Oceanography Committee

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REPORT OF THE

ICES WORKING GROUP ON COD AND CLIMATE CHANGE 2000

Dartmouth, Nova Scotia, Canada
May 11–12, 2000

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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TABLE OF CONTENTS

Section **Page**

1 INTRODUCTION AND TERMS OF REFERENCE

The Working Group on Cod and Climate Change (WGCCC) met at Marine House, 176 Portland Street, Dartmouth, Nova Scotia, Canada, May 11–12, 2000, under the chairmanship of Dr Ken Drinkwater (Bedford Institute of Oceanography, Dartmouth, Canada). There were 25 participants from 8 countries (Canada, Denmark, Germany, Iceland, Norway, Russia, UK and USA) and the ICES/GLOBEC Coordinator. A list of participants is provided in Appendix I.

Apologies were received from J. Gagne and B. de Young (Canada, B. MacKenzie (Denmark)), Bogi Hansen (Faroe Islands), A. Rijnsdorp (Netherlands), A. Folkvord and K. Michalsen (Norway), H. Murua and L. Valdes (Spain), A. Belgrano (Sweden), and M. Fogarty, S. Murawski and J. Steele (USA).

Immediately prior to the Working Group meeting, the ICES Workshop on the Dynamics of Cod Growth (May 8–10) was held. All but 3 of the WGCCC meeting participants took part in the Workshop.

The terms of the reference (C: Res.1999/2C11) for the CCC meeting were:

a) review and evaluate work carried out to date on Cod and Climate Change by the Workshops (Environmental Data in Stock Assessment, Decadal-Scale Ocean Climate Fluctuations, Backward Facing III and IV) and subsequent follow up activities;

b) produce a short synthesis of the major findings from the programme and prepare a plan for a more complete synthesis of results;

c) plan and prepare workshops to be held over the next two years on "Applying Environmental Data in Stock Assessments" (possibly examining the transport of cod larvae between Iceland and West Greenland as a specific example) and on "long-term Climate Change and Prediction" and consider the possibility of a fifth Backward-Facing Workshop;

d) consider and, where feasible, develop data products and summaries that can be provided on a routine basis to the ICES community via the ICES website;

e) examine the 1999 Oceanography Committee Working Group reports and the Terms of Reference for 2000 to identify where intergroup input could be provided or required with the view to formulating key questions requiring inter-disciplinary dialogue during concurrent meetings of the Committee's Working Groups in 2002.

The WGCCC will report to the Oceanography and Living Marine Resource Committees at the 2000 Annual Science Conference.

2 REVIEW OF PAST ACTIVITIES

2.1 The ICES/GLOBEC Programme Office

K. Brander informed the Working Group that funding for his position as GLOBEC/ICES Coordinator is confirmed through to July 2000. Funding from the US will likely extend the position for an additional 6 months but continued funding of the position is uncertain. A review of the GLOBEC/ICES position was undertaken last year by the Steering Committee under Michael Reeve of the USA. That group recommended that the work begun under the GLOBEC Office be continued as part of the core-funded Secretariat work-plan. However, the President of ICES, Dr Scott Parsons, requested a further review under the chairmanship of Dr Alfred Post of Germany to assess the ICES/GLOBEC position and the need for it. Dr Michael Sinclair of Canada is one of the members of the review panel. They are scheduled to report to ICES in June.

K. Drinkwater informed the Working Group that the review panel had not contacted him or the WGCCC to seek our views. He sent an e-mail to Dr Parsons in April expressing concern that the views of the WGCCC would not be considered by this new review panel and stated the difficulty the uncertainty in the position posed in developing our future plans. Dr Parsons replied sympathetically and indicated that the views of the Working Group were known by the review committee and would be taken into account. However, the review panel decision would not be forthcoming until after the June meeting of Bureau and would then be discussed by the Council in September, so that planning by the WGCCC would have to proceed under this uncertainty. Working Group members discussed this and felt it was unacceptable that key CCC participants and funding countries have not been consulted. It was decided that a

communiqué be sent to the ICES General Secretary and the Chair of the review panel, stressing the importance of maintaining the position given that we are entering an important period of synthesis and activities.

2.2 The 5-Year Plan for WGCCC

As background information, the Chair reviewed the 5-year strategic plan for the Working Group that was adopted during the last meeting in May 1998 in Woods Hole, Mass., USA (ICES CM 1998/C:10). The plan consists of 7 major components that are listed below with their main objectives.

(1) Fisheries Management: To incorporate environmental information in a quantitative manner into fisheries management strategies and planning.

(2) Retrospective Analyses: To examine past events or periods as a means of better understanding the links between changes in the environment and fisheries.

(3) Zooplankton-Cod Linkages: To understand the relative importance of zooplankton in determining the variability in cod abundance and production.

(4) Comparative Analyses: To undertake comparative studies of life history strategies and interannual variability in growth, distribution, and abundance between cod stocks around the North Atlantic.

(5) Climate and Atmosphere-Ocean Interactions: To understand and predict climate variability and its associated ecosystem response.

(6) Data Availability and Management: To ensure that environmental and fisheries data are easily and widely available.

(7) Synthesis: To provide a synthesis of the research information obtained on cod stocks.

The tentative timetable of workshops and related activities under these 7 components adopted at that time were:

March 1999	Workshop on the Gadoid Outburst in the North Sea
August 1999	TASC Symposium on Calanus
September 1999	ICES Theme Session on Bio-Physical Modelling
Fall 1999/Winter 2000	Workshop on the Dynamics of Growth in Cod
September 2000	ICES Theme Session on Zooplankton-Cod Linkages
2000/2001	Workshop on Incorporating Environmental Information into Fisheries Management-the West Greenland/Iceland Cod Example
2001	Workshop on Long-term Climate Change and Prediction

In the intervening two years the WGCCC has completed its scheduled activities through to the spring of 2000. The Theme Session on Zooplankton-Cod Linkages scheduled to held during the 2000 Annual Science Conference in Bruges, Belgium was combined with one proposed by the Working Group on Oceanic Hydrography on Environmental Effects on Plankton Communities into one entitled Climate-Plankton-Fish Linkages.

2.3 1999 Theme Session on Application of Coupled Bio-physical Models in Studies of Zooplankton Advection and Dispersion

K. Drinkwater reported that 8 papers and 1 poster were presented at the Theme Session on Bio-Physical Modelling held during the 1999 ICES Annual Science Conference in Stockholm. It was held in one session with 50–100 attendees. He drew the Committee's attention to the report of the Theme Session in the ICES Annual Report for 1998/1999 but also briefly mentioned some of models presented. He felt that the invited review provided by John Shepherd as a wrap-up of the session was particular successful and generated substantial discussion. This is a format that should be used in future

theme sessions if possible. Although it had been hoped that there would have been a larger response to the call for papers in this theme session, the variety of models that were presented and the ensuing discussion including possible future directions, all combined for a successful session.

2.4 1998 Backward Facing III Workshop

C. Werner reported on the Backward Facing III Workshop held at Woods Hole, Mass., USA, in May 1998 entitled Ocean Climate of the NW Atlantic during the 1960s and 1970s and Consequences for Gadoid Populations. The meeting was attended by 25–30 participants representing Canada, Denmark, Germany, Norway, the UK and the USA. The terms of reference for the meeting were:

a) analyse the 1960's and the 1970's ocean climate in the Georges Bank, Scotian Shelf and Gulf of Maine;

b) determine the conditions that may have contributed to the formation of outstanding gadoid year-classes during the 1960's and 1970's including

   i) differences in 3-D circulation fields of "cold" and "warm" years,

   ii) effect of temperature differences on the distribution of predators,

   iii) effect of temperature on larval growth rates,

   iv) temporal and spatial distribution and abundance of eggs, larvae, juveniles and spanners;

c) compare the processes that appear to govern interannual variability in gadoid recruitment on Georges Bank and in other areas of the North Atlantic.

The Workshop proceedings have been published as ICES *Cooperative Research Report* No. 234 (http://www.ices.dk/pubs/crr/crr.htm). The presentation at this year's meeting provided background information in order to determine possible follow-on work by the WGCCC (see Section 3.2).

2.5 1999 Backward Facing IV Workshop

M. Heath presented some of the findings from the Backward Facing IV Workshop held in Aberdeen, Scotland in May 1999 entitled the Gadoid Outburst in the North Sea during the 1960s and 1970s. A total of 20 scientists were in attendance representing Denmark, Germany, Norway, the UK and the USA. The terms of reference for the meeting were to:

a) identify and contrast the components of the physical environment (atmospheric and oceanic) potentially contributing to the high levels of gadoid (e.g., haddock, whiting, saithe, and cod) recruitment in the North Sea and adjacent sea areas during the 1960s and the 1970s;

b) determine the mechanisms by which changes in ocean climate modified recruitment dynamics during the North Sea gadoid outburst. In particular examine:

   i) variations in transport

   ii) match/mismatch in the occurrence of larvae and their prey

   iii) growth and condition of larvae, juveniles and adults

   iv) predation on early life history stages

   v) variations in optimal environments

c) synthesise information on factors influencing gadoid recruitment in the NW Atlantic based on information presented at BF-3

A brief summary was presented in last year's WGCCC report (ICES CM 1999/C: 10) when the Working Group worked by correspondence. The complete report was presented at last year's Annual Science Conference (ICES CM 1999/C:15 Ref ACFM,D,G) and will be published as an ICES *Cooperative Research Report* later this year. As with BFIII, the presentation was to provide the background to the Working Group participants in order to determine possible future work (see Section 3.2).

2.6 2000 Workshop on the Dynamics of Cod Growth

The Workshop on the Dynamics of Cod Growth was held immediately prior to the WGCCC meeting at Dartmouth and attended by 28 participants representing Canada, Denmark, Germany, Iceland, Norway, Russia, the UK and the USA. The Co-Convenors, D. Swain, G. Ottersen and N. Anderson, indicated that the report from the workshop should be completed by the middle of June. The terms of reference for the meeting were:

a) develop models of growth in order to improve the quality of stock forecasting;

b) describe major sources of uncertainty in the prediction of growth rates and advise on further studies to reduce this uncertainty;

c) assess the contribution of growth rate variability to the observed variability in stock biomass and stock forecasts;

d) recommend standard methods for comparing growth rates;

e) develop specific case studies, which will be relevant to the advice of ICES.

During the Workshop several teams were formed to address specific growth-related issues. D. Swain presented a list of their preliminary recommendations. A more concise set of recommendations (eliminating overlap) will appear in the final report. A proposal was made during the WGCCC meeting that the workshop proceedings be published as an ICES *Cooperative Research Report* (CRR) within the coming year. It was argued that this provides a more polished publication and would receive wider distribution. Other CCC members felt that there was still much work to do regarding the growth of cod, even upon completion of the workshop and questioned whether the proceedings should be published as a CRR. The WG therefore decided to postpone the decision on whether to publish the workshop proceedings as a CRR until after completion of the workshop report. Once members have a chance to read the report, the Chair will contact them (by September) to determine a consensus of whether it should be published as a CRR. The discussion and vote will be conducted via the website bulletin board.

Many members praised the use of the web-based bulletin board to exchange both data and ideas prior to the meeting. The website also allowed interested parties unable to attend the Workshop to present their views. The Working Group decided to adopt similar procedures for future workshops.

2.7 Review of Regional GLOBEC Programs

Brief reviews were provided on the status of several other GLOBEC or GLOBEC-related programs.

G. Ottersen reported that the GLOBEC International Project Office (IPO) has been established at Plymouth in the UK with Roger Harris as Chair of the Scientific Steering Committee and Manuel Barange as Director of the IPO. The IPO coordinates the national GLOBEC programs as well as the regional activities of which the WGCCC is one of four. The other three regional working groups are the PICES Climate Change and Carrying Capacity (CCCC), Small Pelagic Fish and Climate Change (SPACC) and the Southern Ocean. In addition, four new working groups have been formed directly under the IPO to bring together GLOBEC researchers working at the national and regional levels. The FOCUS 1 WG deals with retrospective analysis, FOCUS 2 with process studies, FOCUS 3 with prediction and modelling and FOCUS 4 with feedback from ecosystem changes. Members of the WGCCC are represented on the two FOCUS WGs that have been formed. C. Werner is Chair of the FOCUS 3 WG while J. Alheit and K. Drinkwater are members of the FOCUS 1 WG. The purpose of these WGs is to carry out the International GLOBEC Implementation Plan through organising study groups, symposia and meetings. J. Alheit noted that the FOCUS 1 WG would hold its first meeting in Barcelona, Spain, on 18–19 May. One of the items they are proposing is a meeting between GLOBEC researchers and those working on climate dynamics (CLIVAR) and on paleo-oceanography (PAGES). C. Werner indicated that the first meeting of the FOCUS 3 WG will be held in Chapel Hill, North Carolina, USA in June. It will consider specific study areas related to physics and interactions at the higher trophic levels (perhaps with zooplankton and fish as a starting point for the biology). On the operational side, the group will consider establishing formal access to a Supercomputing Centre in North Carolina that would be common to the group.

K. Brander reported on the Trans-Atlantic Study of Calanus (TASC). He noted that a joint TASC & ICES/GLOBEC Newsletter was produced immediately after the TASC Symposium last year to inform the ICES community about the outcome (http://www.ices.dk/newslet/). Much of the work carried out in the TASC programme was funded by national GLOBEC programmes and all of it fitted within the scope of work set out in the International GLOBEC Science and Implementation Plans (IGBP Reports 40 and 47). The relationship between TASC and the ICES/GLOBEC programme has been a very close one. The aims of TASC and of the Cod and Climate Change programme are complementary, as the Introduction to the TASC Symposium by the Convenors made clear. The TASC Symposium provided us with an enormous amount of new information about the population dynamics of Calanus and its relationship with its physical environment, prey and predators. A major challenge over the next few years is to bring this knowledge to bear on questions about marine ecosystem and fisheries assessment and management. There are a number of ways in which ICES can continue to foster such integration, beginning with Theme Sessions at the 2000 Annual Science Conference. M. Heath presented some of the scientific results from the TASC. He highlighted the large-scale processes across the Atlantic and the relationship between the winds, the NAO and Calanus.

M. Heath also reported on recruitment studies conducted in the northern North Sea as part of STEREO. Using numerical models of the circulation coupled with Early Life History (ELH) models he described a study on haddock. Fish spawned to the west and to the north of Scotland were released and drifted with the model currents. They were allowed to grow and die assuming temperature-dependent growth and the mortality rate a function of growth. Density dependent mortality as a function of settlement was also build into the model. These models show good agreement between predicted and observed recruitment. Such models offer great potential for understanding recruitment processes and reveal the importance of considering the within season temporal variability and spatial differences.

G. Lough reported on US GLOBEC Georges Bank Study that recently concluded its fifth and final year of intensive fieldwork involving moorings, bank-wide monthly surveys (January-June) and intensive process studies in alternate years. Since the initial field studies began in spring 1994, more than 100 cruises have been conducted. The research program goals are to (1) determine how physical and biological processes control the population dynamics of the target species *Calanus finmarchicus*, *Pseudocalanus* spp., and the early life stages of cod and haddock, (2) embody this understanding in conceptual and quantitative models to determine how the ecosystem responds over a broad range of space and time scales, and (3) to better understand how climate variability and climate change can affect the distribution, abundance and production of the target organism. The first three phases of this cooperative, inter-agency research program have supported integrated, multi-investigator, interdisciplinary programs of modelling, retrospective analysis, monitoring and process field studies. In Phase I (1995), the field study focus was on stratification/mixing processes, Phase II (1997) on source, retention, and loss of the target organisms, and Phase III (1999) focused on cross-frontal exchange. As part of the 1999 exchange of plankton across the tidal mixing front from April to June, real-time data assimilative modelling of the flow field was carried out with observational studies using CTD, ADCP, dye injections, towed Video Plankton Recorder, and satellite-tracked drifters to provide nowcast/forecast products which could be used for planning sampling strategy. Also noteworthy, haddock recruitment in 1999 continued to be relatively high, second only the 1998 haddock year class, the strongest year classes observed since 1975 and 1978. These and many other research topics can be found in the Report of U.S. GLOBEC Georges Bank Scientific Investigators' Meeting held at the National Academy of Sciences Woods Hole Facility, November 8–10, 1999. A special theme session also was held at the AGU/ASLO 2000 Ocean Sciences Meeting, San Antonio, Texas, January 24–28. A final U.S. GLOBEC Phase IV will begin in 2001 to integrate and synthesise data collected during the field phases of the Georges Bank program. A draft request for proposals was submitted last April to the U.S. GLOBEC Scientific Steering Committee for approval. Proposal submission is expected by December 2000.

E. Head reported that Phase I of Canadian GLOBEC was nearing completion and that a proposal for Phase II had been submitted. Unfortunately, the National Science and Engineering Research Council (NSERC) did not fund the proposal although it was cited as being strong scientifically. The Canadian Department of Fisheries and Oceans will provide limited funding for synthesis of Phase 1 and with a view to submission of a revised GLOBEC program next year. A brief description of 2 GLOBEC-Canada projects carried out at the Bedford Institute was then presented. One was titled "Hydrodynamic and lower-trophic level influences on gadoids on the Scotian Shelf" and the other "Zooplankton supply and production on the Scotian Shelf". The first included retrospective analysis of hydrographic and biological data collected over the last several decades and also incorporated data collected during the project's life span. Amongst the achievements of this project were: (1) development of climatological flow fields for the Scotian Shelf (SS), which showed seasonally variable partial gyres over Browns Bank and Western Bank and the strong winter-time influx of water from the slope on to the central SS; (2) recognition that during the spawning season the retentive capacity of Browns Bank (e.g., for fish eggs and larvae) varies on an interannual basis because of differences in physical forcing; (3) development of a retention/survival index for haddock for Browns Bank; and, (4) development of an early life history model (hydrodynamics + biology) for haddock which was able to reproduce the retention/survival characteristics of 2-year old haddock for Browns Bank. The second project, also had a retrospective element, but consisted mainly of a field programme to examine the roles of the Gulf of St. Lawrence and the offshore as sources of supply of *C. finmarchicus* to the Scotian Shelf. The eggs and nauplii of *C. finmarchicus* have been implicated as good,

if not essential, food for larval groundfish. The study confirmed that the Gulf is the main source for the eastern Scotian Shelf, but indicated that the main source of *C. finmarchicus* for the central and western Scotian Shelf is the offshore.

M. Heath reported that the main contribution to UK GLOBEC is the Marine Productivity Program that focuses upon the Irish Sea. The program is aimed at understanding the physical factors affecting zooplankton dynamics, with the overall goal of coupling models and observations. Phase I has received funding (£1.5m over 2 years) and will be directed towards i) the assembly and dissemination of relevant observational databases, ii) the development and testing of existing biological models in a variety of physical settings and iii) the development of sampling and analytical technologies needed to provide new field data for hypothesis testing. A number of projects have been approved with most expected to be underway by June 2000.

J. Alheit reported that the German GLOBEC programme remains in the proposal stage with the likelihood of submission for funding in the autumn of 2000. The programme involves work in both the Baltic and the North Sea employing a comparative approach. One of its main aims is to examine trophic interactions between zooplankton and fish under the influence of climate variability. The primary fish species being investigated will be herring and sprat. While cod is not directly targeted, there is a strong link between cod and sprat through predation. The work will be coordinated with other European nations. In addition to this prposal, Germany is involved in EU funded programmes including frontal studies in the Skagerrak and in the northern North Sea. Germans are also heavily involved in the GLOBEC Working Group on Small Pelagic Fishes and Climate Change (SPACC). This work is concentrated in the Benguela Current.

3 FUTURE WGCCC ACTIVITIES

3.1 Theme Session on Climate-Plankton-Fish Linkages

The Theme Session on Climate-Plankton-Fish Linkages is scheduled for the 2000 Annual Science Conference at Berges in Belgium. K. Drinkwater, one of the Co-Convenors, reported that to date there have been 21 papers and 6 posters submitted. Of the submitted papers, 8 focus on plankton and their relationship to climate variability, another 11 deal with fish and their relationship with either plankton or climate fluctuations or both. The papers dealing with fish represent a variety of species including cod, haddock, herring and salmon. The subject of the other two papers are unrelated to the Theme Session topic, hence the Co-Convenors have recommended to the ICES Secretariat that these 2 papers be moved to a more appropriate theme session. If none are available then they could be accepted in the present session but as posters. Roger Harris, the Chair of International GLOBEC Scientific Steering Committee has agreed to provide a wrap-up summary of the session.

3.2 Follow-On Activities to the BFIII and BFIV Workshops

Recommendations from BFIII and BFIV included the possibility of follow-up workshops. In addition, at last year's science conference, a Theme Session for the 2001 Annual Science Conference was suggested on Changing Ocean Climate of the North Atlantic and Consequences for Gadoid Populations. This was to be a forum by which the results from these two workshops could be presented to the wider ICES audience. Those Co-Convenors that were present (C. Werner-BFIII; M. Heath-BFIV) expressed the view that upon further reflection they now felt that a follow-up workshop was not the best use of the WG's or the individual scientist's time. In the case of BFIV, it was now generally felt that further analysis of the available data would not produce significant new insights. The Workshop had gone just about as far as it could with the available data. While further research related to issues raised in BFIII has proceeded, much of this work will be presented during the Theme Session on Climate-Plankton-Fish Linkages at this year's Annual Science Conference. As to informing the ICES community, it was generally agreed that the ICES *Cooperative Research Reports* were sufficient. These supply the full details and would be more informative than a few short presentations at the Annual Science Meeting. The WGCCC therefore decided not to proceed with either the follow-up workshops to BFIII and BFIV or the Theme Session initially proposed last year. Instead the WG encouraged those continuing their research, especially related to BFIII, to complete their work and submit it either as a presentation to the ICES Science Conference or as a primary paper.

3.3 Follow-On Activities to the Cod Growth Workshop

The WG generally agreed that there had not been enough time to fully digest all of the results and information from the Cod Growth Workshop held immediately prior to the WGCCC meeting. The WG will therefore await the report before deciding upon future related activities associated with the recommendations. An exception was the use of otolith back-calculations as a means of determining the growth history of cod. Technological methods to determine growth from otoliths have progressed rapidly such that the cost per otolith has been reduced enough to feasibly mount a pan-Atlantic study. K. Brander agreed to push this at the fall European Science Meeting in September. Funding will be sought from

the EU for such a project. Two other decisions related to the Cod Growth Workshop were made by the WG. First, the web-based bulletin board would be maintained and participants were encouraged to continue their work on determining the relative importance of the effect of changes in temperature on cod growth. Second, a Theme Session on Cod Growth should be held during the 2001 Annual Science Conference in Oslo. Drs. Tara Marshall (Norway), Jean-Denis Dutil (Canada) and Larry Buckley (USA) have agreed to co-convene such a theme session.

3.4 Synthesis on Cod

K. Brander opened the discussion on a synthesis of the Cod and Climate Change work by pointing out a review article that he wrote for the US GLOBEC Newsletter. It outlined the various activities that the WGCCC have undertaken and some of the important results. He also noted that the BFIII Workshop proceedings have been published as *a Cooperative Research Report* and the BFIV proceedings will follow shortly.

A lively discussion ensued on the form a synthesis should take. The last major synthesis of cod was published in 1994 from the Cod Symposium held in Reykjavik, Iceland. A new synthesis is warranted as our understanding has advanced significantly since that time. It was agreed that this synthesis should be a major effort of the WG over the next few years. The synthesis will have several components.

First, the WGCCC will continue to assemble all of the available data on cod to facilitate the synthesis. It will be made readily available on the web and on a CD-ROM. In addition, the Cooperative Research Report on Cod Spawning and Early Life History that was published 10 years ago will be updated. G. Lilly suggested that the life history information of the various cod stocks including migration routes, annual cycle of feeding, growth and condition should be included. K. Brander noted that some of this was in the Report but needed to be expanded to include, for example, information on the liver index. Also, the reference list, which researchers found most useful, will be updated. M. Heath suggested that the cod assessment groups should be involved as they have some of the required information.

The second component is assessment-related. K. Frank proposed that we should review possible means of incorporating our present knowledge of cod into the assessment process. One method could be Caddy's Traffic Light Approach. This method proposes that the stock be assessed on the basis of numerous stock indicators, both qualitative and quantitative, including environmental indices. The WG decided that a review and synthesis of methods of incorporating environmental information into the assessment would begin in the coming year. Again, following a suggestion by M. Heath, the assessment working groups within ICES will be contacted to obtain their input.

The third component will be an ICES symposium. H. Loeng informed the WG that Norway has recently funded a five-year study on climate and fisheries and the Bergen Marine Laboratory planned to host a symposium on the links between fish and climate, tentatively in 2004. The WG felt that some of the synthesis papers on cod could be presented at this symposium. The WG decided to endorse this plan and make a recommendation to ICES for a Symposium on Climate Variability and its Effects on North Atlantic Fisheries for 2004 in Bergen. The Co-Chairs for the Symposium would be H. Loeng (Norway), K. Drinkwater (Canada) and Robin Cook or Bill Turrell ? (UK).

The fourth and final component is writing and publication of a book. This was heartily endorsed by the WG but it was felt that multi-year funding would be needed in order to carry out such an endeavour. Funds would allow those working on the book to meet occasionally without putting undue stress on the home institutions of the Working Group members. Also there is need for some secretarial and technical support. It was decided to apply for EU Concerted Action Funding. M. Heath agreed to lead the effort on behalf of the WG with support from K. Frank. In addition, J. Alheit, G. Ottersen and K. Drinkwater will explore the possibility of obtaining funds from the International GLOBEC Office. During the coming year M. Heath and K. Frank will put together a small team of researchers to act as steering committee members for the book, produce an outline and develop a method of approach.

3.5 Future Workshops

3.5.1 Workshop on Larval Drift of Cod from Iceland to Greenland

Building upon the discussion and recommendations of the Workshop on the Application of Environmental Data in Stock Assessments held in Bergen during March 1998, a follow-on workshop to focus upon a case study was proposed by the WGCCC as part of its original 5-year plan. Using the West Greenland/Iceland cod example, models of the circulation would be used to develop transport indices for incorporation into fisheries management models. This Workshop had been tentatively scheduled for 2000 or 2001.

A wide-ranging discussion on this proposed workshop was held. Some WG members noted that there had been several publications on the connection between Icelandic and West Greenland cod and questioned the need for further work on this topic. Others replied that while these studies provided a good qualitative description they are unable to help us predict future states. The aim of the Workshop was to determine if predictions were possible through the development of ocean circulation models and subsequent derivation of a larval transport index. The usefulness of such a workshop to management and the level of interest from assessment scientists was also questioned. B. Bjornson responded that he felt the Icelandic community would be very interested in the results of such a workshop. Several WG members felt strongly that assessment scientists needed to be involved. The modelling effort would require detailed resolution in the nearshore regions off Iceland and West Greenland and be coupled with a larger basin-scale model to resolve the flow between Iceland and Greenland. C. Werner, Chair of the ICES FOCUS 3 Working Group on Modelling and Prediction thought that this might be a problem that some within his WG would be willing to tackle. M. Heath also indicated that models of the region have been developed through TASC although they have not resolved the near coastal regions. B. Bjornson stated that new drift buoy data from around Iceland would be available and may provide valuable current information. Larval drift has been hypothesised to be important in areas elsewhere than Iceland/West Greenland and it was suggested that the workshop should be extended to other geographic areas, including, the Gulf of Maine (between Browns and Georges Banks and Georges and the Middle Atlantic Bight), Davis Strait (West Greenland to Labrador) and around the Faroes.

The WG concluded that a workshop on larval cod transport processes would be held. It will include the Iceland/West Greenland example as well as other areas where larval transport is expected to be important. There would also be a concentrated effort to involve the assessment biologists in the Workshop. It was thought that this workshop could be held in spring 2002 immediately prior to the WGCCC meeting. The location would tentatively be Copenhagen, assuming that is the location of the joint meeting of the WGs. No decision was made on possible Co-Convenors.

3.5.2 Workshop on Long-Term Climate Change and Prediction

Another workshop proposed as part of the original 5-year plan was one on Long-Term Climate Change and Prediction. Its purpose was to explore long-term and short-term predictions in ocean climate, the possible existence of "regime shifts" of climate and the relationship between climate change and their associated ecosystem responses. The mechanisms linking the large-scale atmospheric circulation such as the North Atlantic Oscillation (NAO) to ecosystem changes were to be sought as a follow on from the Workshop on Decadal-Scale Ocean Climate Fluctuations of the North Atlantic held in Copenhagen in September 1997.

It was suggested that since CLIVAR and the AGU (American Geophysical Union) Chapman conference on the NAO scheduled for late November 2000 will be dealing with the physical aspects of the North Atlantic climate, that the WGCCC should concentrate on the biological responses to climate variability and change. Two particular proposals were suggested, both of which would fit the title of "Forward Facing" Workshops. The first was to predict the response of cod stocks to modelled future climate change scenarios based on enhanced CO_2 levels. The second was a workshop that focussed upon climate predictions. This was suggested because of increasing pressure to provide short-term (seasonal to annual) predictions of ocean climate. Concerns were expressed that for either workshop, the term "prediction" may give the impression of a larger certainty than is warranted. In this regard, one of the main aims of such workshops should be to emphasise the uncertainty in any predictions that are forthcoming. It was also suggested that whatever workshop topic was developed, the Working Group on Oceanic Hydrography should be approached to determine if they would be interested in co-sponsoring it. Given the decisions regarding Workshops on Transport and one or two as part of the Synthesis of our knowledge of cod, the WG decided that a workshop on Long-Term Climate Change and Prediction should not be held before 2004. Details on the focus of such a workshop would be left until our next meeting and after discussions with WHOH.

3.6 Tentative Time Table for WGCCC Activities

The Working Group agreed on the following activities as a modified extended version to its previous 5-year plan.

2000	September	Theme Session on Climate-Plankton-Fish Linkages
2001	August	Symposium on Hydrobiological Variability in the ICES Area, 1990–1999.
	September	Theme Session on the Dynamics of Growth of Gadoid Populations
2002	Spring	Workshop on Transport of Cod Larvae
	Spring	WGCCC Meeting
2003		Workshop I on Cod Synthesis
2004		Workshop II on Cod Synthesis
2004		Symposium on Climate Variability and Fisheries
2005		Workshop on Long-term Climate Change and Prediction

There was discussion on whether the WG would sponsor a theme session in 2002. It was noted that if the cod growth theme session is accepted, the WGCCC has sponsored at least one theme session in each of the last 5 years. As a result, the WG decided not to make any proposals for a theme session in 2002.

4 DATA PRODUCTS

At the last meeting of the Oceanography Committee during the 1999 Annual Science Conference, it was decided that all WGs should consider what data products and summaries could be provided on a routine basis to the ICES community via the ICES website. K. Brander lead off the discussion noting that such products have two purposes. One is for ICES scientists and scientific purposes and the other is to provide information for the wider public. While it was agreed that the latter would be useful, it was felt by several WG members that given the limited resources and other demands on our time, priority should be given to the posting of data and data products for scientific purposes. Keith noted that the WG has posted data and data products covering both physical oceanography and fisheries for their last two workshops, BF IV and the recently completed Workshop on Cod Growth. Other possible data to post would be a tagging database for fish and a range of other fisheries data (catches, recruitment, age-specific lengths and weights, condition indices, etc.). While oceanographic data would not be posted by the WGCCC on a regular basis, we could make links to oceanographic data and data such as from the Continuous Plankton Recorder (CPR).

It was stated in the discussion which followed that it is difficult to navigate through the ICES website to find data and data products. An exception is the hydrographic database. The difficulties are in part a result of ICES not having a designated person for web development. While WG members generally agreed that a tagging database would be useful, the required time commitment to carry this out was considered too large to undertake it at present. There was also concern that since there are already several tagging databases in existence, it may not be efficient to create a new one. One possibility is to make links on the web to such databases. H. Loeng stated that the intent of the term of reference regarding data was to obtain possible data products and was not meant to generate databases or data archives. He felt that the WGCCC with its use of the website was doing an adequate job. Many WG members did feel that more fisheries information should be available on the ICES web site, for use by ICES Working Groups. This is something that the Living Marine Resource Committee should be approached to undertake.

5 INTERACTIONS WITH OTHER WORKING GROUPS

At a meeting of WG Chairs at the 88th Statutory Meeting (1999) it was agreed that each working group would examine other working group reports and terms of reference with the view to formulating key questions requiring inter-disciplinary dialogue during possible concurrent meetings of the Committee's Working Groups in 2002.

K. Drinkwater led this discussion, highlighting those working groups with whom he thought interaction would be beneficial. The WGCCC not only considered issues for possible discussion in 2002 but also areas of general and activity-related interest.

The Working Group on Recruitment Processes (WGRP) and their Study Group on Incorporation of Process Information into Stock-Recruitment Models both have overlapping objectives with CCC. The former Chair of the WGRP indicated that they would be interested in the proposed Workshop on the transport of cod larvae between Iceland and West Greenland. The WGCCC Chair agreed to contact the new Chair (Richard Nash) to determine if the WGRP would still be willing to be involved in this Workshop. The Study Group held a meeting in December 1999 where they discussed methods of incorporating environmental indices into fisheries management. The WGCCC needs to open regular communications with this group.

There is presently joint collaboration with the Working Group on Oceanic Hydrography (WGOH). The Theme Session on Climate-Plankton-Fish Linkages for the 2000 Annual Science Conference was a combination of a proposal by WGOH on the effects of climate variability on plankton and one by WGCCC on zooplankton-fish linkages. Members of our working group are also interested and involved in the Symposium sponsored by the WGOH on Hydrobiological Variability in the ICES area, 1990–1999. The WGCCC decided not to schedule any workshops during 2001 to allow our members to participate in this Symposium. The annual reviews of the hydrography in the ICES area produced by the WGOH are also of use to the WGCCC. Finally, we would like to discuss the possibility of involvement of the WGOH in developing our Workshop on Long-term Climate Change and Prediction.

The WGCCC discussed possible collaboration with the Working Group on Marine Data Management (WGMDM) in identifying possible datasets that are in danger of being lost. We also discussed the possibility of help from WGMDM in the development of biological databases, in particular coordinating formats and procedures.

The concern of the Working Group on Zooplankton Ecology (WGZE) with zooplankton monitoring is of interest to the WGCCC along with new technologies for collecting and measuring zooplankton abundance. K. Drinkwater informed the WGCCC that he contacted the Chair of the WGZE prior to their meeting to encourage his members to contribute to the upcoming Theme Session on Climate-Plankton-Fish Linkages.

6 OTHER BUSINESS

6.1 UVAC

S. Skreslet discussed an EU funded study on the effects of ultra-violet radiation (UVR) on the Northeast Arctic cod stock. This investigation is part of a more comprehensive impact study that included other factors such as the effects of variability of the climate and plankton. The impact of UVR on the fish will be investigated both statistically and through dedicated field and laboratory experiments. A second major objective is to develop models to estimate cod stock size based on geophysical information available from remote-sensing and ground-based monitoring. More details of the study are provided in Appendix 2.

The WG agreed to make links on the GLOBEC/ICES website to this study's web page.

6.2 Arctic Climate Impacts Assessment

H. Loeng briefly discussed recent meetings of the Arctic Climate Impacts Assessment (ACIA) group in February and again in April of 2000. The goal of the ACIA is to increase our knowledge of the climate and UVR variability, their impact on the ecosystem and the socio-economic consequences. The purpose of the February meeting held in Washington was to plan a study of the impacts of climate change on Arctic regions. The ultimate aim is to produce an IPCC style publication describing the effects of climate change on the Arctic. Over 40 experts from all the Arctic countries attended the Workshop. Since no new research is planned, the predictions will rely upon existing knowledge. For this reason, ICES was invited as it contains a substantial amount of relevant information. Topics were selected for closer study and there will soon be a call for contributing authors. Besides H. Loeng, K. Drinkwater and R. Dickson attended this meeting. H. Loeng stated that although he was at the meeting on behalf of ICES, he did not believe that he was an official representative of ICES.

K. Brander indicated that he gave a talk to the ACIA in 1999. He pointed out this is one of several issues that are of interest to both ICES and GLOBEC. As GLOBEC Coordinator, it is not always clear whether the activity falls under ICES or GLOBEC. To date decisions have been made between the Coordinator and the General Secretary. Since the number of these issues is increasing, they are taking more time away from the ICES/GLOBEC office. It was suggested that clarification of who represents ICES and how the Coordinator's time should be divided was needed. The WG decided that the Chair should send a letter to the General Secretary asking for clarification on the role of Coordinator in these issues and who can represent ICES.

6.3 NAO Conference

K. Drinkwater reported that an AGU Chapman Conference on the North Atlantic Oscillation (NAO) would be held in late 28 November-1 December 2000 in Spain at the University of Vigo (Orense Campus). The Conference will cover the following topics: ocean, land, sea-ice response to the NAO; global climate change and the NAO; atmospheric processes; coupled ocean-land-sea ice-atmosphere processes; pre-instrumental records of the NAO; impacts of the NAO; and predictability. Deadlines for abstracts is the 15 September.

7 RECOMMENDATIONS AND TERMS OF REFERENCE FOR FUTURE MEETINGS

The following recommendations emerged from the meeting. Recommendation I addresses the activities of the Working Group in 2000/01.

Recommendation I:

The **ICES/GLOBEC Working Group on Cod and Climate Change** (Chair: Dr K. Drinkwater, Canada) will work by correspondence over the next year to:

a) review and evaluate the outcome of the Workshop on the Dynamics of Cod Growth and determine follow-up activities;

b) prepare for the Workshop on the Transport of Cod Larvae;

c) plan and initiate the synthesis of work to date on Cod and Climate Change by:

   i) requesting funds for the preparation of a book on cod and climate change and if successful, holding a meeting of a small steering group to develop an outline for the book as well as plan the necessary activities and determine the people required to write and publish the book;

   ii) assembling references and additional data on cod stocks throughout the North Atlantic with the purpose of making the information available through publication and on a CD;

   iii) examining possible ways by which environmental information can be incorporated into the assessment process;

d) initiate plans for a symposium on Climate Variability and Fisheries;

e) consult with Oceanography Committee Working Groups on possible joint activities and data requirements.

The Workshop will report to the Oceanography Committee at the 2001 Annual Science Conference.

Justification

During the 2000 meeting of the CCCWG a multi-year plan of activities was adopted. This is an extension of the 5-year plan originally laid out during its 1998 meeting for the Oceanography Committee and which was part of Implementation Plan of the International GLOBEC program (The ICES/GLOBEC Cod and Climate Change program is the North Atlantic regional component of the International GLOBEC program). The plan will require further development over the coming year and preparations are needed for the activities identified in it. These can be carried out effectively by correspondence.

a) The Workshop on the Dynamics of Cod Growth was successfully completed in May 2000 and the report is scheduled for completion in June. The extensive information and numerous recommendations will be examined in order to determine what follow-up activities there should be and how best to carry them out. This will include further analysis of the data and decisions on whether to proceed with the development of a single growth model for all stocks. The website bulletin board will continue to be maintained to facilitate communications between participants.

b) A Workshop on the Transport of Cod Larvae has been proposed for the spring of 2002. The aim of the Workshop is to model larval drift and to develop transport indices with the view to predicting effects on recruitment. Emphasis will be on the Iceland/West Greenland connection as well as areas such as the Gulf of Maine, Davis Strait and the Faroes. Incorporation of this information into fisheries management practices will be attempted.

c) (i-iii) Research in recent years has expanded our understanding of the dynamics of individual cod stocks and some of the causes of interannual variability. Comparative studies between stocks, such as those on growth and recruitment, have provided knowledge that was unattainable from stock-specific investigations. This increased knowledge warrants a new synthesis of the present state of our knowledge. It was proposed that this synthesis be in the form of a book but will require some nominal funding for planning meetings as well as secretarial and technical support. Novel ways to incorporate this new knowledge into the assessment process is also planed.

d) The last major symposium on cod was held in 1993. Increased knowledge in the interim on both cod and other species warrants another Symposium on Climate Variability and Fisheries. Plans for such a meeting need to be developed well in advance of the time of the symposium.

e) Several areas of mutual interest and concern with other working groups within the Oceanography Committee have been identified. Relationships with these groups need to be fostered and enhanced. Planning of joint or cooperative activities is required.

Recommendation II:

A Theme Session on the **Dynamics of the Growth of Gadoid Fish Populations** at the 2001 ICES Annual Science Conference in Oslo, Norway under the Co-Chairs of T. Marshall (Norway), J.-D. Dutil (Canada) and L. Buckley (USA).

The objective is to improve our understanding of the relative importance of environmental variables on the growth of cod and other gadoid fishes.

Justification

Widespread changes in the growth rates for many gadoid fishes over the past decade or more have had considerable consequences on stock biomass estimations and predictions. Recent studies have highlighted the possible importance of several variables in influencing growth, including temperature, food, maturation, density-dependence, genetics and size-selective fishing mortality. Understanding the relative importance of these processes on growth from the larval stages through to adults was the aim of the ICES/GLOBEC Workshop on the Dynamics of Cod Growth held in May 2000. A theme session would allow presentation of the findings from this meeting and subsequent follow-on studies to the broader ICES community as well as provide opportunity for others working on similar matters. Expansion to include all gadoid fishes would allow comparisons between cod and other species.

Recommendation III:

A Workshop on the **Transport of Cod Larvae** will be held in Copenhagen (?) during the spring of 2002 to:

Terms of Reference

a) couple circulation models with early life history models to determine the physical and biological processes responsible for the transport or retention of cod larvae;

b) develop, if possible, interannual transport indices based on physical variables that reflect the magnitude of the larvae drift or retention;

c) attempt to incorporate these indices into the cod assessment process.

Justification

The drift of cod larvae has significant implications in several regions of the North Atlantic. For example, Icelandic cod drift as larvae towards West Greenland. When environmental conditions are right off West Greenland, these cod thrive and subsequently return to Iceland to spawn. This can cause large uncertainties in the assessment of the Icelandic stocks. Transport of cod larvae has also been hypothesised to affect recruitment patterns in areas such as the Gulf of Maine, Davis Strait and the Faroes. The Workshop will use circulation models to explore the physical processes that lead to the variability in transport of larvae. Attempts will be made to determine if larval transport indices derived from the model results can be used to improve assessment models.

Recommendation IV:

A Symposium on Influence of **Climate Variability on North Atlantic Fisheries** will be held in Bergen, Norway in 2004 under the Chairman-ship of H. Loeng (Norway), K. Drinkwater (Canada) and Robin Cook or Bill Turrell (UK).

Topics to be covered include:

Climate variability - physical background
Plankton and fisheries
Recruitment
Growth
Distribution and migration
Influence of climate variability on short and medium-term fish stock prediction

A panel discussion and summing up would occur on the last day.

Justification

The synthesis phase of the Cod and Climate Change programme will be coming to an end and a Symposium (ten years after the Cod and Climate Symposium in Reykjavik) will provide a record and measure of progress. It will also encourage input from a wider community, who have not been involved in the Cod and Climate Change programme and may be dealing with other species and other disciplines. One of the main themes for the Symposium will be to evaluate what impact the work can and should have on fisheries assessments. The Symposium is relevant to all five scientific objectives in the ICES Strategic Plan.

APPENDIX 1

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APPENDIX 2

Research Results

European Commission Contract N^{o} EVK3-CT-1999–00012

The Influence of UVR and Climate Conditions on Fish Stocks: A Case Study of the Northeast Arctic Cod (UVAC)

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Abstract

Marine fish resources are in a crisis world wide today, probably mainly due to overexploitation of fish stocks. Simultaneously, it is well-known that fish stocks, especially in regions with harsh natural conditions, e.g., the polar oceans, experience large natural variations depending on natural environmental parameters, such as feeding conditions, sea water temperature, ice coverage and radiation conditions. In today's fishery management, only few of these parameters are considered for fish stock size estimation, which is the basis for determining fishing quota. A more comprehensive understanding of the causal chains of natural impact parameters is essential for a more sustainable exploitation of wild fish stocks in the future. This will be even more relevant, if global change (enhanced greenhouse effect, ozone depletion) and its impact on marine ecosystems will come true as expected by the scientific community.

The main objective of UVAC is to investigate the impact of solar ultra-violet radiation (UVR) on the Northeast Arctic cod stock. This relation will be investigated as part of a more comprehensive impact system, including both other geophysical factors such as climate, and biological species which are important for the cod stock (zooplankton, phytoplankton). The UVR impact will be investigated both statistically using long-term biological and geophysical data records, and in-depth in dedicated field and laboratory experiments. A second major objective is to develop modelling tools, which will be used to estimate cod stock size based on geophysical information available from remote-sensing and ground-based monitoring, thus providing a more reliable basis for a sustainable management of marine resources.

The project will be performed using three sets of biological and geophysical data, covering different time scales and having different levels of information. Data over a 100-year period, consisting of annual cod landing records and *C. finmarchicus* annual biomass estimates on the biological side, and records of local climate conditions, regional climate indices and total ozone/UVR records on the geophysical side, will be used to determine long-term correlations, and, if possible, to separate the impact of climate from that of UVR.

Data with a significantly enhanced degree of detail over a 14-year period (1985–1998) will then be used to investigate the impact of UVR on the species involved in more detail. To this purpose, high-resolution maps of relevant UVR parameters, based on remote-sensing data of total ozone and cloud coverage and calculated with state-of-the art radiative transfer models, will be constructed for the cod spawning area. These investigations will be supported by field and laboratory experiments/studies, which will cover the whole scope of biological and geophysical parameters assumed to play a role in the UVR – cod interaction.

The combined results of the above work will be used to develop modelling tools (short-term process modelling and long-term modelling) which can reproduce past (observed) cod stock variations and predict variability in the future.

The project will hopefully enlighten the influence of a potentially very important natural parameter on marine ecosystems. Integration of UVR impact processes into fish stock size modelling tools have the potential to improve these tools considerably, both in terms of uncertainty reduction and long-term applicability of such tools, which is of great importance for a future sustainable fishery management.