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ICNAF Environmental Symposium
Rome, 27 January-1 February, 1964

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ICNAF Environmental Symposium
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Report by Chairman
Dr. C. E. Lucas

It was Dr. Lionel A. Walford who, while Chairman of the Research and Statistics Committee, first suggested that ICNAF should hold a Symposium concerning the effects of the environment on the fisheries in its area, but it was not until March 1961 that a working party met at the Marine Laboratory in Aberdeen, with the specific task of advising the Commission on environmental matters.

In particular, the Commission requested advice on

(a) the effects of the environment on the survival of the eggs and larvae, growth, long-term abundance and distribution, of cod in particular, but also of redfish and haddock;

(b) how studies of such matters might be directed so as not only to provide evidence of associations and correlations but also to lead to prediction;

(c) what fundamental studies requisite for such investigations and not already proceeding should be initiated; and

(d) how plans could best be laid for holding an Environmental Symposium.

In order to prepare for their task, summaries of information already available to scientific workers under the Commission were drawn up, and these at once revealed that, while there was an abundance of salinity and temperature data for the area, there was a relative scarcity of biological data and a greater scarcity of "chemical" data. Since that time, as the Symposium has shown, there has been some improvement, although this is still largely true, as is shown by the fact that, out of seventeen papers concerning the effects of physical factors, fourteen were directed to evidence from temperatures.

It was in the light of such information that the Working Party recommended, and the Commission subsequently adopted, a general programme of environmental studies (ICNAF Redbook for 1961, pp. 69-86), to include experimental and physiological investigations, and prepared a programme for a Symposium divided into eight sections, each concerning a specific aspect of fisheries environmental problems (p. oo). Of the former, it is possible to say now that several aspects of the environmental programme are in progress, and that in particular the first multi-ship survey of a considerable area of ICNAF waters has been completed under the leadership of Mr. A. J. Lee, and reports on it are being prepared.

Only one significant change was made in the original programme for the Symposium, arising from the recently developed offshore fishery for herring in the southern part of the ICNAF area, as a result of which it was decided to provide an additional section, concerning the environmental aspects of the life of the herring in the N. W. Atlantic. A very important point, however, was the recognition that, while the Commission is responsible for a strictly prescribed area, neither the fish nor their environment are so restricted. Stocks of both cod and redfish, for example, extend almost continuously from the southern part of the area to the north, through Icelandic waters and across to the Barents Sea and Spitsbergen; other species also have wide distributions and the Commission resolved to request the assistance of scientists of the ICES area, in subscribing to a Symposium which in fact would be focussed on the principal groundfish of the North Atlantic area. Work done in the North Sea and other marginal seas was to be excluded, as also pelagic fish in general, but although the objectives of the Symposium were to be limited in this way, it was also recognised that environmental aspects of research on other marine species might be very relevant, so that four special lecturers were invited to provide (a) an up to date account of the hydrography of the North Atlantic area and (b) reviews of environmental studies in relation to the Pacific tuna and sardine fisheries and the Atlantic herring fisheries. Moreover, although the special lectures were to be delivered in full during the Symposium, arrangements were made for all the other contributions to be written and circulated in advance, so that only brief accounts of them need be provided at the meeting, and the bulk of the time available could be given to discussion.

Reference should be made here to the arrangement to hold the Symposium in the FAO Building in Rome, for which ICNAF and the organisers are greatly indebted to the courtesy and hospitality of the Director General, Dr. Sen, and his staff in Fisheries Division. This kind gesture not only solved an urgent problem, but provided a sense of occasion for the whole meeting.

The special lectures and contributions, in somewhat reduced form, are available for all to see in this volume, together with the reports of the Section Conveners. It remains here to give some general impressions of what was undoubtedly a most interesting and valuable symposium, and to express my personal appreciation of the efforts not only of the special lecturers and contributors but of the Secretariat of ICNAF and all those who helped in various ways to prepare for and to organise the Symposium itself. Just examples of the interest it attracted are the facts that some ninety contributions were received and that some seventy scientists attended from twelve countries, several from outside the area. An idea of the progress made in the last few years may be obtained by comparing it with a somewhat similar Symposium organised by ICES in 1951, which attracted only one "physiological" paper, whereas in 1964 it was possible to devote a whole session to experimental and physiological studies (although there was a general feeling that such work needed to be intensified considerably.) It may also be fair to suggest that some of the lessons of that 1951 Symposium have still to be fully digested!

What then came out of the Symposium, apart from the special lectures and numerous contributions of which this volume is a permanent record - of facts and suggested correlations, hypotheses and ideas, and new growing points? Among other things, it attracted from the archives masses of data which might otherwise have taken long to see the light of day! It led to valuable discussions of present problems and future needs. If one has to select one most prominent problem, it concerns those correlations and associations suggested as illustrating relationships between different aspects of life in the sea, both in this Symposium and elsewhere. From one point of view, one of the chief objectives of the "environmentalists" has been to provide evidence for associations between two or more variables. In our environmental studies, one is never concerned simply with any single factor, but always with its possible relationships to the fish and the fisheries themselves, and the usual approach is through the use of correlation analysis. But the elementary assumption that such a simple relationship exists in an inherently complex ecological system is all too often fraught with danger. It is a disturbing thought that we must immediately be dissatisfied with a "very good" correlation in such circumstances, if only because it is so unlikely that life in the sea is as simple as that, particularly when, as so often, the correlates may be separated by several ecological levels, as between the groundfish and the plankton, for example. Here and elsewhere there is the great danger of fallacious, or over-simplified, associations - and in several sections the dangers of this approach were apparent, particularly when trying to provide causal interpretations which might be used for prediction.

This is not to say that correlations should not be looked for and studied, but they require the greatest care in sampling and analytical techniques, and they require either the passage of time for their testing or the application of specific experiments to investigate the basis of the correlations. And even when the raw data are themselves sufficiently reliable, as, for example, series of temperature data with associated data concerning the abundance of organisms, say fish, there is always the snare that in fact the organism may not be responding in any direct manner to temperature, but that the association may in fact be with some other factor, itself associated with temperature. Also, simple temperature associations may themselves be modified by, say, food associations, or change markedly with season. Oceanographic parameters prescribe the containment of fish populations but nearly always we require much more basic knowledge of the ecology and dynamics of both the fish populations and the organisms with which they are associated. To just what factors are the organisms reacting? So often we know too little and there is the greatest need for more detail and more precise experiment and physiological study.

For all that, and particulary where reliable data can be obtained, we do need long series of records, such as temperature records, for associating with fishery data, either directly or through other variables in the ecological pyramid. Although no formal resolutions were passed in this Symposium, (these were left for the Environmental Sub-Committee to consider), it was widely recognised that one ultimate aim must still be to draw on past data so as to be able to predict future events, and that the effects of long-term climatic trends could be most important. Thus it was particularly valuable to have comparisons of hydrographical events in the eastern Atlantic with those in the west, sometimes similar and sometimes otherwise. Such changes in environmental characteristics are far from simple, however, and they are best studied from long series of systematic data (such as some we have now which should be continued and indeed extended, perhaps particularly through the use of instrumented oceanographic buoys). But we urgently need to understand more of their motivation, the processes underlying them and perhaps particularly of their links with meteorological events, air-sea interface relationships, which themselves are of direct interest to fishermen, as some papers ably showed.

Turning now to experimental and physiological studies, despite the progress made during the last ten years, it was some of those who had helped to make this progress who were most conscious of the need for much more detailed knowledge than we have at present of fish physiology and behaviour, and particularly of the sensory channels and the hormone systems that regulate behaviour. How do fish and their larvae react to currents, for example, and how to changing light intensity? Data collection alone is inadequate, for the understanding which is essential. Just as a knowledge of the processes determining vital changes in the oceans is essential, so we have to acquire more understanding of the organisms' reactions to such physical changes, and their rates of change, and of course to each other. While much of this work can and must be done in the laboratory, or on shore in relatively large tanks, much can only be usefully undertaken at sea, sometimes by the study of conditions and life within quite small areas: or within small populations where detailed observations can be made of the fish and the several aspects of their environment at the same time, such as has been suggested by the Herring Committee of ICES for the elucidation of key herring problems.

In fishery research one is, of course, concerned sooner or later with all levels of the ecological pyramid, and in the life of the fish itself there is always the question as to which stages in its life history are the most susceptible to environmental changes and on which to concentrate most productively. Apart from the obvious relevance of the adult stage, most attention so far has been devoted to egg and larval studies but, not for the first time, the question was raised in these meetings whether (a) the resources so far given have been adequate to provide significant results, and (b) in some instances at least, year-class strength and recruitment might not be determined more by mortalities at a rather later stage than those usually examined. In making these points, those concerned were seldom trying to suggest that the relationships existing between larval densities and fish stocks were irrelevant, but rather to ensure that henceforth investigations at this level should be intensive enough to support the conclusions that might be drawn from them, and also to ensure that too facile assumptions were not made that adult numbers depend, or do not depend, substantially on success during critical egg and larval phases.

Many more, and more intensive, egg and larval surveys will undoubtedly be needed, but it is becoming evident that much more attention must be paid to the adolescent stages in the life of the fish which follow the first year of its life, and possibly even the second, and that mortalities should be followed through these as well as in the earliest stages.

Thus, in another context, the meeting was faced again with the need for intensive as well as extensive studies, and reference was naturally made to the ICNAF Environmental Survey, on which some communications were based, and Mr. Lee briefly reported, during the final discussion. In many respects, despite unusual natural difficulties, it had been surprisingly successful - and had certainly shown how by international co-operation a large area can be covered several times in fair detail. Yet 1963 scarcely seemed to have been a "typical" year! Good egg production was followed by very sparse distribution of larvae, both of cod and redfish. Although these surveys were made, the key to the critical point of larval failure may be missing. There was at once keen appreciation of the great efforts made and widely expressed views that at least one more set of surveys must be made (a) to examine conditions in another and possibly more "typical" year and (b) to do this, through international co-operation, in even greater detail. For some purposes, of course, greater detail in certain parts only of the work may suffice.

It is scarcely necessary to add that once again the question was raised as to the information needed by the biologist from the hydrographer to solve his problem, and experience is showing more and more that the essential thing is for hydrographers and biologists - and members of other disciplines - to work together on these problems. This was stressed in the ICES Symposium on "Fisheries Hydrography" in 1951 by Professor Sverdrup, who said that hydrography "must take its place as an integral and indispensable part of the combined effort"! Paraphrasing Professor Sverdrup, the Chairman then said "It is the task of the biologist to demonstrate the reactions of the fish towards different types of environment. In the light of this knowledge the hydrographer should study the processes by which the environment is changed, as well as its momentary condition, so as to be in a position to forecast hydrographic situations of fisheries significance. In particular he made a plea for the hydrographer and the biologist to meet daily and to learn to write and speak so that each understands the other, as well as to disseminate their information speedily." This seems to apply as much today as it did then!

It also became clear that no longer can the "hydrographer" be content merely with measuring temperatures and salinities. In conjunction with their biological colleagues, they should also be measuring water movements, both large and small scale, and the nature and intensity of light at different times and places, and investigating their effects, along with more chemical aspects of the environment.

It might seem almost equally unnecessary to add that biologists and hydrographers, and others, must plan carefully so as to have a reasonable chance of securing the information that is seen to be needed. Yet not only are resources often inadequate enough for this, but often workers are almost too easily satisfied with what is available without the extra effort which alone can promise results. The sea is vast, and the fish roam widely in it. If our work is to be successful, then we have to plan for an ingenious and economical mixture of extensive investigations for certain purposes and intensive - indeed, intimate - investigations to provide the understanding of the processes, biological as well as physical, which govern events over the wider areas: and often the second of these must be tackled first! Indeed, as one of my colleagues expressed it, perhaps the greatest value of the Symposium was that it provided a valuable "confrontation" on several aspects of fisheries research. These and many other matters arising should give food for thought to environmental workers and fish research generally for some time to come.

- A.1 -

ICNAF Environmental Symposium
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Report on Section A

Effect of physical environmental conditions on the distribution of adult fish
(i.e. immediate and seasonal effects)

Convener: A.J.Lee   Rapporteur: J.A.Corlett

In introducing this section Lee referred to the Symposium on Fisheries Hydrography held by ICES at Amsterdam in 1951. Professor H.U.Sverdrup, in his address, had suggested that fisheries hydrography should be concerned particularly with the prediction of availability, i.e. where fish are in space and time, and with the prediction of stock size, i.e. year class strength. In Lee's opinion the hydrographers in pursuing these aims have gone for "short cut" methods such as correlations to predict year class strengths, and the weakness of this approach had been revealed in the discussions on Section B. Much of the work has been concerned with temperature because it is easy to measure and because it may provide a way for fishermen to locate fish. The method of associating local fish distribution with the local temperature distribution is a short cut method as far as the study of factors influencing the distribution of fish is concerned. Temperature is related to such variables as depth, current and food, and it may be that the relations which we find between temperature and fish are not real and that they hide the true controlling factors. In the search for temperature and fish relations we have also tended to lose sight of the fact that the physical environment provides the oceanographic containment of fish stocks: if we combine the physical oceanographic structure with the right physiological trigger we will find the conditions for a self-maintaining and self-contained fish stock.

Of the seventeen papers originally presented to this Section, fourteen concerned the relations between fish and temperature in areas from Block Island Sound to the eastern Barents Sea, and they dealt mostly with cod and haddock. One paper concerned currents and Dr. F.R.H. Jones gave a talk on this subject, which is included here as Paper 17. One paper concerning light (18) was discussed in Section F on Physiology and not in this Section. The temperature papers can be divided broadly into those dealing with seasonal distribution related to temperature and depth of cod (2, 6, 12, 13), haddock (3, 8, 9) and other fish (1), those dealing with short period relations between fish distribution and the near bottom temperature distribution (7, 8, 11, 12, 14) and those dealing with fish living in, dying in, or avoiding unusually cold water (4, 5, 10).

Referring particularly to Paper 14, Blaxter, Beverton, Cushing, Lee and others took part in a discussion on the mechanisms by which fish collect on the favourable side of temperature boundary. It was suggested that fish might swim faster in the unfavourable conditions, but if these are colder they ought to swim slower; it was agreed, however, that a temperature difference of 2°C would probably not have much effect on swimming speed. South east of Bear Island in the spring of 1954 the temperature gradient amounted to 0.75°C per mile: cod have been shown to detect differences of 0.05°C, which in this case would be the change over 150 metres. But the fine structure of the gradient was not known and it might really have been much steeper than had been observed. At some times the fish in a particular water mass might be carried on to a bank in that water mass, but at other times such as north east of Bear Island in the summer of 1956, the change of temperature was due to in situ warming and the fish must have passed from one water mass into another. This discussion emphasised the need for more experimental work on the rate of change of stimulus to which a fish will react, and for more observations on the fine structure of temperature gradients in the water column and of current speeds near the bottom. It was reported that instruments such as trawl thermographs and anchored current meters have recently been developed and can help in tackling these problems.

When fish get into very cold water they sometimes die in large numbers and a discussion on this subject also took place in the Physiology Section, F. Incidentally, it was pointed out that icebergs do not usually cause death through cold as suggested in paper 5: rather, at Greenland, cod often congregate on the lee side of icebergs to feed on the rich plankton resulting from upwelling. Icebergs off Labrador and Newfoundland are, however, indicators of the presence of cold subsurface Labrador Current water.

It was suggested during the discussion that the temperature tolerance of cod appeared to be different on the two sides of the Atlantic, with fish being found in colder water in the north-west. However, a closer consideration of the evidence in Papers 2, 4, 10, 12 and 14 does not bear this out. What does emerge from these papers is that the cod in both areas tolerate lower temperatures in summer than in winter. "Winter" in this sense is from about November to about June. During winter cod are only found in small numbers in temperatures of less than 1.5° or 2°C, and the best catches are taken between 2° and 5°C from Nova Scotia to Labrador and in the Barents Sea. During summer (June to October) cod will tolerate lower temperatures, and large catches may be taken between 0° and 2°C. These large catches in cold water are usually of feeding fish, and in most cases the food is capelin.

Referring to Papers 12 and 13 Corlett spoke about the variation from year to year between 1949 and 1962 of the position of capelin spawning on the Finmark and Murman coasts. The westerly or easterly distribution of the shoals was not clearly related to the water temperature either at the time of spawning or in the previous autumn: and the distribution of the cod, feeding on capelin, seemed to be related more to the position of the capelin shoals than to the water temperature.

Midttun and others said that Papers 12 and 14 agreed as far as the temperature relation of the cod were concerned. But there appeared to be some difference in behaviour between the fish in the southern Barents Sea and those in the Bear Island-Spitsbergen area. Those in the south were mostly pelagic, while further north they were close to the bottom and were not always detected by conventional echo-sounder surveys such as that used by Midttun (Paper 12). The type of survey reported by Beverton and Lee (Paper 14) in which the fish echos near the sea bed were counted on a cathode ray tube, would detect all fish in the bottom 5 fathoms, but did not take account of fish that might be pelagic.

Speaking of the importance of studies of the environmental influences in fish stock assessments, Parrish said that the sorts of investigation which are of major importance are the identification of the boundaries between "population units", which can be treated independently, and the determination of large and persistent changes in the vital parameters of recruitment, growth and natural mortality. With each of these problems the identification of the causal environmental factors would assist greatly in understanding the observed biological features.

Following the papers on currents (16 and 17) the discussion was chiefly concerned with herring, contrasting the situation in the shallow southern North Sea where the fish may spend some time close to the bottom, with the deep Norwegian Sea where the herring do not go deeper than 400 metres, well above the bottom. Supporting Harden Jones' ideas (17), Steele said that it would seem possible that as part of their anti-clockwise migration the herring in the northern North Sea remain in the boundary current at the edge of the Baltic outflow rather than penetrating into the outflow water, although the outflow water contains the main concentrations of Euphausiids, on which the herring feed. Other speakers thought that Harden Jones' "spiral" was too simple to account for all the herring reaching the restricted spawning grounds in the southern North Sea in an area of complex currents. Concerning the Arcto-Norwegian cod, Eggvin said that many years ago Sund had suggested that the southerly migration to the Westfjord takes place in a deep counter-current. The existence of such a counter-current has recently been confirmed, but it is outside the edge of the continental shelf. On the shelf the current runs northeastwards, and the spent cod are in it during their return to the Barents Sea.

In summary Lee said that fisheries hydrographers had concerned themselves mainly with measuring temperature and salinity. As it was clear from the discussions which had taken place in this Section and in Section F that their biological colleagues were greatly interested in such factors as light and currents, he considered that they should be turning a considerable amount of their attention to the study of these.

Key to Papers

New Number	Author	Original Number
1	Edwards	A. 16
2	Jean	A. 7
3	McCracken	A. 8
4	Templeman and Fleming	A. 4
5	Templeman	A. 5
6	Templeman and May	A. 10
7	Cendrero	A. 1
8	Templeman and Hodder	A. 6
9	Templeman and Hodder	A. 13
10	Horsted and Smidt	A. 3
11	Pechenic and Svetlov	A. 9
12	Midttun	A. 17
13	Konstantinov	A. 14
14	Beverton and Lee	A. 12
15	Zharov	A. 11
16	Laevastu	A. 2
17	Jones	-
18	Woodhead	A. 15

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Report on Section B

Effect of the Environment on pelagic and early demersal stages of groundfish

Convener: R.S. Glover Rapporteur: J.M. Colebrook

Fluctuations in the fisheries are the result partly of migration, disease, predation and changes in the availability of the stock to capture but the greatest source of uncertainty about the yield is the variability of year-class strengths. This point was emphasized throughout the papers and during the discussion and it was clear that variations in the strength of a year-class must have their origins at some time before the fish enter the commercial fishery.

Such variations could result from changes in the numbers or mortality of eggs, through predation, developmental, metabolic or density dependent effects. Most of the authors and participants, however, thought it more likely that fluctuations in the strength of a year-class may arise during the planktonic or later phases of the development of the fish as the result of mortality or emigration. Gulland, in contribution B9, draws hypothetical curves showing the sequence of phases of mortality: at first massive (and probably unrelated to year-class strength), then density dependent, followed by the critical phase when the year-class strength is determined.

There is adequate evidence of the dependence of larval fish on various aspects of their external environment. For example, the distribution and abundance of redfish larvae seem to be related to water temperature and the supply of their planktonic food (papers B1, B3, B4 and B17). Russian work on the herring and anchovy shows that the abundance of larvae is dependent on the abundance of their food (B12). Haddock larvae are found in the thermocline off the New England coast (B5). The numbers of cod larvae off West Greenland are positively correlated with temperature (B14). Some of the participants in the symposium discussed the effect of water currents on the drift and survival of larvae. For example, fluctuations in the abundance of haddock larvae at Faroe are related to the strength and direction of wind, presumably through its effect on water movements (B6). In the same paper, Saville provides a detailed analysis of wind, water movement and larval drift in the herring stocks of the Clyde. Predation of 0-group cod by older fish of the same species may be dependent on the growth rate and nutritional condition of the young fish (B7).

There is less evidence of the dependence of year-class strength on the numbers of larvae although Gulland (B9) quotes work which suggests that the abundance of plaice larvae in their later planktonic stages may be related to year-class strength and he gives indirect evidence of similar relationships in Lofoten cod, North Sea haddock and sock-eye salmon. Saville (B6) shows that the abundance of haddock near the end of their planktonic phase near the Faroes was related to the numbers of one year old haddock which are a satisfactory index of subsequent recruitment to the fishery.

The analysis of such relationships must depend on adequate estimates of the distribution and abundance of the young stages. This information is difficult to obtain and has seldom been available in the detail and accuracy required. For this reason, fishery biologists have been compelled to study correlations between the parameters for which estimates are available; for example wind, temperature or planktonic food on the one hand, and the year class strengths on the other. Saville (B6) concludes that there is no relation between wind during the larval phase and subsequent year-classes of haddock in the North Sea or herring in the Clyde. Gulland (B9), in a number of references to his own and other work, finds no relationship (or rather dubious ones) between wind, temperature or plankton and subsequent year-classes of Arcto-Norwegian cod. However, Corlett (B10), using a different estimate of year-class strength, shows correlations between wind, dry weight of plankton and year-class strength of cod in the Barents Sea. Hermann, Hansen and Horsted (B14), whilst claiming that drift of larvae is a major feature of the early life of West Greenland cod, are unable to detect any relation between wind and brood strength. But they do find statistically significant correlations between temperature during the larval phase and the subsequent catch of 6 to 10 year old fish.

It is not surprising that the results should be confusing and contradictory. In a hypothetical case, let us exclude food supply, predation, competition and metabolism, and assume that the size of a year-class is related to the numbers of larvae at some unknown stage of their life history and that these, in turn, are dependent on some unknown function of water movement which, in its turn, is partly a product of the bottom topography and the earth's rotation and partly under the influence of winds. In this very simple model, fishery biologists would often be able to test only the beginning and end of the chain (wind and year-class). Even without the added difficulty of detecting the relevant wind parameter and of deciding how to estimate the strength of a year-class, it would be surprising if a simple linear correlation coefficient would be sufficiently sensitive to test the hypothesis. In the papers and discussions, the danger of fortuitous correlations was emphasized and, since each year yields only one pair of observations, research of this kind is likely to extend over a long period of years.

Some of the contributions drew attention to the importance of treating each population as a separate unit since growth, mortality and migration may differ in different patches of larvae. It was recognized that the numbers and distribution of larvae are dependent on a complex interaction of many factors. None of the physical and biological parameters of nature operates in isolation and it is a dangerous over-simplification to try to study them in isolation. The possibility of using multivariate methods to analyse the natural system as a whole is illustrated in contribution B2, dealing with sources of variation in the plankton.

Repeatedly, in the discussion, it was emphasized that we lack the basic ecological and physiological knowledge which is essential for an adequate understanding of events in the fish stocks. Few of the papers mentioned other organisms in the community, except as food for fish. As Dr. Ahlstrom's special lecture shows (p. 00-00), competition may be very important in determining the abundance of a commercial stock. It is notable that only one of the contributions (B7) deals with 0-group fish. Fairly detailed statistics are available for the adults in fished stocks and there are modest collections of the planktonic stages but there is a most serious dearth of data about all the stages of the fish life cycle between the early larval stage and the entry of adults into the fishery.

One of the most successful developments in recent years has been the method of studying the population dynamics of adult fish in which mortality and growth rates are ascribed to different causes and built up into quantitative models of events in a population. A similar method has been used in studying plankton production by constructing a model of the major terms (such as photosynthesis, respiration and grazing) and inserting into the model as many as possible of the factors impinging on each of these (such as light, temperature, turbulence and nutrients).

It seems highly desirable that an attempt should be made to bring together these two levels of model-making, based on an adequate understanding of the whole system of interacting variables of which fish form a part. Steele (C4) has made a tentative start in this direction with a model of the energy chain from photosynthesis to commercial fisheries.

Objectives of this kind will only be achieved if much greater facilities are available than in the past both for collections at sea and experiments in the laboratory. Frequent and detailed surveys will be needed to detect the critical events which determine larval mortality and year-class strength. But if such surveys are to be successful, it will be necessary to develop improved methods for sampling the larvae and young stages (B5).

We are still left in doubt about the precise critical phase; indeed Baranenkova (B15) concludes that every year class has its own period of maximum mortality. It would seem that a much greater effort must be directed towards an ecological study of the young stages. Knowledge of these pre-recruit stocks is essential in attempts to predict and control fisheries. The technical and intellectual problems are very testing and progress will be dependent on the integration of the skills of marine scientists of many kinds, and on cooperation between laboratories and nations.

- C.1 -

ICNAF Environmental Symposium
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Report on Section C

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

Convener: W. Templeman Rapporteur: A.W. May

Most of the papers of this section dealt with concentrations and behaviour of cod, haddock and other groundfish due to food. It was apparent from these papers (C1, C2, C3, C7) and from other papers (A6, A10, A11, A12, E2) that food can be a concentrating factor for commercial fish, allowing them to gather in large numbers within some part of a favourable temperature and depth range. These concentrations may be in different parts of the preferred temperature and depth range depending on the temperature and depth ranges of the food animals. It is evident that food can modify the temperature and depth preferences of fish and that such preferences can often be best explained in relation to food. The relationship of food to concentrations of commercial fishes should therefore be studied whenever catch and related temperature and depth data are being collected by research vessels.

In discussion Blaxter, with reference to cod becoming glutted with capelin and sinking to the bottom (C3), wondered whether there was any connection between this behaviour and a report in the Underwater Naturalist of "sleeping" cod. Corlett raised the question of how long it takes cod to digest food. He noted that Brunel (C2) quoted from Karpevitch and Bokoff that the time for digestion may vary from 5 to 6 days in the case of a fish meal and from 3 to 3 1/2 days for a Gammarus meal. Corlett's impression, from Barents sea cruises, was that digestion in cod was more rapid than this. Meyer, from personal observation, said that cod taken at mid-day in one of his cruises contained fresh capelin and those taken in the evening contained digested capelin. Templeman remarked that because of the fullness of cod stomachs in the Newfoundland area during the trap season digestion would take longer than this. Kohler said that cod kept in tanks digested a herring meal in 1 day but the cod were not glutted. Hempel said that plaice took 12-24 hours and saithe up to 3 days to clear the stomach, the time depending on stomach fullness and water temperature. Magnusson remarked that feeding of redfish in several areas occurred at well defined periods, thus the stomach would probably be cleared between these periods. Horsted noted that there were 2 daily periods of cod activity in Greenland in late summer and autumn. Food (plankton and capelin) taken in the morning period was all gone by evening. Edwards said that for 8 fish species investigated at Woods Hole there were clear-cut feeding periods, either once or twice a day. Indications from these, and from some observations at sea, were that the stomachs were cleared within 6 hours.

One paper (C4) examined the energy dynamics of the related trophic levels from phytoplankton to commercial fish and concluded that a great deal of the information necessary to apply primary production and related plankton and benthos data to estimation of potential yield of commercial fish is lacking.

There was considerable discussion on the point raised by Beverton as to whether availability of food to adult fish is influenced by their own abundance. In comparing pre- and post-war plaice stocks in the North Sea (Steele) there was an increase in yield, but also an increase in growth rate after the war which is opposite to what is to be expected. It is necessary to distinguish between food as a controlling factor and food fluctuating independently of the fish (Beverton). The plaice food supply had evidently changed but this was not related to density of plaice. Plaice larvae and Ammodytes larvae compete for food and it is possible that Ammodytes may be "controlling" the plaice. The availability of food in relation to growth is likely to differ in different sizes of fish of the same species which use different sizes and kinds of food (Templeman). If large fish are greatly reduced in numbers the large food is not utilized. These kinds of food such as capelin, herring and launce may become more numerous and eat great numbers of the fry of the former predators such as the cod. If the smaller commercial fish are more numerous they are now competitors for food of a small size range and here density dependent effects may be more likely to occur. Flatfish in the Kattegat ate only 2% of the available bottom food and the large changes in stock size of Norwegian herring did not affect the growth rate (Hempel). These results indicate that other factors, rather than food supply are responsible for limitation of stock abundance.

Another paper (C6) described the distribution and abundance of Sphyrion lumpi in relation to redfish in the Gulf of Maine. In discussion it was noted that a well documented example of the effect of parasites on the distribution of adult fish is the great destruction and reduction in stock size of spring-spawning herring in the Gulf of St. Lawrence by at least 2 great epidemics caused by the fungus Ichthyosporidium hoferi. Lucas and Parrish mentioned that Kabata's work on haddock parasitized by Lernaeocera showed that condition factors, liver fat and red blood cell levels were lower in parasitized than in non-parasitized fish of the same length and age. Sundnes noted that the presence of Lernaeocera on Arcto-Norwegian cod has so far not been found to have any adverse effect on the parasitized individuals.

Yearly differences in success of survival of maturity of young Pacific pink and chum salmon, introduced into the Barents and White seas, were attributed (C5), mainly to differences in predation by herring. These young salmon were also eaten by cod, saithe, sea trout and other fishes.

- D.1 -

ICNAF Environmental Symposium
Rome, 27 January-1 February, 1964

Report on Section D

Effect of the environment of the growth, survival and age and size at first maturity

Convener: Paul Hansen   Rapporteur: A. C. Kohler

In Section D, 8 contributions were delivered and they were presented and discussed at the meeting. Six of them dealt with growth (D3, 4, 6, 7, 8 and 9), one with the effect of the production of zooplankton on fatness of sprat and length of herring in the Baltic (D5), and one with the relation of the occurrence of year-classes, in the stock of haddock on the Grand Bank, with year-classes of cod, haddock and herring in all regions in the North Atlantic (D2).

The papers concerning growth covered Newfoundland and the Gulf of St. Lawrence area, West Greenland, Iceland and the Barents Sea. In the papers and in the discussion it was pointed out that many interrelated factors have influence on the growth, but that temperature is a primary one.

In one paper (D6) it was shown that in the Newfoundland-Labrador area water temperatures and growth of cod were very closely related. Laboratory experiments with cod from the Gulf of St. Lawrence area have shown a relation of growth to food consumption, and food consumption again was related to temperature (D3).

Increases in growth rate could be related to special mortality of food organisms, as shown by Kohler, who described a case of epizootic in the herring stock in the area of St. Lawrence (D3); this had the result that moribund herring became an easy prey for the cod.

It was shown in several papers that abundance of food and higher temperatures produce good growth in different kinds of fish. In the Icelandic area it was shown that growth and water temperatures were positively correlated, so that in the warmer parts - the West Iceland area - the growth was greater than in the colder areas north of Iceland, and in the still colder area east of Iceland where the growth was very slow (D4).

Among other factors which have an influence on the growth of fish is the density of population. Some papers suggested that it is the density of the combined stock of haddock in the Barents Sea (all age-groups), and not single rich year-classes, that cause changes in the growth (D8). When a stock has been diminished, e.g. by strong fishing, the growth of the individuals increases.

It was shown in paper D5 that the production of zooplankton in the Baltic is strongly correlated with the growth of sprats and herring, and especially that the fat content increases strongly in years with good amounts of zooplankton.

In the discussion Corlett pointed out that fish having a fish diet rather than crustacean usually grew better: possibly because less energy is expended in gathering food and fish protein is more efficient than crustacean. Horsted also noted that, regarding differences in growth between species, slow-growing redfish eat mainly crustaceans while cod, which grow faster and larger, are fish eaters.

Paper D9 referred to Nikolsky's view that for each species there is an optimum temperature which is the most suitable for metabolism and provides the fastest growth; when the temperatures are above and below this optimum the growth decreases. In the discussion Beverton touched on this problem and referred to a paper by Ursin incorporating temperature data in the Von Bertalanffy growth equation. Kohler added that recent laboratory experiments with cod growth at St. Andrews (N. B.) gave similar results.

Edwards noted the effects of water temperature on the growth of haddock in the Gulf of Maine which show an inverse relation to those being demonstrated for cod. This could be related either to distribution or to fact that haddock in this area may be living near the upper temperature limit mentioned by Beverton.

Temperature is selected for consideration as an environmental factor because it is very easy to measure, but it was pointed out that it was difficult to decide which temperature should be chosen as the relevant one. The ideal temperature would of course be the temperature of the water in which the fish live, but in most cases this will be impossible to measure. In the contributions surface temperatures have been used mainly.

In the discussion Blaxter questioned the use of the Vant Hoff relationship to compare lengths of fish at different temperatures (D4), and also commented on the apparent anomalies regarding findings of improved growth of cod and L_∞ of the Bertalanffy equation at higher temperatures.

Colebrook commented on the possibility that techniques used for correlating temperature and growth might be invalid, but noted that, when a relationship appears in three widely separated areas, there is fairly strong evidence for its existence.

In referring to paper D6 Lee warned against assuming a simple relation between latitude and water temperature at fishing depths in the Northwest Atlantic. Isotherms often tend to run in a North-South rather than East-West direction, especially off Labrador.

- E. 1 -

ICNAF Environmental Symposium
Rome, 27 January-1 February, 1964

Report on Section E

Herring and the environment in the ICNAF Area

Convener: B. E. Skud — Rapporteur: B. B. Parrish

The convener opened the section by outlining the planned schedule, which, following introductory remarks, was the presentation of contributed papers, a special discussion on Bay of Chaleur herring, and the general discussion.

The introductory remarks were directed toward a geographic orientation of herring distribution and fisheries in the Western North Atlantic. The major divisions within the known range from Greenland to Cape Hatteras were Newfoundland, Gulf of St. Lawrence, Nova Scotia, Gulf of Maine, Georges Bank, and the Middle Atlantic Bight. The major spawning areas and seasons were also discussed: spring spawning in Newfoundland, Gulf of St. Lawrence and Nova Scotia, and fall spawning in the Gulf of Maine and Nova Scotia.

The convener reviewed the types of fisheries practised in the ICNAF area and described the various gear utilized and the utilization of the landings. Total catch by country in the last two years was compared:

	1961	1962
Canada	80,000 metric tons	100,000 metric tons
U.S.S.R.	70,000 " "	150,000 " "
U.S.A.	30,000 " "	85,000 " "
Total	180,000 " "	335,000 " "

The convener reviewed the past research efforts in the Western North Atlantic and outlined the results of the 1963 ICNAF meetings which concerned herring, and discussed the long-term needs of research on this species. The objectives of this section of the Symposium were then listed as follows:

1. To call attention to and discuss studies of the environment of herring in the ICNAF area.

2. Appraise recent environmental research on herring with the intent that areas of limited knowledge could be emphasized and that suggestions for programs to improve these deficiencies would be offered.

3. To stress specific problems of concern in the herring fisheries and to cite the relationship of the environment to these problems.

4. To compare the state of knowledge of herring biology in the ICNAF area with other herring fisheries of the world.

There were eight papers in the section and, though all of them did not pertain to the ICNAF area, the information was of particular interest to herring and their environment. The papers and authors are listed below (the presentation was made by the individual whose name appears in parentheses):

E-1 Effect of light on movements of herring in the Bay of Fundy. S. N. Tibbo, Fisheries Research Board of Canada, Biological Station, St. Andrews, N. B. (L. M. Lauzier)

E-2 Distribution of plankton and summer feeding of herring in the Norwegian Sea and on Georges Bank. E. A. Pavshtics, Polar Research Institute for Marine Fisheries and Oceanography, Murmansk, USSR (R. S. Glover)

- E. 2 -

E-3 Water temperatures and the herring fishery of Magdalen Islands, Quebec. L. M. Lauzier and S. N. Tibbo, Fisheries Research Board of Canada, Biological Station, St. Andrews, N. B. (L. M. Lauzier)

E-4 The influence of water masses of the New England and Nova Scotia Shelf on the formation of commercial concentrations of herring. V. A. Bryantsev, Atlantic Research Institute of Marine Fisheries and Oceanography, Kaliningrad, USSR (D. Bumpus)

E-5 Effects of environment on several diseases of herring from the western North Atlantic. Carl J. Sindermann, U. S. Bureau of Commercial Fisheries Biological Laboratory, Boothbay Harbor, Maine (R. L. Edwards)

E-6 Seasonal and areal distribution of Gulf of Maine coastal zooplankton, 1963. Kenneth Sherman, U. S. Bureau of Commercial Fisheries Biological Laboratory, Boothbay Harbor, Maine (J. M. Colebrook)

E-7 Ecology of herring larvae in the coastal waters of Maine. Joseph J. Graham and Harold C. Boyar, U. S. Bureau of Commercial Fisheries Biological Laboratory, Boothbay Harbor, Maine (E. H. Ahlstrom)

E-8 Distribution of wintering herring in the southern part of the Norwegian Sea according to temperature conditions. L. R. Shmarina, Polar Research Institute of Marine Fisheries and Oceanography, Murmansk, USSR (R. S. Glover)

Following this presentation of papers, the convener called attention to those papers in other sections of the Symposium which referred to herring. These were, according to subject:

Herring and the Physical Environment

A-2 by T. Laevastu. Interpretation of fish distribution in respect to currents in the light of available laboratory and field observations.

B-6 by A. Saville. Factors controlling dispersal of the pelagic stages of fish and their influence on survival.

B-8 by Ju. Ju. Marty. Drift migrations and their significance to the biology of food fishes of the North Atlantic.

B-9 by J. Gulland. Survival of the youngest stages of fish, and its relation to year-class strength.

D-5 by W. Mankowski. Some problems of zooplankton production and the problems of fisheries.

F-7 by T. Iles. Factors determining or limiting the physiological reaction of herring to environmental changes.

H-3 by L. Lauzier. Long-term temperature variations in the Scotian Shelf area.

H-8 by D. Bumpus and J. Chase. Changes in the hydrography observed along the east coast of the United States.

H-9 by J. Tait and J. Martin. Inferential biological effects of long-term hydrographical trends deduced from investigations in the Faroe-Shetland Channel.

I-1 by L. Lauzier. Foreshadowing of surface temperatures at St. Andrews, N.B.

I-7 by J. Eggvin. The possibility of forecasting oceanographic conditions in North-West European waters and their significance for fisheries.

Physiology and Biology

F-1 by K. Kalle. Oxygen dependence of vertical migration in shoaling fish.

F-2 by J. Blaxter. Effect of change of light intensity on fish.

F-3 by F. Holliday. The significance of environment/endocrine studies to the investigation and exploitation of fish stocks.

F-5 by G. Hempel. Egg size and fecundity in relation to the environment.

F-8 by G. Sundnes. Energy metabolism and migration of fish.

G-3 by H. Mohr. Changes in the behaviour of fish due to environment and motivation and their influence on fishing.

Incidental references to herring

A-12 by R. Beverton and A. Lee. The influence of hydrographic and other factors on the distribution of cod on the Spitsbergen Shelf.

C-5 by E. Bakshtansky. The impace of the environmental factors on survival of the far eastern young salmon during the acclimatization of the latter in the north-east part of the U. S. S. R.

D-2 by W. Templeman. Relation of periods of successful year-classes of haddock on the Grand Bank to periods of success of year-classes for cod, haddock and herring in areas to the north and east.
D-3 by A. Kohler. Changes in growth, feeding, and density of Gulf of St. Lawrence cod.

The discussion period was then opened with a continuation of a topic first broached in Dr. Hempel's section (F). The discussion concerned spring and fall spawning stocks in the Bay of Chaleur and was initiated by Dr. Harden-Jones. Messrs. Skud, Parrish and Blaxter also participated and the validity of scale ratio and otolith nucleus as a method of indicating when a fish was spawned was discussed.

The general discussion of section papers was then opened. (a) Blaxter drew attention to the differences in temperature preferences of herring in the Northwest and Northeast Atlantic as shown in contributions E8 and E3. In E8, it is stated that spring spawning in the Norwegian Sea does not take place below about 3°C, but in E3, spring spawning is quoted as taking place in the vicinity of Magdalen Islands at lower temperatures; good herring catches are even recorded there at -0.7°C. A somewhat parallel situation is observed with the cod, which appears to occur in colder water in the NW than in the NE Atlantic. Blaxter also asked whether there are any recorded instances of herring being found dead in cold water in the NW Atlantic. Templeman reported that some years ago, in May, herring had been observed floating, dead in Fortune Bay, but it could not, of course, be claimed that their death was necessarily due to the cold water. Herring are commonly found, in winter, in very cold water in bays, such as the Bay of Islands, off Newfoundland. These bays are completely covered with ice in winter, and the herring must spend a considerable part of this time in temperatures below 0°C.

Lauzier announced that the temperature of 2.1°C in the Magdalen Islands area should not be taken as a preferred temperature. In the middle of the season, the temperature is higher, at 5-6°C.

Holliday announced that herring larvae can live at super-colled temperatures.
(b) Parrish asked if large herring concentrations are ever found in the open sea to the south of Newfoundland (Grand Bank area) or in the area between Labrador and W. Greenland (Labrador Sea and Davis Strait).

Templeman replied that some trawl catches of up to several hundred herring have been taken on the southern Grand Bank. A few herring have also been caught by trawlers on St. Pierre Bank. However, no large catches have been reported from these Banks, and herring have not been recorded in cod stomachs in this area. Further, there are no records of herring from the Hamilton Inlet Banks area, either in catches or fish stomachs. Herring are found in the inshore, Labrador area and formerly a good fishery for large, fat herring took place off southern Labrador, mainly from late summer to autumn.

Hansen announced that herring also occur off W. Greenland, from the SW coast northwards to the Arctic Circle. The herring are usually very large fish, up to 45 cm in length. Some tagging experiments have been carried out on these herring, but the recaptures have been taken near to the tagging locality. Herring larvae have been caught in Southern Greenland waters, and fishermen report that there are herring in the open sea waters of the Davis Straits.

Lucas drew attention to the usefulness of predatory fish as samplers of prey species such as herring. Fish stomach analyses should be carried out in these areas.

Convener. There is no evidence of herring in Hudson Bay, but concentrations of *C. pallasii* occur around the North of Alaska.

Glover said that there were no records of herring larvae in the Hardy Plankton Recorder material from Ireland to Newfoundland.

(c) Bumpus questioned whether Labrador water was present in the Gulf of Maine to the extent indicated Bryantsev in contribution E-4. Insufficient Labrador water rounds Avalon Peninsular or the Tail of the Grand Bank for this to be possible. The water in the Gulf of Maine is a complex mixture of slope and coastal water, with minor contributions from the Scotian Shelf, with considerable Laurentian characteristics. The location of the herring concentrations concurs with the divergence of the cyclonic Gulf of Maine gyre and the anti-cyclonic Georges Bank eddy, and the retreat to the westward as the season progresses coincides with the breakdown and diffusion of these circulations.

Lauzier agreed with Bumpus' comments and pointed out that the G. of Maine water masses should be defined as a mixture of 5 water types and not 3, as Bryantsev has done. He further announced that while the relationship between herring catches and wind seems to be good during late winter and early spring, he would not expect it to be so in other seasons when thermal stratification is greater than in the winter.

(d) Dr. Uda commented on the large long-term fluctuations in the Japanese herring and sardine fisheries in the Pacific. These appear to correspond with fluctuations and trends in warming and cooling of the waters in the area. In the cold regions, water transport is lower than in the warmer ones. The records indicate that with warming in the northern Pacific, the herring fishing grounds shift further to the north.

(e) Convener. Is there any evidence that herring change their spawning grounds? There is no evidence that the extensive spawning on Georges Bank was in existence 50 years ago, whereas there was evidence of inshore spawning which is now very limited.

Templeman announced that in the Newfoundland area, spring herring spawn in late May-early June in shallow water (the milt patches can be easily seen) while autumn spawners spawn in considerably deeper water. It is possible that there is more continuity between spring and autumn spawning than we have observed. For example, Capelin on the east coast of Newfoundland begin spawning in very shallow water (on the beach); spawning then continues throughout July and August, extending gradually into deeper water as the inshore water warms up, until in August they may spawn down to 20-25 fathoms or deeper.

(f) Blaxter asked if, as a result of the southerly drift of larvae from Georges Bank, a substantial part of the larvae population is lost to the area? Edwards thought that they would not be lost in the Gulf Stream, but would be held in the SW drift, and so perhaps not lost to the Georges Bank stock.

Convener announced that Colton's observations on the drift of haddock spawning products from the Bank were very pertinent to this question; he also announced that investigations on the larvae of Pacific herring had concluded that larvae are probably lost to the population whenever they move outside the coastal zone.

The section was then closed and was briefly summarized later by the convener. He concluded that some of his objectives were optimistic, but that several areas of limited knowledge were emphasized and existed in European waters as well as in the ICNAF area. Of particular concern in the western North Atlantic was the problem of stock identification, including the separation of spring and autumn spawners. The importance of temperature, water movement and plankton distribution in relation to herring abundance was emphasized. These are in general agreement with the research interest of the ICNAF herring scientists and are areas which are actively being studied.

The convener also cited the excellent presentation of Mr. Parrish as a guest speaker. His talk compared the herring fisheries of the western and eastern North Atlantic in terms of production and ecological boundaries which govern the distribution of herring stocks.

- F. 1 -

ICNAF Environmental Symposium
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Report of Section F

Physiological reactions to changes in the environment

Convener: G. Hempel   Rapporteur: J.H.S. Blaxter

The papers were divided into five main topics:

1. The internal environment (endocrine systems) - Holliday (F3), Woodhead and Woodhead (F6A).

2. Reproduction - Hempel (F5), Hodder (D1), Iles (F7), with additional reference to Steele (C4), Bakshtansky (C5), Mankowski (D5) and Martin and Kohler (H7).

3. Importance of light - Blaxter (F2), Woodhead (A15), with additional reference to Colton (B5), Mohr (G3) and Tibbo (E1). A film by Shaw was also shown.

4. Tolerance to the environment - Lillelund (F4), Kalle (F1), Leivestad (F9), Woodhead and Woodhead (F6B), with additional reference to Cendrero (A1), Horsted and Smidt (A3), Templeman and Fleming (A4), Jean (A7), Templeman and May (A10), Beverton and Lee (A12), Postolaky (B11), Serebryakov (B18).

5. The "artificial" environment - Sundnes.

The purpose of this last section was to provide some background information on immediate and delayed responses of fish to changes in the physical properties of the sea. The classical approach to this problem is the experiment in the aquarium where all factors but one are kept constant (or are assumed to be constant). The limitations of this method have been stressed. Fish live in the aquarium in an unnatural environment which offers only a selected range of stimuli, and where it is almost impossible to control some variables (e.g. atmospheric pressure). The variable supposedly under consideration is often changed over a wider range than that found in natural conditions. Other variables (e.g. the effect of weather on fish movement) have not been studied in isolation at all. In spite of those limitations the potential value of the aquarium approach cannot be gainsaid. Nevertheless, a general improvement in experimental techniques is desirable in order to detect the interaction and influence of groups of environmental variables. For example, the reaction to light might change with different conditions of temperature or food supply. An increase of work done in fish pounds in sheltered areas of the sea is also desirable in an attempt to link aquarium results with investigations at sea.

Observations in the sea can provide valuable information on the importance of environmental factors if they are especially designed for an analysis of this kind, but a simultaneous measurement of the biological and hydrographical features of the habitat is essential. An analysis of data on commercial catches combined with information from meteorological records rarely reveals knowledge of the isolated effect of a single factor.

In general the physiological capabilities of fish, especially in the young stages, are wider than might be assumed from their distribution in the sea. Distribution may be partly imposed on young fish by the location of spawning grounds and the inability of the young stages to change their position substantially by active movements. However, the optimum for fish, or their preference for a certain range of conditions, are certainly narrower than the range of tolerance. One must differentiate between what a fish is capable of withstanding and what it "chooses" to do.

Further, what may seem to be tolerance in a limited experiment may well prove to be deleterious over a longer term, or adverse conditions which fish can live in might later cause premature death or inability to reproduce. The dependence of a physiological process on an environmental factor is rarely a straight-line relationship. Curves with a maximum in the region of preference may be more common than detected so far. Tolerance, preference and the reaction of fish to an environmental factor may change seasonally or with different phases in the life history. The seasonal change in the temperature preference of Arcto-Norwegian cod and their survival near freezing point, and the drop in reactiveness of spawning herring, all described in this section, are good examples of this.

The question of preference is a central problem when considering the spatial distribution of fish and the establishment of physical and chemical boundaries in the otherwise continuous sea. These boundaries cannot always be defined by a single limiting factor, but rather as an accumulation of several conditions, which may be outside the preference of fish but within their range of tolerance. Under such stress the fish might become more sensitive to a single adverse influence. The changes in activity of fish at boundaries of this sort are of the highest importance as, indeed, are changes of activity of fish as a result of temperature, food supply, light or internally-controlled rhythms unconnected with boundaries.

The discussion on the effect of the environment on reproduction showed that we are very poorly informed on what controls spawning time, fecundity and egg size. Some knowledge of these aspects is essential in the furtherance of population dynamics and studies on early survival rates and recruitment. The need for combined studies in the laboratory and at sea has also been stressed. Besides direct influences on the reproduction of fish of a given size and age, indirect influences of the environment, such as food supply and temperature affecting growth rate and possibly maturation, have to be considered.

Most of our fisheries are carried out in the photic zone of the sea where light may have an important influence on the distribution and migration of fish, as well as being essential for feeding, shoaling and spawning in some species and affecting the hormonal cycles. The interrelationship between migratory behaviour and maturation as controlled by the endocrine glands has been discussed in this section in connection with new information on maturing herring and Arctic cod. Apart from light intensity, the effect of transparency on visibility underwater is of far-reaching importance. Comparative measurements of light intensity and visibility made at the same time as biological observations are highly desirable. The help of physical oceanographers would be appreciated in providing overall synoptic charts of light measurements on the sea bed. From these charts biologists could assess whether certain behaviour patterns, particularly visually-controlled net avoidance would, or would not, take place on the various fishing grounds at stated times.

Fish are not only influenced by the environment; they themselves affect their own environment and that of other fish. This is especially evident in a shoal. Reports on possible oxygen lack within a shoal and the reaction of fish to moving patterns of the background show this. The immediate effects of competition and predation on the activity states and growth rates of fish have not been discussed adequately, but the possible loss in terms of fish weight due to a highly active or over-stimulated existence has been mentioned. The value of further investigations in this field is evident.

The convener's thanks are due to his rapporteur, Mr. J. H. S. Blaxter, who prepared the notes for this summary.

- G. 1 -

ICNAF Environmental Symposium
Rome, 27 January - 1 February, 1964.

Report on Section G

The effect of the environment on the process of fishing

Convener: B.B. Parrish   Rapporteur: J.G.Harvey

Although only four contributions were presented to this section of the symposium, their subject matter provided abundant evidence and examples of the importance of various physical and biological factors in their effects on the process of fishing. The factors covered included climate and sea-state relationships, sea-bed topography and structure and biological features of the exploited stocks. The discussions on each are summarised below.

A. Climatic Factors (Contributions G.2 and 1)

1. Meyer's data in contribution G.2 prompted a lively discussion on the importance of investigations of the relation between the occurrence and distribution of ice and meteorological conditions, especially tmospheric pressure and wind, and of the urgent need for the extension of sea-state forecasting in the northern fishing areas.

In reply to a comment from Lee that 1963 had been a bad ice-year in the area covered by the Northwestlant survey, Meyer said that reports from German trawler captains showed it to be an average year; this indicated that ice conditions in the Greenland area can change very rapidly. Laevastu referred to earlier statements of the importance of meteorological data in relation to ice-drift in the Greenland area, and pointed out that this area is the birthplace of sudden atmospheric depressions, which could be predicted somewhat in advance, using heat exchange computations. Harvey also referred to Bjerknes' comparisons between the changes in atmospheric circulation and Smed's surface temperature anomalies for this area.

Uda described the icing-up of trawlers in the north Pacific and asked if this was a frequent occurrence in the east Greenland area. Meyer said that this was not so, but mentioned the loss of two trawlers off Labrador, from icing, in February 1960. Similar losses of trawlers off west Greenland were mentioned by Hansen. Kotthaus also referred to the loss of a trawler in the Angmagssalik district through "black-frost" icing. Lee described the occurrence of this rare phenomenon on the "Ernest Holt" at Bear Island in 1953.

Meyer associated the increase in surface temperature anomaly in the east Greenland area since the war with the movement of haddock into these waters; in recent years, catches of up to 30 baskets per hour has been caught. Hansen stated that no similar increase in haddock had been observed in the west Greenland area.

2. Ewen announced that in addition to the investigation described in his contribution G.1, other work was being carried out in conjunction with the British Meteorological Office, involving the analysis of data collected over the last ten years from observers on British merchant ships, covering the main shipping routes over the world.

There was considerable discussion of the interpretation and validity of the relationship between wind speed and mean wave height in Figure 3 of Ewen's and Hogben's paper. It was agreed that a number of factors could affect it, e.g. wind direction and the length of time it had been blowing, season, proximity to land-masses, etc. Ewen said that the wind speed and wave height data were skipper's estimates based on the appearance of the sea surface, but he announced that a comparison is being made between estimated wave heights and measured values taken by ship-borne wave-recorders.

Lee pointed out that, in Figure 4, the accuracy of the estimates of wave-length appeared to improve as the wave-length increased above 200 ft. Ewen agreed that this was probably because at these lengths, the observers could use the lengths of the vessels as a yardstick. Uda suggested that currents would have an effect on wave height, but Ewen said that in the areas from which these data had been obtained, the currents were almost certainly too small to have any significant effect.

Laevastu concluded the discussion by drawing attention to the usefulness of comparative studies of this type of wind and wave data collected from trawlers in different areas, especially in providing information on sea-state condition for use in hydrographic forecasting and in fishing vessel design.

B. Sea-bed Topography (Contribution G.4)

Following his presentation of Avilovs' contribution, Edwards described work done by Emery on bottom sediments, bottom topography and the associated benthic fauna in the sea areas off the Atlantic coasts of N. America from the Gulf of Maine to Florida.

In reply to a question from the Chairman regarding the available information in other countries on bottom topography and structure of the fishing areas in the north-west Atlantic, Templeman stated that the grounds off Labrador were very badly charted. Cameron described the activities of the Canadian hydrographic service in this area, but emphasised that at present these are concerned principally with depth contouring, rather than determining the detailed nature of the sea-bed structure. Magnusson drew attention to the need for improved bottom charts for the east Greenland waters and of the Reykjanes Ridge. This was supported by Kotthaus who stated that the German charts of east Greenland were in error, most features appearing about 10 miles too far to the east. Meyer drew attention to the difficulty of charting in this area, which was out of range of the recognised navigation systems.

In conclusion, the Chairman pointed to the obvious advantages of international collaboration in the preparation of detailed fishermen's charts in large sea-areas like the north-west Atlantic, and suggested that a much larger scale version of Figure 3 of Avilov's paper would provide valuable information for countries fishing in this region.

C. Biological Factors (Contribution G.3)

3. The importance of the effects of behavioural and distributional features on the accessibility and vulnerability of exploited fish stocks, as outlined in Mohr's paper was emphasised by the Chairman, who instanced the marked effects of diurnal variations in vertical distribution and the differences in behaviour of fish to fishing gear under visual and non-visual conditions as notable examples. Meyer explained that pelagic trawling for cod in Greenland waters was now being investigated in Germany and some good catches had been obtained. However, owing to unpredictable irregularities in vertical distribution, there was a need for trawl which could be fished either on the bottom or in mid-water, according to the observed distribution of fish.

D. Conclusions

In summing up, the Chairman highlighted the following items of major importance, arising from the discussions:-

(a) the importance of more extensive information and forecast services, giving sea-state conditions, and especially of the ice-limits for the northern fishing areas;

(b) the need for international collaboration in the preparation of accurate, large-scale fishermen's sea-bed charts for the North-

West Atlantic and East-Greenland fishing areas;

(c) the need for further intensive studies of distributional and behavioural factors influencing fish capture, and for close collaborations between biologists and gear technologists in fishing gear design and improvement projects.

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ICNAF Environmental Symposium
Rome, 27 January-1 February, 1964

Report on Section H

Effects of long-term trends

Convener: L. M. Lauzier Rapporteur: T. Laevastu

This is the second time in the history of ICNAF that the subject of long-term hydrographic changes and their effects is discussed. The first time was in 1953 during the Annual Meeting of ICNAF. During the present symposium, as well as previously, the main factor considered for bringing long-term changes in evidence was water temperature. Changes in water temperature have a direct effect on the biological processes, the physiological functions as well as on the distribution of animals. However changes in temperature may be the results of changes in the circulation or advection. Temperature changes may indicate a change in the composition of water masses including its biological and chemical (nutrient) contents, a change in productivity. Temperature changes may be, in many cases, "coincidental" with biological changes within the same body of water, both being the effects of a common cause.

The papers and discussions at this session were concerned with the evidence, causes and effects of long-term trends. Related subjects were discussed but two aspects were emphasized: one, the possible causative mechanism of long-term trends and the variations of these trends from western to eastern sectors of the North Atlantic; two, the difficulties in measuring the changes in the fisheries that may be attributed to long-term trends. The possible effects of long-term trends on distribution of fishery resources have been summarized by Dr. A. V. Tåning more than ten years ago. Such effects were pertaining mostly to the northern areas. At the time Dr. Tåning considered these effects, most scientists had in mind the recent warming or amelioration of climate. There are now instances of reversal of trends in some areas. Then will the possible effects of recent cooling trends be the reverse of those considered by Dr. Tåning? It is difficult to give an answer at present; we probably will find that the physical factors have only a secondary effect. Can we wait for another ten years or so for an answer?

May I make for this section on the effects of long-term trends the following recommendation: considering that changes have taken place in the distribution of fish and yield of fisheries in the North Atlantic and that these changes may be attributed to long-term trends or changes in the environment, it is recommended that the observations of environmental factors at coastal stations and offshore points, including weather ships, be continued and encouraged with a dual objective in mind: first, to monitor the climatic conditions; second, to find ways and means for predictions of long-term trends which might infer readjustment of some of the fisheries.

I would like to thank all the contributors for their papers and Dr. T. Laevastu for his assistance, as rapporteur, and his help in the preparation of this report.

- I. 1 -

ICNAF Environmental Symposium
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Report on Section I

Forecasting Environmental Conditions

Convener: D. F. Bumpus Rapporteur: R. L. Edwards

Eight papers were presented in this section, ranging in subject matter from a general discussion of the feasibility and problems of forecasting (Eggvin, I7, Tait, I6, Schule, I8 and Laevastu, I3) to demonstrations of attempts to relate changes to various factors such as meteorological conditions (Iselin, I5, Laevastu, I4, Lauzier, I1 and Harvey, I2).

Several contributions contained both suggestions and evidence that many changes occur weeks and even months in advance of local phenomena, so that some forecasting can already be done even today. In this regard, Eggvin (I7) notes the significant negative air temperature anomalies of 1963, the relative lack of clouds and other related changes that lead Norwegian scientists to anticipate that the deep water of the Norwegian Channel would stay cold for longer than usual by many months with significant effects on the fisheries. This condition persisted during the late months of 1963 and even into January 1964. Tait (I6) makes comparable observations concerning variations in salinity in particular, which cycles over longer periods of time. He states that "the variation is gradual, which tends to this particular phenomenon the aspect of climatic change in the sea, and the fact that it is gradual anticipates the possibility of forecasting it, provided observations in the region are sufficiently regular and systematic".

Schule (I8) presented a thorough review of the problem and scope of operations involved in oceanographic prediction. He discussed four approaches to the problem, namely: 1) a system that concerned itself primarily with factors characterized by continuity or persistence beyond normal day to day changes; 2) the point prediction method, based on, for example a bathythermograph record, modified for a period of time by other predictable or observable factors such as wind, air temperature and cloudiness; 3) the dynamic approach, based on extensive model studies that could ultimately allow for minimum, although admittedly critical imput, to predict change over a wide area. High speed computer capability is mandatory, plus a considerably better general understanding of the hydrographic regions than presently exists for most areas; and 4) the statistical approach, or post hoc approach based on what are today relevant and seemingly causal factors.

With regard to the fourth approach discussed by Schule, two contributions are of direct interest, namely I1, Lauzier and I2, Harvey. Lauzier examined surface temperature records for St. Andrews and other North American localities in detail to determine the degree of predictability that might be achieved without recourse to other data. He showed, for example, that one can predict annual means with a fair level of significance given previous means and the minimum temperature for the year under consideration. Harvey concerned himself more with factors having an apparent or relevant causal connection, such as wind velocity, cloudiness and air temperatures. Highly significant correlations were obtained even though horizontal advection appeared to be the dominant influence in change.

Professor Laevastu pointed out that many events are predictable on the basis of meteorological conditions.

In the discussion that followed, two aspects of prediction were touched upon, - the pragmatic aspect of keeping the fishermen informed and that bearing on academic or research problems. In both the presentations and discussions it was apparent that considerable promise lies in the understanding of the relation between atmospheric and oceanographic phenomena.

In addition to regular systematic temperature and salinity measurements throughout the water column in strategic places, an improved field of current measurements and a monitoring of the changes in the location of oceanographic fronts would contribute toward predictive capabilities. Support in the way of communicative, analysis and forecast procedures need to be considered to make efficient use of the data collection. The Canadian and U. S. Navies already have a data collecting net, analysis sections, and radio facsimile broadcasts of certain aspects of the ocean environment. Cooperation between the fisheries oceanographic programs and the naval predictive services would enhance the interests of both groups.