ICES Oceanography Committee
ICES CM 2004/C:13

Report of the ICES/GLOBEC Working Group on Cod and Climate Change (WGCCC)

9–10 May 2004
Bergen, Norway

This report is not to be quoted without prior consultation with the General Secretary. The document is a report of an Expert Group under the auspices of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council.

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46 · DK-1553 Copenhagen V · Denmark
Telephone + 45 33 38 67 00 · Telefax +45 33 93 42 15
www.ices.dk · info@ices.dk

Contents

1 Introduction and terms of reference

The Working Group on Cod and Climate Change (WGCCC) met in Bergen, Norway from 9–10 May 2004, under the co-Chairmanship of Dr Geir Ottersen (Institute of Marine Research, Bergen, Norway) and Dr. Ken Drinkwater (Institute of Marine Research, Bergen, Norway). There were 16 participants from 8 countries (Canada, Denmark, Germany, Greenland, Iceland, Norway, Spain and USA) and the ICES/GLOBEC Coordinator. A list of participants is provided in Annex 1.

Immediately following the Working Group meeting, the ICES Symposium on the Influence of Climate Change on North Atlantic Fish Stocks was held. All of the WGCCC meeting participants took part in the Symposium.
The terms of the reference (ICES CM 2003/C:11) for the WGCCC meeting were:

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.

G. Ottersen and K. Drinkwater opened the meeting by welcoming the attendees and briefly introduced the agenda. The agenda is provided in Annex 2.

1.1 Review of the Strategic Plan for WGCCC and associated activities

The last strategic plan for the CCC programme was formalised during the WGCCC meeting of May 1998 in Woods Hole, USA and consisted of seven major themes. The themes and their objectives were:

1) **Fisheries Management**: To incorporate environmental information in a quantitative manner into fisheries management strategies and planning.
2) **Retrospective Analyses**: To understand the links between changes in the environment and fisheries through examination of past unusual events or periods in either the physical environment or 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 understand the life history strategies and causes of interannual variability in growth, distribution, and abundance of cod through comparative studies between different 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.

Numerous activities were undertaken by WGCCC since 1998 to fulfil several of these objectives. As a result of the ongoing synthesis activities and the Synthesis Workshop held in 2003, it became clear that while some of the Strategic Goals have been addressed satisfactorily, others were not. As a consequence, WGCCC decided to compile a Revised Strategic and new Action Plan for 2005–2009 based on discussion at the Workshop and Annual Meeting in 2003. It was further decided that the WG would disband in 2009, which coincides with the official end of the GLOBEC programme. The revised CCC plan was circulated in January 2004 and consisted of some of the former topics and objectives, a modified version of others, and one new objective. It was presented to the International GLOBEC Scientific Steering Committee in Swakopmund, Namibia, in April 2004 by Geir Ottersen and accepted by them.

1) **Fisheries Management:** To incorporate environmental information into fisheries management
2) **Zooplankton–Cod Linkages**: To understand the relative importance of zooplankton in determining the variability in cod abundance and production.

3) **Comparative Analyses**: To understand the relative importance of climate variability in causing fluctuations in North Atlantic cod stocks by means of comparative studies.
4) **Climate Change**: To evaluate the impact of climate change scenarios on cod distribution and production throughout the North Atlantic.
5) **Tropho-dynamics of Cod Ecosystems**: To understand the role of cod in the ecosystem and the importance to cod of climate-induced variability in their prey and predators.
6) **Synthesis**: To provide a synthesis of the research information obtained on cod stocks.

Although the objectives related to Retrospective Analysis and Data Management in the former Strategic Plan have not been included in the new Plan, they will not be ignored. Retrospective analyses will play an important role in achieving the new strategic goals 2, 3 and 4. Also, the WGCCC will continue to make data and data products available to the wider scientific community. The new plan was discussed and approved by the WGCCC. The full plan is provided in Annex 3.

2 Review of past activities

2.1 Update on ICES/GLOBEC position and secretariat

In addition to the report prepared annually for the Steering Group (SGNARO), which is presented at the ASC, progress is reported to the ICES Bureau in January and June each year. An updated version of the report to the Bureau in June 2004 is at Annex 4. Information presented here deals with areas of interest to WGCCC and is intended to supplement rather than repeat information in the other progress reports.

Work during the current year can be divided among four major headings:

1 Application of results from the CCC programme within the ICES assessment process. The Coordinator took part in two Study Groups which are developing new applications in 2004:

   a) The Study Group on Growth, Maturity and Condition in Stock Projections (SGGROMAT) in Aberdeen from 19–23 January 2004. One part of the work of this group, which is nearing completion, is the development (with NAFO) of an inventory of tabulated information for estimating reproductive potential. The inventory includes data from more than 200 commercially important pelagic and demersal fish stocks in the North Atlantic. There is some overlap with the material being prepared by WGCCC for the updated CRR on Life History Information on North Atlantic cod stocks. Little progress was made with the other terms of reference on developing process models on growth, maturity, fecundity and condition. This is disappointing, since this Study Group, which followed on from SGPRISM, was regarded as one of the principal activities which would lead to the inclusion of more biological and environmental information into ICES stock assessment procedures.

   b) The meeting of the Regional Ecosystem Study Group for the North Sea (REGNS) was held in Lowestoft from 5–7 April 2004. REGNS was set up in response to the Bergen Ministerial Declaration and is tasked with preparing an Integrated Ecosystem Assessment for the North Sea. The process is expected to take two years and will involve input from many ICES expert groups. The Bergen Declaration invited ICES and GLOBEC to advise on the development of an ecosystem science programme for the North Sea and the Coordinator was there to assist with this and to ensure communication with the International GLOBEC programme. REGNS recognised that the new ICES Head of Science will play a key role in assisting with the coordination required for the Integrated Assessment, in helping to shape the R&D agenda and particularly concerning the effective flow of information between the research, advisory and policy elements of the process.

2 Meetings, talks, papers, and reports. The work being carried out within the CCC programme is relevant to a number of developing areas in the study and assessment of marine ecosystems. The Coordinator was invited to give talks and contribute to a number of studies including:

a) Climate related work – contributing author for Arctic Climate Impact Assessment; development of plankton indicators of climate change for the European Environment Agency; talk on "Consequences of changing climate for North Atlantic cod stocks and implications for fisheries management" Bergen Symposium, May 2004; talk on "Effect of climate change on fish distribution and dynamics in the North Atlantic" Danish PhD course on Climate and Aquatic Ecosystems, Brorfelde, April 2004; lead author on fisheries for fourth IPCC report.

b) Ecosystem approach, development of monitoring and ecosystem indicators, structure of marine ecosystems – keynote talk on "Choosing, presenting and maintaining indicators for marine ecosystem monitoring - experience from the NE Atlantic" at PICES workshop on developing a North Pacific Ecosystem Status Report, Seoul October 2003; keynote talk on "Ecosystem indicators in a varying environment" Paris Symposium, April 2004; talk on "Biological production in the Sea – the physical and chemical basis", EU Brussels, May 2004.

c) A list of publications is included in Annex 4. Three related papers dealing with the link between climate indicators (in particular the NAO) and cod recruitment have been published over the past year. The first (in Nature) provided evidence that the increase in recruitment of cod in the North Sea during the two decades from 1964 was due to favourable planktonic feeding conditions for cod larvae. Plankton changes can be related to the NAO. The paper had extensive press coverage, much of which mistakenly claimed that it showed that fishing was not to blame for the subsequent decline of the cod stock. The second paper (in CJFAS) showed that the NAO affected many of the major North Atlantic cod stocks, but not all in the same way. This is due to the "classic surface footprint" of the NAO, which affects temperature, windfield and precipitation differently, according to a consistent geographic pattern. The third paper (in ICES JMS) showed that the effect of the NAO on six European cod stocks is much greater when their biomass is low. This has major implications for their assessment and management: models of stock and recruitment must take account of possible non-linear environmental effects and recovery plans must take account of likely future scenarios for the NAO or other climatic indicators.

d) Unpublished presentations are available from the ICES/GLOBEC website. A poster about the ICES/GLOBEC programme is also available. It was produced for the UK Marine Productivity Discussion at the Royal Society, London in February and has since been show at the Bergen Symposium and at the CLIVAR Symposium in June 2004.

3 Scientific Steering Committees, Programme Reviews etc. for PNEC (France) , Marine Productivity (UK), German GLOBEC, Norwegian Research Council.

4 Funding renewal and proposal writing.

Proposals for renewed funding were presented and accepted with DEFRA (UK) and the Norwegian Research Council. A proposal for an EU Marie Curie Research Training Network (on fisheries induced adaptive change) was submitted and is expected to go ahead. Other proposals for new or renewed funding are in progress.

The future of the ICES/GLOBEC office depends on obtaining new funding to cover the shortfall which will be left when NSF (US) funding ceases at the end of 2004. There are reasonable prospects that the funding gap can be bridged and the ICES Bureau have reaffirmed their support for the programme and agreement to continue to cover the indirect costs. The possibility of funding from the new EU Networks (principally MARBEF and EUROCEAN) is being explored. These may provide support for activities such as workshops, which are the scientific backbone of the CCC programme.

The ICES Secretariat has been reorganised, with a new Science branch. This is expected to develop the role of ICES in relation to international marine science programmes. The rationale for the reorganisation and its intended impact are not known; they were not discussed with either of the professional secretaries (ICES/GLOBEC and BSRP) currently employed by ICES to work on international marine science programmes. A new Head of Science position has been set up and filled.

At last year's meeting, the WGCCC discussed the long-term future of the ICES/GLOBEC position and the co-Chairs were instructed to write a letter to the ICES President as a means of beginning discussions on the establishment of a position within the ICES secretariat that dealt with climate and environmental issues related to fisheries. It was decided by the co-Chairs to wait until the new president, Dr. Sissenwine, was installed before writing the letter. A letter was sent out in March in conjunction with the announcement of the reorganisation of the ICES secretariat. While the co-Chairs were encouraged to see the establishment of a Head of Science position, the new position will not go as far as we had hoped in terms of promoting and encouraging the use of environmental information into fisheries assessments. Unfortunately, we did not receive any response or acknowledgement of our letter. It was suggested by the WG that a follow-up letter should be written, which K. Drinkwater agreed to do.

2.2 Synthesis activities (TOR A)

2.2.1 Cod book – TOR a (i)

At the 2000 WGCCC Meeting (ICES CM 2000/C:11) it was decided that a major component of the WGCCC 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. In 2003, a Synthesis Workshop was held (ICES CM 2003/C:10) to discuss in detail what each of the chapters would cover, to coordinate the chapters, and to agree upon formats, audience, publication, and a timetable. The chapters and co-authors are:

Chapter 1: Introduction: K. Brander (ICES/GLOBEC) and K. Drinkwater (Norway)
Chapter 2: Stock Structure and History: G. Marteinsdottir (Iceland), D. Ruzzante (Canada) and
Chapter 3: Cod and Climate Change Program: B. Rothschild (USA), S: Sundby (Norway) and R. Dickson (UK)
Chapter 4: Physical Oceanographic Setting: K. Drinkwater (Norway) and H. Loeng (Norway)
Chapter 5: Biological Oceanographic Setting: M. Heath (UK) and G. Lough (USA)
Chapter 6: Growth and Condition: L. Buckley (USA), J.-D. Dutil (Canada) and T. Marshall (UK)
Chapter 7: Recruitment: F. Koester (Denmark) and M. Fogarty (USA)
Chapter 8: Larval Transport: P. Pepin (Canada) and H.-H. Hinrchsen (Germany)
Chapter 9: Distribution and Migration: G. Ottersen (Norway) and D. Swain (Canada)
Chapter 10: The Role of Cod in the Ecosystem: J. Link (USA), G. Lilly (Canada), B. Bogstad (Norway) and H. Sparholt (ICES)
Chapter 11: Implications for Fisheries Management: K. Brander (ICES/GLOBEC) and S. Murawski (USA)
Chapter 12: Response of Cod to Climate Change: K. Drinkwater (Norway) with input from others
Chapter 13: Summary: K. Brander (ICES/GLOBEC) and K. Drinkwater (Norway)

K. Brander and K. Drinkwater, the co-editors, reported that they had explored several possible publishers for the book during the past year. At the 2003 Symposium, the participants favoured publication in the IGBP series. Springer, which publishes the IGBP books, eventually agreed to publish the WGCCC book on cod with conditions comparable to that of other publishers that were contacted. Thus, in February 2004 the editors signed an agreement with Springer to publish the book on cod in the IGBP series with the chapters to be delivered to the publishers by the end of 2004.

At the 2003 Workshop, it was agreed that drafts of the chapters should be sent to the editors by the end of 2003. The editors noted that by time of the 2004 Annual meeting, only one chapter had been submitted with two others believed to be very close. While they understood that most of the other chapters were being written, they stressed to those chapter co-authors who were at the meeting to insure that their chapters be submitted as soon as possible. The editors would also contact those not at the meeting to determine the status of each of the chapters and encourage as early a submission as possible in orders to allow time for reviews, editorial suggestions and rewriting.

During the meeting, the proposed chart of the stocks and their distribution and spawning sites to be used in the book was circulated. There were several comments suggesting both location and name changes. The WG decided that the chart be circulated to those working with the stocks, including those who are contributing to the updated life history report (see below), for their feedback on both the distribution and names. The editors agreed to follow up on this suggestion. Also, K. Brander agreed to make up and send out to the co-authors instructions to the reviewers for the book chapters.

2.2.2 CRR update on Life History Stages for all Major Cod Stocks – TOR a(ii)

Work on editing the drafts has progressed well, due to assistance throughout the past year from Patricia Brander. The reference database has been revised and updated and now contains over 2000 references, which will supersede the database currently available on the website. Including material sent in since May 2004, there are now updated texts for 19 stocks, including all major stocks. All the most recent drafts can be downloaded from the website and are being prepared for publication. Recommendation V is to publish the material as a Cooperative Research Report.

The WG discussed naming of certain stocks, in particular the so-called NE Arctic stock and concluded that the name Arcto-Norwegian was preferable.

The new CRR should, as far as possible, include all relevant material from the old report, rather than simply supplementing that report. Since the printed version of the CRR may become out of date when new information is made available it was decided to maintain the website as a source for updated material.

2.2.3 ICES Symposium

At the meeting, K. Drinkwater and H. Loeng reported that everything was ready for the WGCCC sponsored ICES Symposium on the Influence of Climate Change on North Atlantic Fish Stocks.

The Symposium was held immediately following the WG meeting from 11–14 May at the Radisson SAS Hotel Bryggen in Bergen. Jim Hurrell (USA) set the stage for the Symposium presenting a paper on the NAO, climate

variability and climate change in the North Atlantic and their influence on the oceanography. He noted that most recent models for the IPCC suggest that under climate change scenarios the meridional overturning circulation in the Atlantic will not decrease substantially as first thought and thus the northern North Atlantic Ocean is not expected to undergo cooling. This presentation was followed by 62 talks and 35 posters, organised into five major sessions. These sessions were on Zooplankton, Distribution Shifts, Production (which included sub-sessions on Ecosystems and Trophic Interactions, on Growth, Condition, Reproduction and Mortality and on Recruitment and Abundance), Climate Change Impacts, and Management under a Changing Climate. For each Session, invited papers given, by Mike Heath (UK) on zooplankton, George Rose (Canada) on distribution, Gudrun Marteinsdottir (Iceland) on production, Laura Richards (Canada) on climate change, Colin Bannister (UK) on management issues. The quality of the invited and submitted papers was very high, with much evidence of steady progress in the field of climate effects on fisheries. Of particular note was the evidence of a northward distributional shift of many commercial and non-commercial species in response to recent warming. This included more northerly spawning locations as well. The challenges for incorporation of environmental effects into assessment methodology were much discussed and some possibilities were presented, although no major breakthroughs have yet occurred. With the recent decline in the North Sea cod stocks and the evidence of a role of climate changes plus the evidence of a warmer future climate, it was suggested that fisheries assessment scientists may be forced to incorporate environmental information into their projections, sooner rather than later. Many of the papers and posters can be viewed at http://www.imr.no/2004symposium/web/index.html and will be published in a special issue of the ICES Journal of Marine Science. The co-editors of the issue are H. Loeng (Norway), R. Cook (UK), B. Megrey (USA), and K. Drinkwater (Norway).

2.1 Review of the Workshop and Theme Session on Transport

2.2.1 CRR on Transport Workshop

The WGCCC Cod Transport Workshop (ICES CM 2002/C:13) was held 4–14 April 2003, in Hillerød, 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. This is to be undertaken by K. Brander and K. Drinkwater but due to the other WGCCC activities, little progress was made on this recommendation during the past year. The WG reconfirmed the commitment to this recommendation but that it is to continue to have lower priority than the synthesis activities, i.e., the cod book, and updated CRR on cod and the publication of the 2004 Symposium proceedings.

2.2.4 Theme Session on Transport

K. Drinkwater reported on the WGCCC sponsored Theme Session (O) on Transport of Eggs and Larvae Relevant to Cod Stocks of the North Atlantic held in September 2003 at the ICES ASC in Estonia. This was a follow-up to the Workshop and was co-chaired by Joel Chassé (Canada) and Bjørn Ådlandsvik (Norway). There were a total of seven talks and one poster. Six of the papers considered the transport of eggs and/or larvae and covered five different cod stocks. The last paper considered the aging of fish eggs, which is needed to obtain validation data for egg transport models. The poster discussed the Atlantic flow off Iceland, which transports cod larvae around the island. As part of the Theme Session, Dr. John Steele (USA) provided a summary of the talks following the presentations and his perspective on the subject before leading a general discussion. It was noted that the study of transport processes for fish larvae is progressing rapidly with physical circulation modelling involving particle tracking and individual based temperature dependent growth becoming a mature and standard tool for handling such problems. Further work on developing transport indices for comparison with recruitment indices is needed. From the models presented, it appeared that different processes were important for different stocks, however, further comparisons between stocks is needed and encouraged, especially using similar models. Models require more realism (i.e. food availability and predation) to better account for egg and larval mortality. Future model developments must be extensively validated against field observations.

3 Future WGCCC activities

3.1 Workshops

The WG confirmed its intention to carry out the series of Workshops proposed during the 2003 WGCCC meeting (ICES CM 2003/C:11) for 2005–2009. Emphasis during the meeting was on the planning for those scheduled in 2005 and 2006.

3.1.1 Workshop on the Impact of Zooplankton on Cod Abundance and Production (WKIZC; TOR 3)

The Workshop on the Impact of Zooplankton on Cod Abundance and Production (WKIZC) was scheduled for 2005. The scope of this workshop, as outlined in the new Action Plan, is the following.

Relations between temporal and spatial dynamics of zooplankton and early stages of cod will be examined. 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; and how the relative importance of *Calanus finmarchicus* to other zooplankton species as the prey for cod varies spatially will 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 US and UK GLOBEC studies, Norwegian studies and recent WGCCC activities, including the 2002 Transport Workshop and the 2003 Theme Session on Transport of Cod Eggs and Larvae, as well as output from the ICES 2003 Zooplankton Symposium. As always, WGCCC will pay particular interest to the role of climate.

The proposal for a Workshop on the Impact of Zooplankton on Cod Abundance and Production (WKIZC) in 2005 was sent to the WG on Zooplankton Ecology prior to their annual meeting to solicit their support and participation, including an invitation to nominate a co-Chair. They responded positively in terms of wishing to participate but suggested delaying the Workshop until 2006. While they provided several members who were interested in the Workshop, they did not have anyone at the time of their meeting who agreed to co-Chair the workshop. After some discussion, the WGCCC concluded that if we are to carry out all of our planned activities, we had to hold the Zooplankton Workshop in 2005 and tentatively set it for May-June. The WG instructed G. Ottersen to contact potential co-convenors and re-contact the Chair of the WGZE, Steve Hay, to inform him of our decision to hold the Workshop in 2005. Suggestions for possible convenors included A. Gislason (Iceland and a member of the WGZE), Ø. Fiksen (Norway), and J. Runge (USA). (As of the writing of this report, Ø. Fiksen has agreed to co-Chair the workshop, J. Runge has given a qualified yes but A. Gislason has unfortunately declined.)

The Terms of References for WKIZC are to be drafted by the co-conveners in conjunction with K. Brander and G. Ottersen, based on the outline given above. This must be completed before the September 2004 ICES ASC for approval by ICES. The co-conveners will also take into account proposals put forward by WGPBI who will be holding a Theme Session at the ICES ASC in 2005 on zooplankton modelling and a Workshop on the same topic in 2006. These activities will complement the proposed WKIZC and their proposed Workshop will provide a forum for presenting results from WKIZC and working towards integrating observational and model studies.

The WGCCC also noted that there is a proposal for a non-ICES workshop on Synthesis of Basin-Scale Zooplankton Research in the North Atlantic in Iceland during the spring of 2005, to be convened by P. Wiebe and O. Astthorsson. Cooperation and coordination with this workshop should also be encouraged.

3.1.2 Review of plans for 2006 Workshops (TOR 4)

The 2003 WGCCC meeting suggested two workshops for 2006, (i) the Decline and Recovery of Cod Stocks Throughout the North Atlantic (WKDRC) and (ii) the Influence of Climate on Tropho-Dynamics of Cod Ecosystems (WKICT). The focus of these two workshops was outlined in the WGCCC 2003 report (ICES CM 2003/C:11) and the new Action Plan.

WKDRC: 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.

WKICT: Widely observed changes in abundance, size-at-age and maturity of cod in many stocks throughout the North Atlantic in recent years will be addressed from a tropho-dynamic and bioenergetic perspective. Both observations

and theory will be considered, including mass balance and scaling from individual based modelling. The role of forage species will be reviewed, particularly that of capelin in the Barents Sea and Icelandic waters and sprat in the Baltic. This thus addresses questions about cod dynamics from a more ecosystem-based perspective. Questions to be answered include: To what extent are observed changes in 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. pelagic fish on larvae, harp seals on adults)?

The WG noted that these two workshops had been regarded as complementary and linked when first proposed. Since it would be difficult for the WG to hold two separate workshops in 2006, it was decided to run them as two halves of a single meeting (WKDICE), with different co-conveners. B. Rothschild (USA) volunteered to co-convene the WKDRC.

The Future of Cod in a Changing Climate workshop proposed for 2007 and the output of the WKDICE would provide a basis for this forward look. The WG noted that in some areas, like the Scotian shelf, pronounced ecosystem changes may lead to cod never returning. The WG further noted that marine mammals play an important role in some of the ecosystems within which cod are major predators and also that the work in this field could be part of an ICES input to the International Polar Year in 2007. During the meeting some co-conveners volunteered, others are been sought.

The WG instructed G. Ottersen and K. Brander to also notify the joint ICES/NAFO WG on Harp and Hooded Seals of the Workshop on Tropho-Dynamics as it was expected that they would be interested and may also participate.

3.2 Theme Session for 2005 ASC

The WG discussed possible theme sessions for the ICES ASC in 2005. Since WGCCC did not submit a theme session for the 2004 ASC, it was felt that it should propose one for 2005. The WG agreed that a theme session focusing on the book "Cod in a changing climate" should be put forward (Recommendation III). If selected, some of the co-authors will be asked to present their chapters, followed by a discussion on the book in general. The editors of the book, Drs K. Brander and K. Drinkwater will act as co-conveners.

3.3 Cooperation with CCCC in PICES

During the past several years the PICES (WGCCCC-Climate Change and Carrying Capacity) and ICES (WGCCC) regional GLOBEC programmes having been communicating on climate-related topics of common interest. In 2002, co-Chairs of the two WGs attended and made presentations at the other's annual WG meeting. Discussion has centered on fostering cooperation and joint activities between the two WGs. The WGCCC proposed that similar theme sessions be held at the PICES and ICES 2006 ASC with hopefully members from both WGs in attendance at each. The topic of the theme session will be Physical Processes Influencing Marine Ecosystems. K. Drinkwater, who will be attending the 2004 PICES meeting, will contact the WGCCCC and ask to speak to them about this initiative during their meeting.

3.4 Identification of new WGCCC Co-Chair

K. Drinkwater will be stepping down as co-Chair of the WGCCC following the 2004 ICES ASC. G. Ottersen will remain as co-Chair but requested that a new co-Chair be found. A few possible candidates were canvassed prior to the meeting but they declined the position. At the meeting several other names were mentioned and G. Ottersen and K. Drinkwater were requested to approach them as to their willingness to serve. G. Ottersen indicated he would be willing, at least temporarily and if necessary, to be the Chair until such time as a new co-Chair is found.

3.5 2005 WGCCC Meeting

Discussion was held on the need for a 2005 WG meeting. Given that the Synthesis activities are well underway and should be mostly finished by 2005 and that planning for the workshops for 2005 and 2006 and the theme session for 2005 have been decided upon, it was felt that the WG would work by correspondence in 2005. The main activities would be to complete the planning for, and undertake, the 2005 Zooplankton Workshop and prepare for the 2006 combined Workshops.

4 Other business

4.1 Young Scientists Conference

K. Brander informed the WG about a joint ICES/PICES Young Scientists' conference scheduled for June 2006. The themes for the conference are yet to be decided. The WG strongly supported this initiative and would like to offer a Theme and Keynote Speaker for the Conference – Responses of fish stocks to climate change.

4.2 GLOBEC and IMBER

G. Ottersen updated the WG on the activities of International GLOBEC (Global Ocean Ecosystem Dynamics), of which the WGCCC is the North Atlantic regional programme. Two new regional programmes are in the planning stage, Ecosystem Studies of Sub-Arctic Seas (ESSAS) and Climate Impact on Oceanic Top Predators (CLIOTOP). CLIOTOP focuses mainly upon tuna in the tropical oceans. ESSAS is described below. However, with the ending of GLOBEC in 2009, most of its efforts until then will focus upon synthesis activities of long-term GLOBEC programmes in the form of books and various papers that will be targeted towards scientists, managers and the broader public, including students and schools.

S. Sundby (Norway) provided a brief description and up date on IMBER to the WGCCC. The IMBER (Integrations of Marine Biogeochemistry and Ecosystems Research) Programme is the newest in the IGBP/SCOR family. The science plan for the programme has been developed over the last 1½ years and has now been approved by IGBP. Its overall goal is developing a quantitative and predictive understanding of marine biogeochemical cycles and ecosystems, their interactions in response to global change, and feedbacks of ocean processes to the Earth System. The science plan contains four main themes. These are: (1) Key Processes: What are the key marine biogeochemical cycles, ecosystem processes, and their interactions, that will be impacted by global change?; (2) Sensitivity to Global Change: How will key marine biogeochemical cycles, ecosystems and their interactions, respond to global change?; (3) Interactions with the Earth System: What is the role of the ocean biogeochemistry and ecosystems in regulating climate?; and (4) Responses of Society: What are the relationships between marine biogeochemical cycles, ecosystems, and the human system? IMBER will encourage investigations in four key domains of the ocean: the euphotic zone, the mesopelagic layer, the continental margins and high-latitude and polar ocean areas.

IMBER will develop collaborative activities that will draw on the expertise of other projects and programmes to avoid unnecessary duplication and ensure that IMBER takes an interdisciplinary approach. These collaborative associations will involve GLOBEC, SOLAS, LOICZ, PAGES, CLIVAR, GAIM, DIVERSITAS, IHDP, GEOHAB, GCP, IOCCP, GOOS and GEOTRACES. A close collaborative relationship with GLOBEC will be important to ensure that fully integrated biogeochemistry and ecosystems research is undertaken across the entire food web. A full integration of the two projects will be achieved after 2009 with the formation of a single ocean project within the IGBP II structure. The partnership between IMBER and GLOBEC will ensure coverage of the entire range of trophic levels of marine ecosystems, integrating marine food webs from end to end, with the aim of forming a single project after 2009. This is a joint activity, with IMBER concentrating on the lower trophic levels up to zooplankton, and GLOBEC focusing mainly from the level of zooplankton to top predators. The partnership will address the interaction between phytoplankton and zooplankton and how physical processes and climate change influence this system. Phytoplankton, zooplankton linkages have not been the focus of any other past or present global change projects. The relationship between biogeochemical cycles and ecosystems will be addressed by IMBER in relation to the entire spectrum of trophic levels.

4.3 ESSAS

G. Hunt provided information on ESSAS to the WG. The objectives of ESSAS are to compare, quantify and predict the impact of climate variability on the productivity and sustainability of Sub-Arctic marine ecosystems. Geographically, it includes the northern North Atlantic (Barents Sea, Nordic Seas, Iceland region, Greenland shelves, Newfoundland/ Labrador shelves, Gulf of St. Lawrence and Hudson Bay) and North Pacific (Bering Sea, Sea of Okhotsk and the Oyashio Shelf Region). The North Atlantic regions mean that it overlaps with the CCC programme. Whereas the focus of WGCCC has been primarily on the effects of climate variability and change on cod with also an interest in zooplankton, especially *Calanus finmarchicus*, ESSAS will emphasize more of the ecosystem. They will include as part of their studies, phytoplankton, benthos, various fish species, and marine mammals, all of which CCC has generally not studied. However, WGCCC results and knowledge will be of vital interest to ESSAS. Several members of the WGCCC have been involved with the development of ESSAS.

As a kick-off to ESSAS and to aid in development of its implementation plan, GLOBEC is sponsoring an international Symposium entitled Climate Variability and Sub-Arctic Marine Ecosystems to be held in Victoria, Canada in May of 2005. The organizers of the meeting would like to publish the proceedings in the *ICES Journal* but for this to happen one of the WGs would have to recommend that ICES co-sponsor the Symposium. K. Drinkwater proposed that WGCCC do this since it is the GLOBEC programme within ICES. The WG agreed (see Recommendation IV, Section 5).

5 Recommendations and draft resolutions for future meetings

Recommendation I

The **ICES/GLOBEC Working Group on Cod and Climate Change** [WGCCC] (Co-Chairs: Dr. G. Ottersen, Norway and NN) will work by correspondence to:

a) review and evaluate the progress on the Synthesis Activities including:
   i) publication of the book on cod,
   ii) publication of the CRR on the life history aspects of cod stocks throughout the North Atlantic,
   iii) publication of the proceedings of the Symposium on the Influence of Climate Change on North Atlantic fish stocks;

b) plan and prepare the Workshop on the Impact of Zooplankton on Cod Abundance and Production;

c) plan the back-to-back Workshops on the Decline and Recovery of Cod Stocks Throughout the North Atlantic and on the Influence of Climate on Tropho-Dynamics of Cod Ecosystems;

d) initiate plans for Workshop on Cod and Future Climate Change and discuss other workshops;

e) review and evaluate the results from the Workshop on the transport of cod larvae;

f) plan the Theme Sessions on Cod in a Changing Climate (ASC 2005) and Physics Relevant to Marine Ecosystems (ASC 2006).

The Working Group will report by 31 May to the Oceanography Committee.

Supporting Information

Priority:	This Group is of fundamental importance to the future of the ICES Advisory Process.
Scientific Justification and relation to Action Plan:	Action Plan a (i) :1.2.1, 1.3, 1.6, 1.7, 5.3, 5.13.2 ,8.4, and 10.2 a (ii): 1.2.1, 5.3 ,5.13.2, and 6.1 a(iii) 1.2, 1.3, 1.5, 1.6, 1.7, 5.2, 5.3, 5.13.2, and 10.2 b: 1.2, 1.3, 1.5, 1.7, 4.11.2, 5.3, 5.10, and 5.13.2 c and d:: 1.1, 1.2, 1.3, 1.5, 1.6, 1.7, 4.2, 4.10, 4.11, 5.2, 5.3, and 6.1 e: 1.3 and 1.5 f: 5.14 and 5.15 The work will be carried to review past activities and plan future workshops and theme sessions. a. i. One of the major components of the synthesis planned by the WGCCC is the publication of a book on cod, which is scheduled for publication in 2005. An update on the progress of the book will be provided. 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 in late 2004. The progress towards completion of the CRR will be reviewed. iii. The ICES Symposium was held in May 2005 and publication of the papers will be published in the ICES Journal of Marine Science. A report on the review progress b. 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. Preparation and plans for the workshop will include confirmation of the co-convenors, determining the role of the WGZE, finalizing the terms of reference, determining the location and dates, writing the recommendation, securing a venue, and ensuring the successful completion of the Workshop. c. Planning for the two Workshops for 2006 will be carried out. This will include obtaining co-convenors, establishing dates and a location and drafting the terms of reference. d. As part of the CCC strategic plan, a Workshop on the Response of Cod to Climate Change is scheduled for 2007. Planning for this workshop will begin. e. The Transport Workshop was held in 2002 and it has been recommended that it be published as a CRR. Progress in carrying this work forward will be assessed. f. A Theme Session on Cod in a Changing Climate has been proposed for the ASC in 2005. This would mainly consist of papers taken from the book on cod as part of the CCC synthesis activities. Potential presenters will be contacted. A Theme Session on Physics Relevant to Marine Ecosystems has been discussed in cooperation with PICES. Coordination with PICES will be undertaken.
Resource Requirements:	Assistance of the ICES/GLOBEC Coordinator in maintaining and exchanging information and data to potential participants.
Participants:	This Workshop is expected to attract 15-25 participants, most of who would contribute papers. The majority will be drawn from the ICES scientific community, although a number of scientists from outside ICES are also expected to contribute.
Secretariat Facilities:	None
Financial:	None.
Linkages To Advisory Committees:	Relevant to the work of the ACFM and ACE.
Linkages To other Committees or Groups:	Living Resources, SGNARO, WGZE, WGRP, WGBPI.
Linkages to other Organisations:	GLOBEC is a co-sponsor of the WGCCC.
Secretariat Marginal Cost Share:	–

Recommendation II

A **Workshop on the Impact of Zooplankton on Cod Abundance and Production** [WKIZC] (Ø. Fisken, Norway, and J. Runge, USA) will meet at ICES, Headquarters from xx to xx June 2005 to:

a) to determine the zooplankton species in the diets of cod, their temporal and spatial changes;
b) to determine the variability in zooplankton populations and their relationships to cod;
c) to examine the vital rates (growth, reproduction, mortality, recruitment) of zooplankton which are relevant to cod life histories ("stock assessment" of zooplankton);
d) to determine how the timing of zooplankton production and spatial dynamics (including patchiness) of nauplii relates to the spawning, distribution and survival of early stages of cod;
e) to establish the links between zooplankton and later stages of cod.

This will be carried out using a combination of statistical data analyses, process studies and a variety of modelling approaches. The Workshop report will be presented to the Oceanography Committee at the 2005 Annual Science conference.

Supporting Information

Priority:	This Workshop is a component of the Cod and Climate Change strategic plan.
Scientific Justification and relation to Action Plan:	The Workshop contributes to Actions 1.2, 1.3, 1.5, 1.7, 4.11, 5.2, 5.3, 5.10, 5.13.2, 5.14, 5.15 of the ICES Action Plan. 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.
Resource Requirements:	Assistance of the ICES/GLOBEC Coordinator in maintaining and exchanging information and data to potential participants.
Participants:	This Workshop is expected to attract 15-25 participants, most of who would contribute papers. The majority will be drawn from the ICES scientific community, although a number of scientists from outside ICES are also expected to contribute.
Secretariat Facilities:	None
Financial:	None
Linkages To Advisory Committees:	Relevant to the work of the ACFM and ACE.
Linkages To other Committees or Groups:	Living Resources, SGNARO, WGZE, WGRP, WGBPI.
Linkages to other Organisations:	GLOBEC is a co-sponsor of the WGCCC.
Secretariat Marginal Cost Share:	–

Recommendation III

A Theme Session on Cod in a Changing Climate to be held at the 2005 ICES ASC with K. Brander (ICES/GLOBEC) and K. Drinkwater (Norway) as convenors. This Theme Session will coincide with the 2005 publication of the book on Cod in a Changing Climate and will contribute to the Cod and Climate Change strategic plan.

The book and the Theme Session are intended to make information on status and trends in cod stocks available to a wider public and to make them aware of the contribution of ICES to international marine science. The biological and life history processes underlying climate driven changes in fish stocks include recruitment (i.e. the number of young fish produced), growth, maturation, natural mortality and migration. Thanks the commercial importance of North Atlantic cod, a long history of research and a dedicated programme within ICES on Cod and Climate Change over the past decade, much has been learned about these processes and about their interaction with each other and with the food chain, predators and other components of the marine ecosystem. Cod is probably the most comprehensively studied marine fish species, occupying a key role in several North Atlantic ecosystems. An understanding of its dynamics is of direct and indirect relevance to other species and to gaining insight into the response of the marine ecosystem to climate change and variability. The Cod and Climate Change programme is a regional component of the Global Ocean Ecosystem Dynamics (GLOBEC) programme of IGBP. Speakers will be invited to present the subjects on which they have contributed in the book. They will review many aspects of our knowledge of cod, but will also report new results and analyses. They will use a comparative approach to draw conclusions from differences and similarities between the many stocks, which occupy a range of different physical and biological situations.

Relation to Action Plan: The Theme Session contributes to Actions 1.2, 1.3, 1.5, 1.6, 1.7, 4.10, 4.11, 5.2, 5.3, 5.13.2, 10.2 of the ICES Action Plan.

Resource Requirements: Assistance of the ICES/GLOBEC coordinator.

Participants: This Theme Session is expected to attract 50 participants, with contributions restricted to authors (of whom there are about 30). The Theme Session could attract scientists from outside ICES as well as members of the fisheries community and those with an interest in global change (since the book is being published in the IGBP Global Change series).

Secretariat Facilities: None

Financial: None.

Linkages to Advisory Committees: Relevant to the work of the ACFM and ACE.

Linkages to Other Committees or Groups: Living Resources, SGNARO, WGZE, WGRP, WGBPI.

Linkages to Other Organizations: GLOBEC is a co-sponsor of the WGCCC.

Recommendation IV

A Symposium on **Climate Variability and Sub-Arctic Marine Ecosystems** will be held from 16 to 20 May 2005 in Victoria, B.C., Canada, with G. Hunt (USA) and K. Drinkwater (Norway) as co-Conveners.

The Symposium's scientific objective is *to present current knowledge of the effects of seasonal to multi-decadal climate variability on the structure and function of Sub-Arctic marine ecosystems.* Specific topics include:

a) large-scale climate forcing on the physical oceanography of Sub-Arctic seas;
b) processes structuring Sub-Arctic ecosystems (sea ice, low temperatures, low species diversity, etc.);
c) the transfer and fate of energy through subarctic food webs, from primary producers through zooplankton and benthic fauna to fish, seabirds, marine mammals and fisheries;
d) recent changes in subarctic ecosystems, time scales of variation and possible causes;
e) inter-comparisons between Sub-Arctic marine ecosystems.

The WGCCC proposes that ICES co-sponsor this Symposium with GLOBEC.

Supporting Information

Priority:	This Symposium will contribute to the Cod and Climate Change programme and help foster cooperation with PICES.
Scientific Justification and relation to action plan	A new GLOBEC regional programme is being developed called Ecosystems of Sub-Arctic Seas (ESSAS). GLOBEC is sponsoring a Symposium as a kick-off to the programme and to aid in development of its implementation plan. Geographically, it includes the northern North Atlantic (Barents Sea, Nordic Seas, Iceland region, Greenland shelves, Newfoundland/Labrador shelves, Gulf of St. Lawrence and Hudson Bay) and North Pacific (Bering Sea, Sea of Okhotsk and the Oyashio Shelf Region). Comparative studies of these seas will be a major focus of the programme. Several factors make these Sub-Arctic seas unique: exchange with the Arctic Ocean, seasonal ice cover, freshwater from ice-melt and runoff, dramatic seasonality, reduced sunlight and low biodiversity. Recently, changes in species abundance or distribution have been observed within several Sub-Arctic marine ecosystems, which appear to correlate with fluctuations in the physical environment. These areas are also expected to undergo the largest anthropogenic-induced climate change. The symposium provides the opportunity to highlight what is known about each of the sub-Arctic regions and to begin to compare and contrast how the ecosystems function. It will also provide a gauge by which to measure progress within ESSAS, much as the Cod and Climate Change Symposium held in 1993 has done within the CCC programme. The Symposium contributes to Actions 5.2, 5.3, 5.10, 5.13.2, 5.14, 5.15 of the ICES Action Plan.
Resource Requirements:	It is proposed that the Symposium proceedings be published within the *ICES Journal of Marine Science*.
Participants:	This Symposium is expected to attract 150–200 participants, with the majority drawn from a combination of the ICES and PICES scientific communities. It is expected to also draw in a number of scientists from outside these communities.
Secretariat Facilities:	None
Financial:	Costs associated with publication of the Symposium proceedings.
Linkages to Advisory Committees:	Relevant to the work of the ACFM and ACE.
Linkages to Other Committees or Groups	Living Resources, SGNARO, WGRP, WGBPI.
Linkages to Other Organisations:	GLOBEC and PICES are presently co-sponsoring the Symposium.
Secretariat Marginal Cost Share	–

Recommendation V

The report on **Spawning and Life History Information for North Atlantic Cod Stocks,** edited by K. Brander (ICES), as reviewed by the Chair of the Oceanography Committee, will be published in the *ICES Cooperative Research Report* series. The estimated number of pages is 250.

Supporting Information

Priority:	A previous edition of this report appeared in 1994 (CRR205). It has now been entirely updated and extended. The contents are essential for comparative studies of cod biology and population dynamics. The update has been in progress for several years and is part of the synthesis of results from the ICES/GLOBEC Cod and Climate Change programme.
Scientific Justification and relation to action plan	The report updates a major ICES publication, which is ten years old. It includes extensive, basic biological information about all major North Atlantic cod stocks, as well as over 2000 references to published and "grey" literature on cod. Individual stock summaries are written by experts and provide highly authoritative background information on stock structure, migration, history of the stock, spawning distribution and behaviour, maturity, fecundity, egg and larval distribution and transport and factors affecting larval survival and recruitment. The update shows how much new information has been obtained through basic research over the past ten years, not only on cod itself, but also in relation to the ecosystem and environment. The structured format, based on a checklist, and the summary tables for key variables are designed to aid comparative studies and to help understand and quantify the biology and life history, stock structure, dynamics, and trophic relationships of this commercially and ecologically important species. Hypotheses on the effects of physical forcing, including climate variability, and biological interactions, on recruitment processes are presented and evaluated The report is part of the continuing commitment by ICES to act as the North Atlantic regional implementation body for GLOBEC (through the Cod and Climate Change Programme). It represents the culmination of a substantial effort by the ICES/GLOBEC Cod and Climate Change community. It will be of value in preparing and presenting scientific advice and information on the status and outlook for cod stocks and on the marine ecosystems within which they are often a major component. The drafts of the report have been available on the ICES/GLOBEC website and will continue to be updated there as an up-to-date data and information source. This will help to make the material on the biological status and trends in cod stocks available to a wide public. The ICES/GLOBEC programme contributes to Actions 1.2, 1.3, 1.7, 4.2, 5.13.2, 10.2 of the Action Plan.
Resource Requirements:	Time commitment by ICES/GLOBEC Coordinator
Participants:	N/A
Secretariat Facilities:	None
Financial:	Usual CRR costs
Linkages to Advisory Committees:	The outcome of the activities is of importance to ACFM in view of advice given on some technical measures. The main findings and recommendations of the work have been drawn to the attention of ACFM
Linkages to other Committees or Groups:	The results have implications for LRC and RMC.
Linkages to other Organisations:	
Cost share	ICES 100%

6 Annexes

Annex 1 Participants

Name	Address	E-mail
Carolina Alonso	AZTI Herrera Kaia Portualdea s/n Pasaia Spain 20110	calonso@pas.azti.es
Olafur S Astthorsson	Marine Research Institute Skulagata 4 Reykjavik Iceland	osa@hafro.is
Keith Brander	ICES/GLOBEC Secretary Palaegade 2–4 1261 Copenhagen Denmark	keith@ices.dk
Catriona Clemmesen	Leibniz Institute of Marine Sciences Keil University Dusternbroaker Weg 20 24146 Kiel, Germany	cclemmesen@ifm-geomar.de
Ken Drinkwater	Institute of Marine Research P.O. Box 1870 Nordnes 5024 Bergen, Norway	ken.drinkwater@imr.no
Jean-Denis Dutil	Department of Fisheries and Oceans Maurice Lamontagne Institute 850 Route de la Mer, Mont Joli, Quebec Canada G5H 3Z4	dutilj@dfo-mpo.gc.ca
George Hunt	Department of Ecology and Evolutionary Biology University of California Irvine CA 92697 USA	glhunt@uci.edu
Fritz Koester	DIFRES Charlottenlund Castle DK-2920 Charlottenlund Denmark	fwk@dfu.min.dk
Harald Loeng	Institute of Marine Research P.O. Box 1870 Nordnes 5024 Bergen, Norway	harald.loeng@imr.no
Greg Lough	NMFS, NEFSC 166 Water St. Woods Hole MA 02543 USA	glough@whsun1.wh.whoi.edu
Gudrun Marteinsdottir	University of Iceland Biology Department Sturtugate 7 101 Reykjavik, Iceland	runa@hafro.is

Name	Address	E-mail
Geir Ottersen	Institute of Marine Research, Bergen and University of Oslo, Dept. of Biology PO Box 1050, Blindern, N-0316 Oslo Norway	geir.ottersen@bio.uio.no
Brian Rothschild	SMAST, University of Massachusetts Dartmouth 706 South Rodney French Boulevard New Bedford, MA 02744-1221 USA	brothschild@umassd.edu
Svein Sundby	Institute of Marine Research P.O. Box 1870 Nordnes 5024 Bergen Norway	svein.sundby@imr.no
Einar Svendsen	Institute of Marine Research P.O. Box 1870 Nordnes 5024 Bergen Norway	einar.svendsen@imr.no
Kai Wieland	Greenland Institute of Natural Resources PO Box 570 DK-3900 Nuuk Greenland	wieland@natur.gl

Annex 2 Agenda, WGCCC, 9–10 May 2004, Institute of Marine Research, Bergen, Norway

Sunday, 9 May

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

- Welcome and Practical Items
- Review Terms of Reference (TOR) for Meeting
- Agenda
- Review of Strategic Plan for CCCWG and associated Activities
- Report from ICES/GLOBEC Coordinator
    - Activities for past year and coming year
    - Funding
    - Restructuring of ICES Secretariat

Review of Synthesis Activities (TOR 1)

- [TOR 1a] Book (*Ken Drinkwater and Keith Brander*)
- [TOR 1b] CRR Update (*Keith Brander*)
- ICES Symposium (*Harald Loeng and Ken Drinkwater*)

Review of Transport Workshop (TOR 2)

- Update on Report from Transport Workshop (*Keith Brander and Ken Drinkwater*)

Planning for Zooplankton Workshop (TOR 3)

- Response from WGZE
- Identify Co-convenors
- Topics of Workshop
- Location, Dates

17:30 Adjourn

Monday, 10 May

9:00 Continue Planning for Zooplankton Workshop (if necessary)

Planning for Other Future Workshops (TOR 4)

- Workshop on Tropho-Dynamics of Cod Ecosystems
- Workshop on Decline and Recovery of Cod Stocks
- Others

Potential conveners, times and locations, and possible other workshops not previously identified that should be undertaken will be discussed. (Note any new workshops will probably mean replacement of one that had previously been identified).

- Other possible activities of CCC (*Geir Ottersen*)
    - Theme Sessions for 2005 ASC
    - Others?
- Interaction between PICES and ICES (K*en Drinkwater*)
- Identification of new CCC Co-Chair (*Geir Ottersen*)
- Need for 2005 WG Meeting or Work by Correspondence? (*Geir Ottersen*)
- Other Business (*Geir Ottersen*)

- Wrap-up and Summary (*Ken Drinkwater and Geir Ottersen*)
    - Recommendations
    - Action Items
    - TORs for next year

17:00 Adjourn

Annex 3 ICES/GLOBEC Cod and Climate Change Program
Revised Strategic and new Action Plan for 2005–2009

ICES/GLOBEC
Cod and Climate Change Program

Revised Strategic and new Action Plan for 2005-2009

1

[1]Institute of Marine Research, Bergen, Norway
[2]ICES, Copenhagen, Denmark

3

ICES/GLOBEC
Cod and Climate Change Program

Revised Strategic and new Action Plan for 2005-2009

January 2004

Geir Ottersen[1] and Ken Drinkwater[1] (co-chairs CCC)

and

Keith Brander[2] (ICES/GLOBEC coordinator)

[1]Institute of Marine Research, Bergen, Norway
[2]ICES, Copenhagen, Denmark

3

Contents **Page**

1. Introduction

The ICES Cod and Climate Change program (CCC) was established in 1992 but had is origins in an ICES Study Group on Cod Fluctuations formed in 1990. Atlantic cod (*Gadus morhua*) was chosen as the focus because this species was pan-Atlantic, known to be sensitive to climate fluctuations and there were ample data on cod. It was also felt by the founders of the program that the knowledge learned from studying the effects of climate variability on cod could likely be applied to other, less well-studied species. Some of the programs activities since its beginning are listed in Appendix A. It is the first of the regional programs of International GLOBEC to undertake a formal synthesis of its work (described in detail in section 3). Although the synthesis is scheduled for completion in 2004, the CCC members felt it necessary to continue its work. They outlined a final phase of the Program built upon the synthesis that aims to tackle those essential issues not yet resolved in the earlier work. The CCC will complete its work in 2009, coinciding with the official ending of GLOBEC. This document summarizes the scientific achievements of the CCC, presents the gaps and new questions that have been identified for the final phase of the program and their justification, and outlines a strategy to address them. This revised Strategic Plan was requested by the Scientific Steering Committee (SSC) of International GLOBEC and is principally based upon discussions at the 2003 CCC meeting (ICES 2003a).

2. Past Achievements

Present Strategic Plan

The present strategic plan for the CCC program, initially adopted by International GLOBEC, was formalized during the CCC meeting of May 1998 in Woods Hole, USA (ICES 1998a) and consisted of 7 major themes. The themes and their objectives were:

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

2) **Retrospective Analyses**: To understand the links between changes in the environment and fisheries through examination of past unusual events or periods in either the physical environment or 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 understand the life history strategies and causes of interannual variability in growth, distribution, and abundance of cod through comparative studies between different 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.

Several of these objectives followed from the initial work of the CCC. CCC meetings in Dartmouth, Canada (2000) and Hillerød, Denmark (2002) reconfirmed these broad goals.

Methodology

Much of the scientific work within the CCC program to meet the above objectives has been carried out in workshops; focused meetings where 15-25 scientists, often some from outside the core GLOBEC or ICES community, work for 2-3 days. The workshops include presentations, but give more attention to discussion and synthesis of information made available prior to the meeting. The group attempts to establish conceptual as well as statistical, analytical or numerical models of the key variables and control processes in advance of the meeting so that the workshop can focus on the interpretation of results at a more complete and integrated stage. In recent years the program's web site, including bulletin boards specifically set up for each meeting, has been used for pre-meeting exchange of information. This has also been a successful way of involving colleagues not able to attend the workshops. The results of several of these workshops have been published in the ICES Cooperative Research Report series with others in preparation. The CCC has also hosted general meetings focused upon ICES/GLOBEC as well as CCC goals during the ICES ASC (Annual Science Conference). It has also contributed to several other conferences and symposia, such as the GLOBEC Open Science Symposia.

The CCC members are mostly fisheries oceanographers and fisheries biologists, but at the workshops, the program has a policy of involving experts from other fields of knowledge, including history, pure oceanography, climatology/meteorology, numerical modelling, geochemistry, physiology, and others. In this way the CCC program has been able to delve more thoroughly into chosen topics and involve more scientists in the work of GLOBEC.

Scientific Achievements

The retrospective approach, identified early on in the CCC program, consisted of reanalysis and reconstruction of the physical conditions related to specific large events, either biological or environmental, in an attempt to reveal the importance of climate variability on fish stocks. This led to a series of Backward-Facing Workshops (see Appendix A). These combined retrospective and time series analyses, new process studies and modelling to interpret the causes of specific past events and their effect on populations of cod and other fish. The essential aim was to identify and examine instructive past analogues to present day conditions, in which the effects of environmental variability on fish stocks might be more clearly distinguished from the masking effects of fisheries. The four Backward Facing workshops investigated, respectively, the extreme cold period of the 1880s off the northeastern seaboard of the United States (ICES 1995), the incidence, causes, and ecosystem effects of extreme cold in the marine environment of the Barents Sea and Baltic (ICES 1996a), the consequences for gadoid populations of the cooling of the 1960s in the Northwest Atlantic (ICES 1998a, 1999a) and the "gadoid outburst" in the North Sea in the 1960s and 1970s (ICES 1999b, 2001). In the case of the 1880s cold period, modelling and reconstruction of historical data (using oxygen isotope analysis) identified cold water as the most likely cause of the massive tilefish kill in 1882. This was caused by increased flow of cold Labrador Current waters as far south as Georges Bank and the Middle Atlantic Bight (Marsh et al. 1999) and was related to a decline in the NAO index (Marsh 2000). In other cases, such as the gadoid outburst in the North Sea (ICES 1999b, 2001), climate could not be identified as the direct cause of changes in fish stocks, but probably contributed indirectly (Beaugrand et al. 2003).

In addition to the Backward-Facing Workshops, the CCC worked towards improving the data quality and availability of both fisheries and climate data through their Database workshop (ICES 1996b) and held one of the first scientific meetings to focus on decadal variability in the North Atlantic and the NAO (ICES 1997, 1998c).

More recent workshops have focused upon the effects of climate on the processes that govern production of cod (growth, maturation, egg production, transport during early life, survival and natural mortality). One example is the Workshop on Cod Growth This workshop provided much new information about the role of size-selective fishing, food availability,

environment and genetics in determining the changing growth patterns (ICES 2000a, 2002a). For instance, a new hypothesis regarding the role of sea currents and temperatures in determining growth in juvenile Barents Sea cod was suggested (Ottersen et al. 2002). The growth workshop also led to the development of a major new research program on cod growth within Canada. A workshop on Transport Processes (ICES 2002b) evaluated the effects of variations in transport during early life on subsequent recruitment and examined the coupling of circulation models with early life history models to determine the physical and biological processes responsible for the transport or retention of cod larvae. Cod eggs and larvae travel up to 1600 km during the pelagic stage, but greater distance does not necessarily lead to greater variability in survival and recruitment. Both of these workshops were followed up with theme sessions at the next year's ICES ASC. The ultimate goal for the CCC has been to use the information from the workshops for improved management of sustainable fisheries and the development of methods for achieving this remains an ongoing theme of the programme.

Talks at the Session on Comparative studies of North Atlantic ecosystems at the 2nd GLOBEC Open Science meeting in Qingdao dealt with the response of plankton and fish to climate forcing and the effects of food and environmental limitations on growth production of cod (Dutil and Brander, 2003).

In addition to its own program, the CCC has strongly supported and participated in several other GLOBEC-related activities. Two of the most important were the Trans-Atlantic Calanus Study (TASC) and the ICES Symposium on Hydrobiological Variability in the ICES Area, 1990-1999 (ICES 2003b).

3. Present Synthesis activities

The CCC program is currently undertaking a synthesis of its past work (ICES, 2003c), with three major activities dominating the timetable until the end of 2004:

1. Publication of a book in the IGBP series on the current state of knowledge about cod and its response to climate change

This book will present what we have learned about the effects of climate on cod, especially within the CCC program. A theme throughout the book will be the

comparative approach, i.e. what conclusions can be drawn from differences and similarities between the many North Atlantic cod stocks that occupy a wide range of different physical and biological environments. The relative importance of climate compared to biological and fisheries effects will be addressed. The book will include chapters on the physical and biological oceanographic setting, stock structure, growth, recruitment, larval transport, distribution and migration and the role of cod in the ecosystem. A discussion of the CCC program itself, possible implications for fisheries management of CCC findings, and possible impacts on cod of future climate change will also be covered. As well as reviewing existing research it will include new results and analyses. The book will also assess the progress made since the 1993 Cod and Climate Change Symposium, held in Reykjavik during the very early days of the CCC programme (ICES 1994a).

2. A Symposium on the Influence of Climate Change on North Atlantic Fish Stocks in Bergen, Norway, in May 2004

The main objective of the CCC-sponsored Symposium is to present current knowledge of the impact of climate variability and change on fish stocks and how this may be used in fisheries advice and management. Although the scope of this conference is broader than that of CCC, it fits within the general objectives of the program and CCC science and scientists are heavily involved. The main topics of the conference are

- The impact of climate on the distribution and migration of fish populations
- The effect of climate variability on growth, maturity, recruitment and mortality
- The role of zooplankton in climate-fish relations
- Taking account of climate in the evaluation of the state of fish stocks
- Managing fish stocks under future climate scenarios and in the face of climatic uncertainty

Keynote talks include "Climate variability in the North Atlantic: past, present and future" (J. Hurrell), "The impact of climate on the distribution and migration of fish populations" (G. Rose), "The effect of climate variability on growth, maturity and recruitment" (G. Marteinsdottir), "Zooplankton and the link between climate variability and fish" (M. Heath), "Taking account of climate in the evaluation of the state of fish stocks" (C. O'Brien) and "Managing fish stocks under future climate

scenarios and in the face of climatic uncertainty" (L. Richards). Based upon received abstracts, there will be approximately 60 oral presentations and upwards of 40 posters. Selected papers will appear in a special volume of the ICES Journal of Marine Science. The Symposium also will allow us an opportunity to measure progress relative to the 1993 Cod and Climate Change Symposium (ICES 1994a).

3. A comprehensive report on life history information for North Atlantic cod stocks

The CCC is updating a previous report on life history information on cod stocks throughout the North Atlantic (ICES, 1994b). 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, 2000a) and reaffirmed at the 2002 Meeting (ICES 2002c) that this new information should be collated and published in the form of an updated ICES Consultative Research Report. At the 2003 Meeting (ICES 2003a) scientists representing most of the major stocks around the North Atlantic presented information on their particular stock. The scope of the new report will be somewhat wider than the earlier version and will include information on migration and adult growth in addition to 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 travelled from spawn to settlement, etc.). The report is intended as a comprehensive data source for those studying cod.

4. Remaining Gaps and Questions

The above synthesis activities will be completed in 2004. At that time two of the Strategic Goals (Retrospective Analysis and Data Management) will have been addressed satisfactorily. However, important questions remain under the other Goals.

Zooplankton Linkages. 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. Early studies suggested that *Calanus* were critical for establishing a strong year class in some cod stocks although the mechanisms were

unclear. A major research effort on *Calanus* during TASC focused mainly on the life history of the species and not on its linkages to fish. The theme session on Climate-Plankton-Fish Linkages at the 2000 ICES ASC provided more information on links between zooplankton and fish but various different functional relationships were put forward. Some studies have suggested a negative relationship between abundance of *Calanus finmarchicus* and recruitment of cod whereas others are positive or involve additional factors (Beaugrand et al. 2003). A number of national and regional GLOBEC (or GLOBEC-related) programs have been conducting research on this topic over many years and the aim within CCC will be to draw this work together and look for general conclusions and applications.

Climate and Atmosphere-Ocean Interactions. The objective of this topic was to understand and predict climate variability and its associated ecosystem response. While this was partially addressed in the 1997 Workshop on Decadal Variability (ICES 1997, 1998c), the CCC later felt that further work on the direct links between ocean climate and atmospheric variability should largely be addressed by other programs such as CLIVAR. The decision was made to leave this line of research to those other groups and that we should concentrate on the associated ecosystem response. The assessment of the impact of future climate change on cod is central to GLOBEC concern about effects of global change. Evidence of ecological impacts of rising temperature already exists in northern high latitudes, both from the recent warm period and for the previous warm period, which began in the early 1920s. Scenarios for climate change over the next 50 years show continuing increases in temperature and an investigation of the effects on cod is therefore warranted. The CCC members felt that this topic, which gave the programme its name, should be addressed directly before GLOBEC and CCC end.

Fisheries Management. The ultimate aim of the work under the CCC program was to show how environmental information should be applied in fisheries management. A CCC Workshop was held on this subject in 1998 (ICES 1998d); many scientific communities worldwide have also been struggling with the same issue with limited progress to date. Nevertheless, climate is increasingly recognised as an important component of cod fluctuations, as evidenced by recent discussions over the decline in the North Sea cod stock and the debate over the collapse of the Northern Cod off Newfoundland and Labrador. Continuing work will be encouraged and supported in this area, including collaboration with other groups within ICES, GLOBEC and elsewhere.

Comparative Studies. Most of the cod stocks around the North Atlantic have declined over the past 20 years or so. Landings fell from about 1.6 million tons in 1980 to just over half that in 2000. The decline can be attributed largely to high levels of fishing, but climate variability also played a significant part. In addition to the decline in abundance, there has also been a decrease in growth, particularly in the NW Atlantic, in age composition of the spawning stocks, and in mean age of first maturity. Comparative analysis of the changes in production of cod stocks throughout the North Atlantic give insights into the reasons for the decline, including the relative importance of the environment versus fishing intensity. The causes of the decline and the potential for recovery are among the most important issues for cod fisheries today.

An additional and important gap in our knowledge of cod dynamics and one related to understanding the decline and possible recovery of the cod stocks was identified at the 2003 Meeting. It did not fit clearly under any single one of the existing strategies. Climate influences cod directly through physiology as well as indirectly through prey, predators and competition. There is a need for further understanding of how climate effects on prey species like capelin and sprat and predators such as certain pelagic species and seals influence cod. The decline of cod has occurred at a time when there have been significant changes in ecosystem structure. For example, on the Scotian Shelf, in the North Sea and the Irish Sea there has been an increase in pelagic fish species as well as a general decline in the abundance and condition of the groundfish community, not just cod. This also fits with the general move to more ecosystem-based analysis and management.

Finally, although a Synthesis of our knowledge to date is presently ongoing it was felt that a final synthesis of the entire Cod and Climate Change Program needs to take place.

On the basis of the above the following Strategic Plan is proposed for the final phase of the CCC. It includes some of the former topics and objectives, a modified version of others, and one new objective.

1) **Fisheries Management**: To incorporate environmental information into fisheries management.

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

3) **Comparative Analyses**: To understand the relative importance of climate variability in causing fluctuations in North Atlantic cod stocks by means of comparative studies.

4) **Climate Change**: To evaluate the impact of climate change scenarios on cod distribution and production throughout the North Atlantic.

5) **Tropho-dynamics of Cod Ecosystems**: To understand the role of cod in the ecosystem and the importance to cod of climate-induced variability in their prey and predators.

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

Although the objectives related to Retrospective Analysis and Data Management in the former Strategic Plan have not been included in the new Plan they will not be ignored. Retrospective analyses will play an important role in achieving the new strategic goals 2, 3 and 4. Also, the CCC will continue to make data and data products available to the wider scientific community.

5. Action Plan for the Final Phase of the CCC (2005-2009)

To achieve the above objectives of the final phase of the CCC program, a schedule of workshops is planned for the period 2005 to 2009. Other activities such as Theme Sessions at the ICES Annual Science Conference and collaboration with other ICES working groups or GLOBEC programmes will also be undertaken. Work is being planned with PICES (see below) and collaboration with relevant ICES groups (e.g. SGROMAT) is ongoing. The following list of workshops and suggested times is from discussions at the New Bedford 2003 CCC meeting (ICES 2003a).

A) **Workshop on Impact of Zooplankton on Cod Abundance and Production** (2005)

Relations between temporal and spatial dynamics of zooplankton and early stages of cod will be examined. 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; and how the relative importance of *Calanus finmarchicus* to other zooplankton species as the prey for cod varies spatially will 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 US and UK GLOBEC studies, Norwegians studies and recent CCC activities

including the 2002 Transport Workshop and the 2003 Theme Session on Transport of Cod Eggs and Larvae as well as output from the ICES 2003 Zooplankton Symposium.

Relation to strategic goals

The workshop is focused directly towards Goal 2 in the new Strategic Plan, while also contributing towards Goals 3, 4 and 5.

Suggested cooperation

ICES Working Group on Zooplankton Ecology (WGZE) and with the PICES/ICES proposed workshop on Evidence for and Impacts of Large-Scale Long-Term Variability in Zooplankton Populations.

B) **Workshop on Influence of Climate on Tropho-Dynamics of Cod Ecosystems** (2006)

Widely observed changes in abundance, size-at-age and maturity of cod in many stocks throughout the North Atlantic in recent years will be addressed from a tropho-dynamic and bioenergetic perspective. Both observations and theory will be considered, including mass balance and scaling from individual based modelling. The role of forage species will be reviewed, particularly that of capelin in the Barents Sea and Icelandic waters and sprat in the Baltic. This thus addresses the question of cod from a more ecosystem-based perspective. Questions to be answered include: To what extent are observed changes in 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. pelagic fish on larvae, harp seals on adults)?

Relation to strategic goals

The Action Item addresses Goal 5 and contributes towards Goals 3 and 4.

Suggested cooperation

Bioenergetic and multi-species modellers.

C) **Workshop on Decline (and Recovery) of Cod Stocks Throughout the North Atlantic** (2006)

During the presentations on the update of the cod stocks around the North Atlantic at the 2003 meeting, 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. Building upon the work of Dutil and Brander (2003) that showed the effects of temperature on cod production, the updated information on cod stocks throughout the North Atlantic as part of the ongoing synthesis, and the results from the above Tropho-Dynamics Workshop, the Workshop on the Decline of Cod Stocks will compare the changes that have occurred in all of the cod stocks around the Atlantic to assess the relative importance climate-induced ecosystem changes and fishing as causes of the observed declines.

Relation to strategic goals

This Action is linked to Goal 3 and contributes towards Goal 4.

Suggested cooperation

Assessment Working Groups working on cod.

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

The response in abundance, distribution, and production of cod to climate scenarios for the future will be examined. Results from statistical and dynamic downscaling of output from General Circulation Models (GCMs) will be applied. Established climate-cod relations will be utilised. However, while temperature-cod and NAO-cod links have been studied for many stocks, further analyses through retrospective analyses are necessary for other climate variables. We must also take into consideration that simple linear extrapolation of established relations may be inappropriate due to non-linearities in either climate itself, in the climate-ecology impacts or in the links between cod and other trophic levels. The workshop will build upon the 1997 ICES/GLOBEC Workshop on Prediction and Decadal-Scale Ocean Climate Fluctuations of the North Atlantic (ICES 1997, 1998c), which for the first time brought atmospheric climatologists into the WGCCC community to discuss climate variability and prediction and responses in North Atlantic ecosystems. It will also use information obtained from the CCC program linking the physical environment to distribution, growth, maturity, recruitment, etc. The effects of the expected changes to the cod stocks on human communities will also be addressed.

Relation to Strategic Goals

This Action Item addresses Goal 4.

Cooperation

The CCC will seek input and participation from the CLIVAR community and other scientists working on climate scenarios, in particular statistical or dynamical downscaling from GCMs towards marine settings; climatologists who have shown interest in impacts on marine ecology; and social scientists interested in the societal and economic impacts of the predicted changes to the cod stocks.

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

Although climate is increasingly acknowledged as important for fisheries management, there has been little success in incorporating environmental information into the stock assessments. Part of this is due to the present fisheries assessment models for cod are primarily based on the premise that fishing controls the observed fluctuations in the cod stocks. Fine-tuning of such models with environment is likely to meet with only limited improvements at best. The aim of the Workshop will be to develop other techniques and methods for incorporating environment into fisheries and ecosystem management and to provide examples.

Relation to strategic goals

The workshop is focused directly towards Goal 1.

Cooperation

Scientists directly involved in cod management, for instance representatives from Arctic Fisheries Working Group (AFWG) or Baltic Fisheries Assessment Working Group (WGBFAS).

F) **Synthesis II Workshop** (2009)

As an end to the CCC program in 2009, a second Synthesis Workshop will be held to highlight the results of the program, with special emphasis on the final phase. The subjects to be addressed by the Workshop will depend on results and issues that arise during the next five years.

Relation to strategic goals

The workshop is focused directly towards Goal 6.

6. Relations to International GLOBEC goal and primary objectives

All CCC activities lie within the broad aim of GLOBEC, which *is to advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change.*

GLOBEC has four primary objectives:

Objective 1: To better understand how multiscale physical environmental processes force large-scale changes in marine ecosystems.

This is at the core of CCC activities and is dealt with under Action Item D, as well as B and C.

Objective 2: To determine the relationships between structure and dynamics in a variety of oceanic systems which typify significant components of the global ocean ecosystem, with emphasis on trophodynamic pathways, their variability and the role of nutrition quality in the food web.

Trophodynamics is the focus of Action Item B, but this objective will also be addressed in A. Comparison between different (cod) systems has been and is a much-used approach within CCC and will be the main approach used in Action Item C.

Objective 3: To determine the impacts of global change on stock dynamics using coupled physical, biological and chemical models linked to appropriate observation systems and to develop the capability to predict future impacts.

Linking models of different kinds to field observations has been a chosen approach of CCC. Impacts of global change will be the focus of Action Item D.

Objective 4: To determine how changing marine ecosystems will affect the global earth system by identifying and quantifying feedback mechanisms.

Feedback from the biosphere to the geosphere is not be explicitly dealt with within the CCC program. Societal effects are generally outside the scope of CCC, but will be addressed as part

of the Workshop on Climate Change through the invitation of knowledgeable and interested social scientists.

7. Relations to other GLOBEC Regional Programs

Within the final phase of the CCC Program, we will be seeking collaboration with other regional and national GLOBEC programs, and attempt to identify topics of mutual interest and areas of possible collaboration.

The PICES CCCC Program addresses how climate change affects ecosystem structure and the productivity of key biological species at all trophic levels in the open ocean and coastal North Pacific ecosystems. There is a strong emphasis on the coupling between atmospheric and oceanic processes, their impacts on the production of major living marine resources, and how they respond to climate change on time scales of seasons to centuries. Activities focus both on basin-scale and regional-scale. Although much of the interest within CCCC tends to be on open ocean species such as salmon, the identification of climate effects on fisheries is an obvious common focus to CCCC and CCC, including interest in statistical methods, retrospective analyses, data archaeology, regime shifts, etc. As a result, H. Batchelder, one of the present PICES WGCCCC co-chairs, was invited and attended the Transport Workshop (ICES 2002b) and the ICES WGCCC meeting (ICES 2002c) in May of 2002. In October of 2002, the co-chairs of the CCC and the ICES/GLOBEC Coordinator, attended the PICES/CCC meeting between the OPEN Science Meeting of GLOBEC and the PICES Annual Meeting held in Qingdao, China. CCC co-chair K. Drinkwater made a presentation on the CCC, including its synthesis activities. The discussion centred on fostering cooperation and joint activities between the two WGs. 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 agreed 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 continue to communicate on ways to promote cooperation. At the 2003 ICES ASC a specific proposal for ICES/PICES cooperation was presented in the form of Workshop on Evidence for and Impacts of Large-Scale Long-Term Variability in Zooplankton Populations. This would include members of the CCC as well as the ICES Zooplankton Working Group and other interested parties. Several papers from the North Pacific have been submitted to the

May 2004 Symposium on climate effects on fish stocks in Bergen and offers another opportunity for further discussions.

SPACC focuses on upwelling systems by means of both retrospective studies, in which ecosystem histories are reconstructed by means of time series, paleoecological data, and genetic data and process studies, in which cause-and-effect linkages between fish population dynamics and ocean climate are inferred from comparisons of standard measurements from different ecosystems. SPACC studies linkages between physical forces and biological processes with an emphasis on modelling to interpret multidisciplinary observations, and a focus on zooplankton as a key link between physics and fish productivity. Cause-and-effect linkages between fish, zooplankton and ocean physics can be inferred from comparisons of the many diverse ecosystems dominated by small pelagic fishes. The upwelling regions of SPACC are in many ways different to the geographic areas covered by CCC. However, the SPACC approach of comparing the characteristics and variability of the physical environment, zooplankton population dynamics and fish population dynamics among ecosystems is very similar to the CCC approach of comparing different cod ecosystems. Thus, although no concrete discussions have been entered into, CCC acknowledges common themes of interest and will consider future cooperation with SPACC. Some of this will be fostered through the proposed Workshop by the GLOBEC FOCI 1 Working Group.

ESSAS is in the early implementation phase so it is too early to enter into any collaborative activities. However, CCC expects to establish close links to ESSAS, not least since there is a certain overlap both by geography and species. The CCC co-chairs both being in the ESSAS Planning team allows for a good start too such cooperation.

Strong associations have been established between the US GLOBEC program on Georges Bank and the UK GLOBEC program with several CCC members being involved with one of these programs. The results of these programs are communicated to and incorporated into the CCC program.

References

Beaugrand, G., K.M. Brander, J.A. Lindley, S. Souissi, and P.C. Reid 2003. Plankton have effect on cod recruitment in North Sea. Nature 426:661-664

Dutil, J.-D. and K. Brander. 2003. Comparing productivity of North Atlantic cod (*Gadus morhua*) stocks and limits to growth production. Fish. Oceanogr. 12: 502-512.

ICES 1994a. Cod and Climate Change. ICES Marine Science Symposium. Vol. 198. 693+5 p.

ICES 1994b. Spawning and Life History Information for north Atlantic Cod Stocks. ICES Coop. Res. Rep. 205.

ICES 1995. Report of the Cod and Climate Backward-Facing Workshop, Bedford Institute of Oceanography, Dartmouth, Canada. ICES CM 1995/A:7, 23 pp.

ICES 1996a. Report of the Cod and Climate Backward-Facing Workshop, Institute of Marine Research, Bergen, Norway, 21-23 March 1996. ICES CM 1996/A:9, 25 pp.

ICES 1996b. Report of the ICES/GLOBEC Cod and Climate Database Workshop. 14-16 November 1995, Woods Hole, MA, USA. ICES CM 1996/A:7, 67 pp

ICES 1997. Preliminary Report of the ICES/GLOBEC Workshop on Prediction and Decadal-Scale Ocean Climate Fluctuations of the North Atlantic. ICES CM 1997/A:13, 2pp.

ICES 1998a. Report of the Working Group on Cod and Climate Change ICES CM 1998/C:10, 19pp.

ICES 1998b. Report of the third Backward-Facing Workshop. Ocean Climate of the NW Atlantic during the 1960s and 70s and Consequences for Gadoid Populations. ICES CM 1998/C:9, 89pp.

ICES 1998c. Report of the Workshop on Prediction and Decadal-Scale Ocean Climate Fluctuations of the North Atlantic. ICES CM 1998/C:14, 53pp.

ICES 1998d. Report of the ICES/GLOBEC workshop on application of environmental data in stock assessment. ICES CM 1998/C:1, 97pp.

ICES 1999a. Report of the Workshop on Ocean Climate of the NW Atlantic during the 1960s and 70s and Consequences for Gadoid Populations. ICES Cooperative Research Report 234, 81pp.

ICES 1999b.Workshop on Gadoid Stocks of the North Sea during the 1960's and 1970's. The Fourth Backward-Facing Workshop. ICES CM 1999/C:15, 89pp.

ICES 2000a. ICES/GLOBEC Workshop on the Dynamics of Growth in Cod. ICES CM 2000/C:12, 114pp.

ICES 2000b. Report of the Working Group on Cod and Climate Change ICES CM 2000/C:11, 16 pp.

ICES 2001. Workshop on Gadoid Stocks in the North Sea during the 1960's and 1970's. ICES Cooperative Research Report 244, 55pp

ICES 2002a. Report of the ICES/GLOBEC Workshop on the Dynamics of Growth in Cod. ICES Cooperative Research Report 252, 97pp plus 1 CD.

ICES 2002b. Report of the Workshop on the Transport of Cod Larvae ICES CM 2002/C:13, 44pp.

ICES 2002c. Report of the Working Group on Cod and Climate Change. ICES CM 2002/C:12, 10pp.

ICES 2003a. Report of the Working Group on Cod and Climate Change. ICES CM 2003/C:11, 16pp.

ICES 2003b. Hydrobiological variability in the ICES area, 1990-1999. ICES Marine Science Symposium. Vol. 219. 453+6p.

ICES 2003c. Report of the Workshop on a Synthesis of the Cod and Climate Programme. ICES CM 2003/C:10, 28pp.

Marsh, R. 2000. Modelling changes in North Atlantic circulation under the NAO-minimum forcing of 1877-81. Atmosphere-Ocean 20: 367-393.

Marsh, R., B. Petrie, C.R. Weidman, R.R. Dickson, J.W. Loder, C.G. Hannah, K. Frank, and K. Drinkwater 1999. The Middle Atlantic Bight tilefish fill of 1882. Fish. Oceanogr. 8: 39-49.

Ottersen, G., B. Bogstad, and K. Helle 2002. Do abiotic mechanisms determine interannual variability in length-at-age of juvenile Arcto-Norwegian cod? Can. J. Fish. Aquat. Sci. 59: 57-65.

Appendix A. CCC Activities 1993-2003

This overview includes ICES/GLOBEC Cod and Climate Change workshops and, for recent years, also CCC theme sessions at the ICES Annual Science Conference and conferences with strong CCC involvement. Working group meetings are not included.

1993	August	ICES **Symposium** on Cod and Climate Change
1994	August	Aggregation **Workshop**
1995	March	Backward-Facing **Workshop** I – The tilefish kill of the 1880s
	November	Database **Workshop**
1996	March	Backward-Facing **Workshop** II – Ecosystem effects of cold events in the NE Atlantic
1997	September	**Workshop** on Prediction and decadal-scale ocean climate fluctuations of the North Atlantic (NAO)
1998	March	**Workshop** on Application of environmental data in stock assessment
	May	Backward-Facing **Workshop** III - Ocean climate of the NW Atlantic during the 1960s and 70s and consequences for gadoid populations
1999	March	Backward-Facing **Workshop** IV - The Gadoid Outburst in the North Sea
	August	TASC Symposium on Calanus
	September	ICES ASC **Theme Session** on Bio-Physical Modelling
2000	May	**Workshop** on the Dynamics of Growth in Cod
	September	ICES ASC **Theme Session** on Climate-Plankton-Fish Linkages
2001	August	ICES Symposium on Hydrobiological Variability in the ICES Area, 1990–1999
	September	ICES ASC **Theme Session** on the Dynamics of Gadoid Growth
2002	April	**Workshop** on the Transport of Cod Larvae
	October	**Theme Session** on Comparative Studies of North Atlantic Ecosystems, GLOBEC 2002 Open Science Meeting
	October	**Contributed Session** on Zooplankton-Climate Linkages in Different Regions of the Northern Hemisphere, GLOBEC OSM
2003	May	**Workshop** on Synthesis of the Cod and Climate Change Program
	September	ICES ASC **Theme Session** on the Transport of Cod Larvae

Appendix B. List of CCC reports

ICES 1994a. Cod and Climate Change. ICES Marine Science Symposium. Vol. 198. 693+5 p.

ICES 1994b. Spawning and Life History Information for north Atlantic Cod Stocks. ICES Coop. Res. Rep. 205.

ICES 1994c. Report of the ICES/GLOBEC Cod and Climate "Aggregation workshop". ICES CM 1994/A:10,13 pp.

ICES 1995. Report of the Cod and Climate Backward-Facing Workshop, Bedford Institute of Oceanography, Dartmouth, Canada. ICES CM 1995/A:7, 23 pp.

ICES 1996a. Report of the Cod and Climate Backward-Facing Workshop, Institute of Marine Research, Bergen, Norway, 21-23 March 1996. ICES CM 1996/A:9, 25 pp.

ICES 1996b. Report of the ICES/GLOBEC Cod and Climate Database Workshop. 14-16 November 1995, Woods Hole, MA, USA. ICES CM 1996/A:7, 67 pp.

ICES 1996c. Report of the ICES Working Group on Cod and Climate Change. Institute of Marine Research, Bergen, Norway 25-27 March 1996 ICES CM 1996/A:10.

ICES 1997a Preliminary Report of the ICES/GLOBEC Workshop on Prediction and Decadal-Scale Ocean Climate Fluctuations of the North Atlantic. ICES CM 1997/A:13, 2pp.

ICES 1997b. Report of the Working Group on Cod and Climate Change (by correspondence) ICES CM 1997/A:9, 4pp

ICES 1997c. Report of the ICES/GLOBEC North Atlantic Regional Co-ordination Group. ICES Headquarters, 16-17 June 1997 ICES CM 1997/A:8, 13pp.

ICES 1997d Second Report of the ICES/GLOBEC North Atlantic Regional Co-ordination Group. Reykjavik, Iceland, 28-29 September 1996 ICES CM 1997/A:7, 18pp.

ICES 1998a. Report of the Working Group on Cod and Climate Change ICES CM 1998/C:10, 19pp.

ICES 1998b. Report of the third Backward-Facing Workshop. Ocean Climate of the NW Atlantic during the 1960s and 70s and Consequences for Gadoid Populations. ICES CM 1998/C:9, 89pp.

ICES 1998c. Report of the Workshop on Prediction and Decadal-Scale Ocean Climate Fluctuations of the North Atlantic. ICES CM 1998/C:14, 53pp

ICES 1998d. Report of the ICES/GLOBEC workshop on application of environmental data in stock assessment. ICES CM 1998/C:1, 97pp.

ICES 1998e. Report of the ICES/GLOBEC North Atlantic Regional Co-ordination Group. Woods Hole, USA 9 May ICES CM 1998/C:13, 4pp.

ICES 1998f. Report of the ICES/GLOBEC North Atlantic Regional Co-ordination Group. Baltimore, USA 26 and 29 September 1997 ICES CM 1998/C:11, 10pp.

ICES 1999a. Report of the Workshop on Ocean Climate of the NW Atlantic during the 1960s and 70s and Consequences for Gadoid Populations. ICES Cooperative Research Report 234, 81pp.

ICES 1999b.Workshop on Gadoid Stocks of the North Sea during the 1960's and 1970's. The Fourth Backward-Facing Workshop. ICES CM 1999/C:15, 89pp.

ICES 1999c. Report of the Working Group on Cod and Climate Change ICES CM 1999/C:10, 19pp.

ICES 1999d. Report of ICES/GLOBEC North Atlantic Regional Co-ordination Group. ICES CM 1999/C:1, 10pp.

ICES 1999e. Reort of the Steering Group for the ICES/GLOBEC North Atlantic Regional Office ICES CM 1999/C:12, 19pp.

ICES 2000b. ICES/GLOBEC Workshop on the Dynamics of Growth in Cod ICES CM 2000/C:12, 114pp.

ICES 2000b. Report of the Working Group on Cod and Climate Change ICES CM 2000/C:11, 16 pp.

ICES 2001a. Workshop on Gadoid Stocks in the North Sea during the 1960's and 1970's. ICES Cooperative Research Report 244, 55pp.

ICES 2001b. Report of the Working Group on Cod and Climate Change. ICES CM 2001/C:12, 10pp.

ICES 2001c. Report of the Steering Group for the ICES/GLOBEC North Atlantic Regional Office ICES CM 2001/C:13, 13pp.

ICES 2002a. Report of the ICES/GLOBEC Workshop on the Dynamics of Growth in Cod. ICES Cooperative Research Report 252, 97pp plus 1 CD.

ICES 2002b. Report of the Workshop on the Transport of Cod Larvae ICES CM 2002/C:13, 44pp.

ICES 2002c. Report of the Working Group on Cod and Climate Change. ICES CM 2002/C:12, 10pp.

ICES 2002d. Report of the Steering Group for the ICES/GLOBEC North Atlantic Regional Office ICES CM 2002/C:17, 18pp.

ICES 2002e ICES/GLOBEC Sea-going Workshop for Intercalibration of Plankton ICES Cooperative Research Report 250, 25pp plus 4 CDs.

ICES 2003a. Report of the Working Group on Cod and Climate Change. ICES CM 2003/C:11, 16pp.

ICES 2003b. Report of the Workshop on a Synthesis of the Cod and Climate Programme. ICES CM 2003/C:10, 28pp.

Annex 4 Updated report presented to June 2004 Bureau Meeting

CURRENT STATUS OF THE ICES/GLOBEC PROGRAMME OFFICE

The budget for the ICES/GLOBEC office is secure to the end of 2004, but at a reduced level, which has restricted activities. Dr Brander is currently on 80% pay (this is an agreement which is allowed for in his contract). The ICES/GLOBEC programme has a strategic plan and action plan which runs on to the end of the International GLOBEC programme in 2009 and the Cod and Climate Change Working Group (WGCCC) strongly support the continuation of the ICES/GLOBEC office after 2004.

Some continued funding is in place (see budget table below). The contract with DEFRA (UK) runs to April 2006 and with the Norwegian Research Council to the end of 2006. Funding (on EU projects) in 2005 and future years is currently being negotiated with DIFRES (Denmark). Continuation of Canadian funding will be discussed with their Delegates at the 2004 ASC in Vigo.

The major funding contract with NSF will end this year (see text of message below). Possibilities for a new special cooperative project with NSF are being explored.

A proposal for an EU Marie Curie Network (FishACE) is beginning the contract negotiation phase. It will pay for a post-doctoral fellow at ICES for two years, to work on management advice in relation to fisheries induced adaptive change.

Dr Brander has been invited to act as lead author on fisheries for the fourth IPCC report and funding for this extra work is being sought.

UPDATE ON PROGRESS IN 2004

WGCCC met in Bergen on 8–9 May to review progress with the ongoing Synthesis Activities, which include the book (provisional title *Cod in a Changing Climate*) and the Cooperative Research Report (CRR) on cod life histories. The book will be published by Springer in the IGBP series. Two draft chapter have been submitted to the editors and others are nearing completion. Stock summaries for the CRR have been edited and returned to the authors for checking. All drafts are on the web and will continue to be updated as new material becomes available. A reference database with nearly 2000 entries has been compiled and will replace the existing searchable database on the web: www.ices.dk/ris/risweb.isa.

A poster summarising progress and plans for the CCC programme up to 2009 was prepared for the UK GLOBEC meeting at the Royal Society in February and can be seen on the website: http://www.ices.dk/globec/

The Symposium on Influence of Climate Change on North Atlantic Fish Stocks this May was part of the CCC Synthesis Activities. Papers from the Symposium are available on the website: www.imr.no/2004symposium/web/index.html

WGCCC reviewed the programme of workshops for the period 2005–2009 and proposed co-convenors for the workshop on zooplankton-cod linkages in 2005. Two workshops in 2006 on “Influence of climate on tropho-dynamics of cod ecosystems” and “Decline and recovery of cod stocks throughout the North Atlantic” will run consecutively.

In addition to the work for WGCCC, the Coordinator’s activities in the first half of 2004 include:

- Attending SGGROMAT in January and REGNS in April as part of the effort to apply results from the CCC programme (and GLOBEC more generally) to the advisory work of ICES.
- Reviews of current GLOBEC (or GLOBEC related) programmes in Germany, UK, and France.
- Presenting papers at the Symposium on Ecosystem Indicators for Fisheries Management and the Bergen Symposium (references below).
- Talks on “Effect of climate change on fish distribution and dynamics in the North Atlantic” to a Danish PhD course and on “Biological production in the sea - the physical and chemical basis” to staff of DG Fish in Brussels.

A list of recent publications is given below.

Text of message of 27 February from NSF

“NSF has helped to support the GLOBEC Office at the ICES Secretariat for a decade or more. We believe it has been a fruitful cooperation and well worth the funds the U.S. and other countries have expended.

Both because of the length of time of this commitment and in light of the recent announcement of ICES reorganization, we believe that it is appropriate to draw this phase of support to a close. For this reason, we want to provide you with adequate notice that this year will be the final year of support.

NSF's commitment to support the U.S. academic community in ICES participation will remain strong as ever, and we look forward to the possibility that there may arise new opportunities for us to engage in special cooperative projects involving the Secretariat and other ICES countries.”

ICES-GLOBEC Office – income and expenditure

All in DKK:	2001	2002	2003	2004	2005	2006
Carried forward	105,877	163,268	-24,903	-75,553	-121,094	
Income:						
From USA	433,406	374,650	342,962	302,826		
From Canada	215,575	106,507	92,386	89,691	90,000	
From UK[2]	161,476	134,761	127,613	132,103	140,000	280,2045
From Norway[2]	91,583	98,130	98,130	85,060	90,000	180,0005
From Iceland			14,970			
From Denmark					200,000	
From France						
Total Income	902,040	714,048	676,061	609,680	520,000	469,204
Expenditure						
Salary[4]	610,386	639,228	513,994	610,221		
Pension[3]	208,322	232,385	185,908	0		
T&S [1]	25,400	30,383	26,809	40,000		
Other expenses	541	223	0	5,000		
Total Expenses	844,649	902,219	726,711	655,221		
Balance	163,268	-24,903	-75,553	-121,094		

Notes
1) ICES ceased paying the Coordinator's costs for attending the ASC in 2001
2) UK and Norway pay in arrears
3) Pension is paid in advance therefore zero in final year
4) Salary and pension reduced to 80% from 1 January 2003
5) Includes arrears paid by UK and Norway

Publications

Brander K.M. 2003. What kinds of fish stock predictions do we need and what kinds of information will help us to make better predictions? Scientia Marina 67(1): 21–33.

Brander K.M. 2003. Fisheries and Climate. 2003, Marine Science Frontiers for Europe. Ed. by Wefer G., Lamy F., Mantoura F. Springer-Verlag Berlin Heidelberg New York Tokyo, pp 29–38.

Brander K.M. *et al.* 2003. Changes in fish distribution in the eastern North Atlantic; are we seeing a coherent response to changing temperature? *ICES Marine Science Symposia*, 219: 261–270.

Brander K.M., Dickson, R.R. and Edwards M. 2003. Use of Continuous Plankton Recorder information in support of marine management: applications in fisheries, environmental protection, and in the study of ecosystem response to environmental change. Progress *In* Oceanography, 58: 175–191.

Beaugrand, G., Brander, K.M., Lindley, J.A., Souissi, S., Reid, P.C. 2003. Plankton have effect on cod recruitment in North Sea. Nature, 426: 661–664.

Dutil, J.D., and Brander, K.M. 2003. Comparing productivity of North Atlantic cod (*Gadus morhua*) stocks and limits to growth production Fish. Oceanogr. 12: 4/5, 502–512.

Lindley, J.A., Reid, P.C., and Brander, K.M. 2003. Inverse relationship between cod recruitment in the North Sea and young fish in the continuous plankton recorder survey. Scientia Marina, 67(1): 191–200.

Brander, K.M., and Mohn, R. 2004. Effect of the North Atlantic Oscillation (NAO) on recruitment of Atlantic cod (*Gadus morhua*) Can. J. Fish. Aquat. Sci., 61: xxx.

Brander K.M. 2004. Biological production in the sea – the physical and chemical basis. Paper prepared fro EU DG Fish. Available (in French and English) from ICES/GLOBEC website

Brander K.M. 2005. Cod recruitment is more strongly affected by climate when stock biomass is low. *ICES Journal of Marine Science.*