

Report of the
**ICES/GLOBEC Working Group on
Cod and Climate Change**

New Bedford, USA
7–9 May 2003

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1 INTRODUCTION AND TERMS OF REFERENCE

The Working Group on Cod and Climate Change (WGCCC) met in New Bedford, USA on 7–9 May, 2003, under the co-chairship of Dr. Ken Drinkwater (Bedford Institute of Oceanography, Dartmouth, Canada) and Dr Geir Ottersen (Institute of Marine Research, Bergen). There were 20 participants from 6 countries (Canada, Denmark, Greenland, Norway, Spain and USA) and the ICES/GLOBEC Coordinator. A list of participants is provided in Appendix A.

Immediately prior to the working group meeting, the ICES Workshop on Synthesis of the Cod and Climate Program (5–7 May) was held. Fourteen of the WGCCC meeting participants took part in the Workshop.

The terms of the reference (C: Res.2002/2C12) for the CCC meeting were:

The **ICES/GLOBEC Working Group on Cod and Climate Change** [WGCCC] (Co-Chairs: K. Drinkwater, Canada, and G. Ottersen, Norway) will meet in New Bedford, USA from 7–9 May 2003 to:

- a) review and evaluate the outcome of the Workshop on Synthesis of Cod and Climate Change and determine follow-up activities;
- b) update data and information on the life history of the various North Atlantic cod stocks as part of the synthesis work of the Cod and Climate Change programme;
- c) review plans for:
 - i) the theme session for the 2003 ASC on the Transport of Eggs and Larvae to Cod Stocks of the North Atlantic,
 - ii) the 2004 ICES Symposium on The Influence of Climate Change on North Atlantic Fish Stocks;
- d) discuss the future directions of the Cod and Climate programme.

WGCCC will report by 31 May 2003 for the attention of the Oceanography Committee.

G. Ottersen opened the meeting by welcoming the attendees and briefly introduced the four major components of the agenda. The agenda is provided in Appendix B.

1.1 The Strategic and Action Plans for WGCCC

As background information, the strategic plan for the Working Group adopted during the May 1998 meeting in Woods Hole, Mass., USA (ICES CM 1998/C:10) was presented. The strategic plan consists of 7 major components:

- 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.

A 5-year action plan of activities was developed at the same time and updated in May 2000 (ICES CM 2000/C:11) and again in April 2002 (ICES CM 2002/C:15). The related workshops and activities in the action plans under these 7 components completed during the last four years include:

1999 March*	Workshop on the Gadoid Outburst in the North Sea
1999 August*	TASC Symposium on Calanus
1999 September*	ICES ASC Theme Session on Bio-Physical Modelling
2000 May*	Workshop on the Dynamics of Growth in Cod

2000 September*	ICES ASC Theme Session on Climate-Plankton-Fish Linkages
2001 August**	ICES Symposium on Hydrobiological Variability in the ICES Area, 1990–1999
2001 September**	ICES ASC Theme Session on the Dynamics of Gadoid Growth
2002 April*	Workshop on the Transport of Cod Larvae
2002 October**	Theme Session on Comparative Studies of North Atlantic Ecosystems and a Contributed Session on Zooplankton-Climate Linkages in Different Regions of the Northern Hemisphere at the GLOBEC 2002 Open Science Meeting, in Qingdao, China.
2003 May***	Workshop on Synthesis of the Cod and Climate Change Program

where * denotes activities from the 1998 plan, ** the 2000 update, and *** the 2002 update.

2 REVIEW OF PAST ACTIVITIES

2.1 Update on ICES/GLOBEC Position and Secretariat

K. Brander reported on his activities since the last CCC meeting as the ICES/GLOBEC Coordinator. Recently much of his time has been in the planning and preparations for the Synthesis Workshop and the CCC Meeting. During the year he also produced a number of scientific contributions to present the work carried out within the Cod and Climate Change programme and his own research interests. These include:

Studies of cod growth – Contribution to CRR 252 on Cod Growth and paper on “Explaining and predicting cod growth”. A Working Document analyzing existing methods for predicting growth and suggesting improvements was circulated to assessment WG chairs in August and included in SGGROMAT. Co-authoring a paper on “Comparing productivity of North Atlantic cod stocks and limits to growth production” which J-D Dutil presented in Qingdao and which has been submitted for publication. **Changes in fish distribution** - Major changes in distribution of commercial and non-commercial fish species in the eastern North Atlantic over the past 30 years have resulted in northward shifts of up to 1000 km. Similar changes are observed in plankton and seem to be a coherent response to changing temperature. A paper is in press from the ICES Decadal Symposium and a book chapter published. (Brander, K., 2003, Fisheries and Climate. In: Wefer, G., Lamy, F., and Mantoura, F. (eds), Marine Science Frontiers for Europe. Springer-Verlag, Berlin-Heidelberg-New York-Tokyo, pp. 29–38). **Impact of climate change on the Arctic** - Contribution to the completed draft of the ACIA Marine System chapter and drafting meeting in Bergen. Associate member of a German research programme (Integration) on the Integrated Assessment of Changes in Thermohaline Circulation. **The role of the CPR in marine management** – A paper is in press that shows the value of the CPR time-series, in relation to policy on fisheries, marine pollution, introduced species and biodiversity. Two talks were given on this subject. Dr. Brander is in his fourth year as President of SAHFOS. **Transport of cod larvae** – Editing and contribution to the report of the CCC Transport Workshop that was held in April 2002. **Quantitative Indicators for Ecosystem Management** - Leading the Task Force investigating environmental effects within SCOR-IOC WG 119 which met in Cape Town in December 2002. **Management of Adaptive Responses to Fishing** - Presenting an ICES paper on this subject and contribution to a book chapter. **Use of Environmental Information in Stock Assessment** - Giving several talks on the subject, including the Expert Meeting preceding the 5th Conference on Protection of the North Sea in Bergen. A paper (with Bob Mohn, Canada) on “effects of including the NAO in cod stock-recruitment models” has been submitted. One has just been published. Brander, K. 2003, What kinds of fish stock predictions do we need and what kinds of information will help us to make better predictions? SCI. MAR., 67 (Suppl. 1): 21–33.

Dr. Brander represented ICES at two international conferences and gave talks in Reykjavik in May (US-Icelandic Science Day on North Atlantic Science Connections) and in Qingdao in October (ICES ASC and GLOBEC Open Science Conference). He submitted an EoI for the EU 6th Framework Programme on Pan Atlantic Synthesis of North Atlantic marine ecosystem research and elements of this are included in the next call for proposals. In addition, he took part in reviews of research programmes in the UK, France, Germany, Norway, Canada and the Faroe Islands. This included attending four meetings, giving a talk at each and contributing to the report and evaluation of the programme.

Over the upcoming year, as the Cod and Climate Change programme continues to carry out a synthesis stage, his anticipated work will be focusing upon the book on cod and the CCC programme, an update of the Cooperative Research Report on Spawning and Life History Information for North Atlantic Cod Stocks and the ICES Symposium on the Influence of Climate Change on North Atlantic Fish Stocks, all scheduled for completion in 2004.

Financial support for the ICES/GLOBEC position has fallen recently, due to reduced contributions from some countries, no current EU funding and adverse exchange rate fluctuations. This level of funding, which is secure until the end of 2004, is roughly 80% of the total required to operate the full programme. As a result K. Brander dropped to 80%

working time as from 1 January 2003. Meanwhile efforts will continue to raise additional funding. Some of the current funding contracts for the office continue after 2004, but others would require an extension. At last year's meeting the WG endorsed a proposal to seek funding as part of an EU Network of Excellence in the forthcoming EU FP6 programme. An Expression of Interest was written up entitled Pan ATlantic SYnthesis (PATSY). The relevant call for proposals specifies that the research will be carried out within the framework of international science co-operation in particular with the US.

The WG discussed the finances of the position. While this will be brought up at the SGNARO meeting to be held in conjunction with the 2003 ICES ASC in Estonia in September, the WG felt that it would be worthwhile for Dr. Brander to continue to pursue possible funding avenues. **The possibility of taking part in an EU Network of Excellence proposal is being actively pursued.**

The WG also discussed the long-term future of the ICES/GLOBEC position. In the past, it was suggested that the position should become part of the ICES secretariat but the financing for this has never been available. The WG felt that a position that dealt with climate and environmental issues related to fisheries was essential to ICES in order to provide the best possible fisheries advice. Given that the GLOBEC program will officially end in 2009, the WG decided that ICES should address this issue and the co-chairs were instructed to write a letter to ICES as a means of beginning the discussions on this issue.

2.2 Review of the Workshop on Synthesis of Cod and Climate Change (TOR a)

The Synthesis Workshop took place on 5–7 May 2003, in New Bedford, Mass., USA, immediately prior to the meeting of WGCCC and the Workshop Report appears in ICES CM 2003/C:10. At the 2000 CCC Meeting (ICES CM 2000/C:11) it was decided that a major component of our synthesis activities would be the publication of a book on cod. At the 2002 Meeting (ICES CM 2002/C:15) an outline including specific chapters was adopted and lead co-authors were suggested with K. Brander and K. Drinkwater agreeing to be the co-editors. The book will highlight comparisons between stocks by examining stocks across the full range of environmental conditions over the North Atlantic. It will also highlight climate affects on cod through its life history, but attempt to determine the relative importance of climate compared to biotic influences. The purpose of the 2003 Workshop was to review results from the activities of the Cod and Climate programme over the past 10 years, present synthesis papers on specified chapters of the book and finalize plans for its publication. The chapters and co-authors as of the meeting are:

Chapter 1:	Introduction: Brander (ICES/GLOBEC) and Drinkwater (Canada)
Chapter 2:	Stock Structure and History: Marteinsdottir (Iceland) and Ruzzante (Canada)
Chapter 3:	Cod and Climate Change Program: Rothschild (USA), Sundby (Norway) and Dickson (UK)
Chapter 4:	Physical Oceanographic Setting: Drinkwater (Canada) and Loeng (Norway)
Chapter 5:	Biological Oceanographic Setting: Heath (UK), Tande (Norway)
Chapter 6:	Growth and Condition: Buckley (USA), Dutil (Canada) and Marshall (UK)
Chapter 7:	Recruitment: Koester (Germany) and Murawski (USA)
Chapter 8:	Larval Transport: Pepin (Canada)
Chapter 9:	Distribution and Migration: Ottersen (Norway) and Swain (Canada)
Chapter 10:	The Role of Cod in the Ecosystem: Link (USA), Lilly (Canada), Bogstad (Norway), Sparholt (ICES)
Chapter 11:	Implications for Fisheries Management: Brander (ICES/GLOBEC)
Chapter 12:	Response of Cod to Climate Change: Working Group
Chapter 13:	Summary Brander (ICES/GLOBEC) and Drinkwater (Canada)

Outlines and preliminary presentations of the material to appear in each of the chapters of the book were presented and discussed, with the exception of the Introduction and Summary chapters. The Workshop also conducted extensive discussion of the proposed target audience, content, style, gaps and overlaps in coverage, links between chapters and common elements in the presentation of material (e.g. key charts and maps). The following timetable for the further preparation and review of drafts was agreed upon.

May 2003	Synthesis Workshop
End Sep 2003	Review progress, drafts and deadlines
End Sep 2003	Possible meeting of co-authors attending ICES ASC
Dec 2003	All drafts to be sent to editors
Jan 2004	Drafts to be sent out for Review
March 2004	Return of Reviews
May 2004	Final drafts of the papers to be submitted to editors.
May 2004	Climate and Fisheries Symposium

Authors were asked to submit their drafts earlier than the end of 2003 if possible, in order to spread out the internal review process, which will take place before the material is sent out to external reviewers in early 2004. A password protected forum on the ICES/GLOBEC website will be used to exchange material and develop crosscutting themes between the chapters. The aim is to finalize the manuscripts by May 2004 in order to send the publishers the entire book by the summer of 2004.

The Workshop reviewed three potential publishers. The first was in a special volume of the ICES Journal. The second was an offer by Kluwer who have provided a relatively generous publication offer. The third was to have it published within the IGBP series published by Springer. The IGBP have expressed interest but a decision requires a more detailed outline. The Workshop decided that the synthesis work should be published as a book and not as a series of papers. The potential IGBP publication is to be pursued and K Drinkwater will submit an extended outline based on the material at the workshop. The results of discussions with the IGBP will be posted on the ICES Website and a decision on publication will be made by the co-editors, taking into account any comments provided by the co-authors.

Given that more time was required to digest all of this information, no formal review was undertaken, however, the Working Group felt that the book project was well in hand and no further follow-up activities were required at this time.

2.3 Follow-up on to Transport Workshop

The WGCCC Cod Transport Workshop (ICES CM 2002/C:13) was held 14–17 April, 2003, in Hillerod, Denmark under co-chairs, J. Quinlan (USA) and B. Ådlandsvik (Norway). At the 2002 WGCCC Meeting (ICES CM2002/C:15), it was recommended that the Workshop Report be published as an ICES Cooperative Research Report to allow broader dissemination of the results. Due to other activities, little progress was made on this recommendation. The WG reconfirmed the commitment to this recommendation but that it is to have lower priority than the synthesis activities, i.e. the book and updated CRR on cod and the 2004 Symposium. It was noted that this would not likely be undertaken until late in 2004.

2.4 Cooperation with Working Group on Recruitment Process (WGRP)

As reported last year, several members of the Working Group on Recruitment Processes (WGRP) attended the WGCCC Transport Workshop and the first day of the 2002 Cod and Climate Change meeting to discussion areas of mutual interest. Several overlapping areas of interest between the two WGs were identified including processes affecting recruitment, the role of the environment, and how to incorporate environment into the assessment process. A new study group was established under the WGRP on Growth, Maturity and Condition Indices in Stock Projections (SGGROMAT), whose objectives are to collate data on weights, maturity, condition, fecundity and age-length and length-weight keys for stocks in the North Sea, Irish Sea, Northeast Arctic and Baltic Sea. Several CCC members are also members of this SG. The WGRP was considering a Workshop comparing multispecies and environmental predictions in the Baltic and the Arcto-Norwegian cod stock. It was thought that detailed case studies might help to focus how to incorporate environmental information into the assessments. The WGRP agreed to invite participation of CCC members if and when such a workshop was held. This workshop was not held during the past year, but the WGCCC reconfirmed their interest in working with the WGRP on common problems and instructed the co-chairs to promote open lines of communication with the WGRP.

2.5 Interaction with PICES/GLOBEC Working Group on Climate Change and Carrying Capacity (WGCCCC)

The PICES/GLOBEC WGCCCC is one of four regional GLOBEC programs, as is the ICES Cod and Climate Change Working Group. Although much of the focus of the former tends to be open ocean species such as salmon, the identification of climate effects on fisheries is a common focus to both WGs, including interest in statistical methods, retrospective analyses, data archeology, regime shifts, etc. H. Batchelder, one of the present PICES WGCCCC co-chairs, attended the Transport Workshop and the ICES WGCCC meeting in May of 2002. In October of 2002, the co-chairs of the CCC program, G. Ottersen and K. Drinkwater, and the ICES/GLOBEC Coordinator, K. Brander, attended the PICES WGCCC meeting between the OPEN Science Meeting of GLOBEC and the PICES Annual Meeting held in Qingdao, China. K. Drinkwater made a presentation on the Cod and Climate Change activities, including its synthesis activities. Discussion centered on fostering cooperation and joint activities between the two WGs. As reported last year, the FOCUS 1 WG of International GLOBEC is planning a comparative workshop to examine the similarities and differences between fish stocks around the world. It was reconfirmed that cooperation between the two WGs should initially be fostered through this FOCUS 1 Workshop. In the interim, the co-Chairs of the two WGs will continue to communicate on ways to promote cooperation between the two groups.

3 UPDATE OF THE LIFE HISTORY INFORMATION ON NORTH ATLANTIC COD STOCKS (TOR B)

As part of the synthesis activities, the WGCCC decided to update the life history information on cod stocks throughout the North Atlantic published during 1994 in the ICES Cooperative Research Report (CRR) 205 entitled “Spawning and Life History Information for north Atlantic Cod Stocks”. The 1994 report contained information on most of the major cod stocks and focused upon the early life histories. Much new information has been gathered over the last decade and it was decided at the 2000 Meeting of CCC (ICES CM 2000/C:11) and reaffirmed at the 2002 Meeting (ICES CM 2002/C:15) that this new information should be collated and published in the form of an updated CRR. Those scientists familiar with each of the major cod stocks were contacted during the past year and asked to participate in this endeavor. They were specifically asked to update the original report’s checklist of questions and tables (see Appendix C). The requests included information on landings, spawning stock biomass, recruitment estimates, age of maturity, fecundity as well as data on spawning (dates, duration, temperature, egg size, etc.) and larvae (size, growth and mortality rates, dates of hatching and settlement, distance traveled from spawn to settlement, etc.). They were also asked to provide information on adult cod, in particular information on migration and growth, which was not in the original report. Individuals or groups of scientists were identified for almost all of the major stocks. At the meeting many provided revised texts and updated tables from those in the original CRR. Others simply updated the tables. Brief presentations were made on the following stocks. The authors of the contributions along with the presenters are also given. An * denotes that a written submission was also provided at the meeting or immediately thereafter. These written documents can be viewed on the ICES/GLOBEC website (<http://www.ices.dk/globec>) under CRR on Life History.

Stock Area	Co-authors	Presenter
*US Georges Bank and Gulf of Maine	G. Lough, R. Mayo, and L. O’Brien	L. O’Brien
*Canadian Georges Bank and Gulf of Maine	J. Hunt	J. Hunt
*Western Scotian Shelf	D. Clark	D. Clark
Eastern Scotian Shelf	P. Fanning, R. Mohn, and W. MacEachern	K. Drinkwater
*Southern Gulf of St. Lawrence	G. Chouinard and D. Swain	G. Chouinard
*Northern Gulf of St. Lawrence	J. Dutil, M. Castonguay, A. Frechet	J. Dutil
Newfoundland	G. Lilly	G. Lilly
*Greenland	K. Wieland and M. Storr-Paulsen	K. Weilland
*Iceland	G. Marteinsdottir and O. Asthorsson	K. Brander
*Norway/Barents Sea (NE Arctic Cod)	G. Ottersen, S. Sundby and A. Krovnin	G. Ottersen
*Irish Sea	C. Fox and J. Blanchard	K. Brander
*Baltic	F. Koester, C. Mollmann and B. MacKenzie	F. Koester

In addition, other stocks that will be included in the update but were not presented at the WG meeting include the following.

Stock Area	Co-authors	Information to Date
Faroes Plateau	P. Steingrund and J. Reinert	Tables updated
Faroes Bank	P. Steingrund and J. Reinert	Tables updated
White Sea	A. Krovnin	
West of Scotland	Aberdeen Laboratory	
Celtic Sea	C. Fox and J. Blanchard	
North Sea	C. Fox, J. Blanchard and Peter Wright	

From the presentations it was clear that most of the cod stocks had undergone drastic reductions in abundance over the past 10 to 30 years. Several stocks showed declines in condition and/or size-at-age and some have experienced reductions in the age of maturity.

Several issues were discussed following each of the presentations or at the completion of all of the presentations.. These included:

- e) The relationship between the Canadian and US cod components on Georges Bank was discussed. Although under different management systems, it was felt by many at the meeting that they these fish were from the same stock. It was suggested that the material could therefore be combined for the purposes of the CRR. However, it was left to the contributing authors (Canadian component-J. Hunt; US component-L. O’Brien, G. Lough and R. Mayo) to consider this suggestion and to deal with it as they saw fit.

- f) While the US cod component on Georges Bank was combined with those in the Gulf of Maine for the purposes of the presentation and in their written material, they are considered to be separate stocks based upon tagging results and observed differences in growth rates and recruitment.
- g) K. Drinkwater agreed to provide written material on the eastern Scotian Shelf stock as none had been provided in the 1994 CRR.
- h) There was evidence from the eastern Scotian Shelf stock that there have been changes in age of maturity. This also appears to be the case for several other NW and NE Atlantic stocks. On the Scotian Shelf, it appears as if the changes in cod are part of a larger ecosystem change, with the disappearance of large demersals and the dominance of pelagics and small demersals.
- i) For the Southern Gulf of St. Lawrence stock there has been a change in timing of migration out of the Gulf. It was not clear whether this was a fundamental change or due to changes in abundance and distribution.
- j) Length-fecundity information was presented for the Northern Gulf of St. Lawrence cod stock. It was agreed that such data should be included for all stocks, where available..
- k) As the cod abundances declined on the Scotian Shelf, off Newfoundland (Northern cod), and off West Greenland, shrimp and snow crab (in the former two areas), increased and lucrative fisheries developed.
- l) Several general items were also discussed and agreed upon.

K. Drinkwater and K. Brander will request written information for those stocks whose scientists were unable to attend the meeting.

Although updated tables were provided for the Faroes Plateau and Faroes Bank stocks, updated write-ups on the stocks will also be requested.

A chart showing the locations of spawning, larval drift paths, distribution areas and migration routes of each stock should be included in the write up.

K. Brander and K. Drinkwater will revise the questions in the checklist to bring in more detailed information, especially regarding changes in age and length for maturity. These will be provided to those scientists responsible for the individual stocks and posted on the ICES website.

The updated written submissions and tables should be finished by September 2003 and sent to either K. Brander or K. Drinkwater by the end of September 2003.

The written submissions will be edited and checked for completeness. Corrections or additions will be undertaken where required.

The texts and tables for each stock will be combined into a new CRR. Other possible venues for publication were considered but the WG felt that the CRR was the most appropriate at this time.

- The contributing authors will be identified in the heading for each stocks instead of having a general list of authors near the beginning of the report, as was done in 1994.

4 FUTURE WGCC ACTIVITIES

4.1 Review Plans for the 2003 ASC Theme Session on Transport (TOR c (i))

As a follow-up activity to the Transport Workshop held in 2003, it was recommended by the WG at its 2002 meeting and approved by ICES that at the 2003 ASC in Tallinn, Estonia, for there to be a theme session on the Transport of Larvae Relevant to Cod. The co-convenors are J. Chasse (Canada) and B. Ådlandsvik (Norway). Notices and requests for papers were sent out to the participants of the Transport Workshop and to other potentially interested parties. A total of 8 papers and 2 posters will be presented at the Theme Session.

4.2 Review Plans for 2004 Symposium (TOR c (ii))

H. Loeng reported that the planning of the Symposium on the Influence of Climate Change on North Atlantic Fisheries to be held in Bergen, Norway in May 2004 is well in hand. The brochure on the Symposium was distributed at the 2002 ICES ASC in Copenhagen and since then to numerous laboratories, organizations and meetings. The invited speakers have been arranged and the titles of their talks posted on the web. They include J. Hurrell (USA on Climate variability in the North Atlantic: past, present and future), G. Rose (Canada on The impact of climate on the distribution and migration of fish populations), G. Marteinsdottir (Iceland on The effect of climate variability on growth, maturity and recruitment), M. Heath (UK on Zooplankton and the link between climate variability and fish), C. O'Brien (UK on Taking account of climate in the evaluation of the state of fish stocks) and L. Richards (Canada on Managing fish stocks under future climate scenarios and in the face of climatic uncertainty). A second printing of the brochure with this and other updated information is being printed and will be available by the 2003 ASC. Co-sponsors of the Symposium have been arranged and include the Institute of Marine Research in Bergen, GLOBEC, the National Oceanic and Atmospheric Administration (NOAA) and the City of Bergen. As reported last year, the Symposium Proceedings will be published in a special volume in the ICES Journal of Marine Science. Online registration will be available but is not yet arranged. The cost of the registration will be established in the near future. The following deadlines have been set for the Symposium: Pre-registration, 1 October 2003; Abstracts in, 1 December 2003; Notification of acceptance of contributions, 15 February 2004; and Final registration, 15 March.

4.3 Potential Theme Session for 2004 ASC

Given the number of activities the WG has scheduled for 2004 (the Symposium, the book, the updated CRR on the life history of cod, etc.), it was agreed that no theme session topic would be submitted to inclusion in the 2004 ICES ASC.

4.4 Future Directions of the WGCCC (TOR d)

At the 2002 WG meeting, a discussion was begun regarding the future direction of the WG. Although the group is involved in a synthesis of the CCC program, this did not mean that its work was complete. Potential subjects of future investigation that were suggested included fisheries and ecosystem management and the response of cod to climate change. Given the importance of the topic the WG decided further discussions were needed at this year's WGCCC meeting. In addition, the Scientific Steering Committee (SSC) of International GLOBEC was asking for the CCC's strategic plans after the synthesis activities were completed.

The WG first reaffirmed that the 7 components of its strategic plan identified in 1998 (see section 1.1 for a list) were still valid. It was further agreed that what was needed was an updated action plan containing various activities. It was also noted that GLOBEC as a program under IGBP is scheduled for completion by 2009. It was felt that the WGCCC would develop its plan through to this date. The focus of the discussion centered upon possible workshops that could be held to address the aims of the CCC program.

4.4.1 Identification of Future Workshops

After much discussion the following schedule of workshops was agreed upon by the WG. These included:

Workshop on the Impact of Zooplankton on Cod Abundance and Production (in 2005)

Early stages of zooplankton are important prey for larval and early juvenile stages of cod. For most cod stocks *Calanus* species are the main prey, while in some areas, e.g. the Baltic, other species dominate. Survival and growth through these early stages have been shown to be critical for establishing a strong cod year class in some cod stocks. A better understanding of zooplankton-cod linkages should therefore be an important step towards better early estimates of year class strength and thus recruitment to the cod stocks. The workshop would therefore examine relations between temporal and spatial dynamics of zooplankton and early stages of cod. Issues to be addressed would include how timing of zooplankton production and spatial dynamics of *nauplii* relates to the spawning and distribution patterns of early stages of cod and ultimately cod recruitment. Links between later stages of cod and zooplankton will also be addressed. A combination of statistical data analyses, process studies and a variety of modelling approaches will be applied. The workshop will build on the results of the 2002 workshop and the 2003 theme session on transport of cod eggs and larvae as well as output from the ICES 2003 Zooplankton Symposium. The WG felt that this should be undertaken together with the ICES Working Group on Zooplankton Ecology (WGZE). The co-chairs were requested to contact the chair of the WGZE to ask their interest in co-sponsoring and participating in such a workshop.

Workshop on The Decline (and Recovery) of Cod Stocks Throughout the North Atlantic (in 2006)

During the presentations on the update of the cod stocks around the North Atlantic, the WG was struck by the similarity in the abundance trends of many of the stocks, from high values in the 1960s that in some cases persisted through into the 1970s and 1980s, followed by a decline to relatively low levels. In addition, there were often declines in size-at-age and age of maturity. The cause of these declines and the potential for recovery are among the most important issues for cod fisheries today.. The Workshop will compare the changes that have occurred in all of the cod stocks around the Atlantic and address the relative importance of fishing and climate induced ecosystem changes.

Workshop on the Influence of Climate on Tropho-Dynamics of Cod Ecosystems (in 2006)

This Workshop also addresses the observed changes in size-at-age and maturity, but from a tropho-dynamic and bioenergetic perspective. It can therefore be regarded as complementary to the previous Workshop and could be linked to it. The Workshop will consider both observations and theory, including mass balance and scaling from individual based modelling. The role of forage species will be reviewed, particularly capelin in the Barents Sea and at Iceland and sprat in the Baltic. To what extent are observed changes cod stocks due to climate induced variability in their principal prey species? What is the role of climate change on predators of cod (e.g. harp seals)?

Workshop on The Future of Cod in a Changing Climate (in 2007)

Over the last decade, concern over the impacts of global change in climate have increased . New evidence documents the ecological impacts of rising temperature in northern high latitudes. Scenario studies from GCMs indicate substantial climate change over the next 50 years therefore further investigation into the impacts on cod are warranted. The Workshop will assess how abundance, distribution, and production of cod may respond to future climate scenarios. Results from statistical and dynamic downscaling will be applied together with relations established through retrospective analyses. The WG felt that this topic, which gave the programme its name, should be addressed directly before GLOBEC ends. Scientists working on statistical or dynamical downscaling from GCMs, especially in marine settings (e.g., in Norway the RegClim project), should be invited. K. Drinkwater was willing to be one of the co-chairs.

Workshop on Implications of Results from CCC for Fisheries Management (in 2008)

As recognized at the CCC meeting in 2002, more work is need on the application of the results from the CCC to fisheries management. The WG reconfirmed this by agreeing upon a workshop on the subject. Its aims were not well developed, but should be discussed at all Workshops during the intervening period, in order to ensure that they are addressed. The aim will be to develop techniques and methods for incorporating environment into fisheries and ecosystem management and to provide examples.

Synthesis II Workshop (in 2009)

The WG felt that if the CCC program ends in 2009 when GLOBEC is scheduled to finish, a second Synthesis Workshop should be held to highlight the results of the CCC program. The subjects to be addressed by the Workshop will depend on results and issues that arise during the next five years.

The WG noted that there are likely to be other activities in addition to the Workshops, such as Theme Sessions at the ASC or collaboration with other WGs or GLOBEC programmes, but no definitive plans were made regarding these.

4.5 2004 WGCCC Meeting

The WG decided to hold a meeting prior to the Symposium in Bergen in May of 2004 to (a) assess the progress on the synthesis book on cod and the update of the CRR on the life history of cod. In addition, the WG will (b) review and evaluate the results from the Workshop and Theme Session on the transport of cod larvae, (c) develop detailed plans for the Workshop on the Impact of Zooplankton on Cod Abundance and Production in 2005, and (d) begin planning for the workshops in 2006 and beyond.

5 OTHER BUSINESS

5.1 UV Study Update

C. Alonso (Spain) presented a paper on ultraviolet radiation (UVR) that she co-authored with A. Borja. Entitled

“UVAC- The Influence of UVR and Climate Conditions on Fish Stocks: A Case Study of the Northeast Arctic Cod” this was an update on a presentation to the WGCCC given in 2002, which concentrated on laboratory studies.. The study included field investigations in the Lofoten area of Norway on the influence of environmental factors (turbulence, irradiation, T^a, salinity) on *Calanus finmarchicus*, phytoplankton and cod production and retrospective analyses as well as the laboratory experiments on UV impact on the same species that were presented last year. The field studies indicated a potential negative UV effect (UVB and UVA). Water transparency was found to be a key factor in attenuating biological effects and the position of the organisms in the water column (i.e. turbulence) is essential in controlling the dose to which they will be exposed. In general, daily doses at the critical period (April) do not seem high enough to provoke significant impacts. Only time windows of low ozone, clear skies and calm seas might represent a danger for planktonic organisms. Statistical analysis suggests that between 53–73% of the variance in cod recruitment can be accounted for by oceanic and meteorological factors (including the NAO, the AO, the Gulf Stream Index and turbulence) and UVR. The latter relationship was surprising positive, however, indicating higher UV improved recruitment. This was felt to be likely due to a relationship between a third variable, such as solar radiation, for example. There appears to be a connection between environmental forcing and plankton response, which might control the success of cod recruitment. *Calanus finmarchicus* and *C. hyperboreus* show significant relationships with different environmental factors. For *C. finmarchicus* the relationships were with cloud cover, precipitation, snow accumulation and UVR. For *C. hyperboreus* they were with temperature and turbulence. Both species were related to the NAO and the AO.

5.2 Newfoundland Cod Kill

G. Lilly reported on an event of environmentally-induced mortality of cod. Cod, plus some redfish, were observed floating in Smith Sound in Trinity Bay, Newfoundland, on the 5th of April 2003. The dead fish were lying on their side with their fins up in the air. Examination of the fish showed that they had frozen to death. It was estimated that over the next 2 weeks upwards of approximately 1000 mt of cod died. Trawls and in situ cameras indicated that some frozen cod were also lying on the ocean floor, while other cod were swimming about. Temperatures were below -1.5°C and had fell by the order of 1°C in the previous 2 months or so. It was unclear why the antifreeze protein that is usually found in these fish was not present. Also, unknown is why some fish froze while others did not. It is expected, however, that a seeding agent for ice crystals must have been present for cod can usually survive in supercooled water unless ice crystals form.

6 RECOMMENDATIONS AND TERMS OF REFERENCE FOR FUTURE MEETINGS

Recommendation I:

The ICES/GLOBEC Working Group on Cod and Climate Change (Co-Chairs: Dr. K. Drinkwater, Canada, and Dr. G. Ottersen, Norway) will meet in Bergen (Norway) in May, 2004 to:

- a) review and evaluate the progress on the Synthesis Activities including
 - i) the book on cod
 - ii) the update of the CRR on the life history aspects of cod stocks throughout the North Atlantic
- b) review and evaluate the results from the Workshop and Theme Session on the transport of cod larvae.
- c) to plan and prepare the Workshop on the Impact of Zooplankton on Cod Abundance and Production
- d) to initiate plans for other Workshops.

The Working Group will report to the Oceanography Committee at the 2004 Annual Science Conference.

6.1 Supporting Information

Priority: This Group provides fundamental information and analysis of the current scientific understanding of the impact of environmental processes on fisheries, in particular cod

Scientific Justification:

The meeting will be held to review the present synthesis activities and plan for future workshops.

- a.
 - i. One of the major components of the synthesis planned by the WGCCC is the publication of a book on cod. The Synthesis Workshop held in 2003 outlined the material to be covered in the book and established time lines for its preparation. A review of progress towards publication of the book will be carried out. This work is relevant to items 1.2.1, 1.3, 1.6, 1.7, 5.3, 5.13.2 and 8.4 of the ICES Action Plan.
 - ii. A second component of the synthesis was the update on the life history strategies of all of the major cod stocks around the North Atlantic to be published in a CRR. Presentations were made at the 2003 WGCCC meeting and some written material was provided. Additional work was agreed to at the meeting. Evaluation of the material will be made and the progress towards completion of the CRR will be reviewed. This work is relevant to items 1.2.1, 5.3 and 5.13.2 of the ICES Action Plan.
- b. In 2002 a Workshop on the Transport of Cod Larvae was held and in 2003 at the ICES ASC a follow-up theme session will be held. A review of the results of these projects will be examined and a report on the plans for CRR describing the results will be given. This work is relevant to items 1.3 and 1.5 of the ICES Action Plan.
- c. Early stages of copepod zooplankton, particular *Calanus* species are important prey for larval and early juvenile stages of cod. Survival and growth through these early stages have been shown to be critical for establishing a strong cod year class. A better understanding of zooplankton-cod linkages should therefore be an important step towards better early estimates of year class strength and thus recruitment to the cod stocks. Plans for the workshop will include determining the role of the WGZE, establishment of co-chairs, determining the location and dates, as well as the objectives. This work is relevant to items 1.2, 1.2.1 and 5.3 of the ICES Action Plan.
- d. A number of other Workshops were highlighted at the 2003 CCC meeting. The interest in these topics will be reassessed and planning will begin for those scheduled to begin in 2006. This work is relevant to items 1.2.1, 1.3, 1.5, 1.6, 1.7, 3.5, 5.3, 5.10 and 5.13.2 of the ICES Action Plan.

6.1.1 Relation to Strategic and Action Plans:

The ICES/GLOBEC programme contributes to Goals 1, 4, 5 and 8 of the ICES Strategic Plan. Specific contributions to the Action Plan are included with the Scientific Justification.

Resource Requirements:

Assistance from the ICES/GLOBEC Coordinator in maintaining the exchange of information via the web site, Newsletters, databases and workshop bulletin boards.

Participants: Participation at the WGCCC is usually more than 25. Part of the reason for holding the Meeting immediately prior to and in the same location as the ICES Symposium is to encourage attendance and participation.

Secretariat Facilities: None

Financial: None

Linkages to Advisory Committees:

WGCCC has close relevance to the work of the ACFM and ACE.

Linkages to Other Committees or Groups:

Living Resources Committee. Also links to SGNARO, WGRP, SGGROMAT, SGMPI.

Linkages to Other Organizations:

GLOBEC is a co-sponsor of the WGCCC.

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APPENDIX B: AGENDA

2003 WGCCC MEETING AGENDA

7-9 May, New Bedford, Mass., USA

WEDNESDAY, MAY 7

13:30 Welcome and Introductory Remarks (*Ken Drinkwater and Geir Ottersen, Co-Chairs*)

Agenda

Review Terms of Reference (TOR) for Meeting

- Brief review of Strategic Plan for CCCWG and associated Activities

Review of Synthesis Workshop [TOR a] (*Ken Drinkwater and Keith Brander*)

- Identification of any follow-up activities from Workshop

Update of Life History Information [TOR b] (*Ken Drinkwater*)

- Presentation and Discussion for Cod Stocks:

1	Gulf of Maine, Georges Bank	(<i>Loretta O'Brien, Greg Lough</i>)
2	Canadian Georges Bank	(<i>Joe Hunt</i>)
3	Western Scotian Shelf	(<i>Don Clarke</i>)
4	Eastern Scotian Shelf	(<i>Ken Drinkwater for Paul Fanning</i>)
5	Southern Gulf	(<i>Ghislain Chouinard</i>)
6	Northern Gulf	(<i>Jean-Denis Dutil</i>)
7	St. Pierre Bank	(<i>George Lilly</i>)
8	Southern Newfoundland	(<i>George Lilly</i>)
9	Flemish Cap	(<i>George Lilly</i>)
10	Northern Cod	(<i>George Lilly</i>)

17:00 **Adjourn**

THURSDAY, MAY 8

09:00 Update of Life History Information, continued [TOR b] (*Ken Drinkwater*)

- Presentation and Discussion for Cod Stocks:

11	Greenland	(<i>Kai Wielan</i>)
12	Iceland	(<i>Keith Brander</i>)
13	White Sea	()
14	NE Arctic	(<i>Geir Ottersen</i>)
15	Faroe Plateau and Bank	()
16	W Scotland	()

12:00 **Lunch**

13:30 Update of Life History Information, continued [TOR b] (*Ken Drinkwater*)

- Presentation and Discussion for Cod Stocks:

17	North Sea	()
18	Irish Sea	(<i>Keith Brander</i>)
19	Baltic	(<i>Fritz Koester</i>)

Discussion of Cod Stock Updates

Identification of follow-up work

Publication

- CRR or other venue

Future Directions of WGCCC [TOR d]

The Long-Range Direction of WGCCC (*Geir Ottersen*)

Where should the WGCCC be headed?

Updating the activities

Incorporating Environment in Fisheries Management

Climate Change

Identify Theme Sessions for ASC for 2004

- Future Workshops

17:00 Adjourn

FRIDAY, MAY 9

9:00 Future Directions of WGCCC Continued [TOR d]

- Complete discussion on future directions
Review Plans for 2003 Theme Session [TOR c(i)]
- Theme Session on the Transport of Eggs and Larvae of cod Stocks of the North Atlantic For ICES ASC in 2004 (*Ken Drinkwater*)
- Update on the status and number of presentations
Review Plans for 2004 Symposium [TOR c(ii)]

Symposium on the Influence of Climate Change on North Atlantic Fisheries in 2004 (*Harald Loeng*)

- Update on the planning for the Symposium

Other Business

Update on ICES/GLOBEC Position and Secretariat (*Keith Brander*)

Follow-up on Transport Workshop, April 2002, Hillerod (*Keith Brander*)

Cooperation between WGCCC and WGRP (*Ken Drinkwater*)

- Interaction between PICES and ICES (*Ken Drinkwater*)

Future CCC Meetings (*Geir Ottersen*)

2004 – Meeting in Norway in conjunction with Symposium?

- Terms of Reference?

Wrap-up and Summary (*Ken Drinkwater and Geir Ottersen*)

Recommendations

Action Items

- TORs for next year

12:00 Adjourn

APPENDIX C: CHECKLIST FOR UPDATED CCR

Checklist of Biological and Environmental Data for Comparing Reproductive Strategies

This is the checklist originally circulated by the ICES Larval Ecology Working Group in order to bring together existing data on early life stages of cod and haddock. When reading some of the individual stock sections it may be helpful to refer back to this list of questions, because the numbering and form of the answers follows from this list.

1. Species, Stock and Area of Distribution:

- 1.1 Evidence of stock discreteness, e.g. genetic distance, tagging.
- 1.2 Units for which assessment of spawning stock biomass and recruitment are available.
- 1.3 Time-series of spawning stock biomass and recruitment data e.g. from commercial catch and effort data, fishing surveys or VPA.

2. Time of Spawning:

- 2.1 Date of spawning and interannual variability or trend.
- 2.2 Time of day when spawning occurs.
- 2.3 Timing of spawning season in relation to planktonic production cycle.
- 2.4 Timing of spawning season in relation to hydrographic events.
- 2.5 Timing of spawning season in relation to other fish species which spawn in the same location.

3. Location of Spawning:

- 3.1 Geographic location and extent of spawning area and evidence of its variability from year to year.
- 3.2 Does spawning regularly begin in one part of the spawning area and then move to other parts?
- 3.3 Can the location be described in relation to hydrographic features, e.g. “at the boundary between two water masses”; “in the upper, mixed layer”?
- 3.4 Can location be described in relation to other species, including food organisms and predators?
- 3.5 Can location be described in relation to water mass circulation, e.g. “in the north flowing coastal current”; “in the Taylor column circulation over a bank”? How might this affect transport of eggs and larvae?

4. Biological Details:

- 4.1 Fecundity, i.e. number of eggs produced per female per year (as a function of age). Specific fecundity, i.e. number of eggs produced per unit weight.
- 4.2 Evidence of changes in fecundity with time.
- 4.3 Percentage mature at age (including the population not on the spawning grounds). Length at 50% maturity.
- 4.4 Egg size and evidence of changes with age and with time during the spawning season. Specific gravity of eggs and larvae.
- 4.5 Typical densities, i.e. number per m³ of eggs and larvae.
- 4.6 Incubation rate of eggs. Size of larvae at hatching. Size of yolk sac in relation to size of larva.
- 4.7 Larval development rate as a function of temperature.
- 4.8 Condition factor and nutritional status.
- 4.9 Egg and larval mortality rates.
- 4.10 Time of first feeding of larvae and food at first feeding.
- 4.11 Food of larvae during development.
- 4.12 Evidence of predation during the egg and larval stage?

5. Recruitment

- 5.1 Are there several spawning sites which contribute to the same stock unit (e.g. there are several spawning areas which contribute to the North Sea stock and their relative contribution may vary from year to year).
- 5.2 Earliest time in the life history when year class strength can be predicted.
- 5.3 Hypotheses which have been put forward to account for year-to-year variability in year class strength.
- 5.4 Evidence of long-term trends in recruitment.
- 5.5 Evidence that variability in recruitment is linked to variability of other species in the same area; the same species in other areas or other species in other areas?
- 5.6 Evidence of inter- or intraspecific competition.

In addition we would like information on the following.

6. Migration

- 6.1 Evidence of adult migration
- 6.2 Where and when do they migrate?
- 6.3 Hypotheses on the purpose of the migration, e.g. movement to spawning grounds, to feeding grounds, etc.

7. Adult Growth

- 7.1 Evidence for density-dependent growth
- 7.2 Evidence of temperature-dependent growth