

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

Hillerød, Denmark  
17–19 April 2002

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Conseil International pour l'Exploration de la Mer

## TABLE OF CONTENTS

Section	Page
1 INTRODUCTION AND TERMS OF REFERENCE .....	1
2 REVIEW OF PAST ACTIVITIES.....	1
2.1 The Strategic and Action Plans for WGCCC.....	1
2.2 The ICES/GLOBEC North Atlantic Regional Office .....	2
2.3 2000 Workshop on the Dynamics of Gad Growth and Related Activities .....	2
2.3.1 2001 ASC Theme Session on Gadoid Growth.....	2
2.3.2 GADOLIFE .....	3
2.3.3 Growth studies using otolith back-calculations .....	3
2.4 2001 Decadal Symposium .....	3
2.5 Review of Other GLOBEC Programs.....	3
3 FUTURE WGCCC ACTIVITIES.....	5
3.1 Working Group Interactions .....	5
3.1.1 ICES Working Group on Recruitment Process (WGRP).....	5
3.1.2 PICES/GLOBEC Working Group on Climate Change and Carrying Capacity (WGCCCC).....	6
3.2 Follow-On Activities to the Transport Workshop.....	7
3.3 Synthesis .....	7
3.4 GLOBEC 2002 OPEN Science Meeting.....	9
3.5 ICES 2004 Symposium on the Influence of Climate Change on North Atlantic Fisheries.....	9
3.6 Workshop on Long Term Climate Change and Prediction .....	9
3.7 Long Range Direction of the WGCCC .....	10
3.8 2003 Meeting of the WGCCC .....	10
4 OTHER BUSINESS.....	10
4.1 Arctic Climate Impact Assessment .....	10
4.2 NAO Book .....	11
4.3 Trans-Atlantic Studies.....	11
4.4 UV.....	11
4.5 Effects of Climate Change Scenarios on Cod .....	12
5 RECOMMENDATIONS AND TERMS OF REFERENCE FOR FUTURE MEETINGS .....	12
APPENDIX 1: PARTICIPANTS .....	16
APPENDIX 2: EXPRESSION OF INTEREST FOR THE EU FP6 PROGRAMME.....	18

## 1 INTRODUCTION AND TERMS OF REFERENCE

The Working Group on Cod and Climate Change (WGCCC) met at Hillerød, 17–19 April 2002, under the Chairship of Dr Ken Drinkwater (Bedford Institute of Oceanography, Dartmouth, Canada). There were 25 participants from 9 countries (Canada, Denmark, Germany, Greenland, Ireland, Norway, Russia, UK and USA) and the ICES/GLOBEC Coordinator and the Director of the GLOBEC IPO. A list of participants is provided in Appendix A.

Immediately prior to the working group meeting, the ICES Workshop on the Transport of Cod Larvae (April 14–17) was held. Nineteen of the WGCCC meeting participants took part in the Workshop.

The terms of the reference (C: Res.2001/12) for the CCC meeting were:

The **ICES/GLOBEC Working Group on Cod and Climate Change** (Chair: Dr K. Drinkwater, Canada) will meet in Copenhagen, Denmark, on 19–20 April 2002 to:

- a) continue with the review and evaluation of work carried out to date on Cod and Climate Change including results and possible follow-up work from the Workshop on Transport of Cod Larvae.
- b) plan and prepare workshops over the next two years in order to:
  - i) coordinate the synthesis work and prepare material for the book
  - ii) continue the evaluation of studies on Long Term Climate Change and Prediction
- c) foster further cooperation and interaction with the Working Group on Recruitment Processes, the Study Groups on the Incorporation of Process Information into Stock-Recruitment Models and the Study Group on Modelling of Physical/Biological Interactions.
- d) determine the Working Group's contribution to the GLOBEC Open Science in October 2002.
- e) prepare a summary report listing relevant marine bio-ecological variables and indicators suitable for operational use.

The Workshop will report to the Oceanography Committee at the 2002 Annual Science Conference.

## 2 REVIEW OF PAST ACTIVITIES

### 2.1 The Strategic and Action Plans for WGCCC

As background information, the Chair reviewed the strategic plan for the Working Group that was adopted during the May 1998 meeting in Woods Hole, Mass., USA (ICES CM 1998/C:10) and the action plan developed at the same time along with the updated action plan from the May 2000 meeting in Dartmouth, Nova Scotia, Canada (ICES CM 2000/C:11). The strategic plan consists of 7 major components:

- 1) Fisheries Management: To incorporate environmental information in a quantitative manner into fisheries management strategies and planning.
- 2) Retrospective Analyses: To examine past events or periods as a means of better understanding the links between changes in the environment and fisheries.
- 3) Zooplankton-Cod Linkages: To understand the relative importance of zooplankton in determining the variability in cod abundance and production.
- 4) Comparative Analyses: To undertake comparative studies of life history strategies and interannual variability in growth, distribution, and abundance between cod stocks around the North Atlantic.
- 5) Climate and Atmosphere-Ocean Interactions: To understand and predict climate variability and its associated ecosystem response.
- 6) Data Availability and Management: To ensure that environmental and fisheries data are easily and widely available.
- 7) Synthesis: To provide a synthesis of the research information obtained on cod stocks.

The related workshops and activities in the action plans (\* denotes the 1998 plan, \*\* the 2000 update) under these 7 components completed during the last three years include:

1999 March*	Workshop on the Gadoid Outburst in the North Sea
1999 August*	Participated in TASC Symposium on Calanus

1999 September*	ICES ASC Theme Session on Bio-Physical Modelling
2000 May*	Workshop on the Dynamics of Growth in Cod
2000 September*	ICES ASC Theme Session on Climate-Plankton-Fish Linkages
2001 August**	Participated in WGOH sponsored ICES Symposium on Hydrobiological Variability in the ICES Area, 1990–1999
2001 September**	ICES ASC Theme Session on the Dynamics of Gadoid Growth
2001 April*	Workshop on the Transport of Cod Larvae

## 2.2 The ICES/GLOBEC North Atlantic Regional Office

K. Brander reported that again this year a considerable proportion of his time as Coordinator of the ICES/GLOBEC office has been taken up with funding issues and in assisting the Steering Group for the ICES/GLOBEC North Atlantic programme and Regional Office (SGNARO; ICES CM 2001/C:13). In contrast to the uncertainty of the past couple of years, however, funding for the position of Coordinator now appears secure until 2004, with support from the U.S., the U.K., Canada, and Norway. Substantial progress has also been made on the scientific front. Much of this effort was directed towards planning and support for the Workshop on the Transport of Cod Larvae. In addition, work has continued towards publication of the Workshop on Cod Growth as a Cooperative Research Report. Publication of two issues of the ICES/GLOBEC Newsletter generated a substantial level of interest and correspondence. He also was involved in the North West Atlantic Ecosystem (NORWATE) meeting in June 2001 at Halifax that developed a plan for a pan-Atlantic study of *Calanus finmarchicus*. He presented two talks at the ICES Symposium on Hydrobiological Variability in the ICES Area, 1990–1999 and the opening talk at the SAHFOS-sponsored CPR Symposium held back to back in Edinburgh, Scotland, in August 2001. As well, he delivered a paper on cod growth at the WGCCC sponsored theme session at the 2001 ASC. He also participated in the ICES Planning Group on Comparing the Structure of Marine Ecosystems and attended several GLOBEC and GLOBEC-related meetings. These included taking part in the steering and review process for national GLOBEC programmes in the UK (Marine Productivity) and in Germany. The former is moving into its second fieldwork phase and the latter has been funded and will be entering its fieldwork phase soon. Both are reported on below. In addition to the ICES/GLOBEC work, he is involved in a number of related activities. These include the writing of a chapter on marine ecosystems as part of the Arctic Climate Impact Assessment, where he is taking the lead on the section on fisheries. He also attended the FAO Conference on Responsible Fisheries, the SCOR-IOC WG on Quantitative Ecosystem Indicators, the Expert Conference for 5th North Sea Ministerial Conference and SAHFOS Council meetings.

## 2.3 2000 Workshop on the Dynamics of Cod Growth and Related Activities

As reported last year (ICES CM 2001/C:12), the Workshop on the Dynamics of Cod Growth held on 8–10 May at Dartmouth, Nova Scotia, under the direction of Co-Convenors Neils Anderson (Denmark) Geir Ottersen (Norway) and Doug Swain (Canada) is to be published as an ICES Cooperative Research Report (CRR). It was decided at that time to incorporate papers presented at the theme session on gadoid growth during the 2001 ICES Annual Science Conference. K. Brander and G. Ottersen reported that the Workshop portion of the CRR is ready for publication and is only awaiting the theme session papers. There was some discussion on the form of the papers, whether they would be the full papers or simply abstracts. The WGCCC decided that abstracts or extended abstracts from the theme session should be published but that the full papers could be if the authors would not be publishing them elsewhere.

### 2.3.1 2001 ASC Theme Session on Gadoid Growth

On the recommendation of the 2000 Workshop on Cod Growth, the WGCCC sponsored a theme session on Growth and Condition in Gadoid Stocks and Implications for Sustainable Management with L. Buckley (USA), J.-D. Dutil (Canada) and T. Marshall (Norway) as co-convenors during the 2001 ICES ASC in Oslo, Norway. J.-D. Dutil informed the WG that the theme session was very successful with a total of 30 presentations. Results were presented from laboratory, mesocosm, field and modelling studies and varied from the emphasis on the molecular level to individuals to populations. Several novel approaches were identified including genetic techniques to examine the parental effects on growth and mortality. Parental effects on growth trajectories in larval stages were found to be small and larvae from recruit and repeat spawners had similar growth and mortality rates. Temperature was found to be a dominant factor affecting growth and able to account for the variability in size-at-age for a number of stocks. Other important factors affecting growth included dissolved oxygen, food availability and size-selective fishing. Low oxygen appears to limit ingestion with the driving factor varying with life stage and stock (cold/warm habitats). Growth in recently settled cod and at age 1 or 2 may explain growth trajectories in subsequent years. Factors, which affect growth and condition, were found to affect reproductive investment as well. Improved data on reproductive characteristics are required to estimate effective spawning stock biomass and to investigate stock/recruitment relationships. Bioenergetic models appear to be promising tools for quantifying stock production and reproductive effort. Based on the presentations it was clear that

better understanding of variations in growth and condition requires models and data studies across stocks in contrasting environments. In addition, research survey sampling protocols should include more data, such as maturity, fecundity, liver, gonads and somatic weights. The presenters have been offered the opportunity to publish an abstract or extended abstract in the ICES Cooperative Research Report series as part of the Workshop on Cod Growth.

### **2.3.2 GADOLIFE**

As described in last year's report (ICES CM 2001/C:12), following one of the recommendations from the ICES/GLOBEC 2000 Workshop on the Dynamics of Cod Growth and the Workshop, a team of international scientists wrote a major proposal entitled "Growth Dynamics and Regulation of Energy Allocation in Gadoids of Different Life Strategies and in Different Environments (GADOLIFE)", which was divided into two parts and submitted to Canadian and EU funding agencies separately. The project involved a combination of lab, field, bioenergetic modelling and retrospective analysis studies of growth in gadoids, including cod. Their aim was to improve understanding of growth variations through increased knowledge of food acquisition and energy allocation in gadoids and development of mechanistic bioenergetic models. Included were environmental affects. Comparison of cod stocks in Canada (southern Gulf of St. Lawrence and western Scotian Shelf) with those in the North Sea and the Baltic would be carried out as well as between cod and other species such as haddock, whiting and hake in European waters. While the Canadian proposal obtained funding in 2001, the EU proposal did not but was encouraged to resubmit. Unfortunately, during 2002, although the EU proposal received high praise for its science, it did not receive any funding and will not be resubmitted again. This points out the difficulty of attempting to undertake international science with different funding priorities and schedules.

J.-D. Dutil updated the WGCCC on the activities of GADOLIFE-Canada. It comprises a dual field-laboratory approach with a major focus on growth, condition, metabolism, food consumption, dissolved oxygen and temperature relationships in the laboratory. Field studies are examining monthly changes in length, weight, sex and sexual maturity, body composition (soma and gonads), food consumption through stomach contents and prey energy density analyses, and seasonal distribution and oxygen and temperature fields in the area of distribution. GADOLIFE-Canada is being carried out by 8 researchers from 3 different laboratories with expertise in the fields of fish ecology, physiology, bioenergetics, population dynamics, fish stock assessments and physical oceanography. Modelling is an important component of the program and is being used to focus the lab and field studies. The first year of the three-year programme has been completed successfully.

### **2.3.3 Growth studies using otolith back-calculations**

A number of proposals for continuing work in this area have been put forward, but these do not directly involve the Cod and Climate Change programme at present.

## **2.4 2001 Decadal Symposium**

No WGCCC-sponsored workshops were held in 2001 in order that members could attend and present papers to the WGOH-sponsored ICES Symposium on Hydrobiological Variability in the ICES Area, 1990–1999 held in Edinburgh during August. Several members took advantage of this opportunity. K. Drinkwater reported that there were a total of 42 talks and 59 posters from throughout the North Atlantic covering physical, chemical and biological oceanography as well as fisheries. It was held immediately following the SAHFOS-sponsored workshop celebrating 70 years of the Continuous Plankton Recorder (CPR) and therefore allowed participants to conveniently attend both workshops. The 1990s were identified as a decade of extremes with large variability in many variables including the North Atlantic Oscillation (NAO) index, ice extent and sea and air temperatures. Fisheries also underwent large changes during the decade. Publication of the proceedings of the Decadal Symposium will be in the ICES Marine Science Symposium Series. K. Drinkwater, one of the editors of the proceedings, noted that the papers should be in final form by the ICES 2002 ASC in October with publication, hopefully before the end of 2002.

## **2.5 Review of Other GLOBEC Programs**

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

M. Barange, Director for the **GLOBEC International** Project Office (IPO), and G. Ottersen who is on the Scientific Steering Committee reported on their activities. The IPO coordinates the national GLOBEC programs as well as the regional activities of which the WGCCC is one of four. The other three regional working groups are the PICES Climate Change and Carrying Capacity (CCCC), Small Pelagics and Climate Change (SPACC) and the Southern Ocean. In addition, there are four FOCUS working groups. The FOCUS 1 WG deals with retrospective analysis, 2 with process studies, 3 with prediction and modelling and 4 with feedback from ecosystem changes. The purpose of these WGs are to

carry out the International GLOBEC Implementation Plan through organization of study groups, symposia and meetings by bringing together those working on the national and regional level. The National programmes range from those that are just beginning (i.e., Germany), those that are underway (UK), those that are in their synthesis phase (USA) and those that have been completed (Canada). It was noted that during the past year a number of new national programmes were initiated and others are being planned. The GLOBEC OPEN Science Meeting will be held in Qing Dao, China in October and will consist of various theme sessions of the regional programs, including Cod and Climate Change (see below), and the FOCI Groups. In addition there is a major Zooplankton Symposium to be held May 2003 in Spain. G. Ottersen noted that the FOCUS 1 Working Group held a joint meeting between PAGES (paleo oceanographers) and GLOBEC in 2001 is developing a zooplankton database and wrote a paper on statistical problems in retrospective analysis. A workshop comparing the variability in fish stocks throughout the world's oceans is also being planned. A new regional program focused upon Tuna in the Pacific and the effects of ENSO has begun and talks will be underway later in 2002 about the possibility of an Arctic program centered on the Bering Sea and perhaps the Barents and Labrador Seas as well. M. Barange informed the WG that the International Geosphere-Biosphere Programme (IGBP), under which GLOBEC is a core project, is presently undertaking a re-organization exercise. Results of this exercise will be forthcoming during the following year or two. Also, he noted that while there has been excellent cooperation between the ICES/GLOBEC Office and the IPO of International GLOBEC in the past, it was felt that to maintain this cooperation and maximize mutual support that it may be useful to outline the various responsibilities of each group. This would also help to clarify the duties to clients and sponsors alike. It was agreed that this could be undertaken.

F. Koester and M. St. John reported on **German GLOBEC** that has recently been funded. It aims for a better understanding of the interactions between zooplankton and fish under the influence of physical processes in order to elucidate the principal mechanisms accounting for the high variability of copepod production and of reproductive success of fishes. The results will form the basis for strategic modelling of the recruitment success of fishes. Over the last several decades, herring and sprat, but also numerous copepod populations, in the Baltic and in the North Sea have experienced high fluctuations in recruitment and biomass. Whereas a substantial decrease of individual weight of herrings and sprats at high biomass was documented in the Baltic Sea, a similar relationship was not observed in the North Sea. It is assumed that this phenomenon is caused by food (mainly copepods) limitation in the Baltic Sea. However, it is not clear whether this is due to direct effects of trophic interactions (internal dynamics) in the rather simple Baltic food web or whether the decrease of some copepod populations is a reaction to physical processes (external forcing). An interdisciplinary team of fisheries biologists, planktologists, physiologists, geneticists, physical oceanographers and modellers representing 7 institutions and 11 subprojects will combine to investigate these hypotheses. The influence of physical processes on zooplankton and on the spawn of two planktivorous fish species with different life histories, herring and sprat, and on their trophodynamic interactions will be studied in the Baltic and the North Sea, two ecosystems with very different oceanographic characteristics. This will be done using a combination of field studies, experimental investigations and modelling. The two seas under investigation exhibit a gradient from marine to almost fresh water conditions. Top-down and bottom-up processes will be studied comparatively in both ecosystems. As the Baltic Sea has a considerably lower number of species, the importance of food web complexity for ecosystem functioning can be studied in a comparative manner between the two systems. The same suite of species will be investigated in both areas: the planktivorous clupeids, herring and sprat, and their main food basis, the copepods *Pseudocalanus spec.*, *Acartia spec.*, and *Temora longicornis*. The focus will be on an intra-seasonal and regional comparison of the reactions of egg and larval cohorts of herring and sprat produced at different periods over the entire spawning season with respect to their continually changing physical and biological environments. A tight coupling between field research and modelling is required to enhance our understanding of the two ecosystems. We expect that an improved understanding of the mechanisms governing population fluctuations at short time scales will finally give us insight into the causal relationships of major population fluctuations and ecosystem changes on the decadal scale. The first phase of the project is targeted for 3 years at a cost of 8 million ECU.

J. Quinlan discussed briefly the **US GLOBEC** programme and the Georges Bank project specifically. This project focused on zooplankton on the Bank and how the effects of global change affect the abundance and production of the plankton and fish. The first three phases, including all of the field components, have been completed. Funding for the synthesis phase of the project has been obtained and is just in the process of beginning this year. It has 6 major directions. These include physical oceanography, zooplankton population dynamics, patterns of energy flow, exchange and mixing at tidal fronts, interpretation and synthesis and a symposium. These include modelling, data analysis and retrospective studies. A large number of workshops to bring participants together are planned on topics such as stratification, the retention/loss and cross frontal exchanges, and broad scale studies. The focus of the symposium will be on biological/physical interactions and synthesis.

K. Brander reported on the activities of the **UK Marine Productivity programme**, which is in effect the main UK contribution to GLOBEC. Phase 1 projects began in 2000 and the field-based phase 2 work began in late 2001. The financial support of the Natural Environment Research Council (NERC) totals £6.5m over five years and there are also substantial "in kind" contributions by the fisheries research establishments in Scotland, England and Northern Ireland.

The Marine Productivity programme, together with the Plymouth Marine Laboratory provides much of the support for the International GLOBEC programme office.

Phase 1 of the programme was concerned with assembling and analysing historical data sets; developing and testing existing biological models in a variety of physical settings; and developing technology to provide new field data for hypothesis testing. Much of the work was related to the Irish Sea.

In Phase 2 the research effort is integrated under the following broad questions:

- How are ocean basin-scale patterns of zooplankton abundance maintained?
- How do zooplankton species respond to basin-scale physical forcing?
- What are the impacts of basin-scale physical changes on secondary production in shelf seas?

The fieldwork is principally located in the Irminger Sea, to observe the full annual life-cycle of the *Calanus finmarchicus*. The rationale for this ocean scale activity is that the longer term changes in *Calanus* populations (including those in European shelf seas) may be influenced by the effects of changes in deep water circulation on overwintering stages. This may play a critical part in understanding long term changes in cod stocks.

The programme is integrated with work being undertaken in Norway, Canada, Iceland and the US. More information can be found on the programme website: [www.nerc.ac.uk/funding/thematics/marprod](http://www.nerc.ac.uk/funding/thematics/marprod)

M. St. John also informed the WG about a proposal that was being developed and would be submitted shortly to the EU for funding. Called **RESOLVE**, its objectives are to develop anthropogenic and environmentally based recruitment models for key species in European Regional Seas and to predict via scenario testing the impacts of climate variability and anthropogenic impacts on the dynamics of key indicator species and hence ecosystem structure and function. It consists of 10 major component studies and covers 10 different regional seas from Greenland to the Barents Sea, from the Baltic to the Mediterranean. The component studies often cover several regional seas and consist of retrospective analyses, laboratory studies, field collections, and modelling. The project was submitted in June and final results of whether it has been successful will be known early in 2003.

A. Gallego discussed modelling efforts undertaken during **STEREO**. Its objective is to develop dynamic stock-recruitment relationships that take into account both climate and internal structure of the spawning stock. It is based upon a coupled biophysical model that includes: spatial dependent egg production as a function of condition, age and size structure of the spawners; particle (larval) tracking; individual based growth and survival; and a density dependent settlement model. The model is used to estimate the number of survivors to demersal juvenile stage from different components of the spawning stock and to investigate the relative importance of the characteristics of the spawning population (ages, times, locations, etc.) that contribute to recruitment. The model will be used to generate confidence limits around stock-recruitment relationships, on the basis of environmental variability and the changes in the structure of the spawning stock. The project is nearing completion and a final report on the project should be ready in the near future.

A. Gallego also made a presentation on the new **METACOD** project (The Role of Substock Structure in the Maintenance of Cod Metapopulations). Its objectives are to develop the conceptual and mathematical basis for advising on fisheries management measures to conserve or restore stock biomass and substock diversity. More specifically, the project will use models to develop advice on how catch and/or effort control measures might be structured in space and time to both manage the population abundance and to conserve or rebuild substock structure. The concept is to run a probabilistic simulation of the temporal dynamics of a metapopulation where the stock-recruitment relationship comes from the substock model structure. This will then be compared to the results from a homogeneous stock-recruitment model. Probabilistic simulations will then be run for fishing scenarios with different catches, fishing mortalities and substock catch distributions. In addition, simulations with a collapsed substock structure, varying fishing patterns on surviving substocks will help to estimate probability of restoring stock richness.

### **3 FUTURE WGCCC ACTIVITIES**

#### **3.1 Working Group Interactions**

##### **3.1.1 ICES Working Group on Recruitment Process (WGRP)**

The WGCCC were happy to welcome several members of the Working Group on Recruitment Processes (WGRP) who attended the Transport Workshop and the first day of the Cod and Climate Change meeting. This joint meeting of the

two WGs to discussion areas of mutual interest was arranged between the two chairs and the ICES/GLOBEC Coordinator. P. Pepin, the chair of the WGRP, made a presentation to the WGCCC during the WGCCC meeting to outline some of their aims and activities of the WGRP and to generate discussion regarding possible future collaborations between the two working groups. There are several overlapping interests between the two WGs including the processes affecting recruitment, the role of the environment, and how to incorporate environment into the assessment process. Of particular note was the completion of WGRPs Study Group on Incorporation of Process Information into Stock-Recruitment Models (SGPRISM). They had three successful meetings and have completed their mandate. The final report is available (ICES CM 2002/C:01). The SG was successful in getting assessment and oceanographers working together. From the examples they studied, environmental indices were generally found to be poor predictors of recruitment and at present such indices are not useful for 1-year forecasts. However, it was noted that ICES is going to 5–10 year projections and environmental effects on these time scales will be needed. Ideas of regime shifts with large changes in the biota will certainly be important at these longer time scales. SGPRISM recommended that a new Study Group be formed on Growth, Maturity and Condition Indices in Stock Projections (SGGROMAT) and will be carried forward by WGRP. Their objectives will be to collate data on weights, maturity, condition, fecundity and age-length and length-weight keys for stocks in the North Sea, Irish Sea, Northeast Arctic and Baltic Sea. Also, SGGROMAT will develop the implementation methods for using this information for stock projections. The WGRP is also considering a Workshop on multispecies and environmental predictions in the Baltic because that system is better understood than most. To broaden interest, the Arcto-Norwegian cod stock may also be included for comparison. It was thought that detailed case studies might help to focus how to incorporate environmental information into the assessments.

This presentation generated much discussion. It was acknowledged that there is still poor understanding and information on the effects of food on growth and recruitment. For example, in spite of the emphasis upon Calanus within many of the GLOBEC programmes, there still is a lack of information on its affect on fish. Even in the well-studied US GLOBEC program, researchers noted that more connection needed to be made between the plankton and fish. A better understanding of the important time and space scales for recruitment and growth is needed in order to target the field sampling. There was also a joint interest in how growth varies and its effect on mortality. It was generally felt that there were several areas of common interest and joint activities should be considered. Communications should be improved and the possibility of a joint workshop was discussed. While no specific actions were agreed upon at the meeting, discussion between the chairs will continue. The WGRP members left after the first day to attend their own meeting.

### **3.1.2 PICES/GLOBEC Working Group on Climate Change and Carrying Capacity (WGCCCC)**

The PICES/GLOBEC WGCCCC is one of four regional GLOBEC programs that also includes the ICES Cod and Climate Change Working Group. Although much of the focus of the former group tends to be open ocean species such as salmon, the identification of climate effects on fisheries is a common focus to both WGs, including interest in statistical methods, retrospective analyses, data archaeology, regime shifts, etc. Over the previous year, discussions between the outgoing co-chair of the WGCCCC, D. Welch, and WGCCC members G. Ottersen and K. Drinkwater lead to the suggestion that both groups should explore the possibility of some joint activities. An invitation was given for the co-chairs of WGCCCC to attend the Transport Workshop and the WGCCC meeting, which H. Batchelder, one of the present co-chairs, accepted. He made a presentation on PICES and the activities of the WGCCCC. One of their main aims is to forecast the consequences of climate variability on the ecosystems of the subarctic Pacific. More specifically they are addressing the question of how interannual and decadal variations in ocean conditions affect the species dominance, biomass, and productivity of the key zooplankton and fish species in the ecosystems of the PICES area. In 1997 they established 4 Task Teams: MODEL to advance the development of conceptual and modelling studies; BASS (BASin Scale) to develop the basin-scale component; REX (Regional Experiments) to develop interregional comparisons among national studies; and MONITOR to review, improve and design a monitoring system for ocean and ecosystem observations in the North Pacific including assistance in developing a coordinated program to detect and describe events that strongly affect the North Pacific and providing a liaison role to GOOS. They are working on providing an Ecosystem Status Report (ESR), which will include information on hydrography, chemistry, plankton, fish, mammals and birds. It will include modelling results and attempt to separate anthropogenic and natural variability. The first ESR is scheduled for completion in 2002 and will be written on a 1 to 2 year time frame.

Towards the end of the talk a number of possible topics of mutual interest were presented that might be potential subjects of collaboration between ICES and PICES and WGCCCC and WGCCC, in particular. Regarding the latter these included: investigating the spatial coherence between zooplankton and fish and the role of large scale climate indices such as the NAO, the Pacific Decadal Oscillation (PDO) and the Arctic Oscillation (AO); the development of climate and ecosystem indices, how useful they are and their representativeness; comparisons between pollock in the Pacific with cod in the Atlantic and their responses to climate changes; and how to incorporate environmental information into stock assessments. This resulted in much discussion on how best to foster cooperation and joint activity between the WGs. A joint workshop was suggested. It was noted that 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 decided that cooperation between the two WGs should initially be fostered through the FOCUS 1 Workshop. In the interim, the Chairs of the two WGs will continue to communicate on ways to promote cooperation between the two groups. Finally, as part of that process, K. Brander, K. Drinkwater, and G. Ottersen will attend the WGCCCC meeting following the GLOBEC OPEN Science Meeting in China in October.

Potential collaborations with other working groups within ICES were outlined included topics such as biophysical modelling, work on harmful algal blooms, comparative studies between herring in the Atlantic and Pacific, establishment of CPR transects in the Pacific and fisheries management issues. The WGCCC agreed to notify the appropriate ICES Groups of these interests during the ICES ASC through the Oceanography Committee.

### **3.2 Follow-On Activities to the Transport Workshop**

The Cod Transport Workshop was held immediately prior to the WGCCC meeting under the co-chairs, J. Quinlan (USA) and B. Ådlandsvik (Norway). As most of the WGCCC members had attended the workshop, and given that time was required to digest the information, no formal review of its findings was undertaken. Two decisions were made by the WG regarding the Workshop, however. First, as with most of our recent Workshops, it was recommended that the report of the Workshop be published as a Cooperative Research Report. This will allow broader dissemination of the results of the workshop. Second, to further encourage such work it was decided that a theme session on the Transport of Larvae Relevant to Cod be proposed for the 2003 Annual Science Conference in Oslo. J. Quinlan (USA) and B. Ådlandsvik (Norway) have agreed to be co-convenors for this theme session.

### **3.3 Synthesis**

At the 2000 meeting of the WGCCC (ICES CM 2000/C:11), it was decided to begin a synthesis of the work of the Cod and Climate Change program. It would comprise several components. The major of these were (1) a compilation of available data on cod that would be made available to the broad scientific community, (2) an update of the CRR report (205) on *Spawning and Life History Information for North Atlantic Cod Stocks* published in 1994, (3) an ICES Symposium on Fisheries and Climate and (4) a book on cod based upon the activities of the WG. The Symposium was subsequently recommended and accepted by ICES (see below). Work on data compilation has continued during the past year through preparations for the Transport Workshop but the database is not yet complete. The WG decided that the data compilation should continue and be posted on the web. K. Brander is coordinating this effort and members were encouraged to ensure that all of the required data be provided to him. The WG also agreed that the updating of the CRR 205 report should proceed. It was felt that this should be undertaken over the next year. Scientists familiar with the various cod stocks will be contacted and encouraged to provide updates and possibly expanded versions of the information in CRR 205. These updates should be reviewed at next year's WG meeting.

As reported in last year's report (ICES CM 2001/C:11), a strawman for the book was developed, which the Chair presented to the WG. Since much of the past work of the Cod and Climate Change program has emphasized comparative studies, it was felt that the book should highlight comparisons between stocks and especially look at stocks across the full range of environmental conditions over the North Atlantic. In keeping with GLOBEC aims, the book should also highlight climate affects on cod through its life history, but not exclusively. The relative importance of climate compared to biotic influences such as density dependence, predator-prey interactions, etc. need to be included. The book will consist of an introduction along with chapters on the stock structure, the physical environment, the planktonic environment, growth and reproduction, recruitment, larval transport, distribution and migration, feeding, predation, etc. In addition, there will be chapters on the Cod and Climate Change Program and its role, implications for fisheries management, impacts of climate change on cod, and a summary chapter. Lead authors (generally 2) will be selected for each chapter with support from a small group of contributing authors if necessary. The two lead authors should preferably represent different locations of the Atlantic to ensure a balanced view. K. Brander and K. Drinkwater have agreed to edit the book.

The WG generally agreed with the proposal but with some slight modifications. It was felt that the lead authors should preferably be those who have been involved in the CCC program but it not need be a requirement. Potential lead authors were identified along with possible substitutes. The following chapters were identified by the WG (along with some of the possible lead authors and possible substitutes, the latter being in square brackets).

- Chapter 1: Introduction  
Potential Authors:
- Aims of GLOBEC and the Cod and Climate Change Program
  - Objectives of the book

#### Chapter 2: Stock Structure and History

Potential Authors: Jakobsson (Iceland), Ruzzante (Canada) [Brander, ICES/GLOBEC Coordinator]

- Description of the different stocks (location, genetic differences, abundance and its variability, fishing efforts, etc.)

#### Chapter 3: Cod and Climate Change Program

Potential Authors: Dickson (UK), Rothschild (USA), Sundby (Norway) [Brander]

- The history of the CCC. What has been learned from the Backward Facing Workshops? Successes and failures.

#### Chapter 4: Physical Oceanographic Setting

Potential Authors: Drinkwater (Canada), Loeng (Norway) [Dippner (Germany)]

- Description of the physical oceanography (temperature, salinities, stratification, currents) over the NW Atlantic
- Discuss the temporal variability and its causes (e.g., NAO)

#### Chapter 5: Biological Oceanographic Setting

Potential Authors: Heath (UK), Tande (Norway) [Planque (France)]

- Description of zooplankton species important to cod and how they are affected by climate variability

#### Chapter 6: Growth and Condition

Potential Authors: Buckley (USA), Dutil (Canada), Marshall (Norway) [Bjornsson (Iceland), Swain (Canada), Andersen (Denmark)]

- Description on the main factors affecting growth. This would include results from the workshop on cod growth and the theme session on growth of gadoids.

#### Chapter 7: Recruitment

Potential Authors: Koester (Germany), Murawski (USA) [Planque (France), Pepin (Canada), Lough (USA)]

- What governs recruitment? The comparative work of Planque should be included.

#### Chapter 8: Larval Transport

Potential Authors: Quinlan (USA), Ådlandsvik (Norway) [St. John (Germany)]

- What is the role of larval transport? How does this change between stocks? Results from the Workshop on Transport of Cod Larvae should be included.

#### Chapter 9: Distribution and Migration

Potential Authors: Ottersen (Norway), Swain (Canada) [Castonguay (Canada), Rose (Canada)]

- How does the distribution of cod change with climate variability? What is the migration strategy of cod? What stocks migrate and which ones do not? What does this tell us about the strategies that cod use?

#### Chapter 10: The Role of Cod in the Ecosystem

Potential Authors: Bogstad (Norway)

- What role does cod play in the ecosystem?

#### Chapter 11: Implications for Fisheries Management

Potential Authors: Brander, Frank (Canada)

- From what has been learned through Cod and Climate and our present knowledge of cod, what are the implications for fisheries management and assessments?

#### Chapter 12: Response of Cod to Climate Change

Potential Authors:

- Given available Climate Change Scenarios what can we say about possible changes to cod

#### Chapter 13: Summary

Potential Authors:

- A synthesis of the material presented in the book.
- Future directions

It was decided that the lead authors would be confirmed by the summer of 2002 and that a meeting of those attending the 2002 ASC be held to discuss the book, at which the time the lead authors would be asked to supply outlines of their chapters. The plan would then be to work on the chapters over the following autumn and winter. It was further agreed that a Synthesis Workshop should be held in the spring of 2003 to allow the authors to present the main focus and points of their chapters, obtain feedback, allow comments on linkages between chapters and identify possible missing information. First drafts of the chapters would be ready by the autumn of 2003, final drafts by the spring of 2004 and the results presented at the Symposium on the Influence of Climate Change on North Atlantic Fisheries in the summer of 2004.

The publisher of such a book was discussed. M. Barange offered to ask the IGBP whether they would be willing to publish it. They usually do not publish material from sub-components of their main programs such as the CCC but he was willing to inquire whether they would and inform the WG Chair of the results. K. Brander also agreed to inquire to the publisher of ICES to determine if they might be interested and if so what the associated costs might be.

M. Barange also reminded the WG that International GLOBEC has allocated funding of \$5000 US towards a Synthesis meeting and asked if this was still required. After some discussion it was felt that the WG would like to keep this on the books for this year as one or more of the potential lead authors may not have financial support for travel. If not needed this year, the Chair will notify International GLOBEC.

### **3.4 GLOBEC 2002 OPEN Science Meeting**

The GLOBEC Open Science Meeting is scheduled for 15–18 October 2002, in Qing Dao, China. As a regional program of GLOBEC, the WGCCC is responsible for two sessions during the meeting. One is to be a plenary session with 3 invited speakers and the other for 6 contributed talks. International GLOBEC had requested the Session Topics for both of these near the beginning of 2002. Through consultations between the Chair (K. Drinkwater), the ICES/GLOBEC Coordinator (K. Brander) and the GLOBEC Steering Committee member, G. Ottersen, it was decided that the plenary session would be entitled Comparative Studies of North Atlantic Ecosystems. The contributed session would be on Zooplankton-Climate Linkages in Different Regions of the Northern Hemisphere. These were accepted by International GLOBEC. The co-convenors for the plenary session will be K. Brander and K. Drinkwater and for the contributed session, K. Tande (Norway) and F. Carlotti (France). The discussion during the meeting centered on who the invited speakers should be. After much discussion, the WG agreed to recommend three members who have been active within the WGCCC program and have published on the effects of climate on plankton or fisheries. The three are B. Planque (France), who has published on zooplankton and cod recruitment, G. Ottersen who has published on distribution and abundance variations in cod, and J.-D. Dutil who has examined growth differences amongst cod. Two of the three were at the meeting and accepted the invitation and B. Planque had indicated his willingness to speak if requested.

### **3.5 ICES 2004 Symposium on the Influence of Climate Change on North Atlantic Fisheries**

H. Loeng updated the WG on the progress to date in the planning of the Symposium on the Influence of Climate Change on North Atlantic Fisheries to be held in Bergen, Norway in May 2004. The venue has been booked, a timetable set and information for the brochure has been circulated and agreed to by the Steering Committee members. The brochure will be printed in August and it is hoped to have them ready to give out at the 2002 ASC. There will be invited talks, contributed talks and posters. The Symposium Proceedings will be published in a special volume in the ICES Journal of Marine Science or in the ICES Science Symposium series. The cost of the registration has not been fixed since the amount of the financial support from various sources is waiting confirmation.

H. Loeng asked whether the EU or GLOBEC should be approached to help co-sponsor the Symposium. M. Barange felt that GLOBEC might be willing to co-sponsor the Symposium and agreed to take the request to the Scientific Steering Committee of International GLOBEC. He will notify H. Loeng and the WG chair of the results.

Some of the members of the WG felt that the broad scope of the meeting might result in too large and diverse a group of participants. This may make it difficult to manage. It was felt that the bullets that will appear in the brochure and that outline the main topics to be covered should be elaborated upon, perhaps on the web. It should also be made clear that for the session on incorporation of environmental information into the assessment process that fisheries assessment biologists are being sought. H. Loeng thanked the WG members for their comments and stated that he would take them into consideration.

### **3.6 Workshop on Long Term Climate Change and Prediction**

A workshop on Long Term Climate Change and Prediction was proposed as part of the original 5-year action plan. At the 2000 meeting it was proposed that such a workshop should focus on the response of cod stocks to modelled future climate change scenarios based on enhanced CO<sub>2</sub> levels. A second suggestion was a workshop that focused upon short-term (seasonal to annual) forecasts of ocean climate because of increasing pressure to provide such predictions. In other case, one of the main aims should be to emphasize the uncertainty in any predictions. Given that this Workshop is presently scheduled for no sooner than 2005, the WG decided to postpone further discussion until the next meeting of the WGCCC.

### **3.7 Long Range Direction of the WGCCC**

With the planning of the synthesis of the work of the CCC program well in hand, a discussion was held on the future direction of the WG. It was felt that although it was time for a synthesis, this did not mean that the work of the WGCCC was complete. It was noted that the ICES declaration highlighted the ICES/GLOBEC program as an example of what ICES should be doing more of. The relationship between GLOBEC and GOOS was discussed and it was pointed out that the links between these two programs includes at the top levels with the GLOBEC chair and observer at GOOS meetings. It was suggested that the WG should emphasize the application towards Fisheries and Ecosystem Management, which was one of the seven components of the strategic plan, adopted in 1998. Potential problems that could be tackled by the CCC program include the relationship between stocks (i.e., the spatial scales of variability) and determining the time scale of the recovery of stocks. Members noted that the strength of the WG is in the connections between physics and fish and this should be exploited in determining ecosystem approaches to management. A State-of-the-Cod report could be produced similar to the Working Group on Oceanic Hydrography's annual climate summary. It was mentioned that the WGCCC should be supporting the activities of SGGROMAT and becoming more involved in the incorporation of environment into the assessment process. Finally, one aspect that the WG has not tackled is that of climate change and what affect will climate change have on cod stocks around the North Atlantic, another component of the strategic plan. In summary, the general consensus of the Group was that the next phase of the WGs activities should focus more on the application of the science, including how they might be used for fisheries assessment and ecosystem management as well as for determining impacts of climate change scenarios. Given the importance of the topic of future directions of the WG, it was felt that further discussions were needed before developing an action plan. It was decided that this discussion should be held at next year's WGCCC meeting.

Further in regards to the long-range planning, the Chair noted that he has been in the position for five years (3 meetings) and that a re-election is likely this year. He felt that it was not in the best interest of the WG or himself to stand for the chair again, if it was to be for another five years. At the same time he stated that he would like to see several of the ongoing projects through to fruition such as the synthesis work and the Symposium scheduled for 2004. He therefore proposed to the WG that he would be willing to stay on for another 2 years (until the 2004 ASC) but would like to have a co-chair who would take over as Chair in 2004. He further recommended that G. Ottersen be appointed as that co-Chair because of his interest and active involvement in the WG over the past number of years. G. Ottersen agreed that he would be willing to accept such a position. After some discussion by the WG, this proposal was accepted. The Chair will need to check with H. Dooley at the ICES Secretariat to ensure that co-Chairs would be acceptable, although it was noted that other groups, including the WGRP has co-chairs.

### **3.8 2003 Meeting of the WGCCC**

During the past several years, the WGCCC has been meeting every second year and working by correspondence in the intervening years. However, the WG decided that a meeting would be required in 2003 to carry out the synthesis activity related to the updating of the CRR 205 and to discussions further the long-range plans for the CCC program. It was agreed to hold the meeting immediately following the Synthesis Workshop (directed towards the book). It was decided to tentatively schedule the meeting for Wood's Hole in May and the Chair will explore this possibility during the coming months.

## **4 OTHER BUSINESS**

### **4.1 Arctic Climate Impact Assessment**

At the request of the Arctic Council, an Arctic Climate Impact Assessment (ACIA) is being undertaken. It began in 2000 and an IPCC-like report just on the Arctic is to be published by 2004. The report covers the physical sciences, what changes are expected and what the anticipated impacts will be. The climate change scenarios are to focus on changes in the 2020, 2050 and 2080. It covers the physical and biological sciences as well as socio-economic issues. For the purposes of the report the Arctic includes the definition adopted by AMAP and includes the Nordic Seas, the waters around Iceland and the Labrador Sea. It will also discuss the impact of the climate changes on fish stocks, including cod. Hence the report is of interest to the CCC community. H. Loeng, who is lead author on the Marine System chapter, informed the Working Group about the ACIA process and schedule. Drafts of the various chapters are in different stages with completed chapters to be available for internal (ACIA) review by September of 2002. Following this review, the chapters will be revised and then undergo an external review.

K. Brander, who is involved in the Marine System chapter and responsible for the fisheries section made a brief presentation. He highlighted the fisheries response to the warming in Greenland waters during the 1920s when both "warm-water" fish such as Atlantic cod and salmon pushed their distributions northward while other "cold-water" fish retracted northward. He also discussed the importance of the Polar Front in the distribution and migration of herring

between Iceland and Norway. Not many fish are caught in the Arctic and hence less is known about them. The primary species are Greenland halibut, Polar cod and capelin. There is large uncertainty about what will happen to primary production under global warming scenarios and its effect on fish production. Presently, primary production is generally low in most parts of the Arctic, perhaps because of the ice. Linkages between the zooplankton and fish are also unclear. There are large populations of *Calanus* in the Irminger, Labrador and Norwegian Seas with programs such as UK GLOBEC that will help to elucidate their life histories and hopefully their influence upon fish stocks.

#### **4.2 NAO Book**

In December 2000, an American Geophysical Union (AGU) sponsored workshop on the North Atlantic Oscillation (NAO) was held in Spain. The proceedings of this workshop are being published in the form of several review chapters on the NAO and its effects. The chapters will deal with the meteorological aspects of the NAO, the response of the physical oceanography to the changes in atmospheric forcing associated with the NAO and their biological consequences. In addition, there will be a chapter on NAO indices, including paleo-reconstructions. G. Ottersen informed the WG that the chapters are in the process of review and revision and that it is hoped to have it published by the end of 2002. He is one of the four editors of the book and as well is involved in the chapter on the impacts on the marine ecosystem along with K. Drinkwater.

#### **4.3 Trans-Atlantic Studies**

The North Atlantic GLOBEC community have consistently exerted themselves to maximise cooperation in research activities in order to tackle issues at the appropriate scales, exchange current data, models and ideas on species and systems of common interest and to carry out comparative studies. A number of cooperative research plans have been produced as a result of pan-Atlantic workshops, and many elements of these have been or are being carried out. Sometimes this has been assisted by having programmes, which were funded and ran in parallel in different countries, but often the cooperation persisted in spite of the absence of concurrent funding for particular areas of common interest. The EU and National Science Foundation have recently signed of an Implementing Arrangement for Cooperative Activities in research areas including climate research, marine science and technology, and environmental biology. This provides an opportunity to develop the network of cooperative international research on marine ecosystems and to implement some of the plans for integration, pan-Atlantic comparison and synthesis.

It was proposed that Dr Brander should pursue this opportunity by putting forward an Expression of Interest for the sixth Framework programme of the EU. The technical procedures for the Implementing Arrangement, which the EU and NSF have signed, remain to be worked out, but the Expression of Interest is intended as a marker of the maturity and well-developed state of planning of the North Atlantic GLOBEC community. The Expression of Interest was submitted in June and is included here as Appendix 2.

#### **4.4 UV**

C. Alonso (Spain) presented a paper to the WG on Ultraviolet radiation (UV). UV (280–400 nm) has been recognised as an ecological hazard in aquatic ecosystems and especially for organisms living in the upper layers of the ocean. The eggs and larvae of Atlantic cod (*Gadus morhua*) and of the copepod *Calanus finmarchicus* are key species in the pelagic ecosystems of the North Atlantic and are potentially exposed to high levels of UV radiation when they are spawned in spring. In the frame of a project that envisages the study of the impact of climate change on the arctic cod stock (UVAC), the effects of ambient UV light upon the offspring of these two target species was studied. Their sensitivity to solar UV was determined in a series of laboratory studies, in which eggs and larvae were incubated in the Lofoten Islands area, one of the main spawning sites of the arctic cod stock. It was found that when eggs and larvae were exposed in surface waters (15 cm of depth) during their embryonic stages, in many cases UV light increased mortality and reduced hatching success, viability of hatched larvae and altered the buoyancy. However, when the experiment was run in deeper waters (50–60 cm), the effect was strongly attenuated. Therefore, the negative effects must be viewed with caution. Since planktonic organisms are usually subject to turbulent mixing and thus spend little time in the first few centimetres of the water column, they are likely to receive a much lower total dose than in our experiments. On the other hand, correlation analysis between UV radiation and cod recruitment data series revealed that, for the last 30 years and in the Lofoten area, these two variables are positively correlated. This contradiction between short-term experiments and historical data is difficult to explain with the currently available information. The underlying mechanism is likely to be more complex than a direct effect of UV on mortality of eggs and larvae, possibly acting indirectly through food web interactions.

#### 4.5 Effects of Climate Change Scenarios on Cod

Robin Clark (UK) presented a talk entitled *Modelling the effect of climate change on North Sea cod (2000 to 2050)*. The study investigated the influence of temperature changes on recruitment and growth of cod in the North Sea. Sea surface temperature (SST) from derived from several Hadley Model runs. Estimates of bottom temperatures were derived from taking the mean difference between the SSTs and bottom temperatures for the period 1963 to 1999 and subtracting this difference from the modelled future SSTs. Temperature dependent Ricker stock-recruitment curves and Von Bertalanffy growth curves were also used. Under no climate change and current fishing levels, there was a small rise in recruitment and SSB over present levels by 2050. Low levels of climate change (<1°C over 50 years) resulted in higher SSB but about the same recruitment levels. High levels of change (ca. 2°C over 50 years) lead to lower levels of recruitment and SSB. While the assumptions and methods were discussed and questioned, the WG felt that this study was an excellent example of what needs to be done to address the question of what will happen to fish, and cod in particular, under different climate scenarios. More of these types of quantitative studies should be undertaken.

### 5 RECOMMENDATIONS AND TERMS OF REFERENCE FOR FUTURE MEETINGS

#### Recommendation I:

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

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

The Working Group will report to the Oceanography Committee at the 2003 Annual Science Conference.

#### Supporting Information

**Priority:** This Group is of fundamental importance to the future of the ICES Advisory Process.

Scientific Justification:

During the 2000 annual meeting, the CCCWG updated and extended the 5-year plan adopted in 1998 as part of the Implementation Plan of the International GLOBEC program (The ICES/GLOBEC Cod and Climate Change program is the North Atlantic regional component of the International GLOBEC program.). The plan includes a synthesis of the work and knowledge gained by the Cod and Climate Change program. The meeting will be held to review the synthesis activities and plan for the future.

- a) The Workshop on Synthesis of Cod and Climate Change has been proposed that will immediately proceed the WGCCC meeting. Its purpose is to summarize results from the CCC program in the form of papers that will be published as a book. An evaluation of the success of the workshop in meeting its stated terms of reference will be carried out in order to determine what follow-up activities should be initiated and how best to carry them out.
- b) Another major objective of the synthesis is to provide the scientific community with up-to-date data and information on all Atlantic cod stocks for comparative studies of cod biology and population dynamics. As part of this process, the 1994 CRR 205 on *Spawning and Life History Information for North Atlantic Cod Stocks* that provides a description of each of the stocks will be updated and expanded upon. The meeting will review the progress to date and develop plans for its completion.
  - i) A theme session on transport processes of the larvae of cod and related species has been proposed for the 2003 ICES ASC as a follow-up to the Workshop on Transport of Cod Larvae. The planning and organization of this theme session will be carried out.
  - ii) A WGCCC-sponsored ICES Symposium on Climate Variability and Fisheries has been approved for May 2004. The progress on the planning for the Symposium will be reviewed.

- c) With the synthesis of the past work of the WGCCC underway, future plans and directions for the group began at the 2002 meeting with potential emphasis on the application of the results to fisheries management. These critical discussions will be continued along with the development of possible related activities.

**Relation to Strategic Plan:**

The ICES/GLOBEC programme contributes to Goals 1, 4, 5 and 8 of the ICES Strategic Plan.

**Resource Requirements:**

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

Participants: Participation at the WGCCC is usually more than 25. Part of the reason for holding the Synthesis Workshop immediately prior to and at the same location as the WG meeting is to encourage attendance and participation.

**Secretariat Facilities:** None

**Financial:** None

**Linkages to Advisory Committees:**

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

**Linkages to Other Committees or Groups:**

Living Resources, to the WGCCC reports. Also links to SGNARO, WGRP, SGGROMAT, SGMPI.

**Linkages to Other Organizations:**

GLOBEC is a co-sponsor of the WGCCC.

**Recommendation II:**

A Workshop on the Synthesis of the Cod and Climate Program will be held on May 5–7, 2003 in Wood's Hole, USA under the Chairship of K. Drinkwater (Canada) and K. Brander (ICES/GLOBEC) to:

- a) review what we have learned from the workshops, theme sessions and other activities of the Cod and Climate program over the past 10 years,
- b) present and discussion synthesis papers on specified topics related to the life history of cod,
- c) finalize the plan to publish these synthesis papers as a book on cod.

The Workshop will report to the Working Group on Cod and Climate and to the Oceanography Committee at the 2003 Annual Science Conference.

**Supporting Information**

**Priority:** This Group will contribute to a fundamental component of the Cod and Climate Change strategic plan.

**Scientific Justification:**

The WGCCC has been active for over 10 years. At its 1998 meeting, synthesis of the results from the program was identified as one of the major components of its long-term strategic plan. It was decided at the 2000 meeting that this synthesis should take several forms, the most important being the writing of a book on cod. This book would highlight topics addressed by the WG, summarize our present knowledge of these topics and comment of how the WG has contributed to them. In keeping with the aim of the WGCCC, comparative studies between stocks will be emphasized. At the 2002 WGCCC meeting, an outline of the topics (book chapters) was approved and potential authors identified. A Workshop was recommended to present the topic syntheses in the form of presentations and papers in able to provide an open forum for comments and feedback. This would ensure completeness and provide an opportunity for comments and criticisms. A plan will be developed to revise the synthesis chapters, have them reviewed and finally published. Over the coming year efforts to secure a potential publisher for such a book will be sought. The Workshop will review the results of these efforts and determine future plans

**Relation to Strategic Plan:**

The workshop will contribute to Goals 1, 4, 5 and 10 of the ICES Strategic Plan.

**Resource Requirements:**

Assistance from the ICES/GLOBEC Coordinator in maintaining and exchanging information and data to potential authors.

Participants: This Workshop should attract 20–25 participants, most of who would be lead or contributing authors to the papers. This is expected to include a few scientists from outside the regular ICES scientific community.

**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, to the WGCCC reports. Also links to SGNARO, WGRP, SGGROMAT, and SGMPI.

**Linkages to Other Organizations:**

GLOBEC is a co-sponsor of the WGCCC.

**Recommendation III:**

The ICES/GLOBEC Working Group on Cod and Climate Changes proposes a Theme Session on the Transport of Eggs and Larvae Relevant to Cod Stocks of the North Atlantic at the 2003 ICES Annual Science Conference under the co-Chairship of B. Ådlandsvik (Norway) and John Quinlan (USA).

The objective is to improve our understanding of the role and relative importance of transport in controlling the recruitment of cod, other gadoid fishes and prey species of cod such as capelin.

**Supporting Information**

**Priority:** This Group will contribute to a fundamental component of the Cod and Climate Change strategic plan.

**Scientific Justification:**

Ocean currents transport the eggs and larvae of cod and other gadoid species. In some areas this transport is over 1000 km or more and is essential for maintenance of a stock component (e.g., West Greenland-Iceland connection). For other stocks, transport is important to move them into areas of high food production (e.g., Baltic). The importance of variability in transport on recruitment has been more elusive, however. Understanding the relative importance of transport on cod recruitment was the aim of the ICES/GLOBEC Workshop on the Transport of Cod Larvae held in April 2002. A follow-up theme session would allow time to evaluate the material presented and to explore avenues of research discussed at the Workshop. This would include the development of transport indices for comparison with recruitment indices. The theme session would also provide an opportunity to emphasize the major findings from the Workshop to the broader ICES community. Expansion to include other related fishes and prey species of cod would allow comparisons between cod and these species.

**Relation to Strategic Plan:**

The theme session will contribute to Goals 1, 4, 5 and 8 of the ICES Strategic Plan.

**Resource Requirements:** None.

**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, to the WGCCC reports. Also links to SGNARO, WGRP, SGGROMAT, and SGMPI.

**Linkages to Other Organizations:**

GLOBEC is a co-sponsor of the WGCCC.

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**APPENDIX 2: EXPRESSION OF INTEREST FOR THE EU FP6 PROGRAMME**



EUROPEAN COMMISSION

*EXPRESSIONS OF INTEREST TO IDENTIFY RESEARCH ACTIONS READY FOR SPECIFIC PROGRAMME TOPICS AS A BASIS FOR THE PREPARATION OF WORK PROGRAMMES FOR THE 6<sup>TH</sup> FRAMEWORK PROGRAMME FOR RESEARCH*

EoI n°:

ADMINISTRATIVE INFORMATION					
<i>Name of organisation submitting the EoI</i>		International Council for the Exploration of the Sea			
<i>Contact person details</i>		<i>Title (Dr, Prof ...)</i>	Dr	<i>Gender</i>	F <input type="checkbox"/> M <input checked="" type="checkbox"/>
		<i>Family Name</i>	Brander	<i>First Name</i>	Keith
<i>Address</i>		ICES, Palaegade2-4, DK-1261 Copenhagen K, Denmark			
<i>Telephone No.</i>		4533154225	<i>Fax No.</i>	4533934215	
<i>E-mail</i>		keith@ices.dk			
<i>Title of the expression of interest (up to 10 words)</i>		Pan-Atlantic Synthesis of Marine Ecosystem Research			
<i>Acronym (up to 20 Characters)</i>		PATSY			
<i>This EoI refers to an Integrated Project</i>			<input type="checkbox"/>	<i>This EoI refers to a Network of Excellence</i>	
<i>Sub-Thematic Priority<sup>1</sup> most relevant to your topic</i>			1.1.6.3		
<i>Other relevant Sub-Thematic Priorities<sup>2</sup></i>					
<i>Abstract (max. 10 lines)</i>	National and regional research into the structure and functioning of N. Atlantic marine ecosystems has been undertaken by all riparian states around the N. Atlantic over the past decade. Cooperation is organised within several international projects and the research community has well-developed plans for a Pan Atlantic Synthesis, aiming to apply the resultant knowledge to global change issues, including climate impacts on ecosystem functioning and the implications for biodiversity and sustainable use of natural resources. International cooperation adds value to relevant science carried out in many countries by encouraging integration, comparison and meta-analysis and is needed (i) because Atlantic scale climatic and biological forcing acts on local processes; (ii) to carry out sufficient observations over large geographic scales and (iii) to standardise methods and to exchange and integrate data sets. The Network will include all North Atlantic and European countries. It will be a Cooperative Activity with the US National Science Foundation.				
<i>I request that the information given in this form is not published<sup>3</sup></i>					YES <input type="checkbox"/>
<i>This form <b>must</b> be accompanied by the short document (maximum 5 pages) referred to in Section 3 of the Guide for Submitters.</i>					

<sup>1</sup> Indicate only one sub-thematic priority number given in Annex 1, e.g. 1.1.6.1.i or 1.1.1.ii.b or 2.3

<sup>2</sup> If appropriate, indicate one or more sub-thematic priority numbers given in Annex 1.

<sup>3</sup> Unless you tick the YES box the information included in the Annex 3 form will be published by the Commission Services. The 5 Pages EoI short document will not be published.

## **Pan Atlantic Synthesis of Marine Ecosystem Research (PATSY)**

An Expression of Interest to identify research actions in the priority area Global Change and ecosystems

**Proposer: Dr Keith Brander, International Council for the Exploration of the Sea, Copenhagen**

### **Implementing Arrangements for Cooperative Research Activities**

The recent signing of an Implementing Arrangement between the EC and the US National Science Foundation for Cooperative Activities in research areas including climate research, marine science and technology, and environmental biology provides an opportunity to develop the network of cooperative international research on marine ecosystems and to implement some of the plans for integration, pan-Atlantic comparison and synthesis, which have been discussed and formulated by the scientific community in a series of major international workshops (see footnote)<sup>3</sup>.

### **Rationale**

The North Atlantic influences the climate and biological environment of Europe with major consequences for human settlement, culture, trade and food supply. The shelf seas surrounding Europe are affected by large-scale climatic, oceanographic and biological processes in the North Atlantic. We have become more aware of our reliance on the ecosystem services, which the North Atlantic and the European shelf seas provide, but have also recognised our limited understanding of the functioning of the marine system and of the alterations, which human activities are bringing about. Consequences of global change, including climate impacts, on marine ecosystem functioning, and the implications for biodiversity and sustainable use of natural resources confront all nations, but the scientific community, which is addressing these questions around the North Atlantic, is particularly strong and well organised. It has a relatively long history of marine science and observation, which is essential for the study of long-term change.

Understanding and managing marine ecosystems is a global issue, with particular regional and local features. The influence and state of the North Atlantic is a shared concern among riparian states and there is much to be gained by sharing and synthesising our knowledge; the dynamics of the shelf sea ecosystems are strongly influenced by the ocean basins between them. Given the complexity of marine ecosystems and their remoteness from our everyday experience it will take some time before we become confident that particular management actions will achieve desired effects. The development of institutions and activities that will strengthen our capacity in this direction is an immediate prerequisite and this proposal includes support for activities and institutions, which synthesise and apply the results of that research. An expression of need for and relevance of these activities and institutions is contained in the Ministerial Declaration of the Fifth International Conference on the Protection of the North Sea (March 2002) which states that they *will develop focused research and information gathering which addresses the driving forces of North Sea ecosystem variability, including climatic, biological and human factors, which are critical for maintaining ecosystem structure and function and invite ICES, GLOBEC and other relevant scientific organizations and programmes to consider the priority science issues from the Scientific Expert Conference in Bergen 20–22 February 2002.*

National and regional research into the structure and functioning of North Atlantic marine ecosystems has been undertaken by all riparian states and has intensified over the past decade. Cooperation is organised within several national and international projects, in particular the core projects of the International Geosphere-Biosphere Programme (IGBP), which include GLOBEC (Global Ocean Ecosystem Dynamics), JGOFS (Joint Global Ocean Flux Study) and LOICZ (Land-Ocean Interactions in the Coastal Zone).

The Specific Activities set out below are based on an Announcement of Opportunity for jointly funded research on the impact of climate-related processes on the dynamics of plankton and fish populations drafted by the North Atlantic GLOBEC community. This community has a substantial record of publications, including several major symposia and

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<sup>3</sup> Workshop reports:

1. EuroGLOBEC Science Plan 1997 Report of an international workshop organised jointly by the MAST Programme of the European Commission, DG XII/D-3 and the Baltic Sea Research Institute Warnemünde. 76pp
2. GLOBEC Implementation Plan 1999 IGBP Report 47 207pp
3. GLOBEC related studies in the North Atlantic: A perspective for European/North American research cooperation? 2001 Proceedings of the EurOCEAN 2000 conference p 69-114
4. Proceedings of the workshop on "The Northwest Atlantic ecosystem - a basin scale approach. 2001 Canadian Science Advisory Secretariat Proceedings Series 2001/23 113pp

special issues of journals. It has carried out many cooperative field and experimental studies, which included international exchange of scientists at all career levels from doctoral to senior researchers. The means of information exchange within the community include regular Newsletters for the Trans-Atlantic Study of Calanus and the Cod and Climate Change programme.

## Objectives

- 1) To strengthen the capacity to understand, detect and predict changes in marine ecosystems of the North Atlantic and their consequences for ecosystem functions, biodiversity and sustainable use.
- 2) To provide scientific support for improvement of management strategies for prevention, mitigation and adaptation by producing and applying timely, relevant knowledge of marine ecosystems to the highest possible international standards.

## General approach

Cooperative research will be directed at compiling and standardising field and experimental data, describing and understanding system structures and processes, developing coupled physical-biological models of the dynamics of key species, using observational and experimental data for testing models, and applying results to support improvements in management. The activities set out below are a part of more comprehensive research plans, which deal with a number of marine ecosystems and species, and which are described in the workshop documents listed above.

Specific activities may be carried out by individuals, research groups or by cooperative international groups. The latter may take the form of workshops, theme sessions, symposia and other forms of international information exchange and cooperation. Exchange of personnel, will be encouraged in order to benefit from experience and interaction across the whole North Atlantic research community and to develop scientific capacity in this area.

The North Atlantic GLOBEC community has concentrated over the past decade on *Calanus finmarchicus*, the principal copepod (zooplankton) species of the North Atlantic ecosystem (the EU funded Trans-Atlantic Study of Calanus and many other regional and national programmes), and Atlantic cod (*Gadus morhua*) the principal demersal fish species and a predator on *Calanus* (the ICES/GLOBEC Cod and Climate programme).

## Specific Activities

- 1) Compiling and standardising data sets, including, but not limited to:

Distribution, abundance and life history characteristics of target species. Data may come from research surveys, ships-of-opportunity, moorings, satellites and sampling of catches. The emphasis is on distribution and abundance of target organisms in relation to their physical environment. Integrated, standardised data sets will be made widely available for time series analysis, regional comparisons, modelling of population processes and coupling to structure and variability of the environment.

Data from process and vital-rate studies, including integration of field and laboratory data designed to investigate specific biological and physical processes associated with vertical mixing and stratification, with regional exchange of water and organisms, and with the mechanisms and dynamics of cross-frontal exchange. Examples include: factors shaping variation in cohort formation and recruitment; experimental measurements of vital rates of target species to determine if vertical distribution and vital rates are affected by mixing processes; transport of organisms between regions and across oceanographic boundaries to determine how this influences population distribution and dynamics; how transport of biota is affected by vertical migration; influence of turbulence (all scales) on plankton patchiness, predator-prey interactions, and vital rates.

- 2) Comparing ecosystems and processes between areas and meta-analysis

Regional comparisons across the North Atlantic may include vital rates of target species - recruitment, mortality, fecundity, growth (as a function of food, temperature and stock characteristics), behaviour, predation, trophic interactions, and source populations. The extent and timing of planktonic transport within and between regions and the role of banks and basins as spawning/nursery areas for gadids and their prey need to be examined.

Time series of biological data from both the northeastern and northwestern Atlantic correlate with the North Atlantic Oscillation (NAO), which is an index of climate variability. Studies which clarify the nature of the

processes by which environmental variability affects biological populations within ocean and shelf areas around the North Atlantic will be supported, as will comparisons between regions, using the compiled data sets to identify or eliminate some of the candidate processes and to provide structural background for the modelling activities.

### 3) Coupled physical-biological modelling.

Conceptual and quantitative models are required, to investigate physical and coupled physical/biological processes in the North Atlantic basin and the associated shelf seas, and to synthesise new knowledge of the functioning and variability of the marine ecosystems. Three-dimensional circulation models using both idealized and realistic basin and shelf seas bathymetry and forcing are needed. The role of advection, turbulent mixing, nutrient supply, insolation, predation, and other factors on the early population development of the target species should be examined using both continuous and individual-based models. Studies may involve both diagnostic and predictive models, and include data assimilation to improve model accuracy and understanding of key processes. These and other model approaches will be encouraged, with the following aims: a) to improve understanding of the key physical and biological processes affecting the target species in the North Atlantic; b) to help integrate and synthesize the various physical and biological data collected during the field programs; c) to begin coupling the lower and upper trophic level models for the North Atlantic basin and shelf seas.

Studies that investigate basin scale effects of climate variability are encouraged. For example how is secondary productivity of North Atlantic shelf seas linked to basin-scale, long-term properties of the ocean circulation and climate system?

Ongoing modelling based research programs such as the Climate Variability and Prediction (CLIVAR), and the Global Ocean Data Assimilation Experiment (GODAE) may provide additional opportunities for collaboration in the synthesis.

### 4) Integrating knowledge and application

Applications within this priority area can be expressed in terms of structure (preserving ecosystems, protecting biodiversity and genetic resources), functions (productivity, bio-geochemical cycles) and goods and services (sustainable harvest, ecosystem services). Bringing new scientific knowledge to bear on management applications requires close interaction between scientists, managers and stakeholders. The International Council for the Exploration of the Sea (ICES) is an application-oriented scientific body, established a hundred years ago to provide a forum for cooperative studies of marine ecosystems and their management, particularly the fisheries. It therefore has a role to play and will serve as the principal forum for the integration and application of results.

Results include development of indices to characterize environmental and ecosystem status and change; indices for the physical and lower trophic level system components that characterize the status of the ecosystem, particularly in relation to potential higher trophic level production; indices for environmental variability which influence fish recruitment, growth, distribution and mortality for incorporation into short and long term assessment of fish stocks. Indices may be derived from parameters measured directly, or from output of specific configurations of biological-physical models.

Design of better - more efficient and more informative - monitoring programs.

### 5) Training, capacity building and stakeholder involvement

Developing effective management of marine ecosystems will take many years; therefore training and capacity building is essential. In addition to the usual forms of training, post-doctoral fellowships etc. a regular series of conferences for young scientists, managers and stakeholder representatives will be instigated, in order to foster the exchange of experience between disciplines and the development of close professional contacts early in their careers. ICES ran a conference on Marine Ecosystems for 100 young scientists from 25 countries in 1999.

## **Management and Partnership**

This Expression of Interest is based on plans prepared at the Workshops listed above, which included participants from Canada, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Norway, Poland, Portugal, Romania, Spain, Sweden, UK and USA. A formal partnership for the Network has not been set up at this stage. International and regional Steering Committees for the scientific programmes which provide the background to the proposed synthesis

exist, but the form of a new Steering Group for the Network and the Management Structure associated with it will depend on the modalities which are agreed as part of the Implementing Arrangements for Cooperative Research.