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REPORT OF STEERING GROUP ON COD AND CLIMATE CHANGE

CCC

COD, COPEPODS AND CLIMATE

by

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ABSTRACT

This is a report of the ICES Steering Group on Cod and Climate Change. The report takes note of C.M. 1990/G50 and C.M. 1991/G78 and recommends the establishment of a five-year ICES program on Cod and Climate Change under sponsorship of the ICES Consultative Committee.

INTRODUCTION AND BACKGROUND

This is a report of the Steering Group on Cod and Climate Change (Terms of reference are in Appendix A). It focuses on Term of Reference "b": "encourage communication among regional studies of Cod and Climate Change, including strategies to enhance comparisons [among populations of cod and associated species]".

The relation between cod abundance and climate change is an important component of the general problems of a) understanding fish-stock recruitment processes and b) assessing the relation between ocean physics (on basin and regional scales) and fish stocks. Recognizing this fact, two reports on cod stock fluctuations (C.M. 1990/G50 and C.M. 1991/G78) were prepared by ICES. These reports call attention to the scientific opportunities and the value of developing a coherent pan-Atlantic program to enhance the utility of individual ongoing programs relating cod abundance to climate change (and variability in ocean physics) as well as to contribute to our general understanding of recruitment processes in the North Atlantic.

The recommendations of G50 and G78 involve the development of physical models on basin, regional, and small scales; models of copepod and fish larva interactions; and the study of the interactions between biology and physics. The key recommendations (paraphrased) are,

1. Encourage development of models of North-Atlantic circulation for application to the needs of the Cod and Climate program. Such models might be used to specify the boundary conditions for regional models and describe how changes in climate propagate through the north Atlantic Ocean, including the areas in which the cod live.

2. Encourage, facilitate and monitor the development of regional models which might be used to study the Lagrangian spread of eggs, larvae, and early juveniles and the heat budget to forecast the temperature regime.

3. Encourage studies on how the production of turbulent energy on a small scale, developed from wind stress and energy affect the distribution and encounter rate of planktonic organisms.

4. Review existing models of copepod population dynamics and develop new models, particularly Calanus finmarchicus, the food species in the Northeast Atlantic, and Pseudocalanus sp, the food species on George's Bank. Models should take into account the advection of overwintering populations and variation in the time of onset of the production of such copepod populations.

5. Review shortfalls that might exist in sampling instrumentation and specify any new direction in sampling technology that might be undertaken during the next decade.

6. Encourage study of phenotypic and genotypic differences between stocks at all stages in the life history. Comparative studies should be started on growth, fecundity and migration, taking account of the North Atlantic circulation. Part of such studies may be executed in laboratories and mesocosms.

7. The program on Cod and Climate should be sustained as a long term exercise. A Working Group should be established to meet at the Statutory Meeting to facilitate and coordinate and serve as liaison with other initiatives such as GLOBEC.

A CCC PROGRAM

These recommendations can be thought of as a foundation for a program on cod and climate change. Such a program, Cod and Climate Change (CCC) will enhance the ICES-family capabilities to characterize the variability in North Atlantic cod populations (and of course other stocks as well) in terms of the underlying basin scale and regional variability in climate. CCC could bring together recent advances in Global Change Models (GCMs) and Atlantic-climate models to provide realistic scenarios of basin-scale climate variability and change. Currently, there are several substantial ongoing and planned regional (e.g. Georges Banks, Grand Banks, Nordic Sea, and North Sea) programs investigating the relationship between physical factors (e.g. stratification, cross frontal exchange), and biological factors (e.g. abundance and distribution of copepods), and population dynamics of cod. While each of these regional systems are different, they respond to the same basin-scale climate forcing. By applying realistic Atlantic-basin climate scenarios, as boundary conditions to regional hydrodynamic and biological process models, comparisons between regions will be facilitated and both differences and coherence in regional responses of fish stocks to climate change will be better understood. This approach is proposed as a generic strategy for research on global ecosystem dynamics.

The primary function of the Cod and Climate Change program is to facilitate communication and coordination without interfering with planning or conduct of regional programs. Communication will

be facilitated (a) between global and basin-scale climate modeling and regional research programs, (b) among regional research programs and (c) between ICES and other international studies of climate and global change and ecosystem dynamics (i.e. GLOBEC sponsored by IOC and SCOR). Contributions to the facilitation and communication effort will include a (1) symposium on Cod and Climate Change in Iceland in 1993, (2) a workshop to be held adjacent to the symposium to describe realistic scenarios of climate variability and climate change and to formulate methods for using these scenarios as boundary conditions for regional models, and (3) the development of a Steering Committee made up of representatives of regional programs and the Consultative Committee, to meet to review progress annually at statutory meetings, report on progress to the Consultative Committee, and to represent ICES in other international organizations.

While cod, copepods, and climate change is a focus, CCC is intended to contribute more generally to the understanding of recruitment processes in general which is one of the major problems in fisheries and biological oceanography. It is now generally recognized that major advances in understanding recruitment requires an improved understanding of the planktonic environment in which ichthyoplankton live. CCC will help draw attention to three major components of the planktonic environment vis à vis recruitment which have tended to be ignored. These are: (1) the dynamics of copepods which form a major food source of ichthyoplankton and which are to some extent predators of fish larvae, (2) the physical setting which affects physiological rates of the plankton, and (3) the trophodynamically important encounter rates among plankton prey and predators.

Investigating the effects of the physical environment on ichthyoplankton and hence recruitment is obviously complex and will occupy much of fisheries and biological oceanography in the decade of the 90's.

Since our understanding of the cod, their associated plankton, and the physical environment, is supported by a considerable database and a large array of process studies, cod ecosystems are an outstanding choice for such research. In fact the most significant immediate opportunity for penetrating the recruitment problem may be afforded by the study of the interactions of cod and the physical environment.

Physical processes are a critical component of CCC. This follows because physical properties help to determine the success of recruitment through such effects as:

- microscale mixing as a determinant of predator-prey interactions for plankton,
- advection of planktonic life forms and how it affects retention of life forms in the system,

- water column stratification and the way it acts to concentrate trophic interactions, and
- the supply of nutrients that ultimately fuel the ecosystem.

All of these processes are likely to be affected by possible changes in surface heating or wind stress related to climate change. The climate-induced changes in these effects, and their relative importance, are likely to vary substantially in different parts of the North Atlantic ocean basin: for example, projections in changes in surface temperature (hence water column stability) show considerable variation within the Atlantic, north of 40deg N. Rather than viewing spatial differences in climate change as an unwelcome complication, we should see it as an opportunity, since nature is then providing us with a natural experiment such that different cod stocks are to be subjected to different degrees "natural stress". Thus, we should try to exploit the potential pan-Atlantic variations in climate change to improve our physical and biological understanding.

We need to carry out a multi-faceted scientific program which includes a substantial component on understanding the effects of physical variation on recruitment. First, there is a need for process-level understanding, for example how turbulence effects feeding efficiency in natural populations. Second, there is a need for modeling. This must take place on a local-to-regional scale in order to understand advection and retention mechanisms within a given system. These models, in turn, must be meshed with basin-scale models which incorporate various scenarios of potential climate change. This might simply mean changing lateral and surface boundary conditions, but there should be an agreed-upon set of scenarios which are tested with regional scale physical-biological models. Finally, there is a real need for international coordination in these research efforts. This follows because no one country or group of scientists will be studying all of the different cod ecosystems (hence different realizations of climate change effects) in the North Atlantic. Exploiting the natural experiment calls for pooling of information from all of the different cod and climate efforts. There should be frequent (at least once per year) meetings of interested scientists, and some agreement about the standard measurements and model runs (climate change scenarios) to be made.

It is timely to take on this effort now. First, it behooves us to gain a better understanding of the potential effects of climate change on fisheries so as to better manage fisheries in the future and to understand the signs of climate change. Second, we are ready to undertake the studies at this time. Our sophistication in modeling, observations and in physical-biological coupling is now far enough advanced to allow an intelligent start to be made on what must, by its nature, be a long-term line of research. We are fortunate in that we have many base measurements, both physical and biological, to guide the planning of such an

ambitious study.

In addition to facilitating communication, CCC can contribute to the effectiveness of existing programs by 1) bringing together scientists working on common problems so that a pan-Atlantic and more "global" perspective on each might be attained and by 2) developing a common database so that studies can be compared and "old" data can be added to the database. Specific examples involve procedures to;

- Develop mechanisms for comparing various basin-scale physical models and study how these models can be applied to variability in zooplankton and fish stocks. Facilitate the development of scenarios of realistic climate-change and shorter-term variability that might be applied to setting boundary conditions on regional-scale models.

- Develop mechanisms for regional multinational field studies such as those that might be developed in the Nordic Seas, the North Sea, or the Western Atlantic.

- Develop mechanisms for comparing regional and coastal physical models and studying how these can be coupled with biological phenomena.

- Develop process studies on interactions between mesoscale and small scale physics and the planktonic environment.

- Develop mechanisms for assembling physical and biological data in a common accessible database (to the extent practical).

- Provide a mechanism to develop and facilitate comparative process studies on the dynamics of planktonic ecology appropriate to cod and associated species.

- Facilitate interregional studies of cod and plankton dynamics.

- Provide periodic reports on research and data acquisition.

It is obvious that activities such as those that are outlined above would make a material contribution to each national program; to our understanding of cod and climate; and to the general understanding of the effort of the physical environment on fish-stock recruitment.

RECOMMENDATIONS

The Steering Group For Cod And Climate Change recommends that:

1. Under the sponsorship of the Consultative Committee, ICES establish a five-year program on "Cod and Climate Change" to

address the strategy and objectives described in C.M. 1990/G:50 and C.M. 1991/G:78.

2. A Steering Committee of representatives of regional CCC studies and the Consultative Committee, under the Chairmanship of (to be named), meet at Statutory Meeting to discuss progress and report to the Consultative Committee.

3. ICES continue to sponsor CCC as a regional element of IOC/SCOR GLOBEC. The Chairman of the ICES Steering Committee will serve as the ICES liaison member of International GLOBEC.

4. Consideration be given to the magnitude of coordinative activities and determine whether explicit mechanisms of coordination such as a program office or a paid coordinator who would interact directly with international GLOBEC would be warranted.

5. A Workshop be held in conjunction with the 1993 Symposium in Iceland on Cod and Climate Change to describe realistic scenarios of climate variability and climate change, and to formulate methods for using these scenarios as boundary conditions for regional models. The Workshop will be convened by (to be named).

6. Additional workshops will be held as recommended by the Steering Committee with approval of the Consultative Committee and the Council.

7. ICES publish, in the Cooperative Research Reports series, summaries of historical data on cod populations and associated environmental data.

APPENDIX A

The Study Group on Cod Stock Fluctuations will be replaced by a Steering Group on Cod and Climate Change under the chairmanship of Prof. B. Rothschild (USA) and including Dr. J. Backhaus (Germany), Dr. K. Brander (UK), Dr. K. Frank (Canada), Dr. B. Hansen (Denmark), Dr. M. Heath (UK), and Mr. S. Sundby (Norway), and will work by correspondence in 1992 and in collaboration with the Convener of the 1993 Symposium on "Cod and Climate Change" to:

a) finalize the synposis of information on cod stocks;

b) encourage communication among regional studies of cod and climate change, including strategies to enhance comparisons;

c) consider the suitability of candidate physical/biological process models to cod and climate change research, taking acocunt of the activities of the Working Group on Recruitment Processes and the Study Group on Zooplankton Production;

d) encourage preparation of reports suitable for the Symposium on "Cod and Climate Change" (C.Res.1990/2.3);

e) submit a written report on progress to the Inter-Committee Recruitment Group, the Hydrography Committee, and the Demersal Fish Committee at the 1992 Statutory Meeting.