencies were recorded over the period, the increase in mode being from 7 to 11.5 cm between December 1953 and 1955. During this time no smaller group of fish appeared in the catches which suggests that these fish were completing their second year of growth in 1955. Dr. Templeman also provided extensive scale material for inspection.

Photographs of otoliths of Sebastes marinus, and S. viviparus, prepared in Norway, were presented by Mr. Rollefsen and he claimed that it was impossible to discriminate between the two types of zones as claimed by Dr. Kotthaus. The Norwegian age interpretations agreed substantially with Mr. Kelly's.

Further information on the interpretation of Sebastes otoliths was presented by Dr. Fridriksson. He cited examples of Sebastes otoliths on which up to 70 winter zones could be counted, and he was forced to regard Sebastes as a very slow growing fish.

Discussion of these data revealed clearly that the differences between the growth rates of Sebastes marinus as claimed by Dr. Kotthaus and Mr. Kelly and other workers were due, at least in part, to differences in the interpretation of otolith zones. It was claimed by a number of members present that they could see no sound justification for the basis of discriminating between the multiplicity of zones present, as practiced by Dr. Kotthaus. It was revealed that conformity of interpretation was possible between groups of biologists when the criteria used by Mr. Kelly were adopted, but not so when attempts were made to discriminate between zones. The view was also expressed that there was no a priori justification for not accepting a slow rate of growth for Sebastes, and it was not unreasonable for the incidence of first maturity to be spread over a wide range of years. The cod was cited as an example in which such was the case.

The characteristics of the commercial fisheries for Sebastes were discussed in the light of the two current growth hypotheses. A general feature of these fisheries is that down to at least 400 metres the bulk of the commercial catch is composed of fish less than 60 cm in length. This length corresponds with an age of 7-8 years according to Dr. Kotthaus' interpretation, and of 25-30 years by the "slow growth" workers. Clearly, unless the Sebastes population is

subject to such heavy mortality that the total life span is reduced to 8-10 years, for the fast growth hypothesis to be acceptable large quantities of Sebastes must move out of the exploited areas or must undergo a change in vertical distribution and escape the fishing gear. Furthermore, these fish would be expected to reach a very large size. It is known that the Sebastes marinus population extends to depths greater than those fished intensively at present, and Sebastes of sizes up to 70-80 cm are caught, but there is no evidence at present that large concentrations of "giant" Sebastes exist. On the other hand, on the basis of the slow growth hypothesis, it is not unreasonable to expect the length composition of the population to taper off at 60-65 cm corresponding with ages of 25-30 years; under these circumstances no very great concentrations of older and larger Sebastes would be expected to exist. In this case, large untapped reservoirs of younger Sebastes would be expected, from which the present fished stocks are derived.

The importance of the growth hypotheses in assessing the present state of the Sebastes fisheries was stressed and it was agreed that caution must be exercised in interpreting observed trends in yield and in catch per unit effort of the Sebastes fisheries.

Possible lines of research for resolving the age interpretation problem were discussed. Four possibilities were considered:

(a) Tagging.
(b) Rearing of young Sebastes.
(c) Exploratory fishing to discover untapped reservoirs of Sebastes or concentrations of "giant" fish.
(d) Exchange of material between Sebastes workers, and use of alternative interpretation techniques.

Recommendations:

The following recommendations to the Research and Statistics Committee were made following discussions of these projects:

1. German workers should undertake to tag Sebastes marinus experimentally by the "hook" methods; Danish workers should attempt to tag Sebastes viviparus in the Faroes area, and S. marinus in the west Greenland area; Norwegian workers should look into the possibilities of tagging Sebastes off the Norwegian coast; and North American workers should attempt tagging experiments.

2. Rearing experiments with young Sebastes in aquaria should be attempted by Norwegian and German workers, and by other workers if opportunity and facilities are available.

3. Exploratory fishing expeditions should be made by United States workers to seek out reserve stocks of Sebastes. Attempts should also be made to study the vertical distribution of Sebastes with underwater television.

At the conclusion of the meeting all Sebastes workers were asked to make an intensive and critical review of their age interpretation techniques and wherever possible to seek other sources of information against which to check the bases of their age analyses.

On several occasions during the meetings information was presented which illustrated substantial differences in growth rate between stocks of Sebastes in different parts of the North Atlantic. These differences are greatest between S. viviparus and the two possible subspecies of S. marinus, but there are also differences between the growth rates of the main subspecies of S. marinus in different areas. It was recognized, therefore, that there is a major "racial" problem for Sebastes as well as the age interpretation problem, and it was agreed that Working Party 6 should join with Working Party 7 to discuss this important problem in detail. The discussions and recommendations on this aspect of the Sebastes work are contained in the report of Working Party 7.

Growth Studies:

An important method for studying growth in fish is the taking of length measurements on skeletal structures and calculating the total length of fish at the ends of successive years of life. The scale has been used most extensively in this work but otoliths and opercular bones have been used by some workers.

An essential to the correct application of this method is an accurate knowledge of the form of the fish length-skeletal length relation. When this relation is proportional, the fish length estimates can be made by use of the simple proportionality formula, but if it departs from proportionality, then errors in the estimated total length will result using the proportionality formula unless corrections are applied. The errors will be progressively greater as the calculations are made from progessively larger (older) fish. This will result in biased estimates of growth and apparent differences in mean length (known as Lee's Phenomenon) of fish at any age. It is clear, therefore, that a knowledge of the general form of this relation is very important in the application of this method of growth study and in using it to study real changes of a population with age. Not until it is known that inherent bias has been eliminated can "Lee's Phenomenon" be used as an indication of real changes in the stock with age.

The occurrence of "Lee's Phenomenon" for North Sea haddock and northern North Sea plaice was demonstrated by Mr. Jones. He showed that the estimated lengths at the end of the first year of life decreased substantially when they were calculated using the proportionality formula for scale measurements taken from successively older and larger fish. Detailed analysis of the relation between scale length and fish length showed, however, a curvilinear relation, which requires the use of corrections to the length estimates using the proportionality formula. When these were applied, the magnitude of the differences between calculated lengths was reduced but not eliminated, which suggested that there were real changes in the composition of the stock with age, due either to biological factors or differential rates of mortality amongst the faster and slower growing fish.

Mr. Saetersdal demonstrated a linear but not proportional relation between scale length and fish length in the Norwegian haddock and he showed how, when the correct calculation formula was used in a homogeneous population of young haddock, "Lee's Phenomenon" was not evident in the estimated lengths of haddock at the end of their first year of life. He then showed how with older fish the phenomenon was experienced and could probably be explained on the basis of a range of ages of first maturity throughout the population.

Mr. Boerema outlined the relation between otolith length and fish length of plaice in the southern North Sea and showed a linear relationship. A linear relation between otolith length and fish length had also been recorded for herring by Dutch workers. He pointed to some difficulty in interpreting the point on the otolith of plaice to which measurements should be taken due to possible changes in the widths of the outermost complete hyaline zone.

Means of reducing the time taken in making growth calculations by this method were also discussed, and Dr. Kesteven outlined the essential features of an apparatus by which the estimated fish length can be read off directly.

Discussion of the data showed that lengths calculated from measurements of skeletal structures could provide very important biological information on the ecology of fish populations providing it was known that there was no inherent bias due to the formula used in length calculations. It was recognized, therefore, that the value of this method depended on an accurate knowledge of the fish length-skeletal length relation. It was agreed that all work using this method should be preceded by a study of the fish length-skeletal length relationship for the fish stock under investigation. It was evident from data presented at the meeting that different stocks of a species might give rise to different relationships. A talk on growth studies of the Georges Bank haddock was also given by Mr. C. Taylor to the whole Committee at the end of this meeting. The subject matter of the talk was directly relevant to the topic discussed above, and an abstract of the talk is presented here.

> Linear regressions between back-calculated sizes at age one and sizes at subsequent ages were demonstrated, the slope of these regressions increasing systematically with the age of capture from which back-calculations were made. These regressions tended to have a common point of intersection near which Lee's Phenomenon would not be apparent and beyond which it would occur in a reverse form. This variation of Lee's Phenomenon with back-calculated size at age one was demonstrated for several areas of Georges Bank.
>
> Since the parameter K of the Bertalanffy growth equation was shown to vary systematically with size at age one and age of capture, the hypothesis was advanced that life span varied with rate of growth. It was shown that this hypothesis led to an apparent change in growth rate for the total population but not as great as that actually observed in the data. It was suggested that Lee's Phenomenon in back-calculated data should not be ignored since it might provide clues to the operation and magnitude of mortality rates within a population.

Recommendation:

The following recommendation was passed to the Committee:

1. The Working Party emphasises the importance of a knowledge of relation between the fish length-skeletal structure length in the use of skeletal structures in growth investigations, and it recommends that this relation should be established for all stocks of each of the species for which the method is employed.

3. Mesh Measuring and Mesh Selection Problems

The net-study group comprised the following members of Working Party 6:

Dr. Ancellin
Dr. v. Brandt
Mr. Boerema
Mr. Clark
Mr. Rodriguez
Dr. MacCracken
Mr. Rojo
Mr. Saetersdal
Mr. Parrish

The deliberations of the net-study group were centered on various facets of the problem of mesh measuring in the I.C.N.A.F. area in relation to both experimental work and the enforcement of the mesh regulations. The question of standardisation of mesh measuring procedures between the I.C.N.A.F. and the Permanent Commission areas was considered. The importance of shrinkage in mesh measurement was also dealt with, and a short time was spent in discussing techniques for obtaining mesh selection data. A number of written contributions were presented at the meeting of this group and a list is appended.

Methods of Mesh Measurement:

The discussions of the Working Party were directed towards the following main questions:

(1) What is the best and most practical mesh dimension to adopt in both experimental and enforcement work?

(2) What is the most appropriate and reliable method of measurement?

(3) What distribution of measurements over the net is most appropriate in experimental selection work and in enforcement measures?

(1) The best and most practical mesh dimension:

The group first considered the criteria which govern the choice of mesh dimension in both experimental and practical enforcement work. It was agreed that the most appropriate dimension was the one which gives the simplest and most consistent relationship with the selection properties of the net.

The appropriateness of the present "internal longitudinal stretched mesh dimension" was then reviewed in the light of this criterion. It was agreed that a major advantage of this dimension was that experiments conducted on both sides of the Atlantic revealed a fairly consistent linear relation between it and the 50 percent release length for a number of species of fish over a fairly wide range of mesh sizes in the codend of manila trawls. This permitted selection factors relating mesh size and 50 percent release length to be calculated. Further advantages were the relative ease of obtaining rough measurements quickly and its suitability for conversion to any other required dimension.

There are, however, possible disadvantages to set against this dimension. It has been shown in a number of experiments in the I.C.N.A.F. and European areas that the "selection factors" using this mesh dimension vary with the type of material used in the codend. It is necessary, therefore, to consider whether greater consistency in the selection factors for different materials might be obtained with other mesh dimensions. It is possible also that the differences between the values of the selection factors for different species of fish might be smaller with another dimension.

Discussion of this problem showed that little is known of the relations between selection and other mesh dimensions and it was agreed that for the present the "internal longitudinal stretched dimension" should remain in use both for experimental mesh selection work and as the basis for enforcement of the mesh regulations. The group agreed, however, that experiments should be conducted to provide the necessary information from which choice of the most appropriate dimension can be made.

Recommendations:

1. The "internal longitudinally stretched mesh dimension" should remain in use for the time being both for experimental mesh selection work and as the basis for enforcement of the mesh regulations.

2. Investigations should be made to determine other relevant dimensions which might replace the existing dimensions. The following lines of study are suggested -

(a) A thorough study of existing relevant mesh measurement information.

(b) Measurements should be made of different mesh dimensions of codends made of different materials, and for which the selection characteristics are known. Dimensions suggested are: The internal longitudinally stretched mesh, various "diamond" dimensions, the "square" dimension, and the circular diameter. These dimensions should be measured under a variety of pressures, using suitably constructed gauges.

(c) Selectivity experiments should be conducted at sea using a wide range of mesh sizes for codends made of different materials, and mesh dimensions being measured on the basis of results obtained under (b).

(2) The Method of Measurement:

It was stressed at the outset that for practical enforcement purposes a method of measurement must be adopted which is easy and quick to apply and which is reasonably free from large operator bias. It was agreed also that if possible the method adopted in experimental work should be the same as that used in routine enforcement work, or where this is not adopted the relation between the measurements obtained in the two systems should be known.

The methods of mesh measurement at present adopted for routine checks of the mesh regulations in the I.C.N.A.F and Permanent Commission areas were briefly described by the members present. These methods differ in a number of important respects. Whereas in the I.C.N.A.F. area regulations, a standard measuring gauge, exerting a standard insertion pressure, is prescribed, in the Permanent Commission area no such rigid measuring procedure is specified, and in consequence a number of different measuring systems are employed.

The view was expressed by a number of members representing countries with fishing fleets regularly visiting the I.C.N.A.F. and Permanent Commission mesh regulation areas that if possible standardisation of the measurement procedures in the two areas should be effected, particularly as regards the type of gauge used and the number and distribution of measurements prescribed. It was generally acknowledged that such standardisation was desirable in principle, but it was recognized that there might be formidable practical obstacles to overcome in effecting complete standardisation in these procedures. It was agreed, however, that early steps should be taken to standardise the method of measurement for experimental work in the two areas, and that the question of standardising the system of measurement in the mesh regulation procedures should be looked into.

The problem of the most appropriate pressure to use in mesh measuring was considered in detail. The results of deliberations on mesh measuring methods held at the meeting of the Comparative Fishing Committee of I.C.E.S. in 1955 were made known to the group. These were as follows:

(1) Standardisation of the pressure used in mesh measurement was desirable.

(2) A longitudinal pressure of 3 kg between opposite knots was considered satisfactory for measurement of meshes of codends made of manila, sisal and hemp.

(3) Greater accuracy and consistency in measurement will be obtained with a gauge which exerts a longitudinal force directly rather than at right angles to the mesh.

These conclusions had been combined in a recommendation to be passed to the Permanent Commission.

The relative merits of the "longitudinal" pressure gauge and the vertical pressure gauge as used at present in the I.C.N.A.F. area were considered by the group. Demonstrations of different models of these gauges were given. Results of comparative measurements using these two types of gauges on manila codends were given in a contribution by Mr. Parrish, and similar data were presented to the working party for heavy manila codends by Dr. MacCracken. Whereas Parrish's data showed that the longitudinal pressure gauge gave the smallest variation in readings between different observers, MacCracken's data showed that with the heavier twines the Scottish longitudinal gauge did not give greater consistency than the vertical pressure wedge gauge. Dr. MacCracken showed that for the heavy twine codends (50/4) comparability between values of mesh size obtained with vertical and longitudinal gauges was obtained with pressures of twelve and ten lbs, respectively.

After long discussion of the available data, and the practical considerations which govern the choice of design of measuring gauge, it was agreed that while the longitudinal pressure gauge was preferable in principle, there was insufficient evidence available at present to warrant a recommendation that the standard vertical pressure gauge used in the I.C.N.A.F. regulations should be changed. It was considered, however, that experiments to determine the equivalent pressures between present designs of vertical and horizontal gauges should be made. It was also felt that the task of designing a suitable horizontal pressure gauge should be undertaken by experts.

The principle underlying the choice of pressure for the I.C.N.A.F. "vertical" wedge gauge was discussed and found to agree with the I.C.E.S. principle, i.e., straightening of the twine without tightening the knots.

The results of studies on the choice of pressure were provided in contributions by Mr. Boerema, Dr. v. Brandt and Messrs. Bedford and Beverton. They showed that the critical pressure to apply could probably be gauged with reasonable accuracy from the observed rate of change in mesh size with increasing pressure.

It was agreed that the critical amount of pressure to be applied in measurement differs for different materials. It is less for nets made from fine cotton twine than from the heavier sisal and manila twines. It was evident that at present the appropriate equivalent pressures were not known for all of the wide range of material now used in the construction of trawls and seines, and it was agreed that experiments should be conducted to obtain these pressures.

The possibility of using an appropriate "pressure difference" when measuring meshes of nets made of different materials was considered in order to compensate for their differences in mesh selectivity. It was considered that this matter should be looked into.

The group discussed a proposal made in a contribution by Dr. Went that for practical enforcement purposes measurement practice should revert to the simple "yardstick" or "meterstick" multiple mesh measurement system. This proposal was made on the general grounds that the present trend towards precision measurement with expensive and relatively complex gauges was inadvisable from practical and legal points of view. The group felt that it was unable to comment on the legal aspects of the matter, but from data presented by Mr. Parrish showing a wide range of variation in the relation between "yardstick" and gauge measurements, it was not possible to recommend the adoption of this proposal. It was agreed, however, that Dr. Went's general warning was very pertinent and that more experiments should be conducted to determine the relation between the "yardstick" and gauge measurements.

Conclusions and Recommendations:

1. The use of standard pressure gauges is recommended in both experimental and enforcement work in the I.C.N.A.F. area.

2. Gauges applying a constant "longitudinal" pressure are better in principle than the "vertical" pressure gauges.

3. At present insufficient evidence is available to recommend an alternative gauge to the "vertical" pressure gauge used in the I.C.N.A.F. regulations, but it is recommended that efforts should be made to design a satisfactory longitudinal gauge.

4. Experiments to determine the appropriate "longitudinal" pressures for measuring meshes of nets made of all materials, and especially of materials other than manila, sisal and hemp, should be made.

5. Standardisation of the mesh measuring methods in experimental work should be attempted, and where this is not possible conversion factors for different methods should be worked out.

6. The possibility of standardising the mesh measuring procedures used in the I.C.N.A.F. and Permanent Commission areas should be carefully examined.

(3) Distribution of Measurements:

The group agreed that the choice of the part of the codend over which measurements should be taken was of importance since it is generally found that there are changes in mesh sizes from one part of the codend to another. The group discussed published and unpublished data relating to these problems at considerable length. Mr. Clark reported that American experiments showed that when catches are moderate most of the codend escapement is through its after half, but with large hauls the upper part of the codend was also involved in the selection process. These results agreed with data published by Cassie in New Zealand.

It was clear from the data available that the part of the codend most concerned in the mesh selection process varied according to the size of the catch and the species of fish in the catch. Some experimental data showed that, for some species, parts of the net other than the codend played an important part. It was agreed, however, that much more experimental work should be done to determine the part played by different parts of the net, and by different sections of the codend. In particular, the part played by the underside of the codend in mesh selection should be investigated further as this had an important bearing on the rig which should be adopted in "covered net" mesh selection experiments as well as on the distribution of mesh measurements.

It was agreed in principle by the group that the mesh measurements taken both in experimental mesh selection work and in routine checks of commercial codends under the mesh regulations should be made only in the parts of the net, or the codend, through which the fish escape in significant quantities, but it was recognized that these parts could not be specified with precision at the present time.

The differences between the routine practices adopted in the I.C.N.A.F. and Permanent Commission mesh regulations were discussed. Whereas the I.C.N.A.F. regulations rigidly specify the measurement of complete rows of meshes from the top to the bottom of the codend, the Permanent Commission regulations do not specify which meshes will be measured. The appropriateness of the I.C.N.A.F. procedure was discussed in the light of the existing data and in view of the agreed principle that measurements should be made only in those parts of the

net (or codend) which contribute significantly to the selection process. It was concluded that, at present, there was insufficient available evidence to recommend any change in the present practice.

Recommendations:

1. Research should be carried out to determine which parts of the trawl and seine, and which sections of their codends, contribute most significantly to the release of fish.

2. At present, no changes should be made in the prescribed distribution of measurements in the I.C.N.A.F. regulations, but a review of their appropriateness should be made in due course in the light of results from (1).

Shrinkage of net material:

The relevance of the shrinkage problem to the routine practices applied in the enforcement of mesh regulations was first discussed. The group acknowledged that the most important question which it raised was whether "dry" measurements could be used as a basis for judging whether the "wet" measurements would comply with the mesh size prescribed by the regulations. This depended on there being a consistent shrinkage factor, relating the "dry" and "wet" mesh sizes.

Data was presented by Dr. von Brandt showing the relation between the diameter of the spool used in the construction of trawl codends and the shrunken longitudinal mesh size for different materials. These data showed that there was considerable variation between the "spool" and "shrunken" sizes for different materials. Mr. Clark presented United States data on this subject and outlined the method of net certification used in the Sub-Area 5 regulations. This procedure was based on there being a recognized "dry" - "wet" mesh size conversion factor, which had been determined experimentally.

Experiences of a number of members of the Group indicated that in practice there is a considerable variation in the change of mesh size from the dry-unused to the wet-used state, but that at present there are not sufficient precise data available to determine its magnitude. It was agreed that studies should be made of the changes in mesh size of commercial codends within the I.C.N.A.F. area, and these results should determine whether consistent conversion factors can be determined. The Group agreed that certification of codends was a desirable practice in principle, but recognized that its adoption should be governed by the results of such studies.

It was evident that, while a number of workers had investigated some aspects of net shrinkage, particularly those made of the heavier materials, manila and sisal, little was known about the extent of the change of mesh size in other materials. It was agreed, therefore, that more research on this subject should be carried out by workers in the I.C.N.A.F. area.

Recommendation:

There is a need for a thorough discussion of all existing data on shrinkage in natural and synthetic materials, and of the changes in mesh sizes of nets with use. It is recommended that considerably more research be directed to

shrinkage problems and that the results of these researches be presented at a symposium to be held at a future date and subsequently published.

Mesh Selection Experiments:

The Group had time for only a very brief superficial coverage of this important topic. The items discussed were:-

(1) The most efficient rig to be used in "covered net" mesh selection experiments.

(2) Factors causing variability in mesh selectivity.

The rigs of the covers used by a number of workers present were described and the relative importance of the different features of the rig was discussed. The following features were considered of importance:

(a) The size of the cover relative to the codend.

(b) The position and method of attachment of the cover at the top and bottom of the codend.

(c) Covering the under side of the codend.

It was evident from the descriptions given that there are differences between the rigs used by different workers, and differences of opinion as to the importance of one or more of the features listed above. It was acknowledged that the importance of each of these features might differ for different species of fish and for the characteristics of the gears and fishing methods adopted in different countries and regions. The Group felt that there was room for much more detailed experimental work on the rig of the cover from which the importance of different features could be determined, and it was agreed that this subject should be considered in much greater detail at a future date when more experimental data were available. The Group recommended that experiments should be made to test the effects of using different rigs of cover with particular attention being given to the features outlined above.

The factors, other than mesh size, which influence the selectivity of trawls and seines were briefly discussed. It was evident from available experimental data that there is quite a wide variation between the results of experiments conducted in different areas at different times with different gears and under different fishing practices. It was felt that a number of different factors might play an important part, but that current data did not permit a comprehensive assessment of the most important ones. It was decided again that more experimentation was necessary before these influences could be thoroughly assessed, and it was agreed that the results of this work should be considered in greater detail at a future date.

It became evident during these discussions that a large quantity of unpublished experimental data have been accumulated in different countries which might, when analysed completely, throw light on the importance of different factors affecting selectivity.

Recommendations:

1. Studies of the possible factors bringing about variations in mesh selectivity should be carried out, with particular attention being paid to the following factors:-

(a) Method of rigging the cover.

(b) Effect of catch size.

(c) Effect of towing time.

(d) Effect of towing speed.

(e) Differences between materials.

(f) Amount of escapement through different parts of the net and the codend.

(g) Effect of variations in fish shape in different areas and seasons.

2. The Group stressed the importance of doing this work in conjunction with the mesh measuring work, and recommended that there should be close liaison between all workers in this field in order that the work can be accomplished in the most efficient manner.

3. The Group recommends that the results of these researches be presented by the experts at a symposium to be held at some time in the future.

Comcluding Remark:

The discussions of the many problems concerning mesh measurement and mesh selection convinced the members of the Net Study Group of the desirability of constant close liaison between workers on both sides of the Atlantic. The Group considers that this meeting has been of very great importance and benefit to those present and it recommends that more opportunities to meet and exchange data and ideas should be provided in the future.

Written Contributions presented to Working Party 6

General papers:

(1) Kesteven, G. L. Some considerations concerning the instrumentation for fishery biology.

(2) Parrish, B. B. Some notes on methods used in fishery research.

Biological papers:

(1) Boerema, L. K. and de Veen, G. F. Prelim. notes on the calculation of the growth of plaice from the width of the year rings in the otoliths.

(2) Clark, J. Scale reading consistency of haddock.

(3) Gulland, J. A. Age determination of cod by finrays and otoliths.

(4) Jensen, A. and Clark, G. Time of formation of scale annuli.

(5) Jones, R. Lee's phenomenon of "apparent change in growth rate", with particular reference to haddock and plaice.

(6) Kelly, G. and Clark, G. Outline of contributions of Woods Hole Laboratory.

(7) Kohler, A., Templeman, W., Clark, J., Jensen, A. Scale otolith comparisons.

(8) Kotthaus, A. Age and grwoth in redfish.

(9) MacCracken, F. and Martin, W. R. Outline of contributions from St. Andrews, Laboratory.

(10) Parrish, B. B. Comp. between age readings of North Sea herring from otoliths and scales.

(11) Parrish, B. B. and Trout, G. C. Comparative age readings of haddock from scales and otoliths.

(12) Saetersdal, G. On the use of otoliths and scales of the Arctic haddock.

(13) Templeman, W. and Fleming, A. M. Outline of contributions from St. Johns Laboratory, Newfoundland.

(14) Trout, G. C. The otolith and age determination.

(15) Sharman, D. P. A moethod of photographing herring otoliths.

Mesh measurement and mesh selection:

(1) Bedford, B. C. and Beverton, R. J. H. Observations on mesh measurement.

(2) Boerema, L. K. Some experiments on factors influencing mesh selection in trawl nets.

(3) v. Brandt, A. Measurements of meshes of trawl nets.

(4) Ellis, R. W. Further experiments on the shrinkage of trawl codend meshes.

(5) Ellis, R. W. Experiments to investigate the escape of fish through different parts of the trawl.

(6) Margetts, A. R. Definition and testing of light trawls.

(7) Parris, B. B. Experiments on the shrinkage of trawl codend meshes.

(8) Parrish, B. B. Experiments to determine the effect of the use of a small meshed cover on the fishing power of the otter trawl.

(9) Parrish, B. B. and Pope, J. A. Further results on the effects of using small mesh covers.

(10) Parrish, B. B., Jones, R. and Pope, J. A. A comparison of mesh measuring methods.

VII

DIFFERENTIATION OF FISH STOCKS

Participants

Angeles Alvarino
J. Colton
J. Corlett
A. Fleming
J. H. Fraser
G. Kelly
A. Kotthaus
C. E. Lucas (Convenor)
A. V. Tåning
L. A. Walford

During the course of the discussion, the Working Party welcomed the attendance of Dr. Kesteven from time to time and took opportunity to discuss with him the use of some biological terms. In particular, this working party was asked to consider:

(1) The importance of planktonic stages to the division or intermingling of groundfish stocks.

(2) The identification of stocks in general. Subsequently, a joint meeting was arranged with Working Party 6 (Research Methods) to discuss:

(3) The species and varieties of Redfish.

Communications were solicited in advance for only the first of these topics, and eight papers were circulated before the Working Party met. It was fortunate that some of these concerned aspects of both (1) and (2) while two later contributions were presented at the meeting specifically on item (2). Many valuable comments were made on these two subjects during the course of the discussions, arising from experience and work in progress on both sides of the Atlantic Ocean and elsewhere. Relevant recommendations are set out below. Finally, a valuable, if indeterminate discussion was held on the different groups of Redfish, giving rise to the last recommendation below.

The Working Party met on Monday, Tuesday and Wednesday, 5th to 7th March, and again on Friday, 9th March for a review of their recommendations to the Research and Statistics Committee. It seems necessary to say, however, that so closely were the subject matters of this and other working parties linked that topics of significance to this party were often being discussed elsewhere and vice versa. It was very right that this should have been so, even though it had the consequence that it was not always easy to secure for these meetings sufficient of the experts on different aspects of stock

differentiation for the meetings to be fully representative. Indeed, it may even be that this was in itself an important symptom'. Although the identification of stocks, involving a clear knowledge of characteristics and distribution of species (and subordinate categories), lies at the root of fishery research, many disciplines are necessary for such determinations. At times, it seemed clear that the appropriate experts were very properly concerned with the discussion and resolution of technical problems before attempting to say more about species and stocks'. Nowhere was this more evident or more necessary than in relation to Redfish.

As a basis for discussion notes were circulated by the Chairman setting out some of the principal considerations which have been, or may be, used from time to time in attempting to decide whether the fish in a particular fishery could be regarded as a unit stock, and/or how far they may mingle with fish of another group or groups of the same species. An adjusted and approved copy is attached as a supplement to this report. A unit stock was seen as a group of fish which is not known, at present, to be mixing with others, either during their planktonic stages[1] or later in life; the haddock of the North American Banks and those of the North Sea are good examples of stocks which are not known to mix, but it is not always so easy to decide whether the fish of a particular ground can be so differentiated. The concept seems to be a fundamental one in fisheries research (in population dynamics, etc.), although it is recognized that a group might reasonably be regarded as a unit stock for practical purposes even though it is known that an insignificant proportion of its members may intermingle with others of the species.

It seems fair to say that, despite the body of knowledge represented by the contributions, and the considerable work and experience which lay behind them, the principal feeling at most stages in the discussions was that we need to know much more about the fish in the Commission's area - sometimes about apparently familiar aspects of the lives of fishes, and at others in research fields where only a tentative start has recently been made - if our knowledge of the fisheries in that area is to be placed on sure foundations. The following points attracted particular attention and recommendations were made concerning them:

(1) Discussion inevitably centered on the considerable distances over which fish may drift during their planktonic stages, and the significance of this recruitment for the differentiation of stocks. The stimulating suggestion was made that sometimes the duration of the planktonic phase might be prolonged, as in some other planktonic organisms, particularly if circumstances are not suitable at the normal stage of development for assuming the demersal habit. In association there is the available evidence, and the apparently logical necessity if the stock is to persist in that area, for the return of the adults in due course and their assembly for reproduction over the spawning grounds.

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[1] N.B. This term should be used in preference to the term "Larval drift" used in the working papers as a convenient code for this subject of the Working Party.

It became clear that some of the problems cannot be solved until there is much more detailed knowledge of the habits, physiology and biochemistry of commercial fish during both their planktonic and free-swimming life. Particular interest was shown in the possibility of fish being "conditioned" to the environmental circumstances under which they existed as eggs and larvae, so that they might conceivably be stimulated to "seek out" similar conditions on the approach of maturity.

It was resolved, therefore, to draw attention to the urgent need for (a) more work on the experimental rearing of fish from the egg stage, including investigation of their relationships in early life with their environment, and (b) more and more exact, studies of migration and shoaling in adult fish, and particularly of these aspects of their environment to which they can (and do) react, so as to understand better the means whereby they find their way back to their spawning grounds.

(2) Attention was drawn to our relative scanty knowledge of the ecology of the plankton, and particularly of the distribution of the eggs and planktonic stage of commercial fish, in relation to hydrographical conditions on the Newfoundland and Labrador Banks.

It was resolved to recommend that, while systematic knowledge could best be advanced by the work of specially equipped research vessels, serious consideration should be given to the possibilities of supplementing such work with observations and samples which could be collected by the vessels of the various nations fishing those banks. Once the support and understanding of the owners and skippers has been obtained, simple and semi-automatic gear such as the Hardy Plankton Indicator, could be used regularly with negligible interference to fishing activity.

(3) Some of the most interesting and baffling biological problems were presented during the discussions on Redfish in this and other working parties. Mr. George Kelly opened the discussion on the species and varieties of Redfish in the North Atlantic, followed by Dr. Kotthaus and Dr. Tåning. Mr. Parrish kindly reported on the relevant findings of Working Party No. 6 (Mehtods). It may fairly be said that the Redfish present in most extreme forms many of the problems met in our studies of more familiar species such as cod and haddock. In particular (a) there is no agreement on the taxonomic status of the various "kinds" of Redfish found in the North Atlantic and consequently no useful concept of unit stocks, and (b) there is not only evidence for different growth rates prevailing in different groups, but there is very wide divergence between one worker and the others in age-determination within the same population and, indeed, on the same otoliths'. According to the majority, the redfish grows surprisingly slowly but, according to the other worker, it grows some three or four times as fast'. Interest in the fishery for redfish is steadily increasing on both sides of the Atlantic, and may be expected to increase further so that it is essential to have reliable information about the rates of growth, and relationships between the different groups of fish on both sides of the Atlantic, if the population dynamics are to be analysed. According to the evidence of those who believe these fish grow slowly, overfishing - temporary or long-term, local or more widespread, - might not be distant. On the other hand, as we are still very ignorant of the distribution, spawning grounds and migrations of practically all the groups of redfish, the possibility that there may be relatively large concentrations of redfish which are not exploited (or even exploitable) cannot be ignored.

In all this, it is essential to record that, in most laboratories where redfish are studied, it is at best a part-time occupation; one biologist may be responsible for redfish studies and two or three other tasks as well. Real progress cannot be made in this way. If the Commission considers that the actual and potential importance of the redfish demand that our knowledge of its biology be placed on a sound footing, the intensity of work must be increased. Accordingly, it was resolved to recommend that funds should be made available for a very considerable increase in the skilled manpower and facilities provided to investigate redfish. Particular aspects on which more information is urgently needed are (a) morphology in relation to age, (b) growth-rates, (c) migrations (horizontal and vertical), (d) occurrence and constitution of reproductive concentrations of the fish, (e) spawning places, (f) characteristics of the larvae of the different groups, (g) the subsequent drift of the young stages - all in association with conventional hydrographic data. In addition (h) all available statistics should be examined for evidence of local and more widespread changes in abundance.

Written Contributions Presented to Working Party VII

Contr. No. 1 - Angeles Alvarino	Zooplankton from Newfoundland Waters, June, 1955.
2 - John B. Colton, Jr.	The Adaptability of the Hardy Plankton Recorder to Research Ship Studies.
3 - John B. Colton, Jr.	Report on Studies of the Fluctuations of Year Class Strength of Haddock.
4 - John Corlett	Distribution of larval cod in the Western Barents Sea.
5 - J. H. Fraser	The Drift of the pelagic stages of fish in the N.E. Atlantic and its possible significance to the stocks of commercial fish.
6 - D. H. Steele	Drifts of Redfish Larvae, Sebastes marinus L, in the Western half of the Gulf of St. Lawrence.
7 - A. V. Tåning	Observations on supposed intermingling or a certain connection between some stocks of boreal and subarctic demersal food fishes of the eastern and western Atlantic.
8 - H. J. Aurich	The causes of the changes in the stocks of some summer spawners in the southern North Sea - a working hypothesis.
9 - A. Fleming	On differentiation of cod groups over the Labrador and Newfoundland Banks.
10 - J. Clark	On differentiation of the haddock of Georges and Brown's Banks by vertebral number, in relation to temperature.

Supplement

The following considerations seem to be relevant when trying to decide whether the fish in a particular fishery can be regarded as a unit, or stock, in itself and how far it may be related to other groups or stocks of the same species. For convenience, the considerations can be set out under the headings of A, eggs, larvae and other passive stages, and B, the individually mobile and adult stages.

A. Eggs and Larvae, etc.

(i) First and foremost, it is necessary to determine what current systems exist over and around the spawning grounds. For example, the spawning products of the North Sea haddock would appear to be broadly conserved by the main anti-clockwise eddy in the northern North Sea, although variations among the factors governing this eddy might result in the loss of larvae from the area and, conceivably, their transference towards the area of another haddock fishery. Again, the general clockwise movement of the waters round Iceland not only causes the larvae of cod and saithe to drift appreciably from the spawning grounds but in general tends to retain them over the Icelandic shelf; although on occasion considerable numbers of cod larvae have been known to be diverted from this system and to drift towards Greenland waters.

(ii) In general, horizontal eddy systems such as these tend to maintain the species in the area in question. In some instances, at least in theory, the same effect may even be maintained by a circulation within the vertical plane, as occurs in some truly planktonic species. Uni-lateral drifts, on the other hand, such as influence the plaice of the southern North Sea, for example, tend to carry eggs and larvae steadily away from the spawning grounds, and must logically be complemented by some other conservative system - for example, a counter-current migration of the resulting adults for spawning purposes - if the fishery in question is to persist, and particularly if it is truly a unit of stock in its own right.

(iii) Related matters concern the speed and depth of the local currents, and the extent to which they are influenced more or less by local winds. Thus, both Walford and Carruthers (et al) have produced evidence suggesting that the success of broods may be considerably influenced by the variable direction and strength of winds over the area of the spawning grounds.

(iv) In this context, the rate of development of the larvae in question (i.e. the period taken to attain the individually mobile, and ultimately pelagic or demersal phase), and the environmental factors such as temperature which govern this, are important.

(v) Other factors vital to the success of broods and consequently to the possible transfer of larvae from the grounds of one fishery to those of another are the availability of suitable food - both immediately after the yolk sac stage, and successively as the young fish grow until and when they become demersal or pelagic. Conceivably, less tangible factors, such as the availability of dissolved organic matter, either for direct or accessory nutrition, may be concerned.

B. Mobile and adult stages

(i) Here, migration is concerned and considerations will vary greatly according as the species in question is mainly demersal (e.g.haddock and plaice) or pelagic (e.g. tuna, herring and, an extreme instance, the eel). Evidence for both spawning and feeding migrations has been produced, although much remains to be discovered about the stimuli inducing migration. Broadly speaking, there appears to be a much greater chance of intermingling between apparent "stocks" of pelagic fish, and it is significant that the cod, in which stock inter-relationship has been shown to extend over thousands of miles, is essentially pelagic for a good deal of its life. Even though the major North Atlantic groups of cod may be largely individual, migrations have been traced which link those found at Newfoundland, Greenland, Iceland, Bear Island and the Barents Sea, etc.

(ii) Closely related is the possible existence of depth barriers. These do not seem to be very significant for the cod, perhaps because of its pelagic tendency, but the evidence suggests that they may be more important for the haddock, perhaps depending on the possibility that below certain depths haddock food is insufficiently abundant to attract or retain wandering fish.

(iii) Again, we are also concerned with the normal environmental limits which the species can tolerate - for example, whether it is stenothermal or eurythermal, etc. On the other hand, there is evidence to suggest that within the species, local "stocks" may have evolved different environmental tolerances (e.g. North Sea and Barents Sea cod)

(iv) Other physiological differences may be revealed by marked differences in growth rate. Yet another may be shown by differential susceptibility to parasitisation, although this feature must usually be subject to ecological control. A third arises in the hints of differences in the nature of proteins etc. in various stocks (as shown, for example, by chromatography and electrophoresis).

(v) Apart from such physiological differences, investigation of morphological characters has shown considerable stock differences. Examples are numbers of vertebrae, fin rays, etc., and peculiar characteristics of scales, otoliths, skull formation and even general appearance and taste. It is important to ascertain whether these differences are inherited or environmental (for example, some at least have been shown to be strongly under the influence of temperature).

(vi) On the other hand, it should be remembered that the absence of such morphological, physiological, etc. differences does not necessarily mean that two groups of fish are completely interrelated by continued admixture and interchange of individuals; they may still be quite individual.

(vii) When and where do they spawn?

Ultimately, either under A or B, we are concerned with (1) methods by which populations may intermix and (2) methods by which such intermixing may be detected.

VIII

PLANS FOR THE REVIEW OF COD BIOLOGY TO BE HELD IN THE 1956 ANNUAL MEETING

A meeting of a group of cod experts was held March 5, 1956.

The group drew up plans for the Cod-Symposium to be held in Halifax in connection with the ICNAF meeting in June 1956.

The group concluded that it was necessary to concentrate on the following aspects:

1. Growth. 2. Maturity. 3. Relative Strength of Year-Classes.
4. The effects of temperature on growth, maturity and relative strength of year-classes.

The group stressed the importance of the cooperation of fishermen from all countries fishing in the area in returning tags.

Since cod proved the major part of the landings from the ICNAF area, it seems obvious that the species needs greater attention than it has been receiving. The group therefore recommends that the Working Party on cod be continued and that special meetings on cod should be arranged in connection with the ICNAF meeting for at least one or two years to come.

The group also expressed the wish to arrange a working session in connection with the Cod Symposium to compare methods of age-determination and techniques of measurement and tagging.

IX

A REVIEW OF KNOWLEDGE ABOUT THE ATLANTIC HALIBUT

G. Rollefsen
Discussion Leader in Meeting of Whole Committee

The following contributions were presented:

1.	B. Rasmussen	A short review of the history of the halibut fishery in the Davis Street
2.	B. Rasmussen	Tagging of halibut
3.	F. D. McCracken	On the Biology and Fishing of the Canadian Atlantic Halibut
4.	McIntyre	Notes on Halibut

The papers presented and the following discussions revealed that on both sides of the Atlantic:

1. the young halibut seems to be heavily taxed by gear used for other species.

2. The halibut stocks seem very sensitive to fishing activity.

The discussion brought out that there are considerable difficulties in saving the young halibut from being caught incidentally in other fisheries. It was emphasized however, that it was important to find means of avoiding unnecessary diminution of the recruitment of the stock.

The importance of an increased knowledge of the biology of the halibut was stressed and it was recommended that:

1. a long-term program of research of the Atlantic halibut should be framed.

Due to the fact that the stocks of halibut seem so susceptible to taxation by the fishery, it was recommended that:

2. A constant watch of changes in fishing method and fishing effort should be kept.

Acknowledgments

The Committee wishes to express its gratitude to various persons and organizations not members of ICNAF but observers and participants in this series of working party meetings.

The representatives of FAO, Dr. Kesteven and Mr Holt, have contributed many valuable ideas and given important counsel throughout the discussions. Appreciation is especially due Mr. Holt who graciously accepted leadership of Working Party 3 upon the sudden illness of Mr. Beverton, its Convenor.

The Committee also enjoyed the participation of Dr. Fridriksson, General Secretary of The International Council for the Exploration of the Sea; Dr. J. Furnestin, International Council for the Exploration of the Mediterranean; Dr. L. K Boerema of the Netherlands; and Dr. Adolf Kotthaus and Dr. A. Von Brandt of West Germany. The work of this Committee has been greatly enriched and its conclusions benefited by the participation of these observers.

The Committee expresses its gratitude to L'Institut Scientifique et Technique des Pêches Maritime for its invitation to meet in France and to the Centre d'études et de Recherches Scientifiques at Biarritz for placing its laboratory rooms and facilities at the Committee's disposal throughout its sessions. Dr. Barriety and his staff have been untiring in their efforts to provide the many services which the meetings have demanded.

Participation

Members

Canada	Allister Fleming	Fish. Res. Board of Canada, Biological Station St. Johns, Newfoundland.
	F. D. McCracken	Fish. Res. Board of Canada, Biological Station, St. Andrews, N.B.
	W. R. Martin	Fish. Res. Board of Canada, Biological Station, St. Andrews, N.B.
	W. Templeman	Fish. Res. Board of Canada, Biological Station, St. Johns, Newfoundland.
Denmark	Paul M Hansen	Greenland Fishery Investigations, Charlottenlund Slot, Charlottenlund.
	Aage J. C. Jensen	Danish Institute for Fishery Investigations, Charlottenlund Slot, Charlottenlund.
	Aa. Vedel Tåning	Director, Danish Institute for Fishery Investigations, Charlottenlund Slot, Charlottenlund.
France	J Ancellin	Lab. des Sciences et Tech. des Pêches Mar. Boulogne Sur Mer.
	J. Furnestin	Director, Institut Scient. et Tech. des Pêches Maritimes, 59 Av. Raymond-Poincaré, Paris XVI^{e}.
	G. de la Tourasse	Centre d'Etudes et de Recherches, Biarritz.
	G. Kurc	Inst. Sc. et Techn. des Pêches Maritimes.
	J. Le Toux	Administrateur Civil Marine Marchande.

France	P. Arnè	Directeur Honoraire Musèe de la Mer, Biarritz.
	M. Vibert	Eaux et Forêts (Ingènieur) Recherches Piscicoles, Biarritz.
Norway	G Rollefsen	Dir. Inst. of Marine Research, Directorate of Fish, Bergen.
	G Saetersdal	Inst. of Marine Research, Directorate of Fish, Bergen.
Portugal	Mario Ruivo	Inst. for the Study of Fisheries, Lisbon.
Spain	O. Rodriguez Martin	Biologist, Direccion Generale de Pesca Maritima, Alarcon 1, Madrid.
	Jose Maria Navaz Sanz	Dir. del Laboratorio Oceanografico, San Sebastian.
	Juan Cuesta Urcalay	Dir del Laboratorio Oceanografico, Santander.
	Rafael Lopez Costa	Quimico del Laboratorio de Oceanografia, Vigo.
	Maria de los Angeles Alvarino Gonzales	Biologist, Inst. Español de Oceanografia, Alcala 27, Madrid.
	Alfonso Rojo	Biologist de Pysbe, Aguirre Miramon 2, San Sebastian.
United Kingdom	J. Corlett	Fisheries Laboratory, Lowestoft, England.
	J. H. Fraser	Marine Laboratory Scottish Home Department, Victory Rd., Torry, Aberdeen, Scotland.
	J. A. Gulland	Fisheries Laboratory Lowestoft, England.
	E D. Le Cren	Freshwater Biological Asst., Ambleside, England.

United Kingdom	Rodney Jones	Marine Laboratory Scottish Home Department Victory Rd., Torry, Aberdeen, Scotland.
	C. E. Lucas	Director, Marine Laboratory Scottish Home Department Victory Rd., Torry, Aberdeen, Scotland.
	B. B. Parrish	Marine Laboratory Scottish Home Department Victory Rd., Torry Aberdeen, Scotland.
United States	John R. Clark	Fish and Wildlife Service Woods Hole, Mass.
	John B. Colton	Fish and Wildlife Service Woods Hole, Mass.
	H. W. Graham	Fish and Wildlife Service Woods Hole, Mass.
	G. F. Kelly	Fish and Wildlife Service Woods Hole, Mass.
	Clyde C. Taylor	Fish and Wildlife Service Woods Hole, Mass.
	L. A. Walford	Chief, Branch of Fishery Biology, Fish and Wildlife Service Washington, D. C.
Secretariat, International Commission for the Northwest Atlantic Fisheries	Erik M Paulsen	Executive Secretary Forrest Building, Carleton Street Halifax, N. S., Canada.

Non-member Participants

West Germany	Andres Von Brandt	Federal Representative Institute fur Netzforschung Hamburg
	Adolf Kotthaus	Biologist, Anstalt, Heligoland Abt. Fischereibiologie Bremerhaven.
Netherlands	L. K. Boerema	Fisheries Laboratory Ijmuiden.
F.A.O.	S. J. Holt	Biology Branch Rome, Italy.
	G. L. Kesteven	Chief, Biology Branch Rome, Italy.
International Council for the Exploration of the Sea	A. Fridriksson	General Secretary Bur. du Cons. Inst. pour l'Expl. de la Mer, Charlottenlund Slot, Charlottenlund, Denmark.
International Council for the Exploration of the Mediterranean	J Furnestin	Dir. Inst. Sc. et Tech. des Peches Mar., 59, Av. Raymond-Poincare, Paris XVI^{e}.

Serial # 365 corr.

CORRIGENDA

to Document No.6

REPORT OF THE COMMITTEE ON RESEARCH AND STATISTICS ON AN INTERIM SESSION HELD IN BIARRITZ, FRANCE, MARCH 1-10, 1956.

Page 2 — Under "Subjects", Item III, last line, "Sydney" to read "Sidney".

Page 4 — Line 5, delete sentence reading "This is especially needed in Sub-areas I and III where sampling programs are particularly deficient."

Line 6-7, delete "These areas are of greatest importance in..." and amend to read "The Convention Area is of greatest importance for..."

Page 5 & Page 6 — Delete paragraph beginning "In examining the research programs..." and substitute the following:

"In examining the research programs which the member nations conduct in the Convention area, the Committee finds that they are deficient with respect to redfish and halibut. Redfish is one of the species of great interest to the Commission. Because of certain apparent peculiarities in the life history of the redfish, landings may decrease suddenly and disastrously. This species is one of the most difficult to study, resisting most of the classical techniques of fishery research. Important though it is, difficult though it is to study, probable though a decrease in landings seems in the light of accepted information, none of the member countries fishing for redfish puts enough effort into research on this species to provide the information necessary for prescribing conservation measures. The Committee therefore urges the Commission to give attention to the program of redfish research recommended in Section IV below."

Page 6 — Paragraph beginning "The Committee recommends...", delete "continue" and substitute "should".

Page 7 — Line 5, delete "net" and insert "of nets and other gears" after "studies".

Page 8 — Below title insert "Clyde Taylor, Convenor; Rodney Jones, Rapporteur".

Page 11 — Below title insert "W.R.Martin, Convenor; A.M.Fleming, Rapporteur".
Under "Participants", delete "Chairman" and "Rapporteur"

Page 12 — 8th line from bottom, delete "small"

Page 13 — 6th line from bottom, delete "Denmark, Iceland and Italy" and substitute "Denmark, Norway, Iceland, Italy and Germany".

...../2.

Page 18 Bottom of page, delete "W.R.Martin, Chairman" and "A.M.Fleming, Rapporteur".

Page 19 Below title insert "Sidney Holt, Convenor; John Gulland, Rapporteur".
Under "Participants" delete "(Convenor)" and "(Rapporteur)".

Page 38 Item 9, by S.J.Holt, delete "(Untitled, general examination of problem)" and substitute "A note on the evaluation of fishery resources by the dynamic analysis of stocks and the time factors involved".

Page 40 Top of page, insert

VI

"COMPARISON OF EUROPEAN AND NORTH AMERICAN TECHNIQUES"

"B.B.Parrish, Convenor; J.R.Clark, Rapporteur"

and delete

"Chairman: Mr.B.B.Parrish, U.K."
"Reporter: Mr.J.R.Clark, U.S.A."

Page 61 Below title insert "C.E.Lucas, Convenor"
Under "Participants" delete "(Convenor)"

Page 64 Line 6, sentence beginning "Accordingly, it was resolved to recommend that funds should be made..." to be changed to read as follows "Accordingly,

"It was resolved to recommend that funds should be made etc. etc."

Page 67 Below title insert "G. Rollefsen, Convenor"

Halifax, 8th June, 1956.