ICES WGCCC REPORT 2008

ICES Oceanography Committee

ICES CM 2008/OCC:08

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

16-17 June 2008

ICES Headquarters, Copenhagen

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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

Recommended format for purposes of citation:

ICES. 2008. Report of the ICES/GLOBEC Working Group on Cod and Climate Change (WGCCC), 16-17 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008/OCC:08. 29 pp.

Contents

Executive Summary

- The ICES/GLOBEC Working Group on Cod and Climate Change (WGCCC) has continued to make progress towards the objectives of the Strategic plan adopted in 1998 and revised in 2004. The plan for 2005 until the closure of the group at the end of 2009 covers Fisheries management, Zooplankton-Cod Linkages, Comparative Analyses, Climate Change, Trophodynamics of Cod Ecosystems, and Synthesis.
- The WG continues to work to apply a wide range of science to the improvement of marine ecosystem management and sustainable utilization and will support the integration and synthesis that is now underway in the International GLOBEC programme.
- The 2006 WGCCC Workshop on the Decline and Recovery of cod Stocks throughout the North Atlantic, including trophodynamic effects (WKDRCS) directly lead to or inspired at least 10 papers.
- During the last year the group has initiated two successful workshops, one on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA, a joint venture with other groups) and recently on Cod and Future Climate Change (WCFCC), both directly targeted towards items in our Strategic plan.
- The main focus of the groups work during the rest of 2008 and 2009 will be:
    - Finalizing the WGCCC book on cod
    - Synthesis Theme Session at ICES ASC 2009: "Beyond Cod and Climate Change: Effects of climate variability on marine ecosystems in the ICES area"
    - Workshop at the GLOBEC Open Science Meeting (proposed) WGCCC – *the past, the present and future challenges*
    - Contributing to the GLOBEC book

WGCCC recent scientific highlights

A number of publications related to WGCCC have emerged during the last year. Some are reviewed by Keith Brander in "Cod and Climate Change – a review of some recent studies. GLOBEC International Newsletter 14 (1): 54-55 April 2008". Here we exemplify by three recent studies.

Ice-age survival of Atlantic cod: agreement between palaeoecology models and genetics

Scant scientific attention has been given to the abundance and distribution of marine biota in the face of the lower sea level, and steeper latitudinal gradient in climate, during the ice-age conditions that have dominated the past million years. The glacial persistence of Atlantic cod (*Gadus morhua*) populations is examined using two ecological-niche-models (ENM) and the first broad synthesis of multi-locus gene sequence data for this species.

Bigg, G. R., Cunningham, C. W., Ottersen, G., Pogson, G. H., Wadley, M. R. & Williamson, P. 2008 Ice-age survival of Atlantic cod: agreement between palaeoecology models and genetics. *Proceedings of the Royal Society B-Biological Sciences* **275**, 163-172.

Spatial shifts in spawning habitats of Arcto-Norwegian cod linked to climate variability

This work demonstrates that spawning intensity of Arcto-Norwegian cod at various spawning sites along Norway's 1500 km of coastline is influenced by climate variations. Furthermore, while the recruitment response to temperature is immediate and on an interannual time-scale, the response to changes in spawning site is slower on a multidecadal time-scale. A time-series for 1900–1976 on cod roe indices along the coast shows that the southernmost spawning areas are more important during cold periods, and the northernmost ones in warm periods and coincide with high population fecundity. After 1976, qualitative observations show that there have been poor spawning fisheries in the southernmost spawning areas during the present warm period. From 2003, spawning has been observed along the coast of East Finnmark where it has not been known to take place during the previous 40 years.

Sundby, S., and Nakken, O. 2008. Spatial shifts in spawning habitats of Arcto-Norwegian cod related to multidecadal climate oscillations and climate change. *ICES Journal of Marine Science*, **65**: 953-962.

It is clear from a variety of data that cod in the North Sea do not constitute a homogeneous population that will rapidly redistribute in response to local variability in exploitation. Hence, local exploitation has the potential to deplete local populations. The oceanographic, biological and behavioural processes which maintain the spatial population structures are only partly understood, and one of the key unknown factors is the extent to which cod exhibit homing migrations to natal spawning areas. Here a model comprising 10 interlinked demes of cod in European waters, each representing groups of fish with a common natal origin is described. The spawning locations of fish in each deme are governed by a variety of rules concerning oceanographic dispersal, migration behaviour and straying. The study concludes that active homing is probably not necessary to explain some of the population structures of European cod, while other evidence suggests that homing may be a necessary behaviour to explain the structure of other sub-populations.

Heath, M. R., P. A. Kunzlik, et al. (2008). "A model of meta-population dynamics for North Sea and West of Scotland cod-The dynamic consequences of natal fidelity." *Fisheries Research* **93**(1-2): 92-116.

1 Opening of the meeting

The ICES/GLOBEC Working Group on Cod and Climate Change (WGCCC) met in Copenhagen, Denmark, under the co-chairmanship of Dr Geir Ottersen (Institute of Marine Research, Bergen, Norway) and Dr Kai Wieland (Denmark's Technical University, National Institute of Aquatic Resources, Denmark). There were 7 participants from 3 countries (Denmark, Norway, and USA) and the ICES/GLOBEC Coordinator. A list of participants is provided in Annex 1.

The meeting was opened by Dr Geir Ottersen who presented the Terms of Reference (ToRs, see section 2) and the Agenda (see Annex 2). Immediately following the Working Group meeting, the Workshop on Cod and Future Climate Change [WKCFCC] was held, co-convened by Drs Ken Drinkwater and Corinna Schrum, both from Norway.

2 Terms of reference and adoption of the agenda

According to C. Res 2007/2/OCC08 The ICES/GLOBEC Working Group on Cod and Climate Change [WGCCC] (Co-Chairs: G. Ottersen, Norway and K. Wieland, Denmark) will meet at ICES Headquarters, Copenhagen, Denmark, from 16–17 June (noon) 2008 to:

a) review and evaluate the Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice [WKEFA];

b) review and evaluate the Workshop on the Decline and Recovery of Cod Stocks Throughout the North Atlantic including trophodynamic effects [WKDRCS];

c) review and evaluate the progress on the publication of the WGCCC book;

d) make final preparations for the a Workshop on Cod and Future Climate Change;

e) continue planning for a WGCCC Synthesis Theme Session at ICES ASC 2009.

WGCCC will report by 20 July 2008 for the attention of the Oceanography Committee.

3 Update on status of the book on cod

The publishing of the Synthesis Book on Cod and Climate Change (eds. K. Brander and K. Drinkwater) has unfortunately been substantially delayed due to lack of response from a couple of key authors and the editors having other commitments. However, there have been several positive developments recently and the work is now moving forward. All the main chapters have been delivered to the editors. Most are in good shape, but at least one is not in a suitable format. A lot of editorial work remains. Fortunately Dr Brander has been able to set aside time for work on the book. We now aim for delivering the full manuscript to the publishers by June 2009. The group was further informed that the authors of several of the chapters have submitted manuscripts for original articles to journals or have plans for doing so based upon the same material. This was not regarded as a problem as the format of the book chapters will be different from the papers.

4 GLOBEC book

A book on Global Change and Marine Ecosystems is being written as a major contribution to the Synthesis phase for the International GLOBEC programme and WGCCC is actively contributing. There will be 11 chapters and the aim is to have it published in time for the final GLOBEC Symposium in June 2009. To date drafts of six of the chapters are available on the internal website (see Table below). These have been reviewed and are being put into their final form. The publisher requires the final draft by October 2008

Chapter 3	**Human impacts on marine ecosystems** *Keith Brander, Loo Botsford, Lorenzo Ciannelli, Mike Fogarty, Mike Heath, Benjamin Planque, Lynne Shannon, Kai Wieland*
Chapter 5	**Dynamics of marine ecosystems: ecological processes** *Coleen Moloney, Astrid Jarre, Shingo Kimura, David Mackas, Olivier Maury, Eugene Murphy, William Peterson, Jeffrey Runge and Kazuaki Tadokoro*
Chapter 6	**Dynamics of marine ecosystems: observation and experimentation** *Roger Harris, Larry Buckley, Robert Campbell, Sanae Chiba, Dan Costa, Tommey Dickey, Dian Gifford, Xabier Irigoien, Skip McKinnell, Thomas Kiorboe, Christian Mollman, Mark Ohman, Bill Peterson, Jeff Runge and Enric Saiz*
Chapter 8	**Interactions between changes in marine ecosystems and human communities** *R. Ian Perry, Rosemary Ommer, Rashid Sumaila, Edward Allison, Manuel Barange, Lawrence Hamilton, Marie-Caroline Badjeck and Astrid Jarre*
Chapter 9	**Marine resources management in the face of change: from ecosystem science to ecosystem management** *Manuel Barange, Robert O'Boyle, Kevern Cochrane, Carryn Cunningham, Michael Fogarty, Astrid Jarre, Laurence Kell, Jackie King, Keith Reid, Mike Sinclair and Akihiko Yatsu*
Chapter 10	**Ocean ecosystem responses to future global change scenarios: a way forward** *Shin-ichi Ito, Arthur Miller, Kenneth Drinkwater, Keith Brander, James Hurrell, Yasuhiro Yamanaka, James Overland and Svein Sundby*

5 Workshop on the Decline and Recovery of cod Stocks throughout the North Atlantic, including tropho-dynamic effects (WKDRCS)

This workshop was held in St John's, Newfoundland, Canada, May 2006 and a report was promptly published so there was no need for detailed elaboration. The main discussion focused on the question if the report from the workshop should be enhanced and published as an ICES Cooperative Research Report (CCR). Following consultations with and encouragement from Adi Kellermann, head of the ICES Science programme, and Bill Anthony, ICES Executive editor, a decision was made to make the necessary preparations towards a CCR. We were further advised that the most efficient route would be to approach Dr Pierre Pepin, chair of the Publications Committee directly and his response was positive. He stressed the need to produce the CRR within a short time and Dr Brander will undertake the necessary editing as part of his work programme over the next six months. A recommendation to publish this report was prepared (Recommendation 1).

Dr Wieland further informed the WG on a group paper on Decline and Recovery of cod* based upon the results of WKDRCS, co-authored by most of the participants and presented at the Lowell Wakefield Fisheries Symposium on Resiliency of Gadid Stocks to Fishing and Climate Change in Anchorage, Alaska, USA, October 31–

November 3, 2006. Several WGCCC members participated at this symposium. Papers which resulted from WKDRCS include:

Brander, K. M. 2007. The role of growth changes in the decline and recovery of North Atlantic cod stocks since 1970. ICES Journal of Marine Science, 64: 211-217.

Drinkwater, K.F. 2008. Comparison of the response of Atlantic cod (Gadus morhua) in the high latitude regions of the North Atlantic during the warm periods of the 1920s-1960s and the 1990s-2000s. Deep-Sea Research II. (Accepted pending revision, Revised version submitted).

Hovgård, H. and K. Wieland (2008): Fishery and environmental aspects relevant for the emergence and decline of Atlantic cod (Gadus morhua) in West Greenland waters. In: G.H. Kruse, K. Drinkwater, J.N. Ianelli, J.S. Link, D.L. Stram, V. Wespestad, & D. Woody (eds.), Resilience of gadid stocks to fishing and climate change. Alaska Sea Grant, University of Alaska Fairbanks, p. 89-110.

Lilly, G.R., Wieland, K., Rothschild, B.J., Sundby, S., Drinkwater, K.F., Brander, K., Ottersen, G., Carscadden, J.E., Stenson, G.B., Chouinard, G.A., Swain, D.P., Daan, N., Enberg, K., Hammill, M.O., Rosing-Asvid, A., Svedäng, H., and Vázquez, A. 2008. Decline and recovery of Atlantic cod (Gadus morhua) stocks throughout the North Atlantic. In Resiliency of gadid stocks to fishing and climate change. Edited by G.H. Kruse, K. Drinkwater, J.N. Ianelli, J.S. Link, D.L. Stram, V. Wespestad, and D. Woodby. Alaska Sea Grant, University of Alaska Fairbanks. pp. 39-66.

Lilly, G.R. 2008. The decline, recovery, and collapse of Atlantic cod (Gadus morhua) off Labrador and eastern Newfoundland. In Resiliency of gadid stocks to fishing and climate change. Edited by G.H. Kruse, K. Drinkwater, J.N. Ianelli, J.S. Link, D.L. Stram, V. Wespestad, and D. Woodby. Alaska Sea Grant, University of Alaska Fairbanks. pp. 67-88.

Rothschild, B.J., 2007. Coherence of Atlantic cod stock dynamics in the northwest Atlantic Ocean. Transactions of the American Fisheries Society 136:858-874.

Svedäng, H. & Svenson, A. 2006. Cod (Gadus morhua L.) populations as behavioural units: inference from time series on juvenile cod abundance in the Skagerrak. Journal of Fish Biology 69 (Supplement C): 151–164.

Svedäng, H., Righton, D. & Jonsson, P. 2007. Migratory behaviour of Atlantic cod Gadus morhua: natal homing is the prime stock-separating mechanism. Marine Ecology Progress Series 345: 1-12.

Svedäng, H., Righton, D. & Jonsson, P. 2007. Defining 'natal homing' in marine fish populations; need for inference in fishery science: reply to Bradbury & Laurel (2007). Marine Ecology Progress Series 347: 309-310.

Vitale, F., Börjesson, P., Svedäng, H. & Casini, M. 2008. The spatial distribution of cod (Gadus morhua L.) spawning grounds in the Kattegat, eastern North Sea. Fisheries Research 90: 36-44. doi: 10.1016/j.fishres.2007.09.02

6 Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA)

ToRs and a brief report from the workshop are given in Annex 4. The discussion on WKEFA developed into a general exchange of on how environmental information could be included into fisheries management. While it is hard to see how information on the environment can significantly contribute towards the short-range (typically 1 year) assessments, such information should for many stocks and ecosystems be a part of the harvest control rules. Thus, we should work towards including environmental information in longer term management strategies.

The group decided that the report from WKEFA also should be followed up upon and published as a CCR. Since WKEFA involves other groups than WGCCC the co-conveners Drs Manuel Barange and John Simmonds were contacted and they were in favour of this.

7 Report from GLOBEC SSC meeting Cape Town May 5–6 2008

Dr Svein Sundby, who is a member of the GLOBEC SSC and participated in the meeting, reported on some selected issues including Funding of regional GLOBEC activities, the new regional GLOBEC/IMBER programme ICED, the GLOBEC Legacy, and the GLOBEC OSM in Victoria 22–25 June 2009. WGCCC is invited to submit a suggestion for a workshop during the GLOBEC OSM. The proposal should be submitted before 1 September. GLOBEC SSC expressed concern over the delay in the publication of the WGCCC book. GLOBEC can help move the process forward, as earlier drafted chapters may have been superseded by more recent publications. A more detailed report is given in Annex 5.

8 WGCCC contribution to 3rd GLOBEC Open Science Meeting, Victoria, Canada 22–26 June 2009

The WG enthusiastically welcomed the invitation to submit a suggestion for a workshop and viewed this as an opportunity to present our science to a broader group of marine ecologists. Further, the group decided to apply for a full day workshop. The theme is to be WGCCC – *the past, the present and future challenges* and would include both presentations and discussions. There should be one presentation summarizing the state-of-the-art within our field before WGCCC, several on knowledge gained within the programme, and one on questions identified for future research, the latter a summary to be prepared by the co-conveners. The presentations of knowledge gained through WGCCC should indicatively include

- Results of comparative analyses (across stocks and geographical areas) on e.g. growth, recruitment, distribution and processes important for early life stages and adults
- Advances in modelling, e.g. hierarchy of models
- Effects on stock assessment and management, implications on policy

The outcome of the workshop should be published as 1–3 review/synthesis papers. The group agreed that three co-conveners should be found a.s.a.p., several good candidates were brought forward, and we are now in the process of contacting them. One has so far said yes.

It was further agreed that WGCCC should apply to GLOBEC for a share of the money allocated to covering expenses in connection with the OSM. Since WGCCC is centred around the North Atlantic and the OSM will be held in Victoria the WGs travel expenses will be high. A minimum of 15000 $ was found necessary to cover for conveners, 1–2 invited speakers and possibly 1–2 students.

9 Synthesis Theme Session at ICES ASC 2009: "Beyond Cod and Climate Change: Effects of climate variability on marine ecosystems in the ICES area"

In addition to the book and the GLOBEC OSM, the third pillar in the WGCCC synthesis is the theme session. The proposal to OCC and ConC is given as Annex 7.

This outline is rather broad and a discussion arose on how to narrow in. The focus was along the lines of Ecosystem management, New algorithms for stock assessment including environment, Ecological principles and parameters for stock assessment. It was suggested that the session should result in ICES papers suggesting development of climate work within ICES. The three current co-conveners all have or have recently had central positions within WGCCC. It was felt that the convener team better should reflect that work on environmental effects on fish stocks within ICES is broader than this and several alternative co-conveners were suggested and will be approached.

10 Workshop on Cod and Future Climate Change (WCFCC)

This workshop was to be held directly after the WG meeting. Co-convener Ken Drinkwater informed the group about the preparations. Information including a number of relevant scientific papers by participants and others had been made available on the workshops Sharepoint site at ICES. The ToRs and justification for WCFCC are given in Annex 8. A separate report will be published from WCFCC.

11 Report from ICES/GLOBEC Coordinator – Recent activities and plans for 2008/2009

A full progress report can be found at Annex 9 and an article "From Cod and Climate Change to the IPCC reports", which provides a more personal, long-term view of the programme appeared in the International GLOBEC Newsletter 14 (1): 53-54 in April 2008.

Dr Brander is now an employee of DTU – Aqua (Danish National Institute for Aquatic Resources). He will continue to act as Coordinator of the ICES/GLOBEC programme, but in the context of his work within DTU. The works programme for the rest of 2008 and 2009 is expected to include:

1) Report and papers arising from WKCFCC
2) Continuing the writing and editing of the WGCCC book to the deadline of June 2009
3) Editing the CRR from WKDRCS (Rec. 1) and assisting with editing the CRRs from WKEFA and WKCFCC
4) Organising the open GLOBEC meeting during the 2008 ICES ASC (1800h on 23 September) and thefinal Synthesis Theme Session at the 2009 ASC.
5) Assisting with the organization of the final GLOBEC Symposium in June 2009

12 Work in 2008/2009

WGCCC in its present format will, together with GLOBEC, be closing down at the end of 2009. The main activity in the remaining 1 ½ years is to synthesize the work that has been done within the programme. This will mainly be done through the publication of the WGCCC book, contributions to the GLOBEC book, the workshop at the GLOBEC OSM and the theme session at the ICES 2009 ASC. Each of these has been covered earlier in this report.

In connection with the ASC there will be a business meeting, the last meeting of the WG. This will be a 2 hour open evening meeting after the theme session and will be

followed by a dinner. The main topic for this meeting will be to develop future plans for the WGCCC line of work.

13 Plans for the time after GLOBEC

Although it would be natural to continue with WGCCC related work within ICES, there currently does not seem to be a lot of support for climate related work. The lack of support for the ICES/GLOBEC coordinator is an indication of this. ICES is developing a climate related programme, but the outcome of this still remains unclear. Hopefully, when established, this will give an opportunity for our line of work.

Ongoing, and especially the relatively recently started GLOBEC programmes are expected to amalgamate into IMBER. IGBP expects ESSAS, CLIOTOP and ICED to be integrated with ongoing IMBER activities. IMBER could then be a natural home also for WGCCC related work. However, it is difficult to say how IMBER will evolve from 2009. This, to a large degree, depends on the IMBER SSC, which currently is swayed towards ocean biogeochemistry, not ecology. However, the transition task theme (lead by John Field) is looking at amalgamation.

There are several international programmes that may be an outlet for work now done within WGCCC. This includes EUROCEANS, BASIN, and ESSAS (within or independent of IMBER).

14 Recommendations and draft resolutions for future meetings

Recommendation 1

The report on **Decline and Recovery of cod Stocks throughout the North Atlantic, including tropho-dynamic effects (WKDRCS),** edited by Dr K Brander, 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 150 and the report will be prepared for publication by December 2008.

Supporting Information

Priority:	
Scientific Justification and relation to action plan	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 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 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 providing advice on causes and rates of decline and recovery of stocks which are impacted by fishing and environmental change. It provides a background for advice on some technical measures.
Linkages to other Committees or Groups:	The results have implications for LRC and RMC.
Linkages to other Organisations:	
Cost share	ICES 100%

Recommendation 2

The report on the **Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA)** as reviewed by the Chair of the Oceanography Committee will be published in the *ICES Cooperative Research Report* series.

Supporting Information

Priority:	
Scientific Justification and relation to action plan	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 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 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.
Linkages to other Committees or Groups:	The results have implications for LRC and RMC.
Linkages to other Organisations:	
Cost share	ICES 100%

Recommendation 3

The report on the Workshop **on Cod and Future Climate Change (WCFCC)** edited by Drs Ken Drinkwater, Joachim Dippner, and Corinna Schrum, as reviewed by the Chair of the Oceanography Committee, will be published in the *ICES Cooperative Research Report* series.

Supporting Information

Priority:	
Scientific Justification and relation to action plan	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 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 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.
Linkages to other Committees or Groups:	The results have implications for LRC and RMC.
Linkages to other Organisations:	
Cost share	ICES 100%

Annex 1: List of participants

NAME	ADDRESS	EMAIL
Keith Brander	DTU Aqua, National Institute of Aquatic Resources, Technical University of Denmark, Charlottenlund Slot, Jægersborg Allé 1, 2920 Charlottenlund, Denmark	kbr@aqua.dtu.dk
Ken Drinkwater	Institute of Marine Research, PO Box 1870 Nordnes, N-5817 Bergen, Norway	ken.drinkwater@imr.no
Peter Munk	DTU Aqua, National Institute of Aquatic Resources, Technical University of Denmark, Afd. for Havøkologi og Akvakultur, Kavalergården 6, 2920 Charlottenlund, Denmark	pm@difres.dk
Geir Ottersen	Institute of Marine Research, Gaustadalleen 21, N-0349 Oslo, Norway	geir.ottersen@imr.no
Brian Rothschild	School for Marine Science and Technology, University of Massachusetts Dartmouth, 706 South Rodney French Boulevard, New Bedford, Massachusetts 02744-1221, USA	brothschild@umassd.edu>
Svein Sundby	Institute of Marine Research, PO Box 1870 Nordnes, N-5817 Bergen, Norway	svein.sundby@imr.no
Kai Wieland	DTU Aqua, National Institute of Aquatic Resources, Technical University of Denmark, Nordsøcentret, Postboks 101, 9850 Hirtshals, Denmark	kw@aqua.dtu.dk

Annex 2: Agenda

WGCCC Annual Meeting Agenda
June 16-17, 2008
ICES Headquarter, Copenhagen, Denmark

Monday, 16 June

09:00 Welcome and Introductory Remarks (*Geir Ottersen and Kai Wieland, Co-Chairs*)

- Welcome
- Review Terms of Reference [ToR] for the meeting
- Agenda

Practical Information *(Claire Welling, ICES)*

Update on status of the book on cod [ToR c] (*Keith Brander*)

Workshop on the Decline and Recovery of cod Stocks throughout the North Atlantic, including tropho-dynamic effects (WKDRCS) [ToR b] (*Kai Wieland*)

- Review and evaluation, publication of report
- Recent publications related to the workshop topic

Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA) [ToR a] (*Keith Brander*)

- Review and evaluation of the workshop
- Publication as Cooperative Research Report
- Other recent activities in this field of research

Report from GLOBEC SSC meeting May 5-6 2008 *(Svein Sundby)*

WGCCC contribution to 3rd GLOBEC Open Science Meeting Victoria 22-26/6 2009 *(Geir Ottersen introduction to discussion)*

Tuesday, 17 June

9:00 Synthesis Theme Session at ICES ASC 2009: "Beyond Cod and Climate Change: Effects of climate variability on marine ecosystems in the ICES area". [TOR e] (*Geir Ottersen*)

- Status of planning

Workshop on Cod and Future Climate Change WCFCC [ToR d] (*Ken Drinkwater*)

- Status of preparation

Report from ICES/GLOBEC Coordinator (*Keith Brander*)

- Activities in 2007 and plans for 2008/2009

Other business (*Geir Ottersen*)

- Next meeting
- Work in 2008/2009
- Plans for the time after GLOBEC

Wrap-up and Summary (*Kai Wieland and Geir Ottersen*)

- Recommendations
- ToRs for 2009

12:00 Closure (*Geir Ottersen and Kai Wieland*)

Annex 3: Terms of Reference 2008

According to C. Res 2007/2/OCC08 The ICES/GLOBEC Working Group on Cod and Climate Change [WGCCC] (Co-Chairs: G. Ottersen, Norway and K. Wieland, Denmark) will meet at ICES Headquarters, Copenhagen, Denmark, from 16–17 June (noon) 2008 to:

a) review and evaluate the Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice [WKEFA];

b) review and evaluate the Workshop on the Decline and Recovery of Cod Stocks Throughout the North Atlantic including trophodynamic effects [WKDRCS];

c) review and evaluate the progress on the publication of the WGCCC book;

d) make final preparations for the a Workshop on Cod and Future Climate Change;

e) continue planning for a WGCCC Synthesis Theme Session at ICES ASC 2009.

WGCCC will report by 20 July 2008 for the attention of 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:	The work will be carried out to review past activities and plan future Workshops and Theme Sessions. WKEFA was held in June 2007. It dealt directly with item 1 in the WGCCC Action plan. The outcome of the workshop will be evaluated and it will be decided if the report should be published as a CRR. WKDRCS was held 9-12 May 2007 and a report has been published. The workshop deals with items 3 and 5 in the WGCCC Action plan. The outcome will be evaluated and it will be decided if the report should be published as a CRR. One of the major components of the synthesis planned by the WGCCC is the publication of a book on cod. A lot of good material has been written, but some missing chapters are still delaying the process. An update will be provided. The final preparations for the Workshop on Cod and Future Climate Change will be carried out. It deals directly with item 4 in the WGCCC Action plan. The planning of a final Synthesis Theme Session at ICES ASC 2009 will continue
Resource requirements:	None.
Participants:	This WG meeting is expected to attract 15-20 participants.
Secretariat facilities:	None
Financial:	None
Linkages to advisory committees:	Relevant to the work of ACOM.
Linkages to other committees or groups:	Living Resources, WGZE, WGRP, WGBPI.
Linkages to other organizations:	GLOBEC is a co-sponsor of WGCCC.

Annex 4: Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA)

The workshop was co-convened by Manuel Barange, UK/GLOBEC, and John Simmonds, UK and met at ICES Headquarters, Copenhagen, Denmark, from 21–22 February 2007 (scoping meeting) and 18–22 June 2007 (main meeting). The workshop was co-sponsored by ICES, EUR-OCEANS, and GLOBEC and co-initiated by WGCCC with a focuses directly on action item 1) in our Strategic Plan.

During the preparatory meeting in February a strategy was developed and a number of relevant case studies identified. During the main workshop 14 case studies, involving a wide range of demersal and pelagic stocks, demonstrated the influence of environmental change. These cases were then used to discuss and formulate generic concepts for improving fisheries management strategies and advice considering interactions under four main aspects,

a) Entries and exits from populations (recruitment, natural mortality and migration)
b) Internal population processes, encompassing a range of aspects associated with growth maturation and reproduction.
c) Location and habitat (including such aspects as vertical and horizontal movement)
d) Multispecies interactions

While it has been long accepted that we are providing fisheries advice within the context of a varying environment, the workshop considered that we need to take into account not only of stochastic variability but also trends and shifts in the environment as we develop scientific advice. We recognize that changes in physical drivers at many scales of space and time act together and this will result in changes in habitat. Through complex linkages these changes will result in differences in fish location, growth, maturation and reproductive potential. These differences may then influence recruitment and abundance leading to changes in natural mortality due to different species interactions. The workshop concluded that the effects of environmental change on fisheries management are better addressed by separating variability according to the time-scale of the changes.

As a general recommendation the workshop concluded that in the light of climate change, rather than assuming that the mean of a given parameter derived from the (recent) past will best define the future we should consider trends and attempt to estimate them. This calls for the development of a number of tools that evaluate estimates of current values and current trends in the presence of noise in both measurement and environment. The workshop concluded with a number of specific recommendations under changes in:

- Productivity regimes that require adapting management procedures or procedures robust to regime shifts.
- Habitat influencing measurement and stock carrying capacity.
- Growth and maturation influencing short and medium term advice.
- Recruitment changes due to environmental influence in the short and medium term.

Recommendations also include the use of multispecies models primarily for hypothesis testing and testing management procedures. Finally we recognize the need for longer term prediction and thus for developing climate scenarios for sensitive areas.

Annex 5: Report from GLOBEC SSC meeting Cape Town 5–6 May 2008

Dr S. Sundby reported on some selected issues from the GLOBEC SSC meeting in Cape Town 5–6 May 2008:

Funding of regional GLOBEC activities

GLOBEC is in its final year in 2009. The GLOBEC Open Science Meeting (OSM) in Victoria, B.C., 22–25 June 2009 will be the major activity of GLOBEC this year. The GLOBEC International Project Office (IPO) will be terminated in the beginning of 2010. GLOBEC will, however, still have resources for the regional programmes to fund smaller projects and meetings in 2009. Deadline for submission of such proposals is 1 September.

Message to WGCCC programme

WGCCC is invited to submit suggestion for a workshop during the GLOBEC OSM. The proposal should be submitted to Jürgen Alheit, Olivier Maury and Hal Batchelder, and deadline is 1 September. GLOBEC SSC expressed concern over the delay in the publication of the WGCCC book. GLOBEC can help move the process forward, as earlier drafted chapters may have been superseded by more recent publications.

The new regional GLOBEC/IMBER programme ICED

Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) is a new GLOBEC-IMBER project. The Science Plan / Implementation Strategy (SP/IS) was with some minor comments approved jointly by the GLOBEC and IMBER SSCs.

GLOBEC Legacy

Kevern Cochrane noted that researchers are behind NGOs in their success to translate science into policy advice. He reflected on the obligation of GLOBEC to secure a legacy, and on the need to cater for the wide stakeholder audience of the programme (Science fora, UN agencies, funding agencies, etc.).

The GLOBEC SSC emphasized the need for two specific products: a GLOBEC brochure, summarizing the science (a la IGBP Science Series 4) and a GLOBEC Summary for Policy makers (a la IPCC). The Brochure could include the latest science presented at the third OSM, as well as the key messages from the GLOBEC book (selected by the lead authors) and from special issues of the regional programmes (selected by their Chairs). The Brochure should reflect on where we were when GLOBEC started and how far we have gone in understanding climate impacts, in developing coupled models, in predicting processes, etc. The Summary for Policymakers could be cross-linked to the Brochure, again following the IPCC mould. It was noted that the DFID FAO policy briefs on climate and fisheries could be a good model to consider as well. Astrid Jarre suggested involving people with one foot on the science and one on the policy side (e.g. Poul Dengbol). Kevern Cochrane proposed using scientific writers (e.g. Claire Attwood, from South Africa, who worked for BENEFIT/ BCLME projects). It was noted that for these products to see the light it may be necessary to contract the work outside. OM brought up the possibility of a symposium statement to be drafted in time for the OSM, to engage the media, with GLOBEC's position regarding the state of the marine ecosystem.

On other legacy issues Manuel Barange noted that a new website design was about to be implemented, with a more modern look and an easier structure, in preparation for

the fact that post 2010 the site will continue to exist but will not be updated and will become instead a depository of information. He also noted that the IPO has 3 copies of all project outputs, to deposit at the end of GLOBEC in three Institutions. There was some discussion as to the space required for this and the difficulty of identifying willing libraries. This was followed by an update from Dawn Ashby on the metadatabases of GLOBEC and the need to update records before the end of GLOBEC.

GLOBEC OSM in Victoria 22–25 June 2009

The structure of OSM was discussed: two days of workshops, three days of plenary sessions (GLOBEC achievements, Ecosystem structure, function and forcing, Ecosystem prediction and monitoring and Ecosystem management and human dimensions, Into the Future), and poster sessions. The session "Into the future" will include a slot for IMBER, the presentation of the GLOBEC synthesis book and a round table discussion.

IPO will draft an e-mail, in consultation with the symposium Convenors and workshop conveners (JA, OM, Hal Batchelder), to circulate among regional and national programme leaders and Focus WG members, to call for proposed workshop titles. All proposals are to be received by the workshop conveners by September 1. The symposium conveners will make the final decision on the workshops to be approved following the recommendation of the workshop conveners. Criteria for selection include: cross-cutting, forward-looking, outputs. It should be encouraged that sessions should be chaired by the new generation of scientists.

There is still need to raise about 90 000 USD to fund the OSM. Among the possible organizations to be requested to contribute is ICES.

Annex 6: Workshops and theme sessions at the 3rd GLOBEC OSM

As GLOBEC International efforts will conclude in December 2009, the OSM will be the main forum to show the main achievements of the programme and to plan for future initiatives. To cater for this dual objective the OSM steering committee would like to engage the broader GLOBEC community in developing an exciting and innovative symposium programme.

The first two days of the OSM (22–23 June) will be devoted to running topical **Workshops/Theme sessions**, addressing specific aspects of GLOBEC's science. We envisage running between 8–12 workshops depending on their duration and subject to space limitations. The objective of these Workshops/ Theme sessions can vary to include:

- In depth discussions on a particular topic requiring hand-on data analysis and/or model runs
- Presentations focused on a particular aspect of GLOBEC's science and followed by discussion
- Writing sessions leading to a synthetic or integrative output paper or research proposal

All Workshops/Theme sessions should have clearly defined outputs, e.a. a research paper, a special issue in a leading journal, a position paper, etc. In addition to this, proposals will be ranked according to their "forward-looking" and "cross-cutting" aspects.

We would like to **encourage all of you to suggest topics for these workshops/theme sessions**. All proposals must include the following information:

- Title of the session
- Potential Chairs (including an e-mail address)
- Brief summary of the objectives (half a page)
- Format (working session, all presentations plus discussion, etc.; including duration –half a day, full day, two days; potential number of participants)
- Output

This information must be send to the three workshop/ theme session conveners, Jürgen Alheit (juergen.alheit@io-warnemuende.de), Hal Batchelder (hbatchelder@oce.orst.edu) and Olivier Maury (Olivier.Maury@ird.fr). The conveners will rank the proposals, and the OSM Steering Committee will finalize the programme.

To ensure adequate advertising of the workshops/theme sessions we need topics to be suggested as indicated above by **1 September 2008**.

We are looking forward to hearing from you. Victoria 2009 will be a great community celebration for all GLOBECians out there, and we really want it to be your event.

Annex 7: Proposal to OCC and CONC for Theme Session at the ICES Annual Science Conference 2009 in Berlin synthesizing the work of WGCCC and looking at the future development of climate related work within ICES

The WGCCC programme has stimulated a wide range of research on cod, the ecosystems in which it occurs and the physical, biological and human drivers which shape its life history and population dynamics. This Theme Session will be an opportunity to take stock of what we have learned and to ask what progress we have made in resolving some of the issues which provided the scientific and management impetus for the programme. These include:

i) better understanding of the processes governing recruitment

ii) the importance of processes in later life (growth, maturation, mortality) in governing population changes and in maintaining resilience

iii) the interaction between population dynamics of zooplankton and the productivity of cod

iv) the influence of hydroclimatic variables on observed long-term changes in cod populations

v) top-down and bottom-up changes in ecosystems in which cod plays or used to play a major role

vi) the role of spatial dynamics and meta-population structure

vii) changes in management strategies which have or should have resulted from new insights.

The emphasis will be on papers which take a broad, critical overview of developments in the field and do not focus only on specific processes within a single-stock.

The formal ending of the GLOBEC programme does not mark the end of research in this area and the Theme Session will provide a forum for proposals and discussion of new strategic initiatives within ICES and within new international programmes such as IMBER. Proposals will be particularly sought for further developments in

1) strategic management which incorporates future climate scenarios and the attendant process uncertainty

2) end-to-end modelling of marine production leading to top predators such as cod

3) application of operational oceanographic products to improve fisheries management at all time-scales

4) understanding resilience and non-linear processes.

Theme Session proposal

The ICES/GLOBEC Working Group on Cod and Climate Change [WGCCC] proposes a Theme Session for the 2009 Annual Science Conference:

Title: Advances in marine ecosystem research: what we have learned from GLOBEC and what we can carry forward in future climate related programmes.

Theme Session conveners: Geir Ottersen, Norway, Keith Brander, Denmark and Ken Drinkwater, Norway.

Supporting Information

Priority:	Timely in 2009.
Scientific Justification	Much of the national, regional and international research on marine ecosystems over the past decade has been carried out under the GLOBEC programme, whose aim is "to develop our understanding of the structure and functioning of marine ecosystems and how they respond to changing physical forcing". This decade coincided with growing awareness of the impact of climate change, with the result that the GLOBEC programme gradually shifted its focus to dealing with these longer time-scales of change as well as with responses of the marine ecosystem at shorter and interannual scales. The GLOBEC programme is now drawing to an end and it is timely to review the lessons which have been learned and to consider how to carry forward important and fruitful elements into future programmes, such as IMBER and the evolving ICES programme on climate. Within ICES, the Cod and Climate Change programme was a major, but by no means the only GLOBEC activity and papers are invited which deal with all relevant marine ecosystem research.
Resource Requirements:	
Participants:	It is expected that responses to a call for contributions will reflect the wide interest and active research current in this subject area.
Secretariat Facilities:	None
Financial:	No financial implications
Linkages To Advisory Committees:	ACFM, ACE
Linkages To other Committees or Groups:	Many
Linkages to other Organisations:	GLOBEC, IGBP, IMBER, CLIVAR, SCOR, GOOS, EU and national programmes
Secretariat Marginal Cost Share:	

Annex 8: ToRs and justification for A Workshop on Cod and Future Climate Change [WKCFCC, 2007/2/OCC09]

ToRs and justification for A Workshop on Cod and Future Climate Change [WKCFCC, 2007/2/OCC09] (Co-Chairs: K. Drinkwater, Norway, J. Dippner, Germany, and, C. Schrum, Norway, will meet at ICES Headquarters, Copenhagen, Denmark from 17 June (12 noon) –20 June (12 noon) 2008 to:

In response to future climate change scenarios

a) adopt 20–50-year probabilistic projections of future temperature and salinity as a basis for projections of fish population dynamics and distribution (also nutrients)

b) develop methodologies and make projections of likely changes phytoplankton and zooplankton production and distribution, especially those species eaten by cod and their predators or prey during their life histories;

c) develop methodologies and make projections of likely changes in prey and predators of cod including the forage fish, such as capelin, herring, sprat and mackerel;

d) develop methodologies and make projections of likely changes in cod production (growth, reproduction, mortality, recruitment) and distribution.

This will be carried out using a combination of retrospective data analyses and a variety of modelling approaches.

WKCFCC will report by 20 July 2008 for the attention of the OCC, LRC, and ACOM.

Supporting Information

Priority:	This Workshop will contribute to the Cod and Climate Change strategic plan.
Scientific justification and relation to action plan:	The Workshop will contribute to Goals 1, 4, 5 and 10 of the ICES Strategic Plan Many of the regions currently occupied by Atlantic cod are predicted to undergo significant warming in response to climate change and in recent years much of the North Atlantic has experienced such warming. Increasingly, managers, politicians and the general public have been asking what will be the impacts of future climate change. Such information for cod and the marine ecosystems have been limited. Indeed, the few published studies have usually considered the response of individual species to increased warming without considering other components of the marine ecosystem, such as their prey or predators. However, climate change is expected to impact both the structure and function of marine ecosystems and to develop more plausible impact scenarios we must consider the species as part of the ecosystem. Using our increased understanding gained through the ICES/GLOBEC Cod and Climate Change program, including past workshops, plus other research on the effects of climate variability on cod and its supporting ecosystem, the impact of future climate scenarios on the marine ecosystems of the North Atlantic and especially cod will be developed.
Resource requirements:	None.
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 ACOM.
Linkages to other committees or groups:	Living Resources, WGZE, WGRP, WGBPI.
Linkages to other organizations:	GLOBEC is a co-sponsor of the workshop.

Annex 9: Report from ICES/GLOBEC Coordinator

Update of the progress report provided for the ICES Bureau in February 2008

Activity leader: Keith Brander

Objectives and Background

The major task was to apply scientific results from the GLOBEC programme and elsewhere to providing advice in four principal areas.

Task 1: Fisheries management strategies

The coordinator helped to set up, attended and contributed to a Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA) in June 2007 (ICES CM 2007/ACFM:25). He contributed to the development of science and ideas in this area through publications and the review and development of research programmes (e.g. the UK QUEST programme http://web.pml.ac.uk/quest-fish/default.htm). Recent publications include an editorial on "Tackling Climate Change Impacts on EU Fisheries" for the newsletter of the Institute for European Environmental Policy and a paper in a Special Feature on Climate Change and Food Security in the Proceedings of the National Academy of Science.

Task 2: Changes in distribution and abundance of fish and other marine biota due to climate

The coordinator helped to coordinate the activities of a number of ICES working groups in 2007, which were dealing with the OSPAR request on changes in distribution related to ocean climate. He corresponded with the chairs of Working Group on Oceanic Hydrography (WGOH) and attended their meeting (March 2007) in order to identify which of their products would be most relevant to the biological expert groups. He did a similar coordination job in relation to GODAE and IMBER (Paris, June 2007). He corresponded with a number of modellers and data scientists (particularly at the UK Met Office) in order to obtain consistent, state-of-the art hind cast and forecast fields of ocean climate data for use by biological expert groups in tackling the OSPAR request. He attended the meeting of the Working Group on Regional Ecosystem Descriptions (WGRED February 2007), the Working Group on Ecosystem Effects of Fishing Activities (WGECO April 2007 and May 2008) and the Advisory Group on Climate (which drafted the report for OSPAR 28-30 May, 2008), contributing the rationale, methodology and meta-analysis. He produced a report on indicators of fish distribution change for the European Environment Agency (EEA) and is co-author of a paper on "Causes and prediction of abrupt climate-driven ecosystem shifts in the North Atlantic", which is in press.

Task 3: Climate impact assessments

The IPCC fourth assessment report was completed and is now published. The coordinator was lead author on fisheries and a contributing author on other chapters. The IPCC were awarded the 2007 Nobel Peace Prize "for their efforts to build up and disseminate greater knowledge of man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".

The coordinator wrote papers and articles for PNAS, J. Marine Systems and the Encyclopaedia of Ocean Science on climate impacts and gave seminars at the University of Århus, the International Maritime University in Malmö and DG Fish of the European Commission. He gave invited talks on climate impacts at conferences in

Reykjavik (January 2008), Bergen (April 2008), Bonn (May 2008), Gijon (May 2008) and Malmö (June 2008).

The WKEFA was the major Cod and Climate Change related activity in 2007. Other parts of the programme, in particular the book, made slow progress, because of late delivery of key chapters. This has now been resolved and the editing and writing is underway. The coordinator is lead author for a chapter on Human Impacts on Marine Ecosystems for the GLOBEC Synthesis book and contributed to one of the other chapters. Both of these chapters were completed on time in March 2008.

Task 4: Fisheries Induced Evolution

A postdoctoral post was advertised to work on the management implications of fisheries induced evolution within the Marie Curie Research Training Network FishACE and interviews were held in February 2007. However, a major disagreement over the appointment and over the narrow view of the science within the programme resulted in withdrawal from the Network. Nevertheless, a successful ICES workshop (SGFIAC http://www.ices.dk/reports/RMC/2007/SGFIAC/directory.asp) was set up from an initiative started by the ICES/GLOBEC coordinator and a Policy Forum paper was published in Science, advocating Evolutionary Impact Assessment as a framework for quantifying the effects of harvest-induced evolution on the utility generated by fish stocks.

The coordinator was invited to give the final summing up for the NAFO/PICES/ICES Symposium on Reproductive and Recruitment Processes of Exploited Marine Fish Stocks (Lisbon, October 2007). This has been written up for publication in the NAFO Journal.

Future work

The ICES Consultative Committee, which took over the role of the Steering Group for the ICES/GLOBEC office, recommended in June 2007 that the GLOBEC office should be kept running until the end of 2009 and that ICES should make a financial commitment in order to encourage other sponsors (nations) to continue with their support. However, this recommendation was rejected by the Bureau. The project office in ICES was therefore closed at the end of 2007, but is continuing at the Danish National Institute for Aquatic Resources (DTU-Aqua).

Publications

Brander, K. M. 2007. The role of growth changes in the decline and recovery of North Atlantic cod stocks since 1970. ICES Journal of Marine Science, 64: 211–217.

Brander, K. M. 2007. Tackling Climate Change Impacts on EU Fisheries. El Anzuelo - European Newsletter on Fisheries and the Environment, 19: 1.

Brander, K. M. 2007. Climate change and food security special feature: global fish production and climate change. Proceedings of the National Academy of Sciences, 104: 19 709–19 714.

Brander, K. M. 2008. Fisheries and Climate. In Encyclopedia of Ocean Sciences, online edition. Ed. by J. H. Steele, K. K. Turekian, and S. A. Thorpe.

Easterling, W. E., P. K. Aggarwal, P. Batima, K. M. Brander, L. Erda, S. M. Howden, A. Kirilenko, J. Morton, J.-F. Soussana, J. Schmidhuber and F. N. Tubiello, 2007: Food, fibre and forest products. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 273–313

Jorgensen, C., Enberg, K., Dunlop, E. S., Arlinghaus, R., Boukal, D. S., Brander, K., Ernande, B., Gardmark, A., Johnston, F., Matsumura, S., Pardoe, H., Raab, K., Silva, A., Vainikka, A., Dieckmann, U., Heino, M., and Rijnsdorp, A. D. 2007. Ecology: Managing Evolving Fish Stocks. Science, 318: 1247–1248.

G.R. Lilly, K. Wieland, B. Rothschild, S. Sundby, K. Drinkwater, K. Brander, G. Ottersen, J. Carscadden, G. Stenson, G. Chouinard, D. Swain, N. Daan, K. Enberg, M. Hammill, A. Rosing-Asvid, H. Svedäng, and A. Vázquez. 2008. Decline and recovery of Atlantic cod (Gadus morhua) stocks throughout the North Atlantic. In Resiliency of gadid stocks to fishing and climate change, Edited by G. Kruse, K. Drinkwater, J.N. Ianelli, J.S. Link, D.L. Stram, V. Wespestad, and D. Woodby. Alaska Sea Grant College Program, Fairbanks, Alaska. Pp 39-66.

Submitted, accepted and in press

Beaugrand, G., Edwards, M., Brander, K., Luczak, C., Ibanez, F. in press. Causes and prediction of abrupt climate-driven ecosystem shifts in the North Atlantic. Ecology Letters.

Brander, K. M. 2008. Impacts of climate change on fisheries. Journal of Marine Systems, in press.

Brander, K. M. submitted Summing Up - Symposium on Reproductive and Recruitment Processes of Exploited Marine Fish Stocks. Journal of Northwest Atlantic Fishery Science.

Brander, K, Botsford, L., Ciannelli, L., Fogarty, M., Heath, M., Planque, B., Shannon, L., Wieland,,K. submitted Human impacts on marine ecosystems (chapter for GLOBEC Synthesis book)

Brander, K. submitted Effects of climate change on marine ecosystems. (chapter for Swedish schoolbook)

Jennings, S., and Brander, K. M. 2008. Predicting the effects of climate change on marine communities and the consequences for fisheries. Journal of Marine Systems, in press.

Perry, R. I., Cury, P., Brander, K. M., Jennings, S., Möllmann, C., and Planque, B. 2008. Sensitivity of Marine Systems to Climate and Fishing: concepts, issues and management responses. Journal of Marine Systems, in press.

Annex 10: WGCCC Terms of Reference 2009

The **ICES/GLOBEC Working Group on Cod and Climate Change [WGCCC]** (Co-Chairs: Dr. G. Ottersen, Norway and Dr. Kai Wieland, Denmark) will, in its present format, be closing down at the end of 2009 together with GLOBEC. WGCCC will work by correspondence in 2008-2009 (with a 2 hour meeting in connection with the 2009 ASC) to:

a) publish the reports on three recent workshops, as reviewed by the Chair of the Oceanography Committee, in the *ICES Cooperative Research Report* series:

i) Decline and Recovery of cod Stocks throughout the North Atlantic, including tropho-dynamic effects (WKDRCS), ii) Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA), and iii) Cod and Future Climate Change (WCFCC).

b) continue working towards finalizing the WGCCC book on cod;

c) contribute to the GLOBEC synthesis book;

d) plan and hold a theme session at the 2009 ICES ASC on Advances in marine ecosystem research: what we have learned from GLOBEC and what we can carry forward in future climate related programs (suggested conveners: Geir Ottersen, Norway, Keith Brander, Denmark and Ken Drinkwater, Norway;

e) organize a workshop at the 3rd GLOBEC Open Science Meeting Victoria, Canada 22-26 June 2009 on *CCC – the past, the present and future challenges*.

WGCCC will report by 1 November 2009 for the attention of the Oceanography Committee.

Supporting Information

Priority:	The group is developing the application of environmental information in the Advisory Process and also the relationship between ecosystem change and fish population dynamics. It therefore has high priority.
Scientific justification and relation to action plan:	The work will be carried out to review past activities, and carry out synthesis activities including books, the workshop and theme sessions. By the end of 2009 we aim to have thoroughly covered all items in our Strategic plan.
Resource requirements:	The research programmes which provide the main input to this group are already underway, and resources already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants:	The Group is normally attended by some 15–20 members and guests.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	Linkages with advisory committees are being developed.
Linkages to other committees or groups:	Living Resources Committee, WGZE, and WGRP Expert Groups
Linkages to other organizations:	Close linkages with other GLOBEC activities and also some links to PICES.