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Marine Laboratory, Aberdeen

14-20 March, 1961

Report to the Research and Statistics Committee

Contents

I. Introduction, List of questions, Meetings, etc.

The relevant recommendations of the Commission were as follows:

(1) That a symposium on "The Influence of the Environment on the Distribution and Abundance of the Principal Groundfish in the ICNAF Area" be held in 1962 or 1963; and

(2) That a selected working party of fisheries biologists and hydrographers be requested to advise, at the expense of the Commission, on the best methods for answering the following questions:

(a) What are the effects of the environment on the survival of the eggs and larvae, and on the abundance and growth of year classes of cod, and their effects on long-term abundance and distribution of adult cod, in the Commission's area; while the main emphasis should be on cod, it would be useful in such studies to obtain any relevant evidence on both redfish and haddock.

(b) Further, how can such studies be directed so as to provide not only evidence of associations and correlations but also to lead speedily towards the prediction of such effects as long in advance as possible.

(c) Thinking in terms of the more immediate actions and reactions between the fish and factors in their environments, what fundamental studies not already proceeding should be initiated in one laboratory or another.

(d) Dependent upon the answers to (a) and (b) in particular, what standardization of methods is needed and what system of compiling, collecting, synthesizing and circulating data is needed for the Commission's purposes - with what staff, if any - bearing in mind the Commission's general principle that the bulk of its research should be done in and by the member laboratories, and the advantages to be gained by evolving methods similar to those adopted by ICES.

(e) How plans can best be laid for holding the Symposium set out in (1) above, so as to further the Commission's environmental investigations both before it and thereafter; the principal objective should be as defined but this should not preclude inviting some recognized authorities to contribute on relevant topics.

The Working Party's advice on these questions is set out below: specifically

Question (a) V. pp.9-15

(b) V. Subarea 1: Introduction and paras. 1, 2 and 7; Subareas 2 and 3: Introduction and paras. 1, 2, 3 and 6; Subarea 4: Introduction and para. 1; Subarea 5: paras. 1, 2, 3 and 5; General: Sections 2 and 7.

(c) V. Subareas 2 and 3: paras. 1 and 2; Subarea 4: Introduction and para. 1; General: Sections 1 and 5

(d) V., pp.16-17

(e) IV., pp. 1-5

Attention is also drawn to the general considerations on pp. 5-6

While many of the answers are relevant to cod and also other commercial species, there are proposals specially relating to

haddock in V, Subareas 2 and 3: Introduction and para.2;
Subarea 4: para. 1;
Subarea 5: paras. 1-3 and 4, and to

redfish in VI, Subarea 1: para. 7;
Subareas 2 and 3: para. 6
and on pp.15-16

II. Meetings, Material, etc.

Meetings

The following scientists were nominated by the Chairman of the Research and Statistics Committee to form the Working Party: Mr. F. Hermann, Dr.L.M.Lauzier, Mr.A.J.Lee, Dr.C.E.Lucas (Convener), Dr.Ju.Ju.Marty, Dr. A. Meyer and Dr.L.A.Walford.

Advantage was taken of the meeting of ICES in Moscow to arrange for those members of the Working Party who could be available to meet informally and discuss preliminary arrangements for the meeting to be held in Aberdeen. Dr. Lucas reported that it would not be possible for Dr. Walford and Dr. Meyer to serve and that Dr. Krefft would be taking the place of Dr. Meyer. Mr.J.E.King was meanwhile taking Dr.Walford's place, and it was subsequently decided that Dr. H. Graham would replace him. Those present in Moscow included: Mr. Hermann, Dr. King, Dr. Krefft, Dr. Lauzier, Mr. Lee, Dr. Lucas and Dr. Marty. A note concerning this informal meeting is attached (Appendix I).

The formal meeting was convened on March 14 at the Marine Laboratory in Aberdeen, when Dr. Graham, Mr. Hermann, Dr. Krefft, Dr. Lauzier, Mr. Lee, Dr. Lucas (Chairman) and Dr. Marty were present. In accordance with the discretion given to the Working Party, Mr. J. Corlett (Fisheries Laboratory, Lowestoft), Mr.R.S.Glover (Oceanographic Laboratory, Edinburgh), and Mr.B.B.Parrish (Marine Laboratory, Aberdeen) were co-opted for the period of the meeting. For the discussion on data centres and the indexing of hydrographic data, the Party also had the assistance of Dr.J.B.Tait (Chairman of the ICES Hydrographic Committee).

Meetings were held on Tuesday, Wednesday, Thursday, Friday, Saturday and Monday (14th-20th March), with informal meetings on Sunday 19th. The questions posed by the Commission were discussed in turn and the principles of the recommendations agreed in preliminary drafts. The time available, however, did not permit drafting of a full report in Aberdeen, and it was agreed that this should be done by correspondence, subject to final approval by those who could be present at a one-day meeting to be held in Woods Hole, prior to the meeting of the Research and Statistics Committee in May. It was therefore decided (a) to circulate a draft of the report among members for comment before the end of April, and (b) to ask the Executive Secretary to request the Governments concerned to include members of the Working Party in their scientific delegations, so as to permit as many as possible to meet in Woods Hole on May 27. The following pages record the recommendations thus agreed and the considerations on which they are based.

Material provided

As a result of preliminary requests made by the Secretariat, a number of useful papers was provided for the meetings in Aberdeen (list attached as Appendix II), of which copies have been filed with the Secretariat. In particular, information about hydrographic work undertaken during recent years was provided by Canada, Denmark, Germany, Iceland, Norway, United Kingdom, United States of America, and Union of Soviet Socialist Republics. In addition, charts and notes were provided by workers from Canada, Denmark and the U.S.A. on the known facts of the biology of the cod in the Commission's Area, together with supplementary information concerning environmental work in progress, particularly on the biological side. Special papers* on results obtained since the last ICNAF meeting were provided by Mr. Hermann (Copenhagen) on year-class/temperature correlations and by Messrs. Henderson, Bainbridge and Robinson (Edinburgh) on material (redfish larvae and plankton) from the recent extensions of the Continuous Plankton Recorder survey. The Working Party was also assisted in its work by a paper from Mr.B.B.Parrish (Aberdeen), summarising problems met by the Assessment Working Party which involve environmental studies in their solution (Appendix III).

*It is expected that these will be circulated generally for the Commission's Annual Meeting.

III. Basic principles determining discussions and recommendations

Throughout their discussions, the Working Party had particularly in mind the remit given to them by the Commission (quoted above), while taking into consideration comments made at an ad hoc meeting of ICNAF scientists, when assembled for the Regional meeting at Woods Hole in December 1960 (Appendix II of Document No.3 for the forthcoming General Meeting). In addition, the Working Party had in mind the questions which they considered the fishing industry would most wish to have answered, and some which the fish biologists would wish to put to the environmentalists, as well as the over-riding need for the closest collaboration between both groups of scientists if such questions are to be answered satisfactorily. Members also had in mind the available resources, the need for strengthening them in some respects, and the distinction in research between what would be desirable and what is essential. In all their considerations, as will be seen below, they were influenced by the relatively vulnerable position of the ICNAF fisheries on the edge of the Atlantic Slope, and the past history and probable future incidence of severe climatic changes in the northern subareas. In the light of these points they considered progressively what information is already available, and what projects are being investigated, subarea by subarea, so as best to decide on the requirements for a symposium and to plan for longer term research.

IV. General considerations

1. The term "environment" is used generally in the questions posed to the Working Party. It is an all-embracing term, and very properly comprises all those processes and bodies which are external to the fish: water movements; the physical and chemical properties of the waters; other organisms (prey and predator) and their secretions; fishermen; and even the sun and conceivably the pole star! We know that many of these directly affect the fish and, as our knowledge develops, we may expect to identify other environmental components of significance. Meanwhile, at any one time, we can only consider those we know or suspect and stress the significance of those which seem most influential. Among these are the temperature and salinity and chemistry of the water, other fish, the composition and abundance of phytoplankton and zooplankton, the composition and abundance of benthos and the topography of the bottom; in particular circumstances only a few of these may prove to be important.

2. The members were impressed by the wide range of conventional hydrographic data (temperature and salinity) available, particularly for some of the subareas, although they were constantly reminded that these had seldom been studied in relation to fisheries problems, and that the information was not always immediately relevant to those problems. There is moreover a general scarcity of chemical information other than salinity. In particular, they considered the series of hydrographic sections which were available in some regions, as providing information which might assist in identifying short and long term climatic trends and in the estimation of water movements. Certain limitations in their use for these purposes were recognised and a note is attached (Appendix IV) commenting specifically on these limitations. In brief, it would appear as though they can be used to provide relative indices, with certain provisos.

3. The members were also impressed with the relative paucity of environmental data on the biological side, although they were able to note very encouraging developments in recent years. It is satisfactory that a number of these relate to more closely integrated studies than previously, and they welcomed the attention now being paid to benthic studies in relation to the fisheries.

4. It is necessary to stress that the need for precision in the identification of fish stocks, and for the fullest knowledge of fish migrations, is probably as great as it is in stock assessment studies. The stocks and their components are the essential units towards which the environmental studies should be directed, while sound knowledge of fish movements is vital in relation to observed environmental differences.

5. In general, as regards the different aspects of fishery research mentioned in 1-4, it is stressed that progress can only be irregular until the efforts directed to the different aspects of fishery research are balanced and developed through genuinely co-operative studies by the scientists concerned.

6. The Working Party noted that, while in certain directions work still needs to be initiated, in others much field work has already been done although in some analysis is only in progress or has apparently not yet been begun. It is strongly urged that wherever possible such analyses should be completed before the Symposium, so that the maximum information can then be available. It is recognised, too, that when this information is available it may lead to some modifications in the research proposals set out below, and to greater precision in their formulation. Action on the present proposals need not be held in abeyance until the symposium is completed, however, particularly on those concerning new or relatively new work.

7. It is recognised that the delay in analysing material already obtained, and in beginning projects already envisaged, is caused by staff shortages in some cases, particularly on the environmental side. In some laboratories "environmental" studies are seriously undermanned. For many of the projects suggested below, additional staff will be needed or, alternatively, a different allocation of staff, since satisfactory progress in some aspects of fisheries investigations cannot usefully be made in isolation.

8. It is strongly urged that all the responsible authorities consider carefully, and particularly in the light of the proposals set out below, how best they can strengthen the environmental sides of their fisheries research staffs, both on the hydrographic and on the biological sides.

9. It is a truism to say that the fisheries problems of the ICNAF Area cannot be considered and solved solely within the administrative boundaries of that Area, but repeatedly in its considerations the Working Party were faced with questions as to the oceanic regime in waters outside the Area and the relationship of stocks in the Area to those outside it, and indeed with problems of the migrations of some of the stocks to and from the Area. It is their view that the fisheries for which the Commission is responsible can only be understood as parts of a series of fishing banks fringing the North Atlantic. For their understanding, it is necessary to take into account the whole oceanic regime of the North Atlantic, with particular reference to the Gulf Stream, Arctic influences and interrelationships with the deep waters offshore, as well as to the over-riding role played by meteorological events. In making these points, the Working Party noted that ICES has recently been considering rather similar "environmental" problems, and has valuable and relevant information to contribute. Not only is ICES concerned mostly with the same species of fish, but at least two of them, the cod and the redfish, extend more or less continuously from the southwest to the northeast of the North Atlantic.

10. It was in the light of the points made in 9. that the Working Party framed its proposals for answering the questions posed by the Research and Statistics Committee, and that it ventured in particular to revise the original proposals for the Symposium.

V. Proposals for a Joint ICNAF/ICES "Environmental" Symposium, 1963

Recognising

(a) the serious concern of ICES with similar "environmental" problems, and

(b) the reasons set out above, which determine that ICNAF problems (environmental and otherwise) cannot be investigated solely by programmes which are restricted to its area,

the Environmental Working Party is of the view that ICES should be invited to co-sponsor a symposium entitled "The Influence of the Environment on the Principal Groundfish Stocks in the North Atlantic*", to be held over six days prior to the meeting of the ICNAF Research and Statistics Committee in 1963. The principal objectives should be as defined below, but this should not preclude inviting recognised authorities to contribute specified reviews on relevant topics, such as pelagic "environmental" studies, whether made in the North Atlantic or elsewhere.

A major aim of this symposium would be to bring together fish biologists and workers in relevant fields of biology and hydrography, with the object of reviewing fully the available knowledge in the field of investigation, and of demonstrating its vital place in fisheries research and in oceanographical research generally.

(a) For such a symposium, the Working Party consider that the major objectives should be to secure contributions concerning:

1. The factors whereby the location and availability of fish stocks are limited from time to time, on and off the fishing grounds:- e.g. by temperature and other physical factors, distribution of food organisms (plankton, nekton and benthos), parasites etc.

2. The relevant features of the physiology and behaviour of particular groundfish which are associated with these limiting factors.

3. The effects of such limiting factors on the growth, age of first maturity, and survival of particular groundfish in particular areas.

4. The longer term influence of such limiting factors, whereby fish stocks may be continuously restricted or enabled to extend their areas of distribution and availability.

5. The possibility of predicting the onset of critical phases in these factors.

6. The effects of environmental conditions on the planktonic and early demersal stages of fish, and on the plankton and benthos as the food supply of these fish.

7. How environmental factors affect the process of fishing.

(b) It is proposed, therefore, that the Symposium be sub-divided into sessions, on the topics set out below, to run consecutively:-

1. Effect of physical environmental conditions on the distribution of adult fish.

2. Effect of the biological environment (including parasites) on the distribution of adult fish.

3. Effect of the environment on growth, survival and age at first maturity.

* i.e. comprising the whole ICNAF Area and that of ICES (excluding the Baltic, North and Irish Seas and the English Channel).

4. Effect of the environment on pelagic and early demersal phases of groundfish.

5. Effect of long-term trends.

6. Physiological reactions to changes in the environment.

7. Forecasting environmental conditions.

8. Effect of the environment on the process of fishing.

(c) A Chairman should be selected for the whole Symposium and, for each of these topics, a Convener should be selected (at least eighteen months in advance, if possible) with the responsibility of securing contributions for his subject. These should be available in ample time for circulation at least two months in advance to those attending the Symposium. It is proposed that the contributions should not be read at the meetings; the object of the meetings should rather be to discuss the papers in the light of related work and the immediate research needs of the Commission. For this purpose it is important that contributors should be able to attend.

Contributions to the Symposium should be invited by the Conveners from the scientists of the ICES and ICNAF regions, but it should also be the special tasks of the Conveners to invite papers from particularly qualified scientists working in the area, to ensure that the major objectives of the various sessions are achieved.

(d) Finally, as selected relevant material, it is proposed that special "review" lecturers be invited to address the whole meeting on four topics:

(1) A review of the hydrography of the area, as an introduction to the Symposium.

(2) Reviews of the effects of the environment on)
)
(a) the Pacific salmon)
)
(b) the ~~Atlanto-Scandian~~ herring) as "evening" lectures
)
(c) the tuna)

At two informal meetings the Working Party drew up for its own guidance, and for that of the conveners, a list of possible conveners and contributors for each of the eight subjects and of possible lecturers for the reviews.

VI. Proposals for Research

These proposals are set out in relation to (1) available knowledge of 'environmental' work which has been proceeding within the Commission's area, and further work being initiated and (2) the serious gaps in local knowledge which our general understanding of oceanographic processes and fish biology reveal or imply. The object has been, to endorse the value of existing or envisaged projects where they seem essential to the Commission's objectives, and to underline the urgent need for an intensification of the work in some directions and its initiation in others. A list of projects is therefore set out, subarea by subarea, together with notes on some projects of more general concern. In accordance with the Commission's remit, they should be regarded as relating particularly to the Cod fisheries, unless otherwise stated, but most are in fact relevant to any of the fisheries proceeding in the Commission's Area.

If the list is a long one, this is because, despite their riches (which are by no means restricted to the fisheries) the seas are a great and relatively unexplored resource. In the Working Party's view none of the projects are merely academic exercises. All and, as our understanding grows, more are needed. Doubtless, other suggestions will emerge from the Symposium. On the other hand, our research resources are limited - and will still be so even if we increase these resources. The proposals have therefore been limited to the most important and the most likely to be productive of essential information. It is recommended that, if these proposals are accepted in principle, working parties of scientists who would be actively concerned are selected to plan the individual projects in the necessary detail. At least some of these must be, and can only be, achieved by collaboration between laboratories and research vessels. They will be the more costly, but it must be recognised that we each take our portion of the produce and should therefore do our share of the research. Those concerned will benefit in many ways from the collaboration.

Subarea 1

It is particularly in this area that most concern has been felt about the immediate and long-term effects of environmental changes on the fishable stocks. We have historical evidence of how fisheries near the limits of a stock's endurance may succeed or fail within relatively narrow environmental differences. We know how the present Greenland fisheries developed broadly in relation to relatively slight temperature increases, and we also know how even within the present history of the fisheries there have been significant temperature variations since the twenties when they began to develop. It is not surprising therefore that recent work has provided suggestive evidence of association between the success and failure of year-classes and relatively small temperature changes in the local waters. Such effects are as important in determining mortality rates etc. for assessment studies as they are of importance to the fishery itself. Undoubtedly one of the most important projects is to devise studies whereby the effects of environmental changes may be forecast - either immediately in terms of the success or failure of larval broods relative to the recruit classes of some years later, or alternatively through direct prediction of environmental conditions.

1. The Working Party therefore wish to stress the importance of research into the effects of the "climatic hazard" on cod year-class strengths from a long-term point of view. For this investigation of long series of environmental observations will be particularly valuable both in terms of mean regional data, and in terms of more specific data such as can be obtained from research ships specially working in the area where the fish and their larvae are found. Though the subsurface observations hitherto obtained from the research ships are rather few, the available evidence suggests that such fluctuations are more closely correlated with year-class fluctuations than are surface observations. Regular hydrographic observations taken between April and June should greatly increase our understanding of many features in year-class fluctuations. Again, data collected from appropriate weatherships should prove useful. In order to facilitate this work, efforts should be made to devise suitable apparatus for use on research vessels, 'search' vessels and weatherships. In all such studies, it may be valuable to investigate the sequential relationships of data collected in neighbouring areas and regions.

2. In such a programme attention should undoubtedly be paid to meteorological as well

as hydrographical data, particularly in so far as processed data concerning pressure differences may provide convenient summaries of environmental conditions prevailing over selected areas.

3. While the general current regime in this region is appreciated, more information is needed on the drift of eggs and fry along the coasts from east to west Greenland, and up the west coast and across the Davis Strait, in order to determine how far stocks of cod and redfish found off the coast of Labrador may be supported in part from spawnings to the east (see also p.14 below).

4. Despite the useful information already collected on spawning grounds and nurseries, evidence suggests that they are still known insufficiently, and efforts should be made to extend our knowledge of these grounds along both the east and west coasts of Greenland.

5. In relation to this question, it is particularly important to have more specific information about relevant current speeds and directions. There is some uncertainty as to the interpretation of current speeds, as deduced by hydrodynamical methods from standard sections taken at right angles to the local coasts (Appendix IV), and further investigation is needed, possibly by alternative methods.

6. Inevitably, in view of the limited research resources and the nature of the principal fisheries in the area, there is some uncertainty as to the identity of fish stocks (e.g. those off the east and west coasts of Greenland). Despite the valuable work already done, there is need for much more intensive tagging experiments devised specifically with this need in view, as also to investigate possible interrelationships between the stocks of this area and others. These should be supplemented by studies of otolith types and meristic characters, as also by blood group and blood serum investigations.

7. While there are no haddock stocks in the subarea, there are important redfish stocks, to which the same remarks apply as to the cod in (1) above. It is, however, typical of the present nature of our knowledge of the biology of the redfish that the problems met in Subarea 1 do not differ greatly from important redfish problems met elsewhere and they are most conveniently dealt with together in a special section (p.15).

Subareas 2 and 3

In both of these subareas, as in Subarea 1, the Working Party stressed the importance of the effects of both short and long-term variations in environmental conditions. While the possible long-term consequences may not be so serious for Subarea 3 as they are for Subarea 1, they are probably quite as acute for Subarea 2 and they could be considerable for Subarea 3. The more immediate effects of environmental changes on the stocks of these areas can be acute even for cod. It may be that for haddock the potential effects in this region are more drastic.

For these reasons the Working Party

1. ~~The~~ emphasise the need for research into the effect of temperature on the distribution of cod (and other species of commercial value). It is important that the cod-temperature studies being maintained in these regions should be reviewed as soon as possible and the programme intensified. The results may provide vital information for our understanding of the limiting conditions for fisheries here and elsewhere.

2. Althouth cod is the more important, there are valuable haddock stocks in Subarea 3. These are subject to severe fluctuations, the fisheries depending sometimes for several years on the success of a particular year-class. Not only are such circumstances of key importance to the fishery, so that the ability to predict them would be invaluable, but the available data regarding such extreme fluctuations in year-class strengths might provide unusually good opportunities for investigating the environmental conditions responsible for them, in accordance with the proposals (temperature and currents) made in item 5. In association it is important to know when and where the haddock spawn each year, so that the conditions can be determined and associated with the success or failure of spawning, larval drift, etc.

3. Meanwhile, the Working Party advise that useful information might be provided by examining existing series of hydrographical data to find the magnitude of the trends and fluctuations, since this information might indicate to what extent the annual spawnings, etc., might be affected by local environmental conditions. Similar studies might also provide useful information as regards the immediate effects of the environment upon the "availability" of the existing stocks to the fisheries from year to year.

4. It is as important for environmental studies as for population studies to have the best possible information on stock identity. Information on year-classes may be helpful here and even more important is direct information concerning interrelationships between the stocks. It is therefore of the utmost importance that the valuable tagging projects in progress in this region should be reviewed just as soon as possible.

5. In relation to these and several other problems, there is urgent need for more information as regards year-class strengths in these subareas: (a) in the interpretation of stock identity (b) in relation to fluctuations in the fisheries themselves, and (c) in more direct relation to environmental studies. Owing to the complex nature of water movements in these and adjacent subareas, and some uncertainties regarding stock identity, there is need for more up-to-date information concerning spawning, larval success and subsequent drift in relation to contemporary environmental conditions. The probable value of studying these in relation to the isolated fishery of Flemish Cap should be considered (see also p.14).

6. As in all the other subareas, there are acute redfish problems demanding investigation, although many of them are common to all (see p.15). It is important, however, to maintain the studies already begun for the Labrador coast of the association between meteorological conditions and the availability of redfish on the coastal banks.

Subarea 4

The Working Party noted that in this subarea the fisheries are, broadly speaking, in the middle of the environmental range of the cod; for this reason the more extreme long-term effects of environmental conditions need not be expected, although there are periodic changes in the abundance of this and other species. They noted with approval, therefore, the work proceeding on long-term fluctuations in water temperatures, as bases for correlations with changes in species composition and year-class strength of the major groundfish species.

1. This is, however, a subarea in which the short-term changes of environmental conditions may be appreciable and, therefore, one very suitable for studies of these effects. The Working Party stressed the value of research into the migrations of cod in the Gulf of St. Lawrence, in relation to the hydrographic regime. They noted with approval the preliminary studies of seasonal changes in Magdalen Shallows and the proposal to continue to study there the associated seasonal changes in the distribution of fish. They also endorsed the proposal to continue the studies of the ratios of cod: haddock catches in association with environmental conditions, in order to investigate the possibilities of a long-term prediction service. In all this work, further information on the interrelationships between the different fisheries will be valuable, both within the subarea and between this and adjacent subareas.

2. As in other subareas, the necessity for more precise information on the distribution of spawning grounds and the subsequent drift of the eggs and larvae was noted, particularly in view of the fact that important spawning grounds are situated on the edge of the banks and, conceivably, are subject to environmental fluctuations which might be very significant for future success or disaster. The Working Party noted with approval the plans for reporting on preliminary studies of water transport, especially those concerning the use of bottom drifters, and hope that this work will be extended.

3. The subject of larval drift is reviewed further below (p.14), in relation to other subareas, but within this subarea, special attention was given to the possible value of an extension of the Continuous Plankton Recorder survey run from the Oceanographic Laboratory in Edinburgh. The useful information already being obtained, on records between Reykjavik

and Newfoundland, pointed to the value in Subarea 4 of regular records being obtained between St. John's, Newfoundland and Halifax, Nova Scotia, and as far south as Boston, Mass., if possible. The Working Party therefore recommend that the staffs of the St. Andrews, Woods Hole (Fish and Wildlife) and Edinburgh Laboratories should consider as soon as possible how such an extension might be arranged. As a second priority, members preferred records taken from U.S. Weather Ships en route to Ocean Weather Station B.

4. Meanwhile the Working Party noted the work already proceeding, and that envisaged, for more detailed investigation of the feeding of groundfish species in this subarea and for related studies on the production of the bottom animals which are important elements in the food of cod and haddock. They endorse the value of these studies, and stress the importance, in this work, of associated experimental studies of the digestion rates and food requirements, for maintenance and growth, of the principal groundfish species and note with approval the work already in progress.

5. As in each of the other subareas, there are a number of redfish problems for investigation (see p.15).

Subarea 5

From the fishery point of view, this is primarily a haddock and redfish area, although cod, hake, flounder and sea-scallop support valuable fisheries. Cod in this subarea is at the southern end of its range. The Working Party noted the U.S. plan to increase their programme of environmental studies in two years time, when a new research vessel is expected to be ready for service.

1. In the view of the Working Party, the long series of age-composition data for the Georges Bank haddock stock are among the most valuable for environmental studies. Although some studies of the relation of local meteorological conditions and related water conditions to year-class strengths have been made, the U.S. should consider the feasibility of extending them. The fluctuations in the haddock year-class strength on Georges Bank represent a clear example of changes in fish abundance which are not solely related to the activities of man. They offer an opportunity to relate natural fluctuations to environmental conditions. The oceanography of the Gulf of Maine and Georges Bank (and whatever adjacent areas are required) should be examined for a period of years in an attempt to determine the conditions which result in high survival of haddock and which are conducive to failures of year-classes. An alternative and most important investigation would be the direct study of haddock egg production on the local banks, and the subsequent drift of the eggs and larvae in relation to environmental conditions, so as to know more precisely the fate of the young fish over a series of years.

2. Among several hypotheses, implying the effects of different environmental factors, one states that good survival results from a circulation pattern which permits the eggs and larvae to remain on Georges Bank or in the Gulf of Maine, whereas poor year-classes result from a movement of water off the bank to the southeast. Another theory relates high mortality of the young stages to unusual intrusions of warm slope water on the bank in the spring of the year. Among others, there is a third hypothesis that the fate of the larvae may depend on the availability of, first, abundant phytoplankton, and then of appropriate zooplankton; the possibilities of zooplankton predation should not be forgotten. The Working Party consider that an investigation such as that outlined below (p.14) would enable such hypotheses to be tested here and elsewhere in the Commission's area.

3. The members noted the plan to make regular surveys of the distribution of groundfish, with simultaneous hydrographic observations in Subarea 5. These surveys are expected to provide valuable information on the seasonal and longer-term variations in distribution and abundance of the important species in relation to temperature, depth, and other environmental conditions, and should also provide information for relating long-term changes to changes in the occurrence of the fish.

4. It was also noted that cod data are to be analysed, with a view to obtaining age compositions of that species in Subarea 5. Similarly, it is understood that age compositions for

yellowtail flounder stocks on Georges Bank will soon become available. Such analyses would be useful in providing additional biological information on annual fluctuations.

5. The members endorsed the plans for conducting benthic studies in Subarea 5, designed to describe the kind and quantity of benthic fauna throughout the subarea. These should be expanded to include further studies of the food habits of the fish species in the area and to investigate the importance of benthic fauna for the distribution and abundance of fish stocks. Such studies can be of further value, in the absence of other environmental data, in that benthic changes can indicate the effects of long-term trends and, owing to the sessile nature and relative persistence of benthic communities, can permit relatively economical types of investigation.

General Proposals

Just as one cannot usefully consider the whole ICNAF Area in isolation, one cannot consider its subareas in isolation. Some of the points mentioned above have general application and there are others which have not been mentioned. These are set out below.

While none have been stressed as more important than the others, it is worth drawing special attention to 3 and 4, concerning proposals for environmental studies in connection with the distribution of fish larvae and redfish respectively.

1. Tolerance to environmental conditions

The Working Party recognised that we are still very ignorant about the direct influence of different factors in the environment on fishes and of their reactions to them. So that wide-ranging studies of the physiology and behaviour of fishes, commercial and otherwise, will be needed before we can properly understand vital aspects of the fisheries, and these will have to be made both in the field and in the laboratory. Therefore, they commend such studies in general to all the research organisations concerned. The field is great, however, and priorities must be set.

Among the several relevant studies of the physiology and behaviour of commercial fish, the Working Party particularly wish to stress the importance of detailed studies, in the laboratory and in the field, of the tolerance of fish to environmental conditions. Both in relation to spawning and subsequent larval development, more information is required concerning the tolerance of cod and other larvae to particular conditions, while it is also necessary to investigate the tolerance of the planktonic food of the larvae. Similarly, information concerning the tolerance of recruit and adult fish to environmental conditions, as also the tolerance of their food organisms, would be invaluable, both in relation to short and long term environmental changes. Related studies should be made of the seasonal abundance of the zooplankton, comprising the bulk of the food of the fish larvae, as also of the timing of the seasonal outbursts of phytoplankton and zooplankton in relation to the time of spawning of the fish.

For this reason, the Working Party particularly wished to endorse the plans already envisaged to make regular surveys of the distribution of groundfish, with simultaneous environmental observations, and commend these plans to other workers in the area. These surveys are expected to provide valuable information on the seasonal and longer-term variations in distribution and abundance of the important species in relation to temperature, depth, and other environmental conditions, and should also provide information for relating long-term changes to changes in the abundance and distribution of the fish. Bottom temperature observations should be made with all trawl hauls.

2. Influence of currents

Particularly in relation to the distribution of fish larvae and the plankton, their tolerance and their drift with the local currents, it is most important to have more specific information in all areas about relevant current speeds and directions (but see Appendix IV).

The more localised currents envisaged here, however, are governed by variations in the flow of the major current systems of the area, which in turn are related to those being revealed by the study of the oceanography of the whole North Atlantic. Attention has already been drawn (p.6) to the significance of such studies for research in the ICNAF Area. The Working Party felt an urgent need for more information about the whole water regime of the North Atlantic, how it is maintained, what are its major variations and how they are brought about. While attacks on this broad problem are being made in some quarters, there is not yet the co-ordinated and extensive attack on this vital problem which it deserves. It is perhaps significant that we do not yet have a truly synoptic picture of the water regime of the North Atlantic.

In addition, the members wish to stress the significance of meteorological phenomena, on the large scale in supplying energy for the whole North Atlantic regime, and on the smaller scale in directly influencing local water movements by variable or persistent winds. Evidence is accruing in several quarters that in all fisheries environmental studies attention should be paid to meteorological as well as oceanographical data, particularly in so far as processed data concerning pressure differences may provide convenient summaries of environmental conditions prevailing over selected areas. In all such studies, however, the Working Party stress the importance of simultaneous study of hydrographical data, since it is ultimately essential to understand the intermediate phenomena between the meteorological and biological levels.

3. Plankton and egg and larval studies

The Working Party gave considerable thought to the problem of investigating the distribution of eggs and larvae of the principal commercial species in each subarea and of plankton studies in general. The complexity and effort required for such investigations was recognised and much thought was given to the likelihood of securing valuable results from any particular investigation. After very careful consideration the members decided to recommend that a special collaborative attack should be made on these problems in the ICNAF Area.

The Working Party recognised that, if made successfully, such studies are potentially important not only for environmental investigations but also in furthering the development of stock assessment studies, in many fisheries. They also recognised that the ICNAF Area, however, in which a series of most valuable fisheries are situated on the edge of a major continental slope, may present particularly important and valuable opportunities for a specially co-ordinated attack on the problem. Special reference has been made above to the value of egg and larval studies in ~~Area~~ 1, over the Flemish Cap and on Georges Bank. From north to south there are a series of spawning grounds which would appear to be particularly vulnerable to deviations in the normal regime of the waters flowing constantly past them and in meteorological conditions. The whole of the Nova Scotian coast is another example, ~~and Georges Bank yet another~~. In the simplest terms, persistent winds on or offshore could conceivably lead to major success or failure of one or more spawnings. The Working Party therefore strongly recommend that the Commission should plan for a co-operative plankton and hydrographic survey as soon as possible, in which research vessels from all the member countries would combine; this would comprise a study of the distribution and subsequent drift of eggs and larvae at several points along the eastern edge of the Area, over a period of three months (e.g. April, May, June). In conjunction, it would be possible, and desirable, to study the distribution of the associated plankton, as food supplies, as predators and as "indicators" of water conditions. In planning such a survey it will be essential to proceed so that the broad results can be made available to the Commission at the first possible moment, for on the success or failure of such a collaborative programme would depend important decisions as to the value of repeating it, over a term of years, either wholly or in part.

Tentatively it is suggested that this project might be planned for the spring of 1963. If this proposal is adopted, it would be essential for a planning group to be appointed this year, since the most detailed advance consideration is needed if there are to be reasonable hopes of success.

4. Redfish

In considering the ICNAF fisheries area by area, the Working Party were forced to acknowledge the serious limitations in our knowledge of the biology of the redfish and that, with odd exceptions, the problems met in one area do not differ greatly from those met elsewhere, so that they are most conveniently dealt with together.

Perhaps the most important ecological problem is that of determining the relationship between the redfish stocks found in the Commission's Area (and those on the Atlantic fishing grounds to the east) and the "pool" of oceanic redfish which, the results of larval surveys would imply, extends across a broad band of the North Atlantic Ocean. Both the Assessment Working Party and this one have had to face the curious problem of locally intense "stocks" being discovered, which on occasion have appeared to be rapidly fished out, but in the absence of the conventional signs of overfishing. In general it has not been possible to distinguish the effects of fishing upon a genuinely self-maintaining stock from those on a purely local section of a stock, nor indeed from the effects of marked environmental changes (some of which have been noted) which may have brought about significant changes in fish distribution.

Meanwhile the information obtained from the recent extension of the Plankton Recorder survey, combined with the various other data concerning the distribution of redfish larvae, has shown how, during the spring and early summer, redfish larvae are distributed in a more or less continuous broad band from the North American coast through Icelandic waters to the Norwegian and Barents Seas. Such a broad distribution is unusual for a commercial fish and it indicates that at the "spawning" season there must assemble vast numbers of females (at least), not only on the oceanic banks but right over stretches of the ocean which are normally unfished. These are the principal signs of the existence, at least seasonally, of a vast pool of redfish. Not only does the question arise as to whether fisheries for these fish might be developed by pelagic trawling or lining. The important possibility also arises that most of the presently exploited groups may simply constitute the fringes or isolated offshoots of a very large population, from which they may be replenished either continuously or periodically according to the environmental situation in the area; alternatively, they may genuinely constitute distinct unit stocks.

Unfortunately we still know next to nothing about the migrations of redfish, or about the drift of their larvae, and all too little about their environmental requirements. The Working Party recognised the value of the hypothesis set out above (and in Appendix III) and urged the importance of local tests of its significance, by the detailed study of the local abundance and distribution of redfish, in relation to fishing and environmental conditions, particularly local temperature, topography and food distribution. But they also stress the vital importance of studying the over-all distribution of redfish in the North Atlantic in relation to temperature, water structure and meteorological conditions. Much of the necessary work, therefore, must be undertaken in the ICES as well as in the ICNAF areas.

For this purpose they advocate, in addition to studies in the conventional fisheries, the initiation and development of experiments using pelagic trawls and lines in order to study the distribution of redfish of all ages, particularly in relation to temperature and water movements. In this it would be valuable to have early information from Continuous Plankton records of the larval distribution, since this information would convey important inferences regarding the oceanic distribution of females, at least. As information develops, from CPR studies and more conventional plankton investigations, important inferences could also be drawn as to the abundance of females in oceanic waters, and for this reason it seems important to intensify studies of the fecundity of redfish.

The members were particularly impressed with the evidence over a wide area that the year 1958 was apparently most unfavourable for "spawning", and stressed the importance of seeking among hydrographical data for environmental associations. They noted that the years 1957-1959 cover the period of the IGY surveys and anticipate that unusually abundant material should be available for studying this point.

The Working Party noted, as regards the "types" of redfish, that the available evidence suggests the type marinus to be unusually abundant among the larvae collected and the type mentella among the adults. Further information is urgently needed regarding the different types of redfish and their distribution, but meanwhile the party strongly recommended special studies of the types in relation to temperature, depth and food on all research vessel cruises.

The members also noted the relative paucity of information about the 0-group and 'nursery' stages of the redfish and recommend that these and their distribution should be studied more intensively, and always in association with data concerning environmental conditions.

5. Stock identity

Inevitably, in view of the limited research resources and the nature of the principal fisheries in the area, there is some uncertainty as to the identity of fish stocks. Despite the valuable work already done, there is need for much more intensive tagging experiments devised specifically with this objective to investigate possible interrelationships between the stocks of different subareas. These should be supplemented by studies of otolith types and meristic characters, as also by blood group and blood serum investigations.

In relation to this and several other problems, there is urgent need for more information as regards year-class strengths in the Commission's area: (a) in the interpretation of stock identity, (b) in relation to fluctuations in the fisheries themselves and (c) in direct relation to environmental studies. Owing to the complex nature of water movements in the area, and some uncertainties regarding stock identity, there is also need for more up-to-date information concerning spawning, larval success and subsequent drift in relation to contemporary environmental conditions.

6. Groundfish in relation to other fish species

Since the distribution and abundance of the commercially important species may be influenced by the abundance of other species, it was noted with approval that the U.S. and Canadian surveys will in future record all species present in the trawl catches. Such work could be of considerable correlative value, as well as of commercial use as the fisheries develop, and it is recommended that this step be taken by research vessels of member countries in all areas, to include also measurements of fish of the principal species.

7. Groundfish in relation to benthos

The members also noted with approval the plans already envisaged for conducting benthic studies, designed to describe the kind and quantity of benthic fauna. These should be expanded to include further studies of the food habits of the species in the area and to investigate the importance of benthic fauna for the distribution and abundance of fish stocks. Such studies can be of further value, in the absence of other environmental data, by indicating the effects of long-term trends and, owing to the sessile nature and relative persistence of benthic communities, they can permit relatively economical types of investigation.

VII. Advice on collection and exchange of data, etc.

In addition to advising on plans for a symposium and for future environmental research, the Working Party were asked...."what standardisation of methods is needed and what system of compiling, collecting, synthesising and circulating data is needed for the Commission's purposes - with what staff, if any - bearing in mind the Commission's general principle that the bulk of its research should be done in and by the member laboratories, and the advantages to be gained by evolving methods similar to those adopted by ICES." These questions were discussed at length and Dr.J.B.Tait, Chairman of the ICES Hydrographical Committee, was co-opted for the purposes of this discussion.

1. Standardisation of methods etc.

(a) This problem is common to the whole of oceanography and has recently been discussed by the UNESCO Inter-governmental Conference on Oceanography, held in Copenhagen in 1960. This body recommended that UNESCO should be responsible for the standardisation of methods in oceanography. The Group decided therefore to recommend that the Commission should take no special action at this stage, but that ICNAF requirements should in due course be considered in the light of the report UNESCO may be expected to make, in the hope that this will not be too long delayed.

(b) Members noted however that

i. there is already reasonable agreement between hydrographers on the standardisation of basic temperature, salinity and depth measurement techniques, while

ii. standardisation of phytoplankton methods was discussed at the ICES Symposium on Primary Production, held in Bergen in 1957, so that meanwhile ICNAF countries should be recommended to follow the recommendations of that Symposium.

iii. Members also noted that ICES is holding a symposium on zooplankton, or secondary production, in Copenhagen, this year, and that this will include a discussion on methods of collecting zooplankton; the party therefore considered that ICNAF should await the outcome of that discussion, and then consider adopting its recommendations pending the report from UNESCO.

Further, members noted the experience of ICES countries in standardising methods in several joint programmes, such as that of the nine-boat Faroe-Iceland Ridge survey conducted in 1960, and they agreed that it was most important, in any ICNAF collaborative programme such as that proposed elsewhere in this report (p.14) and in smaller programmes, that standardisation of methods should be agreed at the planning stage. Methods of compiling and reporting results should also be agreed when planning such surveys.

2. Compiling, Collecting, Synthesising and Circulating Data

The available information on existing and projected world data centres was discussed at some length, and is set out in Appendix V.

(a) Hydrographical Data. The Working Party consider that, in view of the existence already of at least three established modern Data Centres covering the ICNAF area for hydrographical observations, the setting up of an additional and separate Data Centre under ICNAF is unnecessary. Providing that the following conditions are fulfilled, it is recommended that ICNAF members should submit their hydrographical data to any of the recognised Data Centres:

i. that all hydrographical information from and pertaining to the ICNAF area will be procurable from the same Data Centre by any country or agency;

ii. that there are facilities for the interchange of these hydrographical data among the Data Centres;

iii. that the methods of recording hydrographical data at the several Data Centres are uniform.

The doubts which exist in regard to i., ii. and iii. can be discussed and as far as possible resolved at a meeting to be held in conjunction with the ICNAF Annual Meeting in Woods Hole in May 1961, members of the Working Party undertaking to arrange for the attendance at this meeting of authoritative spokesmen in respect of the existing Data Centres.

(b) Biological Data

The Group noted that (1) the Intergovernmental Conference on Oceanography had agreed that the World Data Centres should eventually file biological data, but that no system had been discussed; (2) the U.S. National Oceanographic Data Centre committee had considered storing biological data but had made no announcement concerning their conclusions.

The Group therefore agreed to make no recommendation at this stage, except as follows:

Meanwhile, and particularly pending international decisions on these points, the Working Party endorses for the ICNAF area the recommendation of the Subcommittee on Environmental Research, made at the 1959 meeting, that each country should send annually lists of hydrographic stations occupied during the previous year, their dates and the kinds of information collected (Red Book for 1959, p.68). These lists should also include reports of plankton and other biological data collected and might conveniently be in the form of quarterly charts showing the stations occupied, distinguished as to objectives, etc.; they should also show to which data centre any data have already been, or will be, sent.

Members further wished to emphasise the importance of early analysis of data and the early reporting to the Commission of the results.

APPENDIX I

Meeting of the Environmental Working Party

Informal meeting of available members, held during the ICES meeting in Moscow, 21 Sept. 1960.

The Working Party was convened informally by Dr. Lucas (Convener) in order to make plans for the full meeting of the group in Aberdeen. Present: Dr.Ju.Ju.Marty (with Dr.M.V. Fedesov and Dr.A.P.Alexseev), Dr. F. Hermann, Dr.L.M.Lauzier, Professor G. Dietrich, Dr. G. Krefft and Mr.A.J.Lee. The group was informed that it would not be possible for Dr. Walford and Dr. Meyer to serve and that Dr. Krefft was taking the place of Dr. Meyer; unfortunately, Mr.J.E.King, representing Dr. Walford, had not arrived in time for the meeting(1).

The Convener briefly outlined the events leading to the appointment of the Working Party, referring first to the objectives set out in items (a)-(f) on page 2 of the Report of the ICNAF Environmental Subcommittee, and then to the specific questions put to the groups - (a)-(e) on page 4 of that report. He emphasised the need to concentrate on definite problems if progress is to be made, as well as the need for hydrographers and biologists to work together - in committee, in the field, and in the laboratory - on these problems.

Data. In response to the Convener's request for lists of hydrographic data relevant to the ICNAF area, Dr. Lauzier and Dr. Krefft had already been able to provide drafts of data obtained by Canada and the Federal Republic of Germany, respectively. The manner in which these had been completed was discussed, a few modifications were suggested, and it was decided that lists from all countries in similar form would be of great value. In general, they should indicate the range of data in some detail for the years 1950 onwards, with broader indications of previous data, particularly when available for key stations over long periods. Lists should include bibliographies of published data and relevant papers, as well as of laboratory reports where possible; indications of how raw data can be made available would be valuable. Dr. Marty and Dr. Hermann foresaw no difficulties in providing similar information for the USSR and Denmark within about two months, and it was understood that a list for the USA was already being prepared.(1) The Convener was asked to request similar lists from other member countries via the Secretariat (preferably 10 and at least 7 copies).

Preparatory Work. Dr. Hermann was arranging for preliminary correlations to be made of surface temperature and wind data, with those of larval abundance and year-class strength of cod in the Greenland area; he would also see whether sufficient deep temperature data were available for similar correlations and compare distributions of surface and deep data. These steps were welcomed by the group and reference was also made to the probable relevance of a paper already contributed by the Federal Republic to a WMO publication(2); it was felt that useful correlations might be obtained on the basis of air-pressure gradients between Weather Ship B and other coastal stations. Relevant data could also be obtained from publications of the U.S. Coast Guard (International Ice Observation and Ice Patrol Service in the North Atlantic Ocean), and in due course charts would be prepared of the collaborative surveys made in spring and autumn under IGY, once funds were made available. The Convener referred to the U.S. offer to provide from their Hydrographic Office 10-day charts of surface temperature distribution and it was agreed that they would be valuable to all members and indeed to all member countries.(3)

Consideration was again given to the specific questions (a)-(e) put to the Committee, and the Convener emphasised the need for conjoint biological and hydrographical investigations directed to particular problems. The value of collaborative hydro-biological surveys under ICNAF, say once per year, was also emphasized. As to past data, the chief problem would be how to organise and integrate them economically so that all could use them to the best advantage; this might best be done by workers in each country assuming responsibility for selected problems in particular areas. Both of these questions were to be considered further in Aberdeen and recommendations made to the Commission for 1962. Members were asked to keep them under review meanwhile.

It was decided to concentrate during the Aberdeen meeting particularly on cod, whilst noting any information relevant to haddock and redfish which might emerge. Consideration was

then given to the biological data available. It was decided to request as soon as possible before the end of the year

(1) summaries of information on life histories, spawning areas and seasons, larval drift, nursery grounds and fishing areas of cod (with all times and dates as far as possible), perhaps most suitably in the form of 1 or 2 charts for different areas (the names of Drs. Templeman, Yves Jean and Martin from Canada, Hansen from Denmark, and Wise[4] from USA were suggested), and

(2) relevant information being compiled by the ICNAF Working Party on Fish Stock Assessments, particularly of long-term data.

It was felt that it might also be useful if, during the Aberdeen meeting, the temporary assistance of U.K. workers concerned with such matters (such as Messrs. Beverton and Parrish) could be sought, and Dr. Lucas thought that this might be possible.

Date of Aberdeen Meeting. Since this meeting in Moscow had allowed arrangements to be agreed in advance, it was decided that the formal meeting in Aberdeen should be held in March. All those members present would be available throughout March, and it was decided for general and personal convenience that the dates of this meeting might most suitably be arranged in relation to those of the meeting of the Assessment Group in Lowestoft.[5]

In adjourning the meeting, the Convener thanked the members and other scientists who had taken part for their assistance.

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(1) Mr. King subsequently arrived in Moscow, when he was given an account of the meeting and kindly took part in some useful discussions with Dr. Lauzier and the Convener. He brought with him a useful compilation of U.S. hydrographic data, for the period 1958-1960, and it is understood that this can conveniently be extended in accordance with the desires expressed by the meeting.

(2) Mr. Lee has now kindly provided a reference to this publication ('Relations between maritime meteorology and fishery biology: Relationships between meteorological factors and fish distribution', submitted by the Federal Republic of Germany, Item 22, CMM-III/Doc. 9, World Meteorological Organization: Commission for Maritime Meteorology, Third Session, Utrecht, 14.VII.1960).

(3) It is understood that the first of these charts will soon be available and copies thenceforth will be circulated to all members of the group.

(4) Mr. King's information is that Mr. Wise has now resigned from the U.S. Fish and Wildlife Service and this enquiry will therefore be directed to the U.S. Laboratory at Woods Hole.

(5) Subsequent discussions with representative members of the various North Atlantic working parties due to meet during March led to a proposal that this meeting be held in Aberdeen across the dates 14th-20th March inclusive, so as to fit most conveniently with the travelling of members who also have to attend other working parties.

APPENDIX II

Meeting of the Environmental Working Party

List of papers etc. circulated to members of the Working Party and deposited with the Secretariat.

1. Hydrographic investigations in the ICNAF Area made by Danish ships.
2. Hydrographic investigations in the ICNAF Area made by German ships.
3. Mean sea surface temperature charts (U.S.)
4. Inventory of U.S. bathythermograph data.
5. Oceanographic station data provisional chart (U.S.)
6. Representative list of U.S. cruises conducting hydrographic work in the ICNAF Area (1958).
7. Oceanographic observations made by the Fisheries Research Board of Canada in the ICNAF Area during 1950-59.
8. Table and lists of U.K. hydrographic data collected in the ICNAF Area 1950-1960.
9. Chart of hydrographic observations from the ICNAF Area listed in the Lowestoft Laboratory.
10. Hydrographic investigations in the ICNAF Area made by Norwegian ships.
11. Preliminary report on oceanographic observations obtained by the USSR in the ICNAF Area
12. Details of Icelandic cruises in the ICNAF Area, 1958-60.
13. Information concerning environmental observations obtained in the ICNAF Area by the Station de Biologie Marine, Grande Riviere.
14. "Relations between maritime meteorology and fishery biology" (Germany). (ref. in note 2 of Moscow meeting, Appendix I).
15. Mr. Hermann's paper on "Correlations between the West Greenland stock of cod and environmental factors".
16. German analysis of data on atmospheric circulation in the Northwest Atlantic Area.
17. Summary of biological information on cod in Subarea 1.
18. Summary of biological information on cod in Subareas 2 and 3.
19. Summary of biological information on cod in Subarea 4.
20. Summary of biological information on cod in Subarea 5.
21. Report on the distribution of redfish larvae obtained in the ICNAF Area with the Continuous Plankton Recorder, etc.
22. Preliminary report on plankton sampling (CPR) between Iceland and Newfoundland.
23. Notes concerning recent tagging projects and plankton work undertaken from the St.John's Station.
24. Notes concerning plankton and other work undertaken from the St.Andrews Station.
25. Charts illustrating special biological cruises made from the Woods Hole (Fish and Wildlife Service) Laboratory.
26. German observations on type composition of the redfish sampled at the Bremerhaven fish market.
27. Notes from the Lowestoft Laboratory on fishing off Labrador.
28. Charts of the distribution of Sebastes, mentella and marinus, in Subareas 1, 2 and 3 (USSR)
29. Notes on relevant points for consideration arising from the Fish Assessment Studies.

APPENDIX III

Meeting of the Environmental Working Party

Notes on Problems encountered by Fishery Assessment Working Group

General

The main task undertaken by the Fishery Assessment Working Group has been to examine the effects of fishing on the principal stocks of cod, haddock, redfish and halibut in the ICNAF region, and where possible to estimate the immediate and long term effects on yield of changes in the codend mesh size in the trawl fisheries, and also the effects of other possible conservation measures.

While, as the Second Progress Report of the Working Group (presented to the Research and Statistics Committee at the Bergen Meeting in June 1960) shows, substantial progress was made in fulfilling this task, the Group was unable, for some fisheries to make detailed, precise assessments. This was due in some cases simply to incomplete or inadequate sampling data for estimating the parameters of the exploited stocks but in others (notably redfish and halibut) it was due to the lack of more fundamental biological information concerning, in particular, identity and delimitation of unit stocks, the seasonal movements and mixing of stock components, and the longer term fluctuations and trends in distribution, composition and abundance in each exploited area.

The provision of more precise information on these important problems must constitute the principal objectives of future biological research in the ICNAF area, and it is in relation to some or all of them that associated environmental research is likely to be most profitable. In view of the large number of important unknowns, the vastness of the region and its environmental complexity, a most important first step is to identify and delimit the principal research requirements, and to assign priorities, in order that the limited research vessel and other resources can be deployed most efficiently and effectively in relation to them.

Priority Problems

In the following notes, an attempt is made to itemise some of the gaps in current knowledge and difficulties concerning aspects of the biology of the main ICNAF species, encountered by the Fishery Assessment Working Group, which may be of relevance to the planning of future environmental research in the area.

1. Subarea 1 Cod (West Greenland)

Current evidence indicates that the cod fished off the West Greenland coast do not form a single unit stock. Those fished inshore in the coastal fjords are distinct, and do not mix with the major offshore concentrations, fished on the banks between Cape Farewell and 71°-73°N. However, it is not clear whether the offshore cod form one stock, which mixes freely throughout its range, or whether it forms two or more stocks with little or no mixing between them. The results of tagging experiments conducted over a large number of years suggest that the latter is the case, and that at least two groups, a southern one, in Divisions 1E and F, which is closely related to the East Greenland and Icelandic stocks, and one or more northern ones in Divisions 1, A, B, C and D.

At present, however, the number of offshore stocks, their boundaries and their seasonal and longer term movements are not known clearly (for its purpose, the Fishery Assessment Working Group treated the offshore cod as a single unit). Furthermore, it would seem that the biological situation in this region, which is at the extremity of the cod's range, is governed critically by climatic and environmental factors. For example, in some seasons, bottom temperatures on the offshore banks are close to, or even below, the average minimum tolerance level for cod and this probably governs the seasonal distribution, availability and pattern of movement between deep slope and shallower bank water and also the annual survival rates of the exploited concentrations. Similarly, as observed in the 1920's and 1930's longer term trends in the climatic and environmental situation in this region would probably

have important effects on the extent of the cod's distribution in this area, their annual survival, migration and growth rates and the permanence of the stock groups.

It seems clear therefore that detailed and intensive long term biological and environmental studies are required in this area, in order to elucidate further the current stock sub-divisions and their relations with the environmental complex, and perhaps more important to provide evidence of environmental trends critical to the distribution, abundance and survival of each of them.

2. Cod in Subareas 3 and 2

The cod fisheries in Subarea 3 (Newfoundland) like those in Subarea 1, are amongst the most important in the ICNAF area. They reached almost half million tons between 1954-1957. The Subarea 2 (Labrador coast) cod fisheries are much smaller, being confined principally to inshore grounds. However, for the present purpose, it is convenient to group them with the Subarea 3 fisheries.

As a result of longer term and more intensive research, principally by Canadian (Newfoundland) workers, more is known of the biology of the cod in this region than in Subarea 1, especially with regard to stock separation and identity. Current evidence indicates the presence of the following stocks, between which there is little or no mixing:-

(a) East coast of Newfoundland (Divisions 3K and L)

This stock probably also extends into the Labrador area.

(b) Central and southern Grand Bank (Divisions 3N and O)

(c) South and west coast of Newfoundland (Division 3P)

The fish in this area mix freely with those in Division 4R and form with them a common stock. More recent analyses suggest that the cod in this area may in fact be split into more than one stock.

(d) Flemish cap (Division 3M)

The stock in this area is a relatively small one.

Particular features of the cod fisheries based on these stocks, and their biology, of importance to the Fishery Assessment Group's analyses and of relevance to the present group, are as follows:-

(a) Many of the fisheries exhibit seasonal inshore-offshore (e.g. Division 3K and L), or deep water-shallow water movements (e.g. Division 3N and O).

(b) These movements coincide with seasonal environmental changes (e.g. temperature), by which they may be governed.

(c) Wide fluctuations in yields are experienced in the seasonal or total annual fisheries, which again seem to be related to annual environmental fluctuations.

(d) The fishery in any locality is often sharply localised, again it seems, in relation to the specific environmental complex in the region.

(e) The growth rates of the stocks differ markedly between themselves and also differ from those in Subareas 4 and 5, of which the former is more or less in the middle of the cod range and the latter at the other end.

Thus, the cod stocks in these subareas, like those in Subarea 1, encounter wide fluctuations in environmental factors, both seasonally and from year to year, which may govern

critically, the short and longer term distribution, movements and survival. Further, at least in the northern part of the area, the fish are near the extremity of their biological range. Again, more detailed study of the short and longer term changes in the environmental situation is required, to determine the permanence of the current stock situation, and its influence on the distribution, abundance and survival of each stock unit.

3. Redfish: Subareas 1, 2 and 3 (eastern and northern part)

Apart from Subareas 5, 4 and the southern and western parts of Subarea 3, the redfish fisheries in the ICNAF area are of relatively recent origin. However, in recent years, large redfish fisheries have developed on the continental slops in Subareas 1, 2 and 3 (Divisions 3K, L and M) and are now of major importance.

Racial investigations have shown that the redfish exploited in the former regions of a different group from those exploited in the newer slope fisheries. It is possible therefore to make a first sub-division of the redfish population in the ICNAF area into the two groups, the rosefish of the American and Canadian east coast and the redfish of the oceanic slope regions.

Relatively little is known of the general and population biology of the oceanic slope form (Sebastes marinus), on which the new fisheries and those in the north-east Atlantic (e.g. Icelandic area, Barents Sea) are based.

The fisheries for this form in the different areas are known to take place on the edge of the continental shelf, or on the slopes of oceanic banks in depths ranging up to 300-400 metres. The principal question is do these exploited groups constitute the fringes or isolated offshoots from a very large oceanic population, from which they are replenished either continuously or periodically, according to the environmental situation in the area, or do they constitute distinct unit stocks?

It is known from plankton surveys in the northern part of the eastern and central Atlantic that larval distribution is very widespread, thus pointing to a large oceanic population, but it is not known what relation this bears to the groups exploited at present.

The answer to the above question is important for the assessment of the effects of fishing on the exploited concentrations of Sebastes marinus and in gauging the importance of conservation measures. The statistics of the fisheries in some areas (including those in the north-east Atlantic) show rapid and sharp declines in catch per unit effort following the commencement of exploitation.

It is clear that a close and more extensive study is required of the distribution and abundance of the oceanic redfish population, its seasonal and annual changes, and its link with the exploited groups. Associated environmental studies are required to determine the factors determining these limits.

4. Halibut: all subareas.

There are no halibut fisheries in the ICNAF area comparable with those for cod, haddock or Sebastes, but it is, or has been fished in all subareas.

Very little information is available on halibut biology in the whole area. The results of tagging experiments suggest that there is little or no interchange between Subarea 1 and other ICNAF subareas, but information on further sub-divisions of the population is incomplete. Little is known of the factors governing the distribution of halibut, its spawning localities, and their environmental features.

5. Haddock in Subarea 3

The ICNAF haddock fisheries are located in Subareas 3 (3N, O and P), 4 (4X, V and W) and 5. Separate stocks occur in each of these subareas.

A striking feature of the Subarea 3 haddock fisheries since the war has been the marked short term fluctuations in yields, due to large short-term changes in the abundance of the exploited stock. This has been shown to be due to very large fluctuations in year-class strength. Fluctuations in year-class strength are of course common to all of the haddock stocks in the ICNAF area, but in this subarea they are of exceptionally large magnitude. The fishery is therefore often dependent for its success on one, or at the most two year-classes.

As for most other species in this and other regions, the factors governing these fluctuations are not known, but it is significant that they occur towards the extremity of the haddock's range in a region subject to a highly variable environmental complex, by which they may be critically governed.

Conclusions

These examples do not cover all the gaps in current knowledge of those aspects of general fish biology in the ICNAF area, of major relevance to reliable fishery assessment. For example, no mention is made of the magnitudes of the apparent natural mortality rates, information on which is lacking, or is incomplete for many of the stocks. However, they may serve to illustrate some of the more important sorts of problem with respect to which environmental research might be most usefully planned. It is clear that a number of the important current fisheries in the ICNAF area are centred on stocks of fish near the extremity of their biological range, where their distribution, abundance, growth and survival are most susceptible to short term changes and longer term trends in the environmental complex. The species and regions where this seems to be most critical are as follows:

Subarea 1	cod
Subarea 2	cod
Subarea 3	cod and haddock
Subarea 1, 2 and 3	redfish
Subarea 5	cod at the warmer end of its range.

Fishery assessments, on which possible future conservation measures may be based have had to be made for these stocks on the biological situation as it is known at present. It is of great importance that a close check should be maintained on this situation in order that significant changes, particularly of a long term nature can be detected, measured and if possible assigned to their causal agencies. It seems therefore, that attention might be focussed on detailed long term environmental studies, linked with associated biological studies, in one or more of these "critical" areas. The cod in Subareas 1, 2 or 3, or the haddock in Subarea 3 might form the starting point.

APPENDIX IV

Meeting of the Environmental Working Party

March 1961

Notes on the value of hydrographic sections being made in the area

1. Standard hydrographic sections are of value in that, if they are worked for a long period at fixed times during the year, they yield indices of certain variables such as temperature, salinity and current. These indices can be used for identifying both long and short term oceanic climatic trends in an area and for calculating correlations with year-class strengths, but it must be borne in mind that such correlations are no proof of causality.

As it is probable that such factors as temperature and currents have greatest influence on the fish during its larval stage, it is especially important that the sections are worked at the time of the year when the fry is planktonic.

However, before the indices can be used with any confidence, some knowledge is required of the representativeness of a particular section in a particular month. For example, are the changes in the oceanic circulation so rapid, or the internal wave effects so great, as to make a section meaningless as an index to conditions in a particular season?

2. The sections are of little use for determining actual current speeds because of the limitations of the method of dynamic computations, unless some direct current measurements are made at fixed points to which the dynamic computations can be related. The drift of icebergs in the Labrador-Newfoundland area has been used as such a check. The failure of the method to give absolute current values lessens the confidence that can be placed on the index of current referred to in para. 1, particula ly in the bank and slope parts of a section. Nevertheless, although the absolute values of current may be wrong, the relative values will not be so greatly in er or, so that the index can still be used with certain provisos.